UNIVERSITY OF CALIFORNIA

Los Angeles

Innovation, the Scientists and the State:

Programmatic Innovation and the Creation of

the Soviet Space Program

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Political Science

by

Andrew John Aldrin

1996

The dissertation of Andrew John Aldrin is approved.

Richard Anderson

Hans Rogger

Donald Chisholm, Committee Chair

University of California

1996

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

VITA

1985	B.A., Political Science University of California at Santa Barbara Santa Barbara, California
1985-1987	Professional Research Staff Institute for Defense Analyses Alexandria, Virginia
1987	M.A., Science, Technology, and Public Policy George Washington University Washington D.C.
1987-1991	Graduate Fellow RAND/UCLA Center for Soviet Studies
1987-1996	Consultant The RAND Corporation Santa Monica, California

PUBLICATIONS AND PRESENTATIONS

Aldrin, Andrew J., (1989) "Lessons from the History of the Development of Soviet Rocketry" paper presented at the American Association for the Advancement of Slavic Studies annual conference, Chicago Ill.

Aldrin, Andrew J., (1995) "Defense Enterprise Adaptation and Implications for the Russian Missile Industry" paper presented at Monterey Institute for International Studies and the Naval Postgraduate School Conference on Defense Conversion and the MTCR, Monterey, California.

Aldrin, Andrew J., (1996) "Defense Enterprise Adaptation in St. Petersburg," in Selected Conference Papers on Commercializing High Technology: East and West, Stanford University, (Palo Alto: Stanford University Center for International Security and Arms Control, 1996)

ABSTRACT OF THE DISSERTATION

Innovation, the Scientists, and the State: Programmatic Innovation and the Creation of the Soviet Space Program

by

Andrew John Aldrin

Doctor of Philosophy in Political Science

University of California, Los Angeles

Professor Donald Chisholm, Chair

This dissertation examines the relationship between the state leadership and the scientific community during the course of state sponsored, large-scale, highly original, technological innovations -- programmatic innovations. It considers the dilemma faced by the state in encouraging innovation without wasting resources, and posits the proposition that the scientific community must achieve a high degree of autonomy for programmatic innovation to successfully occur. A three-stage process of programmatic innovation is developed including stages of 1) conceptualization and initiation, 2) organizational emergence, and 3) institutionalization.

The proposition is tested through observation of interactions between the state leadership and the scientists in which the actors possess conflicting interests. The case study chosen is the development of the Soviet missile and space programs, representing a single crucial test of the proposition that scientific autonomy is necessary for programmatic innovation. Through extensive use of interviews with participants in the early Soviet missile and space programs, the case study observes high levels of scientific autonomy throughout the programs, and further notes that scientific autonomy was the primary contributor to programmatic success.

In conclusion, the dissertation examines three other large-scale programs in order to test and expand the general theory. Observation of the U.S. atomic bomb program and the U.S. ICBM program supports the proposition of the study, noting a strong connection between scientific autonomy and programmatic success. The Soviet atomic bomb program is examined as a case of programmatic emulation, demonstrating that scientific autonomy may be constrained in such cases. The differences between innovation and emulation in terms of the relationship between the scientists and the state leadership are significant, and reinforce the assertion that there are different classes of innovative activities which require different analytic perspectives. Finally, this study concludes that the best method by which the state leadership can encourage innovation without sacrificing control is to divide the research, development, and production processes into stages requiring formal decisions, while allowing the scientists autonomy within those stages.

CHAPTER 1

Research, however, is the exploration of the unknown. It is speculative, uncertain. It cannot be standardized. It succeeds, moreover, in virtually direct proportion to its freedom from performance controls...

Vannevar Bush (1945)

INNOVATION, THE SCIENTISTS AND THE STATE

At 10:28 p.m., Moscow time, October 4, 1957 another rocket was launched from the steppes of Kazakhstan. But unlike any rocket launched before it, a part of this rocket would not return to Earth. The 80 kg. sphere atop Korolev's R-7 rocket continued to orbit around the Earth for several years, a small radio transmitter inside emitting a "beep beep" heard round the world. The launch of Sputnik was a defining moment in history. For historians and philosophers, it marked the beginning of the "Space Age." Mankind took his first tentative step into the cosmos, where surely the greatest of wonders awaited in the years to come. For political leaders and policy makers, this date was of less noble significance, but far more important. It underscored the first Soviet victory in its technological competition with the United States which characterized the Cold War. US technological hegemony had been cracked. U.S. Secretary of State Averell Harriman found it as "shocking: that a backward nation like the USSR could perform such a feat." Senator Henry Jackson called it "a devastating blow to US scientific, industrial and technological prestige" which plunged the US into "a week of shame and danger."[1] The shock of Sputnik reverberated with the launch of the first man into space, a Russian, Iuri Gagarin. Like Harriman, policy makers, pundits, and people everywhere puzzled over how a technological backwater like the Soviet Union won the early heats of the space race.

For political scientists and public administrators, the question was almost rhetorical. The answer, they assumed, was that Soviet political and military leadership focused a sizable portion of the nations' scientific and technological effort on the single goal of beating America into space.[2] The Soviets began running early and hard, and beat the Americans into space in order to demonstrate the superiority of a centrally-planned socialist system. Political scientists, examining this program concluded that it was a top-down effort.[3] For 25 years this view persisted. Holloway noted that

---

[1] See *New York Times*, October 8, 9, 10, 1957.

[2] See in particular William Schaeur, *The Politics of Space: A Comparison of the Soviet and American Space Programs*, (New York: Holmes and Meier, 1976).

[3] For an historical interpretation of the sputnik launch see in particular, Walter A. McDougall, *The Heavens and the Earth: a Political History of the Space Age*, (New York: Basic Books, 1985); For interpretations of the program by political scientists see David Holloway, "Innovation in the Defense Sector: Battle Tanks and ICBMs," in Ronald Amann and Julian Cooper, *Industrial Innovation in the Soviet Union*, (New Haven: Yale University Press, 1982); Karl F. Spielmann, *Analyzing Soviet*

> a crucial feature of the ICBM program is that ever since the decisions to undertake development of the atomic bomb and long-range rockets it has enjoyed the highest priority. The top party leaders have place great importance on the creation of strategic power, and have devoted time, energy and resources to ensuring the success of ICBM development. Stalin's role in the decisions of the mid-40s has already been noted. Khrushchev's memoirs suggest that when he was First Secretary of the Central Committee he too played the dominant role in the Politburo.[4]

Speilman and Evangelista are among others concluding that the ICBM case was consistent with a leadership driven program.[5]

However, much has changed in the former Soviet Union since these authors examined the subject. Now the assumption can be tested, and subjected to empirical warrant and validation. History has literally been brought out of the safe. Data, previously considered to be unimaginably secret is now openly discussed in journals, at historical conferences, and even in popular newspapers published in Russia. Engineers, policy makers and scientists, whose very existence was kept secret, now openly discuss past Soviet military programs with Western researchers. This newfound wealth of information paints a very different picture of the Soviet space program's development.

Strategic Arms Decisions, (Boulder: Westview Press, 1978); and Matthew Evangelista, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies,* (Ithaca NY: Cornell, 1988).

[4]See Holloway, "Innovation in the Defense Sector... p. 401.

[5]See Spielmann, *Analyzing Soviet Strategic Arms Decisions...* pp. 109-145. Evangelista, *Innovation and the Arms Race...* pp. 243-244

There is no question that Stalin provided necessary support for the development of long-range ballistic missiles. But the evidence suggests that rockets were a not high priority for Stalin. Greater attention was devoted to developing long-range aviation, cruise missiles, and anti-aircraft missiles. The Soviet military was openly hostile to missiles, and was dragged, kicking and screaming, into the space age. Recently released information reveals that the mutation of the missile program into a space program was even more interesting. The Chief Designer of Long-Range Missiles, Sergei Korolev, kept Stalin and the rest of the political, military, and economic leadership intentionally in the dark the regarding the early development of a space program. When the military and economic leadership was made aware of the possibility of a space program, after four years of covert research, they rejected the idea, forcing proponents to sell the program to a reluctant Academy of Sciences. The political leadership ultimately accepted the program, but only after repeated entreaties by Korolev, who finally carried the day by convincing them that there would be a tremendous political payoff to putting a Soviet satellite in space before the Americans.

This explanation of the genesis and success of the Soviet space departs dramatically from the top-down process typically assumed to be the model for technological development in the Soviet Union.[6] In fact, development of the Soviet space

---

[6] See Zbigniev Brzezinski and Samuel P. Huntington, *Political Power: USA/USSR,* (New York, 1972)

program closely resembles the classical version of the development of American programs in which ideas "bubble up from the bottom," rendering a case, once a fairly uninteresting to social scientists, significantly more intriguing.[7]

Are there certain common processes necessary for successful innovation in states with very different governmental systems? Government-sponsored technological programs are executed within comparable environments, across most countries. Conditions of virtual monopsony and monopoly prevail in most defense industries. Evaluation of the success of innovations is performed by relatively small groups of military and political elite, rather than by the much larger group of consumers that evaluate most civilian innovations. The market for concepts small, and the same organization is often charged with both researching the problem and devising a solution as well as producing the system.[8] Given these similarities, it is entirely plausible that nations with very different governments, such as the Soviet Union and the United States, would come to similar organizational solutions for similar sets of technical problems and tasks. Wilson, Burns and Stalker, and Thompson have asserted that an identifiable type of organizational structure is most appropriate for tasks of innovation.[9]

---

[7] See Brzezinski and Huntington, *Political Power: USA/USSR* ... pp. 228-229.

[8] See Tracy Lewis, "Defense Procurement and the Theory of Agency," in Jim Leitzel (ed.) *Economics and National Security*,(Boulder CO: Westview Press, 1993) pp. 57-72.

[9] See James Q. Wilson, "Innovation in Organizations: Notes Toward a Theory," in James D. Thompson, *Approaches to Organizational Design,* (Pittsburgh: University of Pittsburgh Press, 1966); James D.

The case of the Soviet space program could therefore test hypotheses that innovation processes are similar across very different governments. The totalitarian society which existed in the Soviet Union under Stalin was perhaps the least likely environment to produce innovation process similar to those of the United States. As Brzezinski and Huntington observed:

> In the United States, pressures for change tend to bubble up continually...In the Soviet Union, in contrast, innovation tends to have a stop and start, trial and error quality. ***Major changes are initiated from the top.***[10]

Evangelista argued that the reason for these different research styles lay in the vastly different structures of the United States and Soviet Union.[11]

The basic dynamic operating in government sponsored technological innovation is described by the relationship between the scientific-technological and industrial communities and the political leadership of a government which has the authority to initiate, close down, or significantly altering a technological program. For this study, I shall term this term the former "the scientists" and the latter group "the leadership." The tension between the two groups derives from the scientists' desire for the leadership to give them unlimited resources to pursue their scientific ambitions while conducting

---

Thompson, *Organizations in Action*, (New York: McGraw-Hill, 1966); and T. Burn and G.M. Stalker, *The Management of Innovation*, (London: Tavistock, 1961).

[10]See Brzezinski and Huntington, *Political Power: USA/USSR* ... pp. 228-229. Emphasis added.

[11]Evangelista characterized the United States as society centered and the Soviet Union as "state centered." See, Evangelista, *Innovation and the Arms Race....*

minimal oversight. The leadership, on the other hand, is sensitive to costs and wants to tightly control the scientists' activities to ensure that it gets the "most bang for the buck" or "rubble for the ruble." This study is an exploration of this relationship arguing that for the largest, most original cases of technological innovation the scientists must obtain significant autonomy from the leadership.

THE DILEMMA OF INNOVATION

For good reason, national governments do not readily engage in innovative large-scale technological programs. Large-scale programs, particularly those involving unproven technologies, are long-term, high risk, and invariably expensive undertakings – all of which are anathema to the leadership. At the time when decisions must be made on programs, success is highly uncertain; precisely the conditions under which political leaders loathe making such commitments. Over the long period of development, the leadership must continue to justify the tremendous expenditure of these programs to their constituents. On the other side of the ledger, the prospects for political profits are dim. Long-term programs offer little, if any, hope for the short term payoffs so important for political support. Further, the early period of technologically innovative programs is often characterized by failures which, while the scientists find them informative and educational, are hard to depict politically as something other than expensive disasters. *Worse,* the secretive nature of most military technology programs makes it difficult to advertise success in a manner timely enough for political leaders. However, secrecy is rarely sufficient to conceal failure.

A political decision to initiate a new program is only the first step through the gantlet. Once the politicians have decided to initiate a new program they must push it through public bureaucracies which are not only resistant to change, but are inherently anti-innovative organizations. Not only do they suffer from problems of stagnation endemic to large-scale, hierarchical organizations, but they are also subjected to constant public demands to meet performance indices, generally not imposed upon private organizations, such as fairness and openness, which often further impede innovation.[12] Wilson cautions that we

> ought not to be surprised that organizations [public bureaucracies] resist innovation. They are supposed to resist it. The reason an organization is created is in large part to replace the uncertain expectations and haphazard activities of voluntary endeavors with the stability and routine of organized relationships.[13]

---

[12] On stagnation of public bureaucracies see, Anthony Downs, *Inside Bureaucracy,* (Boston: Little Brown, 1967) pp. 132-157. On factors which make public bureaucracies less innovative than private ones see Wilson *Bureaucracy, op. cit.* pp. 221-232 and Downs, *Inside Bureaucracy...* pp. 158-211.

[13] See James Q. Wilson, *Bureaucracy,* (New York: Basic Books, 1989), p. 221. See also Aaron Wildavsky "The Self-Evaluating Organization," *Public Administration Review,* Vol. 32 (1972) pp. 509-520.

If an agency commits to a technology program, the program must now be protected from budgetary raiders. Since most technology programs are expensive, each new program competes with established claimants for scarce resources. Competing agencies argue that the new program is unnecessary, or that existing technology can perform the same mission at lower costs. They can be formidable adversaries enjoying the advantages of existing constituencies and proven track records. Furthermore, if a new technology program is to survive, it must escape the cradle and progress beyond the initial project; follow-on work must be developed and supported. Thus, new programs must find means to sustain themselves over repeated cycles of individual project approval, development, production and obsolescence. Superior technology is not necessary nor sufficient for success.

And yet, political leaderships decide to establish new technology programs, and administrative agencies somehow manage to support these political decisions and implement new technology programs. In fact, the latter 20th century is characterized by government sponsored technological innovation.[14] How did this happen? Was it at the direction of political leaders striving to win the strategic competition with other nations?

---

[14] Most of this innovation has, of course, been directed at the developing weapons systems. For discussions of the overall strategic competition see Graham T. Allison, "Questions About the Arms Race: Who's Racing Whom? A Bureaucratic Perspective" in Robert L. Pfaltzgraff Jr. *Contrasting Approaches to Strategic Arms Control,* (Lexington MA: D.C. Heath, 1974); Evangelista, *Innovation and the Arms Race...* For a commentary on the competition between the US and Soviet space programs see Walter A. McDougall, *The Heavens and the Earth: a political history of the space age,* (New York: Basic Books, 1985).

The realist approach contends that the strategic competition itself drives innovation: nations must innovate to survive.[15] Some scholars argue that it is the scientists themselves who have pushed innovation through the bureaucracy.[16] Those from the bureaucratic politics tradition take the view that innovation begins with the scientists and is transferred up through the bureaucracy, with each succeeding layer being convinced of the scientists' arguments.[17] The literature on this question is rich, but does not present a consensus of opinion.

The majority of work focuses on the phenomenon of arms races between nations, and is ideological in character, and prescriptive in conclusion. With few exceptions, the

---

[15] A broad overview of this perspective is presented in Kenneth Waltz, *Theory of International Politics,* (Reading MA: Addison-Wesley, 1979). The issue of the effect of systemic competition is explored more closely in Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars,* (Cornell, Ithaca, 1984), and the interaction of technological innovation is also explored in George Rathjens, "the Dynamics of the Arms Race," *Scientific American,* April, 1969. Others have extended this rational actor model somewhat, concluding that leadership decisionmaking was an important ingredient exacerbating the international competition. Karl F. Speilmann *Analyzing Soviet Strategic Arms Decisions,* (Boulder: Westview, 1978); and, Robert Jervis *Perception and Misperception in International Politics,* (Princeton NJ: Princeton University Press, 1976).

[16] See Ralph E. Lapp, *The Weapons Culture,* (New York: Norton, 1968); Herbert York, *Race to Oblivion: A Participants View of the Arms Race,* (New York: Simon and Schuster, 1974); Donald MacKenzie, *Inventing Accuracy: a Historical Sociology of Nuclear Missile Guidance,* (Cambridge MA: MIT Press, 1990); Solly Zuckerman, *Nuclear Illusion and Reality,* (New York: Viking, 1982); Harvey Brooks, "The Military Innovation System and the Qualitative Arms Race," *Daedalus,* Vol. 104 (Summer 1975); and Deitrich Schroeer, *Science, Technology and the Arms Race,* (New York: Wiley, 1984).

[17] This would include arms race theories based on the bureaucratic politics paradigm. See Jonathan B. Stein, *From H-Bomb to Star Wars: The politics of strategic decision making,* (Lexington MA: Lexington Books, 1984); Graham T. Allison, "Questions About the Arms Race: Who's Racing Whom? A Bureaucratic Perspective" in Robert L. Pfaltzgraff Jr. *Contrasting Approaches to Strategic Arms Control,* (Lexington MA: D.C. Heath, 1974); and Morton H. Halpern, *Bureaucratic Politics and Foreign Policy,* (Washington D.C.: Brookings, 1974).

question has been: how can weapons innovation be prevented?[18] Since the end of the Cold War, this literature has disappeared. Military innovation is being reconsidered from the more positive perspective of: how can we encourage innovation?[19] However, many of the underlying processes remain poorly understood. This study intentionally assumes the value of innovation, and asks only: how *does* innovation occur and succeed?

In a competitive international environment, the pressure to innovate places leaders in an uncomfortable dilemma: how can we innovate without wasting state resources?[20] They need to innovate in order to maintain some approximation of technological parity with their competitors.[21] One side argues that uncertainty over the actual technological capabilities of other nations makes calculation of the necessary threshold of innovation difficult. Consequently, there is an incentive to innovate as much as possible, allowing

---

[18] In general the argument has been that weapons innovations have resulted in decreased security. (See deterrence literature) Two exceptions, argued that weapons innovations have produced increased security. See Albert Wohlstetter, "Legends of the Strategic Arms Race, *Strategic Review,* Fall 1974, pp. 5-48; and Kevin Lewis, "Balance and Counterbalance: Technology and the Arms Race," *Orbis,* Vol. 14, (Summer, 1985) pp. 259-269.

[19] For a positive normative approach to innovation in military organizations see Stephen Peter Rosen, *Winning the Next War: Innovation in the Modern Military,* (Ithaca: Cornell University Press, 1991)

[20] The spectrum of state control and the consequences arising from positioning state institutions at certain points are explored in Are Rip and Anton J. Nederhof, "Between Dirigism and Laissez-Faire: Effects of Implementing the Science Policy Priority for Biotechnology in the Netherlands," *Research Policy,* Vol. 15 (1986) pp. 253-268; and A.J. Nederhof, "Between Accommodation and Orchestration: The Implementation the Science Policy Priority for Biotechnology in the Netherlands," *Research Policy,* Vol. 19(1990) pp. 379-386.

[21] This is the basic position of realists and provides a starting point for most other discussions of technological arms races. See Evangelista, *Technology and the Arms Race...*

weapons designers and producers to engage in relatively unfettered innovation supported by generous sums of money.[22] Given the general inability of the leadership to predict which innovations will be successful and which will not, this strategy also permits the greatest hedge against uncertainty of domestic technological and productive capacities.[23]

This argument was most forcefully and successfully advanced by Vannevar Bush, in a 1945 report *Science: the Endless Frontier,* which was adopted by the Truman administration.[24] His argument, that scientists should control military R&D, has characterized the US military industrial system since WW II.[25] Eminent scientists, Bush asserted, "have no intention of being pushed around or placed in an inferior status, or of placing the judgments at which they arrive by the sweat of their brows before men of

---

[22] For a discussion of the problem of dealing with the uncertainties of imperfect intelligence regarding enemy capabilities see Rosen, *Winning the Next War...* pp. 185-220.

[23] See Rosen, *Winning the next War...* pp. 221-250.

[24] This unpublished report was co-authored by James B. Conant, President of Harvard University, Frank B. Jewett, President of the Academy of Sciences and Chairman of the Board of Bell Telephone Laboratories, and Karl T. Compton, President of M.I.T.

[25] For a discussion of this point see Deborah Shapely, Rustrum Roy, *Lost at the Frontier: U.S. Science and Technology Policy Adrift,* (Philadelphia: ISI Press, 1985) pp.. 1-37,

another profession for inexpert dissection or distortion."[26] There is a large body of literature adding support to his argument.[27]

Uncritically implemented, Bush's strategy could have proven to be extraordinarily expensive. As rich as the United States was in the immediate post WW II decades, it could not afford to pursue every idea of every scientist. Consequently, the leadership had an incentive to attempt to limit expenditures and control the innovative process. Substantial research supports the notion that the leadership needs to control scientists in order to successfully innovate. The US Department of Defense performed a study contradicting the assumption of Bush and the weapons scientists, arguing that "a clear understanding of DoD need motivated 95% of scientific technological innovation for the

---

[26] The points made in *Science the Endless* Frontier are incorporated into Vannevar Bush, *Modern Arms and Free Men,* (New York: Simon and Schuster, 1949) pp. 253-54, as cited in Rosen, *Winning the Next War...* p. 225.

[27] A somewhat less self-interested account is offered by Bruno Latour who observes that scientific endeavors are characterized by scientists developing elaborate techniques for convincing their research sponsors to provide financial support for their projects while permitting the scientists almost complete autonomy over the research and development activities. See Bruno Latour, *Science in Action,* (Cambridge: Harvard, 1987). Burns and Stalker researched several innovative firms, and found that innovation was most likely to occur in firms with an *organic* structure permitting free and open lines of communication and a relative absence of hierarchy. See Tom Burns and T.M. Stalker, *The Management of Innovation,* (London: Tavistock, 1961). Evangelista, argued that the reason the United States enjoyed much higher rates of innovation than the Soviet Union was that scientists were relatively free to innovate on their own in the United States. See Evangelista... Van Crevald argued the point perhaps most forcefully that "During the twentieth century...none of the important devices that have transformed war--from the airplane through the tank, the jet engine, radar, the helicopter, the atom bomb and so on all the down to the electronic computer--owed its origins to a doctrinal requirement laid down by people in uniform." Martin van Crevald, *Technology and War: From 2000 B.C. to the Present,* (New York: Free Press, 1989).

military.[28] Similarly, with respect to weapons innovation from a historical perspective, Rosen cautions that the scientists must be carefully managed by the military customers.[29] Hone and Mandeles take perhaps the most extreme point arguing that: "innovation depends on a clearly articulated demand for a particular tactic; procedures to evaluate experience with, and alter, the innovation, and organizational advocacy."[30]

While there is almost complete lack of consensus over the direction of causality, there is general agreement among scholars on the subject that the relationship of the scientist and the leadership is critical to understanding state-sponsored technological innovation.[31] Missing from most studies is an analytic framework for explication of the

---

[28] See Raymond Isenson, "Project Hindsight: An Empirical Study of the Sources of Ideas Utilized in Operational Weapons Systems," in William H. Gruberand Donald G. Marquis, eds., *Factors in the Transfer of Technology,* (Cambridge: MIT Press, 1969) p. 70. As cited in Rosen, *Winning the Next War,* pp. 42-43. A comparative political scientist, Evangelista, views compellance as the rule for military innovation in the Soviet Union. See Evangelista... See Thomas C. Hone and Mark D. Mandeles, "Interwar Innovation in Three Navies: U.S. Navy, Royal Navy, Imperial Japanese Navy." *Naval War College Review,* Vol. 40, No. 2 (Spring 1987) pp. 63-83.

[29] See Rosen *Winning the next War...*

[30] See Hone and Mandeles, "Interwar Innovation in Three Navies...

[31] The lack of consensus among scholars is abundantly clear, and in fact extends to the study of innovation in general. Steven Rosen perhaps best summarized the confusion through reference to another study noting: "One survey published in 1971 stated that academics had come up with thirty-eight different propositions about innovation, and that they disagreed about thirty-four of these. The four that were not the subject of controversy were the four which had not yet been discussed by academic experts." See E. Rogers and F. Schoemaker, *Communications of Innovations,* (New York: Free Press, 1971) cited in Rosen, *Winning the Next War,* pp. 4-5. Evangelista pays explicit attention to the relationship between the state and society concluding that the difference in the relationship between the relative strength of the Soviet state and the weakness of the US government explain the different patterns of innovation observed in the two states. See Evangelista, *Innovation and the Arms Race,...* Rosen examined the role of military program management and concluded that the most successful cases of innovation were ones in which scientists were closely monitored by uniformed officers. York argued

relationship between scientists, the leadership, and innovation. Accordingly, I begin with the proposition that there are two fundamental actors involved in state innovation: the *leadership*[32] as the consumer of innovation, and the *scientists*,[33] as the producers of innovations, and that the process of innovation can be described in terms of the complex relationship between these actors.

The relationship between the leadership and scientists can be described in terms of *scientific autonomy*. Wilson, drawing from Selznik, considers autonomy in both internal and external terms. Internally, autonomy refers to the organizational mission. Scientific organizations which define their own research agenda with a clear long-term plan hold the highest levels of autonomy. Externally, high autonomy is achieved by developing and maintaining sole jurisdiction over a particular mission, with political support to maintain that mission.[34] Thus, ***a scientific organization which holds a monopoly over a technological program and is able to maintain political support for that mission would***

---

that the relative autonomy of scientists from state control led a virtually uncontrollable arms race between the United States and the Soviet Union. See York, *Race to Oblivion...*

[32] The term "leadership" is used as an abbreviated reference to the political, military, and industrial government leaders who are vested with the authority over initiation or closure of the innovative project. The appropriate specification of leadership will be case specific. The level within a hiearchy at which an administrator acquires this authority depends of course on the program. The largest program are useually decided upon only at the highest levels of national leadership. Lower level innovations usually never reach the level of national leadership. Thus, the appropriate specification of leadership will be specific to the level of innovation.

[33] The term "scientists" is used here as an abbreviated reference to the scientific-technological, and industrial community which conceives of, designs and produces technological hardware.

[34] See Wilson, *Bureaucracy...* esp. pp. 181-182.

have high levels of autonomy. The highest levels of scientific autonomy would thus be typified by complete control of the scientists over their research agenda.

DEFINING INNOVATION

The study of innovation continues to vex social scientists searching for a single explanation for all innovations.[35] Downs' and Mohr's comments on the state of the field in 1976 are still germane:

> Unfortunately, the theoretical value of the research that has been done is problematic. Perhaps the most alarming characteristic of the body of empirical study of innovation is the extreme variance among its findings, what we call instability. Factors found to be important for innovation in one study are found to be considerably less important, not important at all or even inversely important in another study. This phenomenon occurs with relentless regularity.[36]

---

[35] On the inability of social scientists, be they economists, social psychologists, political scientists, or sociologists to explain innovation see in particular George W. Downs and Lawrence B. Mohr, "Conceptual Issues in the Study of Innovation," *Administrative Sciences Quarterly,* Vol. 21 (December 1976) pp. 700-714. Who note that "of the 38 propositions bearing directly on the act of innovation ...34 were supported in some studies and found to receive no support in others. The 4 propositions with a consistent record were treated in very few studies." In this statement, Downs and Mohr are referring to the work of Everett M. Rogers, and F. Floyd Shoemaker, *Communication of Innovation: A Cross-Cultural Approach,* (New York: The Free Press, 1971. More recently Rosen noted that these problems with explanation of innovation persist. See Rosen, *Winning the Next War,* ... esp. pp. 1-51.

[36] See Downs and Mohr, "Conceptual Issues in the Study of Innovation," ...

The problem largely stems from the tendency to overextend the reach of theoretical propositions. The range of activities considered by innovation theorists is extraordinarily broad. For example, Barnett describes innovation as

> any thought, behavior or thing that is new because it is qualitatively different from existing forms...Strictly speaking, every innovation is an idea, or a constellation of ideas; but some innovation by their nature must remain mental organizations only, whereas others may be given overt and tangible expression.[37]

We are left with the notion that innovation might include anything from the introduction of nuclear weapons into the armed forces, to the idea, but not necessarily the act, of serving jelly instead of glazed doughnuts at a meeting, a range clearly too large to be useful for developing a productive understanding of innovation.

The answer, Downs and Mohr suggested, "is to reject the notion that a unitary theory of innovation exists and postulate the existence of distinct types of innovations whose adoption can best be explained by a number of correspondingly distinct theories."[38] The precise frame of reference they recommend is to consider the relationship between an organization and one particular innovation. In their terminology, innovation-decision

---

[37]See, H.G. Barnett, *Innovation: The Basis of Culture Change* (New York: McGraw Hill, 1953) p. 7, as quoted in Gerald Zaltman, Robert Duncan, and Jonny Holbeck, *Innovations and Organizations*, (New York: John Wiley and Sons, 1973) p. 9.

[38] See Downs and Mohr, "Conceptual Issues..." p. 701; Downs and Mohr are drawing on the work of Lloyd A. Rowe, and Willian B. Boise, "Organizational Innovation Current research and Evolving Concepts," *Public Administration Review*, Vol. 34, (1974) pp. 284-392; The same point has been made more recently by Wilson, *Bureaucracy*...; and Rosen, *Winning the Next War*...

design "focuses our attention on the shifting incentives and constraints that are relevant to the decision to innovate." Its strength lies in connecting "the study of innovation with the study of adoptability in a manner that is both illuminating and efficient."[39] It suggests that we begin with a study tracing the process of innovation and adoption of a single technology within a single organization.[40]

While the domain of any such study must be carefully bounded, care must be taken that it is not limited to trivial phenomenon. One practical step in this direction is to focus on state-sponsored technological innovations. There are good reasons for choosing this class of innovative activity. Since WW II, federally-funded research has constituted between 1/2 and 2/3 of *all* R&D performed in the United States. Of federally-funded research, defense and space related programs have constituted between 60% and 85% and of defense work, and 86% of defense R&D has involved technological development tied to specific hardware systems.[41] If we are to focus on a specific economic sector of innovation, the most important, in terms of dollars spent and national priority, lies in defense and space related programmatic development.

---

[39] See Downs and Mohr, "Conceptual Issues..." pp. 706-707.

[40] This would, of course, only comprise a single observation.

[41] Figures from National Science Foundation as cited in David C. Mowery and Nathan Rosenberg, "The U.S. National Innovation System," in Richard R. Nelson (ed.) *National Innovation Systems: A Comparative Analysis,* (Oxford: Oxford University Press, 1993) pp. 29-76.

Several classes of innovation are excluded by the scope of this study. Phenomena such as policy innovations, the introduction of innovative procedures, and other activities which break from bureaucratic norms, are unrelated processes which do not necessarily revolve around the relationship between the scientists and the leadership are areas of technological innovation I will expressly leave these outside the domain of this study.[42] Some other areas of innovative activity do revolve around the relationship between the scientists and the leadership, but the argument advanced here is that the relationship is likely to be different for innovations which are smaller in scale and less original, than for those which are large in scale and most original.

Even so, the scope of activities considered is still too large. It could include everything from the development of a new tail rudder to the introduction of nuclear weapons. It is unreasonable to expect that the relationship between the scientists and the leadership would be similar for two such disparate innovations.[43] Two defining characteristics of state innovation relate to the overall level of effort, or *scale*, and the degree to which the innovation really represents something new, or the *originality* of the

---

[42] On policy innovation see Nelson W. Polsby, *Political Innovation in America: the Politics of Policy Initiation,* (New Haven: Yale University Press, 1984). On procedural innovation see Wilson, *Bureaucracy...*

[43] To illustrate the point we need only consider that a small group of scientists is probably deeply involved in the redesign of the tail rudder, the project has great meaning to them. The state leadership, on the other hand is probably totally unaware of the effort. The cast of characters would be very different for nuclear weapons which involve the very highest levels of state leadership.

program. Both of these characteristics have strong effects on the relationship between the scientists and the leadership. For this study we want to consider those innovations in which the relationship between the two is highlighted and is most important -- those innovations which are largest in scale and demand the greatest originality.

Expensive new programs or projects are of a different character than those requiring only modest financial and political support. By their very nature, large-scale programs attract a high degree of political attention. Not only is it difficult to gain initial approval of an expensive program, but once initiated, the leadership tries to closely watch the way money is spent.[44] The Administrator of NASA during the Apollo program aptly described the monitoring burden placed upon large-scale programs.

> They are subject to constant watchfulness on the part of supporter and opponent alike. Today, they must operate under the glare of TV lights, not at times of their own choosing, but when someone else wants to look them over. They tend also to be subject to a double standard. When anything goes wrong, there is a rush for the seven-power glass and the microscope. Mistakes are heavily taxed.[45]

Thus, every million dollars of space station money is examined more closely than the billions spent by NASA on other projects, because the space station is the largest single

---

[44] See James E. Webb, *Space Age Management: The Large-scale Approach,* (New York: McGraw-Hill, 1969).

[45] *Ibid.* pp. 63-64.

program.[46] Occasionally, large-scale programs, such as the atomic bomb can be hidden from scrutiny of a large part of the political leadership, but such programs are clearly the exception.

For the scientists, large-scale is both a blessing and a curse. They want the money, but not the attention. In the majority of cases, they have to accept both or nothing at all. Therefore, as scale increases, so does the likelihood of conflict between the scientists and the leadership.[47] These conflicts are not easily resolved as Schumacher notes:

> Large-scale policy objectives, as we will see, are not easily reconciled to the dominant political environment of pluralist bargaining and scarce resources. The danger looms that many important policy objectives will fail to be realized because they will prove to be large-scale objectives for which commitment and resources could not be obtained at requisite levels. Large-scale policies are extremely vulnerable to the compromise and reduction processes of distributive politics.[48]

Because they put the greatest strain on the relationship between the scientists and the leadership, we should begin by looking at innovations which involve creation of new large-scale technology programs.

---

[46] See Howard McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice,* (Baltimore: Johns Hopkins, 1990)

[47] Pfeffer argues that conditions of resource scarcity are the most import factor leading to conflict in organizations. See Pfeffer, *Power in Organizations...*

[48] Schulman introduces the concept of policy scale as a means of defining costly new policy programs and the difficulties inherent in maintaining these programs. Although he discusses other more political dimensions, costs is clearly central to his definition. See Paul R. Schulman, *Large-scale Policymaking,* (New York, Elsevier, 1980)

The second dimension of innovation is ***originality***. When dealing with a completely new set of technologies scientists are at a far greater advantage in their relations with leadership. They have a variety of tools at their disposal to ensure that they maintain their informational advantage in order to convince political sponsors to support their projects.[49] Scientists are accustomed to coping with uncertainty; in fact, they seek it out. Leadership, however, attempts to structure its decisionmaking environment to limit the degree of uncertainty. Consequently, programs which are highly original place the greatest stress upon the relationship between scientists and the leadership.

A program may use existing technologies to perform new missions, or new technologies to perform existing missions. These differences are important for the relationship between the scientists and the leadership. For the scientists, the best situation is using new technologies to perform existing missions. In this case the leadership and the user community already have a clear idea of what they want to do, the scientists are simply presenting the possibility of better methods. There is an existing constituency for the program, but the scientists still hold an informational advantage over how the goal is to be accomplished. Most technological innovations fall into this category. Conversely, scientists are in the weakest position when existing technologies are being used to perform new missions. Here, they scientists hold a smaller informational advantage, and the

---

[49] See Latour, *Science in Action...*

leadership has a better awareness of the basic goals of the nation and how the new program might fit into those goals. Initiation of the space programs in both the United States and the Soviet Union falls into this category. Both programs relied upon the proven technologies of ballistic missiles to perform completely new policy missions.

A critical aspect of innovation which has gone all but unmentioned in the literature is the difference between innovation and emulation.[50] Initiating a program which is completely new presents the leadership with a very different problem than copying the innovation of a competing state. With emulation, leadership may draw upon the innovating state's experience for a great deal of information regarding the costs, risks and benefits of a program.[51] There is no dilemma. The leadership knows what to do and must simply direct its resources at accomplishing a well defined task, and one which clearly can be accomplished. Since an emulating leadership already has some idea of the efficacy of a prospective innovation, it faces less risk that it will fail to accomplish its stated goals. The

---

[50] The most important exception to this would be in Alexander Gershenkhron, *Economic Backwardness in Historical Perspective,*(Cambridge: Harvard University Press, 1962). Evangelista also observes that the Soviet Union tended to follow U.S. innovations, but failed to make the distinction explicit. See Evangelista, *Innovation and the Arms Race...* Other studies of innovation in the business world have also drawn the distinction between firms which are first to market with a product and those following. See in particular, David J. Teece, "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy," *Research Policy,* Vol. 15 (1986) pp. 285-305. Nevertheless, these references are rare, and those drawing out the implications rarer still.

[51] The distinction between innovation and emulation goes deeper than whether or not a nation was first to develop something. To gain the benefits of emulation, a trailing state must derive some knowledge of the costs, benefits and risks from the leading program. A primary example of emulation would be the Soviet atomic bomb program which benefited from considerable insight regarding how the United States built its bomb.

leadership's major problem is one of implementation. Thus, innovations put the leadership in a weaker position than emulation.

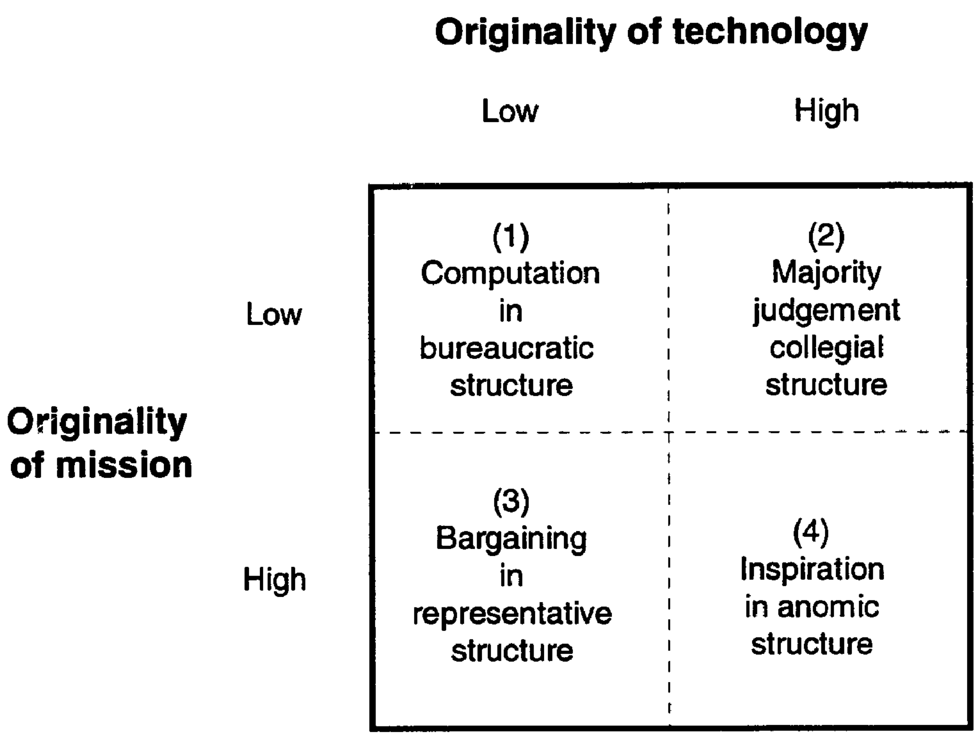

Figure 1.1 -- Modes of Originality of Technological Innovations

Figure 1.1 represents an adaptation of a decision-making matrix originally proposed by Thompson and Tuden.[52] In place of uncertainty of means, I have substituted originality of technology, and substituted originality of mission for uncertainty over goals. In cell 1 are innovations of low originality. Since the technology and missions are understood, decisions on these are a simple cost-benefit analysis. The vast majority of innovations fall into this category. This level of originality would include development of new generations of weapons systems utilizing existing technology and modifications of existing systems. Decision making for such routine innovations usually remains within the scientific community and lower level administrative agencies.

Cell 2 typifies a decision making situation in which the mission is understood, but there is uncertainty over technology. Scientific collegia are an appropriate body for considering whether a particular technological approach will prove effective. After the United States developed the atomic bomb, the possibility of developing a thermonuclear bomb was considered by a high level scientific advisory board -- the General Advisory Commission, which advised against producing the super bomb.[53] Most innovation

[52] See James D. Thompson and Arthur Tuden, "Strategies, Structures, and Process of Organizational Decision," in James D. Thompson et. al. *Comparative Studies in Administration,* (Pittsburgh: University of Pittsburgh Press, 1959)

[53] See Herbert F. York, *The Advisors: Oppenheimer, Teller, and the Superbomb,* (San Francisco: W.H. Freeman and Company, 1976)

decisions of this type do not require such high level advisory groups. Lower level scientific advisory committees are proliferated in the U.S. defense industrial bureaucracy.[54]

In cell 3, when the technology is understood, but there is some uncertainty, or disagreement over the utility of the mission to be performed by a new system, bargains must be struck. In an environment of limited budgetary resources, agreement must be reached over whether one mission will be undertaken or another. Such questions are best resolved in a representative structure in which each competing proposal has a veto power. In practice, decision making over entirely new mission areas are most often made at the highest levels of leadership. When the U.S. decided to develop the Space Shuttle, a bargain had to be struck between the Department f Defense which wanted a heavy-lift unmanned launch vehicle and NASA which wanted a small, manned, reusable space craft to ferry astronauts to and from the yet to be proposed space station. The compromise reached was to develop large, manned reusable space craft.

Cell 4 is where the most interesting and important innovative activity takes place. What decision making structure is appropriate when neither the mission nor the technology is clearly understood? Thompson and Tuden's answer is that the best structure may be a lack of structure, or *anomic* decision making environment. Under such conditions decision making often requires the intervention of either an inspirational leader

---

[54] *Ibid.*

or outside expertise. This structure or unclear goals, means, and lines of authority closely resembles the "garbage can decision-making" process developed by March.[55] In this environment, proposals held by scientists go out in search of problems held by leaders and come together at the point of decision making opportunities or windows of opportunity.[56] It is a bottom-up process of scientists working a decision-making system which is in somewhat of a state of disarray. Many of the more important innovations of modern times developed along these lines including the atomic bomb, the U.S. space program, and the lunar landing program.[57]

---

[55] The original work describing this phenomenon was in Michael D. Cohen, James G. March and Johan P. Olsen, "A Garbage Can Model of Organizational Choice," *Administrative Sciences Quarterly,* Vol. 17 (1972) pp. 1-25, more recent and detailed accounts appear in James G. March and Johan P. Olsen (eds.), *Ambiguity and Choice in Organizations,* (Bergen Norway: Universitetsforlaget, 1976); and James G. March and Roger Weissinger-Baylon, *Ambiguity and Command: Organizational Perspectives on Military Decision Making,* (Marshfield MA: Pitman Publishing, 1986).

[56] This particular version of "garbage-can decision-making" was developed in John W. Kingdon, *Agendas, Alternatives, and Public Policies,* (Boston: Little Brown, 1984)

[57] On the atomic bomb decision making process see Rhodes..., on the U.S. space program see MacDougall; and, Logsdon on the decision to go to the moon.

Originality of program

Scale of program		Low	High
	Low	(1) Computation in bureaucratic structure	(2) Majority judgement collegial structure
	High	(3) Bargaining in representative structure	(4) Inspiration in anomic structure

Figure 1.2 --Scale and Originality of Innovation

Figure 1.2 considers a similar matrix relating scale to originality of an innovation. In cell 1 computational decisions are made at lower levels of the administrative buraucracy. In cell 2 the originality of an innovation suggests that a collegial body should be formed composed of users, and scientists in order to determine whether a new program will provide useful results. Because the scale is low, such decisions may not included national level leadership. In cell 3 the costs of an innovation,even though it represents little change from the present, requires that tradoffs be made. The leadership cannot afford to engage in all new expensive program, so bargains must be struck beween competing claimants. But when the scale in increased, advisory committees are unable to make the difficult tradeoffs between programs which lie outside their perview. The decision must be made at the highest level. The trouble is that technological competence drops as one moves up to higher levels of leadership. Consequently, the national level leadership is more uncertain of the efficacy of an innovtion than lower levels. Often they will have to believe in the judgement of a trusted advisor. But if the innovation is highly original,how is the advisor to know? Again, the situation might be described as a "garbage can' in which scientific entrepreneurs search out leaders, or their advisors, and attempt to sell them on a program by attaching it to a ral or illusory problem.

Because of their political importance, in cases where the scale and originality are highest, the leadership's interest in controlling programs will be greater than programs with less originality and smaller scale. The scientists need for autonomy will be highest because of the high technological uncertainty.[58] At the same time, however, the informational deficiencies of the leadership will be at their greatest and the ability of the leadership to exercise control will be weakest. It is therefore cases of high originality and large scale which promise to shed the greatest light on the dilemma of innovation. We should also expect the relationship between the scientists and the leadership to be

[58] See Latour, *Sciene in Action...*

qualitatively different for less significant innovations. These types of innovation may not be comparable. To borrow Wilson's metaphor, they represent different types of disease.[59]

To be useful for this study, the dimensions of innovation must be considered within the context of government policies.[60] Policymaking is made at different levels of government. Decision making related to minor innovations is primarily made at the middling levels of government, whereas the most important innovations command the attention of the highest levels of political leadership.

Governmental technological innovation can be usefully divided into three levels: ***subsystem modification, project innovation,*** and ***programmatic innovation***. In this schema, the lowest level is subsystem modification; at an intermediate level is project innovation; and at the highest level lies *programmatic innovation*. There is a strong relationship between the following taxonomy and scale and originality. *Programmatic innovation* involves large-scale, and high originality tends to have higher levels of these

---

[59] Wilson asserted "innovations differ so greatly in character that trying to find one theory to explain them all is like trying to find one medical theory to explain all diseases..." See Wilson, *Bureaucracy*...p. 227.

[60] Most studies of innovation tend to focus on the private sector, or treat public and private innovations as comparable. However, several studies draw explicit contrasts between the public and private environment with respect to innovation. See in particular John W. Kingdon, *Agendas, Alternatives, and Public Policies,* (Boston: Little Brown, 1984), Victor Thompson, *Bureaucracy and Innovation,* (University Alabama: University of Alabama Press, 1969); Polsby, *Political Innovation in America*... and Wilson, *Bureaucracy*...

dimensions while subsystem modifications will tend to have lower levels of scale and originality.

Subsystem modification involves innovations in an existing system which allow it to perform its existing mission better. Thus, adoption of continuous-aim naval gunfire was a subsystem modification. From the standpoint of the national government, it did not require any substantial reorganization of the national mission, that of the Navy, or even that of the ships fitted with the new guns.[61] Subsystem innovations may have humble beginnings but lead to much greater scale innovations. The stirrup was only a modification of an existing system, but led to far reaching changes in other weapons and indeed the way wars were fought.[62] The vast majority of subsystem modifications however, go largely unnoticed by state leaders, military commanders, and scholars. Decision making and management of these innovations takes place at the lower levels of the end-user community. The major effects of this level of innovation are always borne first and foremost upon the operators of systems. Only in rare cases would subsystem modifications assume a large-scale, and while they may involve innovative technologies very seldom will these innovations involve the creation of new missions, or lead to ramifications at the higher political levels.

---

[61] See Elting Morrison, *Men, Machines and Modern Times,* (Cambridge: MIT Press, 1966)

[62] See Van Crevald, *Technology and War...* and Lynn White Jr. *Medieval Technology and Social Change,* (Oxford: Oxford University Press, 1962).

Project innovation involves development of a new technological apparatus, with all of its associated hardware and software. *Project innovations* include the development of a new system, but not a class of systems. The creation of a new fighter/bomber such as the F-111 or F-16 is a project innovation. *Project innovation* may involve introduction of new technologies, but does not involve creation of new missions at the political level. Thus the introduction of the F-86, the first jet-powered fighter, is more project innovation than *programmatic innovation*. One could also argue that the atomic bomb was simply a better bomb: new technology, old mission. Initially, this may have been true. However, over time, the political leadership came to view the atomic bomb quite differently from conventional weapons. By the Eisenhower Presidency, the atomic bomb was considered a very different sort of policy tool than a conventional weapon. This suggests a certain gestation period for the political adoption of *programmatic innovations*: until such adoption takes place, an innovation may remain at the project level. *Project innovations* are occasionally of such scale that they require consideration at the highest political levels, but that consideration usually focuses on the issue of whether or not to spend the scarce resources, ***not*** whether the new system is intrinsically useful. For example, from 1947 until 1953 the U.S. political leadership was not considering the utility and feasibility of ICBMs, but rather their costs.

*Programmatic innovation*s are at a higher level of innovation. There are two distinguishing differences between project and *programmatic innovation*. First, there is a political difference in the way a new system is considered. *Programmatic innovation*s create new missions at the level of the political leadership. Nuclear weapons created the mission of strategic nuclear deterrence; anti-ballistic missile (ABM) systems created the mission of strategic defense, manned space programs -- space propaganda, and so on. Project innovation, by comparison, only improves the execution of an existing mission. For example, the F-111 improved the tactical nuclear weapons strike mission. Naturally, there are gray areas. Was the Polaris a new mission (i.e. a totally survivable nuclear strike capability) or just an improvement in the survivability of existing capabilities? Within each class of innovation there are degrees. It is useful therefore, to concentrate on developments which are unambiguous, the most obvious cases of *programmatic innovation*. Such cases control for one of the variables in understanding the relationship between the scientists, the leadership and innovation.

The second distinguishing characteristic of *programmatic innovation* is that it creates a new technological paradigm.[63] A *project innovation* becomes *programmatic* as it gives rise to other projects. Many spin-off projects may develop for agencies which had nothing to do with the original project. New programs co-opt scientists from other programs, and attract entering scientists and engineers who see the new program as more technically interesting or professionally promising.

---

[63] I have in mind Kuhn's definition of a scientific paradigm which involves the organization of new groupings of scientists, textbooks, conferences, around a new scientific concept. The notion is straightforwardly applied to technology. See Kuhn, *The Structure of Scientific Revolutions...*

In most cases, development of new programs begins with a single seminal project. Following development of the first three atomic bombs, the United States embarked on a nuclear weapons program. The dynamic was similar for the Soviets. The U.S. nuclear program included a variety of projects, from small, battlefield tactical nuclear weapons, to multi-megaton warheads. It included three national laboratories, several processing facilities, and scientists and engineers in the thousands.[64] The creation of the U.S. and Soviet missile and space programs also fall within this category of innovations.[65]

Inevitably, *programmatic innovation* involves large-scale and high originality. But some programs involve higher scale and originality. Table 1.1 lists cases of programmatic innovation in the United States and the Soviet Union since WW II. At the top of the list are programs with the greatest scale and originality. At the upper end of the spectrum, lies the Soviet missile and space program -- very high in both scale and originality. At its height, the program employed ***one million*** scientists, technicians, engineers, and workers. From the seminal short-range missile project, the program generated everything from strategic missiles and photo reconnaissance satellites, to manned space stations. It was also the only instance in which the Soviet Union clearly lead the United States, and involved utilization of new technologies to perform new political missions. The U.S

---

[64] For a description of the program see Rhodes, *The Making of the Atomic Bomb...* On the Soviet side see David Holloway, *Stalin and the Bomb: the Soviet Union and Atomic Energy 1939-1956*, (New Haven: Yale University Press, 1994).

[65] See in particular McDougall, *The Heavens and the Earth...*

missile and space program falls only slightly below its Soviet counterpart -- primarily because of emulative effects.[66]

At the lower end of the scale we might consider programs such as the U.S. space station, of lower scale and originality. This program, still in the stages of development, involves creation of new political missions using new technologies, and will require creation of new systems to support its operation. Just as surely, there will be follow-on space stations once the currently envisioned system matures. However, its level of originality and scale pales in comparison with some other cases of *programmatic innovation.*

[66] Clearly, the U.S. trailed the Soviets, but it is not clear whether the U.S. leadership was able to make use of the Soviet advantage to gain valuable information regarding Soviet technological choices. See Beard, *Developing the ICBM...*; and McDougall, *The Heavens and the Earth...*

Table 1.1 -- Important Post WW II Programs

Programs	Scale	Originality		
		Innovation/ emulation	Mission	Technology
USSR missile/space prog.	Very large scale	Innovation	New: strategic bombardment, space propaganda	Broad range of new technologies
US A-bomb	Large scale	Innovation	Existing: strategic bombardment New: nuclear deterrence	Narrow range of new technologies
US ICBM prog.	Very large scale	Innovation	Existing: strategic bombardment	Broad range of new technologies
US space prog.	Large scale	Innovation	New: reconnaissance, propaganda	Broad range of new technologies
USSR A-bomb	Large scale	Emulation	New: strategic bombardment, nuclear deterrence	Narrow range of transferred technologies
US Sentinal/ Safeguard	Medium scale	Emulation	New: ABM defense	Broad range of new technologies
US SLBM prog.	Medium scale	Innovation	Existing: strategic bombardment	Narrow range of new technologies
US space station	Medium scale	Emulation	Existing: manned spaceflight	Broad range of new technologies

This section identified several characteristics of innovations important for relationships between scientists and leadership. As scale and originality increase, the leadership acquires a greater interest in the program, and will be more inclined to exercise their authority over cases of *programmatic innovation* than *project innovation* or *subsystem modification*. However, the uncertainty of the technology makes this job more difficult, and the scientists gain a greater level of independence from the leadership because of uncertainty due to the uniqueness of the technology in *programmatic innovations*. The effect of the dilemma of innovation is thus exaggerated. The leadership is simultaneously pressured to allow the scientists to innovate freely because the potential benefits are greatest for *programmatic innovations*, but because of the high cost, it wants to maintain the greatest control. Putting these innovations in an organizational context which recognizes the environment of state sponsored innovation provides clear and meaningful boundaries for this study. What remains is to develop the appropriate analytic tools.

DEVELOPING AN ANALYTIC FRAMEWORK

Three apparently discrete analytic frameworks are candidates for this study: (1) principal-agency theory, drawn from rationalist theories of politics and economics, (2) organization theory, drawing primarily from sociology and cognitive psychology, and (3) bureaucratic politics based on historical cases. While some hold these schools to be entirely incompatible with each other, they are in fact compatible in many ways.[67] Each

---

[67] On the conflict between organization theory and rationalist schools of theory for an argument from the perspective of an organization theorist see Herbert A. Simon "Organizations and Markets," *Journal of Economic Perspectives*, Vol. 5:2 (Spring 1991) pp. 25-44; for the rationalist viewpoint see Terry Moe, "Politics and the Theory of Organization," *Journal of Law, Economics and Organization*, Vol. 7 (1991 special edition) pp. 106-129. For the position of the bureaucratic politics school see Graham Allison, *Essence of Decision: Explaining the Cuban Missile Crisis*, (Glenview Ill.: Scott Foresman, 1971)

has strengths and weaknesses, and transitions between them present no insurmountable intellectual problems. Principal-agency theory mirrors the basic dilemma of innovation, but provides only weak tools for resolving that dilemma and leads to questionable conclusions. Organization theory, on the other hand, provides rich evidence for how individual organizations behave under the highly uncertain conditions of *programmatic innovation*, but is relatively weak in describing the overall relationship between organizations in a hierarchical, multiorganizational environment. Bureaucratic politics essentially provides a transition between the two schools, but has focused on normative issues and avoided the theoretical questions being considered here.

The relationship between the scientists and the leadership is framed by theories of the relationship between principals and agents. Principal-agency theory derives from microeconomic theories of the relationship between owners (principals) and workers (agents).[68] These theories have been adapted to deal with the problems of political control over public bureaucracies.[69] In cases of *programmatic innovation* the principals are the

---

[68] Principal-agency theory as applied to governmental environments is in its relative infancy. For some the early work applied to behavior in the private sector see Michael C. Jensen, and Willian Meckling, "Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure," *Journal of Financial Economics,* Vol. 3 (October, 1976) pp. 305-360; Eugene Fama, "Agency Problems and the Theory of the Firm," *Journal of Political Economy,* Vol. 88 (April, 1980) pp. 288-307, and Eugene F. Fama and Michael C. Jensen, "Separation of Ownership and Control," *Journal of Law and Economics,* Vol. 26 (June, 1983) pp. 301-325.

[69] See Terry Moe, "The New Economics of Organization," *American Journal of Political Science,* Vol. 28 (November, 1984) pp. 739-777; Terry Moe, "Politics and the Theory of Organization," *Journal of Law, Economics and Organization,* Vol. 7 (1991 special edition) pp. 106-129; Mathew D. McCubbins and Thomas Schwartz, "Congressional Oversight Overlooked: Police Patrols versus Fire Alarms,

leadership which makes decisions on program initiation, cancellation, or significant revisions. The agents are the scientific-technological, and industrial community which designs and builds the systems which comprise *programmatic innovations*.[70] In most governments there is a vast gulf between the two, filled with administrative agencies charged with ensuring that the decisions of the political leadership are faithfully implemented. In the terms of principal-agency these agencies are acting as monitors for the principals.

Principal-agency focuses upon informational asymmetries between the political leadership (principals) and the individual bureaus (agents) and the alignment of incentives;

> in particular, on information available to bureaucrats -- on their true "types" (honesty, personal goals, policy positions) and their true performance -- that politicians do not automatically possess and often can only acquire with much imprecision and expense. It then encourages us to inquire into the monitoring devices and incentive structures -- aspects of institutional design -- that mitigate the asymmetry and thus minimize the problems of adverse selection and moral hazard that will otherwise cause bureaucrats to depart from their political directives.[71]

Political Sciences Quarterly, Vol. 28:1 (1984) pp. 165-179. and Barry Weingast, "The Congressional-Bureaucratic System: A Principal-Agent Perspective," *Public Choice* Vol. 44 (1984) pp. 147-192.

[70] See Jonathan Bendor, Serge Taylor, and Roland Van Gaalen, "Stacking the Deck: Bureaucratic Missions and Policy Design," *American Political Science Review*, Vol. 81, pp. 873-896.

[71] Moe "The New Economics of Organization..."

Thus principal-agency theory describes the relationship between the leadership (principal) and the scientists (agents).[72] It assumes that there is basic competition between the scientists and the leadership, and it provides some idea of the tools which each sides uses in this struggle. This framework treats the military service or government agency which ultimately uses the systems produced by the scientists as a principal whose interests are consistent with, if not identical to those of the leadership.[73] The leadership will first attempt to establish incentives to encourage the scientists to engage in useful innovation.[74] Since the leadership cannot be certain that the incentives are working perfectly, it will employ monitors to supervise the activities of the scientists.[75] The scientists in turn will use their expertise to manipulate their relationship with the leadership so that the leadership provides them with all of the resources they might need to pursue their research agendas with minimal oversight.[76]

---

[72] As we will see below the canonical model of principal agent relations will, require significant modifications for application to initiation and control of innovative programs.

[73] As we will see, military often acts as a monitor to a greater degree than it does a principal. This is particularly the case with respect to *programmatic innovation*. For an application of the principal-agency framework to defense procurement see Tracy Lewis, "Defense Procurement and the Theory of Agency," in Jim Leitzel (ed.) *Economics and National Security*,(Boulder CO: Westview Press, 1993) pp. 57-72.

[74] On incentives and risks see in particular David E. M. Sappington, "Incentives in Principal-Agent Relationships," *Journal of Economic Perspectives*, Vol. 5, No. 2, (Spring 1991) pp. 45-66;

[75] See McCubbins and Schwartz, "Congressional Oversight Overlooked..."

[76] See Michael W. Lawless and Linda L. Price, "An Agency Perspective on New Technology Champions," *Organizational Science*, (1992) 3:3 pp. 342-355; see also Jonathan Bendor, Serge Taylor,

The principal-agency literature is thin on the subject of innovation, however. Lawless and Price undertook one of the few such investigations. They pointed out that the basic problem from the principals' perspective was one of maintaining control over agents as technological proponents:

> Where the agency relationship is between technology champions and users, there are potential problems in controlling either behavior or outcomes. Two features of technological innovation limit user's ability to control champion's performance. First the champion is a *specialized purveyor* of the new technology -- a unique source with few substitutes. Second, *technological uncertainty* reduces the predictability of outcomes.[77]

They believe that it will be difficult to overcome potential divergencies in the interests of principals and agents, concluding: "Finally, although champions' and users' preferences are likely to diverge, organizational practices and culture may promote the alignment of goals and values."[78] However, for principal-agency theorists, organizational practices and culture remain exogenous.

General problems with distribution of risk and uncertainty are amplified in cases of *programmatic innovation*. As the scale of innovation increases, so does uncertainty and

---

and Roland Van Gaalen, "Stacking the Deck: Bureaucratic Missions and Policy Design," *American Political Science Review,* Vol. 81 No 3. (September 1987) pp. 873-896.

[77] See Lawless and Price ...p 346.

[78] *Ibid.*p 353.

risk.[79] Projects become more expensive, failures more costly and difficult to conceal. Under most conditions, scientists are ill-disposed to absorb such high risk, and the vast majority of risk must be passed on to the leadership. This makes perfect sense, since the leadership accumulates the majority of benefits, in terms of increased national security, from successful development and deployment of a new system. Even if the leadership wished to devise a contract distributing the risks and payoffs, it could not because neither risks nor benefits can be accurately calculated. If the scientist cannot publicly claim credit for secret projects, as is often the case with defense-related technologies, the leadership is hard pressed to develop non-monetary incentives for the scientist to succeed.[80]

More generally, principal-agency theory would assert that under such conditions, where risks are high and benefits cannot be calculated in order to develop profit and risk sharing arrangements, the appropriate organization would be characterized by high levels of monitoring.[81] In this instance, principal-agency theory differs dramatically in its application to private and public settings. This difference requires that political scientists take a modified view of principal agency.

> In politics, people with very different interests engage in a struggle to control and exercise public authority. The struggle comes about because public authority does not belong to anyone -- it is up for grabs -- and because it is enormously valuable:

---

[79] See Sappington..., Bendor...; and McCubbins.

[80] See Lawless and Price, "An Agency Perspective..."

[81] See Sappington..., Bendor...; and McCubbins.

> for whoever wins hold of it has the right to make law for everyone. The winners can thus, quite legitimately, promote their own interests through policies and structures of their own design. This may entail very substantial costs for the losers, who have no choice but to accept what the winners dish out.
>
> The power of public authority is essentially coercive. People can be forced to accept outcomes that make them worse off, outcomes they would never agree to in a world of voluntary exchange. The upshot is that political institutions, most of which arise our of the politics of structural choice, are means of legal coercion and redistribution. They are structures by which winners impose their will on everyone else.[82]

Including state power adds another piece to the puzzle. Given monitoring sufficiently accurate to know that the scientists are not acting in the leadership's interest, the leadership can compel the scientists to act accordingly by resorting to, or threatening, legal sanctions.[83]

Most applications of principal-agency provide only a static description of actors' positions. It is concerned primarily with implementation of previously determined policies. It says little about how innovations are proposed and decided upon. Once the model is extended into the realm of decisionmaking, the leadership's capacity for control grows more limited. Only if the political leadership is able to gain accurate information regarding the mission and budgetary utility functions for the scientists, and there is sufficient

---

[82] See Moe "Politics and the Theory of Organization,"...

[83] Wilson argues however, that the state's ability to compel is more often than not sharply constrained by bureaucratic rules. See Wilson, *Bureaucracy*...esp. pp. 155-156.

competition among scientists, may it devise mechanisms which will induce the scientists to provide them with an unbiased assessment of programmatic options.[84]

The principal-agency framework has identified the basic issue and the two key actors in the process of *programmatic innovation*: the scientists and the leadership. It asserts that the interests of these two key actors will often be at variance because the high degree of uncertainty inherent in innovative programs makes it difficult for the leadership to establish contractual relations which will adequately induce the scientists to act in the leadership's interest. To compensate, the leadership introduces a third actor, the monitor, to observe and supervise the scientists' activities, and make policy recommendations to the political leadership. Principal-agency would predict that for successful innovation to take place the leadership must possess the capacity for close monitoring, and use it to constrain the scientists to pursue only leadership-directed programs.

However, monitoring agencies usually perform administrative functions in addition to monitoring. Programmatic monitoring is, for example, only one of the functions of the United States Congress.[85] Administrative agencies monitor programs under their control. The upper levels of the agencies serve as conduits between the leadership and the scientists under their direction.[86] In practice, pure monitoring agencies, such as inspector

---

[84] See Bendor, Taylor, and Van Gaalen, "Stacking the Deck..."

[85] See McCubbins, "Congressional Oversight..."

[86] See Wilson, *Bureaucracy...*

generals, are uncommon. The division of duties between monitoring and implementation often presents monitoring agencies with competing incentives – supporting their own programs, and reporting the problems in their programs. There is the danger that they could become captive of the scientists they are supposed to monitor.[87] These agencies should be distinguished from pure monitoring organizations. For this study, agencies charged with both monitoring and implementation will be termed as *administrators* or *administrative agencies.*

Innovation and Principal-Agency: Limitations and Extensions

While principal-agency theory identifies the actors and issues involved in state innovation, it is not satisfactory in predicting outcomes. Empirical evidence challenges the causal direction suggested by the principal-agent model. History is full of cases of innovation occurring despite – if not because of – weak leadership direction and monitoring. Few within the U.S government had any understanding of the atomic bomb program, and those who did gave the scientists *carte blanche* to develop the program as they saw fit.[88] Admiral Raborn developed an elaborate scheme for maintaining the

[87] See Downs, *Inside Bureaucracy...*

[88] See in particular Richard Rhodes, *The Making of the Atomic Bomb,* (New York: Simon and Schuster, 1986).

autonomy of the Polaris missile program from a resistant Navy.[89] The development of tactical nuclear weapons in the United States resulted from a well orchestrated campaign by U.S. nuclear weapons scientists.[90] The Lockheed Skunk Works was successful precisely because of its autonomy from meddling Congressmen and Air Force generals.[91] The list of projects initiated, promoted and maintained by entrepreneurial scientists could be extended.[92] Van Crevald sums up the issue asserting that during:

> the twentieth century...none of the important devices that have transformed war -- from the airplane through the tank, the jet engine, radar, the helicopter, the atom bomb and so on all the way down the electronic computer -- owed its origins to a doctrinal requirement laid down by people in uniform.[93]

Principal-agency theorists understand that theirs is a stylized model of government. Williamson incorporates concepts of bounded rationality into his transaction-cost model, which traces its lineage to principal agency, but he concedes that innovation is a special

---

[89] See Harvey Sapolsky, *The Polaris System Development: Bureaucratic and Programmatic success in Government* (Cambridge: Harvard University Press, 1972)

[90] See Evangelista, *Innovation and the Arms Race...*

[91] See the account of the Skunk Works written by the director of the organization from 1975 until 1991. Ben R. Rich and Leo Janos, *Skunk Works,* (Boston: Little Brown, 1994).

[92] For further examples see Evangelista, *Innovation and the Arms Race...*; and Van Crevald, *Technology and War...* for a discussion policy entrepreneurs see Jameson W. Doig and Erwin C. Hargrove, *Leadership and Innovation: a Biographical Perspective on Entrepreneurs in Government,* (Baltimore: Johns Hopkins University Press, 1987).

[93] See van Crevald, *Technology and War...* p 220.

case falling outside the general call for hierarchical organization.[94] In their study of choice among R&D alternatives, Bendor, Taylor and van Galeen concluded that they were

> struck by how demanding the prerequisites for full control are. Indeed, we suspect that the modern tools of principal-agent analysis and search theory will demonstrate that rational superiors would not strive for complete control: even if feasible, it would be too expensive. Because of these limits, the older literature on bureaucratic influence still has much to teach us.[95]

The suggestion that principal-agency might be supplemented through reference to the literature on bureaucratic politics is cogent for this study. Much of this literature deals directly with state-sponsored, primarily military, R&D programs.[96] The bureaucratic politics framework argues that:

> What a government does in any particular instance can be understood largely as a result of bargaining among players positioned hierarchically in the government. The bargaining follows regularized circuits. Both the bargaining and the results are

---

[94] See in particular Oliver Williamson, *Markets and Hierarchies: Analysis and Antitrust Implications*, (New York: Free Press, 1975).

[95] See Bendor, "Stacking the Deck..." pp. 889-890.

[96] Work falling under this classification would include: Beard, *Developing the ICBM...*; a discussion of the ABM decision in Halpern, *Bureaucratic Politics and Foreign Policy*, (Washington D.C.: Brookings, 1974); Armacost, *The Thor Jupiter Controversy...*; Greenwood, *Developing the MIRV...*; Logsdon, *The Decision to Go to the Moon...*; Sapolsky, *The Polaris Program..;* and, Coulam, *Illusions of Choice.....* On the Soviet side the literature is more sparse and less explicitly affiliated with the bureaucratic politics school would include Arthur Alexander's discussion of the Soviet procurement system in *The Soviet Weapons Development Process*, (London: International Institute for Strategic Studies, 1976) Adelphi Papers 147-148; and David Holloway, *The Soviet Union and the Arms Race*, (New Haven: Yale University Press, 1983).

importantly affected by a number of constraints, in particular, organizational processes and shared values.[97]

In essence, this formulation closely resembles that of principal-agency theory with the addition of constraints introduced by organizational factors. Bureaucratic politics also argues that that leadership qualities play an important role in determining the outcome of "decision games."

This work is expressly empirical and inductive. It argues that the real locus of power lies in neither scientists nor leaders, but in the bureaucratic system itself. Thus, Greenwood argues that although the idea of multiple, independent re-entry vehicles (MIRVs) for ICBM's came from many different scientific sources, the real power came from the procurement system itself, which virtually ensured the innovation would be introduced once a full-scale design decision was undertaken. Most of the leadership's control over development was illusory.[98] Coulam found that the leadership's limited rationality led them to support development of the F-111 despite the fact that it was inconsistent with doctrine, and was clearly incapable of completing the missions assigned to it.[99] Along slightly different lines, Beard discovered that the US ICBM program was

---

[97] See Graham T. Allison and Morton Halpern, "Bureaucratic Politics: A Paradigm and Some Implications: *World Politics,* Vol. 24, supplement (Spring 1972).

[98] See Greenwood, *Making the MIRV...*

[99] See Coulam, *Illusions of Choice...*

hopelessly mired in bureaucratic red tape until the leadership of the Air Force ceded control over the project to General Bernard Schriever and the Ramo Woolridge Corp., isolating the project from most leadership control.[100] Sapolsky found that the ability of the program office in charge of the Polaris missile development to use various bureaucratic smoke screens to protect the program from a distrustful Navy leadership was instrumental in its success.[101]

The bureaucratic politics school provides a link between principal-agency and the body of literature coming under the heading of organization theory. Theorists in this realm offer a wealth of detailed insights into several issues which bear direct relation to the subject at hand. Of greatest significance for this study are discussions of leadership decision making process under conditions of high uncertainty and short time horizons;[102]

---

[100] See Beard, *Developing the ICBM...*

[101] See Sapolsky, *The Polaris Program...*

[102] The original formulation that decision makers exercised only "bounded-rationality" was provided by Herbert Simon, *Administrative Behavior: a Study of Decision Making Processes in Administrative Organizations,* (New York: Macmillan, 1947); Simon was later joined, and this line of inquiry continued by James G. March in March and Simon, *Organizations,* (New York: John Wiley, 1958). This work later into what is popularly know as "garbage can" theories of decision making. The original work describing this phenomenon was in Michael D. Cohen, James G. March and Johan P. Olsen, "A Garbage Can Model of Organizational Choice," *Administrative Sciences Quarterly,* Vol. 17 (1972) pp. 1-25, more recent and detailed accounts appear in James G. March and Johan P. Olsen (eds.), *Ambiguity and Choice in Organizations,* (Bergen Norway: Universitetsforlaget, 1976); and James G. March and Roger Weissinger-Baylon, *Ambiguity and Command: Organizational Perspectives on Military Decision Making,* (Marshfield MA: Pitman Publishing, 1986).

the role information plays in determining in organizational performance and structure;[103] means by which struggles for control are waged,[104] and, informal coordination among interdependent organizations.[105]

This literature offers several insights on issues left unresolved by the principal-agency framework. The most generally accepted proposition from this school is that decision makers are only intendedly rational.[106] While they strive to make optimal decisions they seldom posses sufficient information, time, or intellectual capabilities to make completely rational choices. Instead, as uncertainty increases and available time decreases, there is a tendency for new ideas advocated by "policy entrepreneurs" to gain quick leadership approval.[107] This line of inquiry suggests that we should pay close

---

[103] On the role of information in shaping organizational structure see Arthur L. Stinchcombe, *Information and Organizations,* (Berkeley CA: University of California Press, 1990); James D. Thompson, *Organizations in Action,* (New York: McGraw Hill, 1966)' and Tom Burns and T.M. Stalker, *The Management of Innovation,* (London: Tavistock, 1961). On information as a source of power see Jeffrey Pfeffer, *Power in Organizations*, (Cambridge: Ballinger, 1981).

[104] This work began with the original formulation by James G. March and Richard Cyert, *A Behavioral Theory of the Firm...* A more recent examination can be found in Pfeffer, *Power in Organizations...*

[105] See Donald Chisholm, *Coordination Without Hierarchy: Informal Structures in Multiorganizational Systems,* (Berkeley: University of California Press, 1989).

[106] This is perhaps the only point on which there is general agreement between economics based principal agency theorists and organization theorists owing most of their heritage to sociology. On this general agreement see in particular, Williamson, *Markets and Hierarchy...;* and, Moe, "Politics and the Theory of Organization..."

[107] This is the basic thrust of garbage-can theory and is most clearly set forth in March and Olsen, *Ambiguity and Choice...*; the basic framework is elaborated upon and tested in a governmental setting in Kingdon, *Agendas, Alternatives and Public Policies...*

attention to the decision making environment of leadership at the time that critical decisions are being made. Particular attention should be devoted to the amount of time leadership devotes to a particular decision, the level of consensus over goals and means, and its understanding of the technology.

High uncertainty and short time horizons work to the advantage of the scientists in their struggles to gain leadership approval for their projects.[108] The F-111 was approved as a result of a perceived deficiency in US capabilities which needed to be quickly redressed, and the fighter was accepted on the Air Forces recommendation as the best available alternative.[109] Similarly, the manned lunar program came about as the conjunction of a crisis due to the Soviet orbiting of the first man in space, and the desire of Werner Von Braun to pursue lunar exploration. It was not chosen on the basis of technical merit, but because it was the only alternative presented which was both spectacular and one which the U.S. political leadership believed we could accomplish before the Soviets.[110]

Principal-agency theory is predicated on the importance of information, but contributes little to understanding how it is used as a tool by agents. Organization

---

[108] See Kingdon, *Agendas, Alternatives and Public Policies...*

[109] See Coulam, *The Illusion of Choice...*

[110] See Logsdon, *The Decision to Go to the Moon...*

theorists have devoted significant attention to the role of information. Pfeffer and Stinchcombe have demonstrated that control over information necessary to resolve uncertainty is a powerful source of influence over organizational behavior.[111] Salancik and Pfeffer concluded:

> The influence of a subunit or an individual on a decision is a function of (1) the kind of uncertainty faced by an organization, (2) the particular characteristic or capability which enables reducing organizational uncertainty, and (3) the degree to which a particular subunit possess this characteristic. As decision-making contexts vary, so do the sources of organizational uncertainty, and consequently, the bases for influence in organizational decision-making.[112]

In the hands of the scientists, information control is a particularly powerful tool for resolving uncertainty. Oppenheimer used the scientists' monopoly of information as leverage against the military administrator of the atomic bomb program.[113] Admiral Rickover was able to control virtually all information on the atomic submarine in order to maintain autonomy from oversight.[114] On the other side of the coin, Lavrentii Beriia was

---

[111] Stinchcombe, *Information and Organizations...*; Thompson, *Organizations in Action...*); and Pfeffer, *Power in Organizations...*

[112] Gerald R. Salancik and Jeffrey Pfeffer, "Uncertainty, Secrecy and the Choice of Similar Others," *Social Psychology,* Vol. 41 (1978) pp. 243-255; as cited in Pfeffer, *Power in Organizations...* p. 112.

[113] See Rhodes, *Making the Atomic Bomb...*

[114] See Doig and Hargrove, *Leadership and Innovation...* pp. 96-123.

able to use his intelligence information on the American atomic bomb program as means of checking on the validity of claims of the chief Soviet atomic scientist Igor Kurchatov.[115]

While it has been approached with some ambivalence by political scientists in general and falls outside the principal-agency framework altogether, leadership is particularly important for innovation. Wilson offers the following reasoning for considering it in this study:

> If a John Russell had not been commandant of the Marine Corps or William Moffett had not been chief of the Bureau of Aeronautics, the Fleet Marine Force and carrier-based naval aviation would not have emerged when and as they did.
>
> It is for this reason, I think, that little progress has been made in developing theories of innovation. Not only do innovations differ so greatly in character that trying to find one theory to explain them all is like trying to find one medical theory to explain all diseases, but innovations are so heavily dependent on executive interests and beliefs as to make the chance appearance of a change-oriented personality enormously important in explaining change. It is not easy to build a useful social science theory out of "chance appearance."[116]

In an empirical study, Howell and Higgins noted a strong connection between the emergence of technological champions and innovation.

> one variable that has been strongly linked to the success of technological innovations in the presence of a champion. This is an individual who informally emerges in an

[115] See Holloway, *Stalin and the Bomb...*

[116]See, James Q. Wilson, *Bureaucracy*, *op. cit.* p. 227.

> organization and makes a decisive contribution to the innovation by actively and enthusiastically promoting its progress through the critical (organizational) stages.[117]

Schon went further asserting that, with respect to military innovation, "where radical innovation is concerned, the emergence of a champion ***is required***...the new idea either finds a champion or dies."[118] Lewis and Doig and Hargrove have noted the importance of leadership for the success of the bureau.[119]

One does not have to search for cases in which leadership qualities were a crucial component in the success of the program: Bernard Schriever and the ICBM, Admiral Raborn and the Polaris, Robert Oppenheimer and the atomic bomb, to name but a few.[120] Conversely, there are documented programmatic failures notably lacking strong leadership: the F-111 and the early US ABM program.[121] There are however, few obvious cases of programmatic failure and strong programmatic leadership, leading to the

---

[117]Jane M. Howell and Christopher A. Higgens, "Champions of Technological Innovation" *Administrative Science Quarterly*, 35 (June 1990)p. 317

[118]Donald A. Schon, "Champions for Radical New Inventions: *Harvard Business Review*, 41, (March-April 1963) p. 84. Emphasis added.

[119]Eugene Lewis, *Public Entrepreneurship*, (Bloomington Ind.: Indiana University Press, 1980), p. 9. and, Doig and Hargrove, *Leadership and Innovation...*

[120] On the Polaris program see Sapolsky, *The Polaris Program..* On the development of the first US ICBM see Beard, *Making the ICBM...* See also Rhodes, *Making the Atomic Bomb...*

[121] On the F-111 see Coulam, *The Illusion of Choice...* On the ABM see Halpern, *Bureaucratic Politics and Foreign Policy...*

question of whether successful, strong leadership is defined by programmatic success. We need be cautious not to fall into a tautological trap here.

Principal-agency also assumes a simplified set of relations between leadership and scientists, either comprising one principal and a single agency, or a single agent and multiple principals. It falls short in multiorganizational systems involving many agents, by assuming that there will be hierarchical relations. In such systems informal organization often emerges which provides a more efficient form than hierarchy. Chisholm explains that informal coordination is often critical for *programmatic innovation*:

> Informal systems of coordination have many virtues. They tend to be flexible and adaptive. The disruptive effects of innovation in a formal hierarchy, because of its tightly coupled interdependencies, are avoided in the more loosely coupled, flat, informal system of coordination. Such informal systems are problem oriented and pragmatic. They are self-organizing in the sense that they respond to the effects of experience rather than to the a priori demands of organizational designers.[122]

For complex, highly uncertain technological projects, ability of an organization to rapidly adapt to change is critical to the success of the program.[123] Information on technological developments must be rapidly communicated to the appropriate scientists who will be affected by the development. As new technological paths open, a project must incorporate new participants, while discarding others. Such flexibility is difficult in a

---

[122] See Chisholm, *Coordination Without Hierarchy,* ...p. 12.

[123] See Burns and Stalker, *Management of Innovation...*

rigidly structured hierarchy. The necessity of informal coordination at lower levels has serious implications for the ability of the leadership to control the development of a program. If the scientists are completely free to make programmatic changes without resort to hierarchical approval mechanisms, then the leadership has completely lost control and yet innovation cannot occur without it.

Principal-agency theories point out that there will be a struggle between leadership and scientists in which information control will play a primary role. For *programmatic innovation* to occur this theory places high requirements on administrators but fall short in predicting the results of this interaction. Organization theory delves deeper into the capacities of leadership and administrators and suggests the unavoidable irrationalities of bureaucratic life put the scientists in a stronger position. It also points out that information is but one of the tools in the scientists hand. Consequently, organizational theorists lead us closer to the hypothesis that the scientists not only ***can*** be independent from the leadership, but goes further to suggest that perhaps the scientist ***must*** be independent in order for innovation to succeed. To examine this hypothesis further, we need to explore the ***process*** of innovation.

THE PROCESS OF PROGRAMMATIC INNOVATION

Programmatic innovation does not occur with a single decision or event, it is invariably a long-term process, taking years, if not decades, to move from initial conception to institutionalization of a new program. Over this period of time the relationship between the scientist and leadership changes in important ways. Within the organizations themselves there will be significant changes. It is useful, for this study, to demarcate three stages of *programmatic innovation*: 1) conceptualization and project approval; 2) emergence of organizational structure; and, 3) institutionalization of program.

According to Marquis and Meyers, technological innovation

> is a complex activity which proceeds from the conceptualization of a new idea to a solution of the problem and then to the actual utilization of a new item of economic or social value. (Alternatively) innovation is not a single action but total process of interrelated sub-processes. It is not just the conception of a new idea, not the invention of a new device, nor the development of a new market. The process is all of these things acting in an integrated fashion...[124]

Kuhn described scientific revolutions as having common sequences of events.[125] Kuhn's formulation is useful here because it translates scientific lifecycles into terms familiar to the organizational theorist. Normal science, is a highly structured and

---

[124]See, Donald G. Marquis and Sumner Myers, *Successful Industrial Innovations*, (Washington D.C.: National Academy of Sciences, USGPO, 1969) p. 1; as quoted in Zaltman, et. al., *op. cit.*, p. 7.

[125] See Thomas Kuhn, *The Structure of Scientific Revolutions*, (Chicago: University of Chicago Press, 1969).

organized activity -- puzzle solving." It is governed by standard operating procedures and at least an informal hierarchy:

> A scientific community consists, in this view, of the practitioners of a scientific specialty. To an extent unparalleled in most other fields, they have undergone similar educations and professional initiations; in the process they have absorbed the same technical literature and drawn many of the same lessons from it. Within such groups communication is relatively full and professional judgment relatively unanimous. Because the attention of different scientific communities is, on the other hand, focused on different matters, professional communication across group lines is sometimes arduous, often results in misunderstanding, and may, if pursued, evoke significant and previously unsuspected disagreement.[126]

New scientific communities are formed by new entrants into the field who develop their own new set of questions, drawing in members from other communities to form a new community. As this community is being formulated, it is very much a new organization and behaves as such. Problems are solved on a *de novo* basis, but over time, standard operating procedures are developed as the community matures.

Organizational lifecycles therefore play an important role in the management of science. A new government bureau "is initially dominated either by advocates or zealots, it normally goes through an early phase of rapid growth, and it must immediately begin seeking sources of external support in order to survive."[127] As a bureau grows, even in the presence of external support, there are certain inevitable internal and external "brakes

---

[126] Kuhn, *The Structure of Scientific Revolutions...* p. 177.

[127] See Downs, *Inside Bureaucracy...* p. 5.

on acceleration." Ultimately a bureau experiences a "decelerator effect" and falls into decline, but may never go away.[128]

Evangelista applied the concept of lifecycles to weapons innovation. With respect to the United States he posited:

> The first of the five stages in which U.S. weapons innovations are carried out generally begins with scientists in weapons laboratories and military officials in close contact with them recognize technical possibilities for new weapons. They actively promote the military applications of their technological discoveries in a process of consensus building that starts with the military-technical community and is gradually pushed up to include high-level military officials, Congress, and usually the Executive. At some point, advocates of the innovation may be assisted by an often unrelated foreign development or the appearance of threat. In the later stages, as supporters seek advanced development and production of the new weapon, they appeal to a more specific threat, sometimes one quite different from the threat that provided the earlier opportunity to promote their innovation.[129]

In Evangelista's terminology, this is the classic "bottom-up" process moving from the scientists to the leadership for high level endorsement. This framework is useful primarily because it recognizes innovation as a *process*, and because it postulates substantively that the program proposal moves up from the scientists through monitoring agencies and finally to the leadership.

---

[128] *Ibid.*

[129] In Evangelista's system, the sequences of Soviet and American development were held in opposition with the American process characterized as bottom up and the Soviet process as top down. From Evangelista, *Innovation and the Arms Race*...p. 53.

Drawing from the above work, the chronological scheme employed in this study posits three basic phases to the development of *programmatic innovation*. The first is initial conceptualization of a seminal project, and approval by the leadership. Overlapping this phase is the second phase, the creation of the organizational structure. Finally, comes the institutionalization of innovation in which the innovation becomes recognized and utilized by the leadership as an important part of its policy making repertoire, thus beginning the process of routinization.

Conceptualization and Initial Approval

Scientists are in the business of producing ideas; political leaders are in the business of advancing the national interests. How the two come together is a complicated and delicate process which is never quite the same for any two programs. In some cases, the scientists clearly take the initiative and formulate and execute almost a sort of battle plan for assaulting the leadership with a completely new technological idea. Such was clearly the case when Teller and Szilard approached President Roosevelt with the idea of building an atomic bomb.[130] In other cases, the leadership takes the initiative, issuing a requirement without prodding from the scientific community, as did Stalin in ordering development of long range bombers.[131] In most cases however, the process looks more

---

[130] See Rhodes, *The Making of the Atomic Bomb...*

[131] See Steven J. Zaloga, *Target America: The Soviet Union and the Strategic Arms Race 1945-1964*, (London: Jane's, 1993)

like that posited by Evangelista, in which scientists see a new technological challenge and develop a constituency among the military users, slowly but deliberately pushing the idea up through the bureaucracy. Military users formulate draft requirements, often with active participation of the scientists who will ultimately build the system. A symbiotic relationship often forms between users and scientists. Ultimately, a decision must be made at the appropriate levels on whether to proceed with the project. In cases of *programmatic innovation*, inevitably the decision is made at the level of the higher levels of national leadership.

At this point in the R&D process, the leadership ***appears*** all powerful. It controls the money, and its decision is final. There is no higher court of appeal. The reality is probably different. At this early stage, the leadership's informational deficiency is at its greatest. It may have little choice but to accept the scientists' claims for cost and performance. It is a Weberian struggle of authority of incumbency versus authority of expertise.[132] But both sides' ability to exercise their potential power can be affected by other factors.

Much hinges upon the ability of the scientists to develop an early constituency -- some established group within the government which will provide support. This is their first and most important task.

---

[132] An excellent discussion of these sources of power is found in Pfeffer, *Power in Organizations...*

> The principal source of power is a constituency. This plain fact repeated by generations of students of public administration still seems lost on those people (business executives, in particular) who upon taking a high level job in Washington complain about the amount of time they must spend attending to the demands and needs of outside groups. All this time spent currying favor and placating critics, they argue, is time taken away from the real work of the agency, which is to `do the job.' No. The real work of the government executive *is* to curry favor and placate critics.[133]

The most obvious source for early support is from other members of the scientific community.[134] But this can be a double-edged sword, as competing scientists may turn out to be the strongest opponents of a proposed program. Vannevar Bush, the leading spokesman for the American scientific community in the immediate post war years, almost single-handedly killed U.S. efforts to developing ICBMs.[135] Scientists may also turn to the military end users of proposed systems with the promise of new missions for their services.[136]

The quality of the political leadership's decision making is an important variable. With truly novel technologies it is unlikely that the leadership will be able to muster the technological expertise to call the scientists' bluff. It must make its decision based upon incomplete information. If the leadership is able to reduce the constraints on its rationality

---

[133]*Ibid.* p. 204. Italics in original.

[134] See Latour, *Science in Action...*; and, York, *Race to Oblivion...*

[135] See Beard, *Developing the ICBM...*

[136] See Evangelista, *Innovation and the Arms Race...*

by giving sufficient time to consider alternatives, develop some understanding of the technology, develop clear lines of authority, and gain consensus on basic goals for the program, then it is more likely that the leadership will be able to counter the informational advantages of the scientists.[137]

Nevertheless, the leadership does have options. Scientists will push for an "all or nothing decision" arguing that large-scale commitments must be made at this point, or the project will founder. In his study of large-scale policymaking, Schumacher found that funding for many such programs is indivisible. The government must commit a large amount of resources to the project for a long period of time it is to realize any benefits at all. To provide less than long-term commitment of resources would mean killing the project altogether.[138] This puts the scientists in a difficult position. The leadership will push for an incremental program in which there will be many review points at which the decision can be made to discontinue the project.[139] Therefore, for projects in which the scale of the initial decision is high, the scientists should muster all their available sources of power before taking the decision to the leadership. In most cases, however, the decision

---

[137] See Kingdon, *Agendas, Alternatives and Public Policies...*; Cohen, March and Olsen, "A Garbage Can Model...;" and March and Olsen, *Ambiguity and Choice...*

[138]See Schulman, *Large-scale Policy Making...*

[139] For a discussion of incrementalism as a strategy see Charles Lindblom, "The Science of Muddling Through" *Public Administration Review,* (1958); Rosen, *Winning the Next War...* ; and Aaron Wildavsky *The Politics of the Budgetary Process,* (Boston: Little Brown and Co., 1964) for incrementalism in practice see Howard McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice,* (Baltimore: Johns Hopkins, 1990).

need not be all or nothing, but scientists may present it as such, while maintaining a fall-back strategy in the event that the leadership provides only incremental approval.

Emergence of New Program Organization

The decision to initiate a new program is usually followed by directives outlining the organizational structure to develop the new system. The organizational scheme may represent only minor modifications of existing arrangements, or may go so far as to involve the creation of entirely new administrative organizations as large as service branches. As is the case with any organization, the initial survival of a government organization is precarious.[140] A new organization risks either disbandment or irrelevance if it is not able to attract sufficient support from constituents. At the same time, the organizational genesis is also the most dynamic and creative period. The potential for conflict is also high. Both the ability of the leadership to exert control and the informational advantages of the scientists are at their greatest during this period. The basic character of the relationship between the scientists and the leadership is defined during this period, and the range of outcomes is wide. The actions of the principle actors contribute greatly to the outcome.

---

[140]On the initial period of growth in private organizations see John R. Kimberly, Robert H. Miles, and Associaes, *The Organizational Lifecycle: Issues in the Creation, Transformation, and Decline of Organizations*, (San Francisco: Jossey Bass, 1980). and; Downs, *Inside Bureaucracy...*

Informally, there will already have been some degree of spontaneous reorganization of scientists necessary for the conception of entirely new programs. This informal interaction may vary greatly: from exchanges of letters, conference papers, etc. over the course of weeks; to collaboration on experiments and prototypes over the course of years. In the early stages of the development of a new area of science, new informal organizations of scientists are created which often grow into formal organizations.[141] Scientists who pioneered the basic research, continue on to the development of the technology and ultimately to the development of systems themselves. Enrico Fermi, Leo Szilard and Hans Bethe pioneered the basic research which led to the discovery of fission and went on to participate in the engineering which led to the construction of the first atomic bomb.[142] Sergei Korolev and Valentin Glushko were not only among the world's first rocket scientists – who developed the theories leading to rocket propulsion – they continued to be the leading figures in the Soviet rocket and space programs until their deaths in 1966 and 1987 respectively.[143] Similarly, Werner Von Braun worked on rocketry in from the late 1930s in Germany and then in the United States until his death in

---

[141] Kuhn, notes that this is the process of creating a new paradigm, which involves creation of a new scientific community. See Kuhn, *The Structure of Scientific Revolutions...*

[142] See Richard Rhodes, *The Making of the Atomic Bomb*, (New York: Simon and Schuster, 1986).

[143] The history of the Soviet rocket program will be developed in some detail in ensuing sections of this study. For existing histories of the program see Valentin Glushko, *Razvitie raketostronniia i kosmonavtiki v SSSR*, (Moscow: Mashinostroenie, 1987). For a history written in English see McDougall, *The Heavans and the Earth...*

1972.[144] Not only did scientists in these new fields move on to become engineers, as their projects developed salience, they combined into autonomous organizations. Nuclear physicists were combined into the Manhattan District, the German rocket scientists were combined at Peenemunde, and the Soviet rocket scientists coalesced into the Council of Chief Designers.[145]

The emergence of autonomous lower level organizations out of existing agencies is critical for the survival of programs. The US ICBM program languished until the Western Research Division of the USAF was created.[146] Similarly, the Special Projects Office of the Navy was crucial to the Fleet Ballistic Missile Program.[147] On the other side of the coin, lack of organization hamstrung the development of the US space program before Sputnik, and may have played a key role in the restricted development of ABM systems in the United States.[148]

---

[144]See Frederick Ordway, *The Rocket Team,* (Cambridge, MA: MIT Press, 1972).

[145]The Council was actually several different design organizations but they functioned as a single unit under Korolev's direction.

[146]See Beard, *Developing the ICBM...*

[147] Sapolsky, *The Polaris Program...*

[148] McDougall, *The Heavens and the Earth...* on the reaction to Sputnik. It is interesting to note that the Safeguard Sentinel program was organized within the Army, while SDIO is an independent organization reporting directly to the Secretary of defense. This independence has played a critical role in the program's survival.

Formal government directives setting forth organizational assignment for new programs have important consequences for the relationship between scientists and leadership. The U.S. ICBM program was buried within the Air Force, which strongly resisted the new program on the basis that it would threaten the future of manned strategic bombers, which it viewed as its core mission.[149] In contrast, Sapolsky concluded that isolation of the Naval Polaris missile program from the rest of the Navy within a Special Projects Office, went a long way toward explaining the success of this program.[150] The independence of the Manhattan District has long been recognized as one of the key factors in the success of the U.S. atomic bomb program. It would appear that the scientists should strive for placement in a totally new organizational structure, or at least within an existing organization which is unrelated to the technology or mission.

Scope and staffing of administrative agencies are equally important. Administrative agencies with oversight limited to a single program (or policy alternative) will tend to become captives of the scientists they are engaged to monitor. Such administrators will be hard pressed to consider closing down the program on which their agency depends for existence. Moreover, as the power and prestige of their own agency will tend to be tied to the success of the scientists program, administrative agencies will

---

149 See Beard, *Developing the ICBM...*

150 See Sapolsky, *The Polaris Program...*

attempt to put a positive spin on any potentially adverse information.[151] The delicate balancing act between the leadership and the scientists which the administrative agencies must perform is made even more difficult by staffing problems. It will be difficult for the leadership to staff the administrative agency will people who are scientifically competent, without recruiting from the ranks of the scientists themselves. These new administrators strongly identify with the interests of their former colleagues.[152] Staff members recruited from ranks of the leadership will be more loyal to the leadership, but the ability to effectively monitor a program which they do not fully understand is questionable.

Individual leadership is the defining characteristic of a nascent organization.[153] Not only is this important for getting the innovation started, or "jumping through the window of opportunity,"[154] it is a crucial factor in the precarious period of a program prior to reaching its initial threshold.[155] The tasks facing, and skills required of, the leader of the emerging organization tend to be quite different from those facing the entrepreneur selling a program. Individuals who are both excellent administrators and entrepreneurs are

---

[151] See Downs, *Inside Bureaucracy...*

[152] See Downs, *Inside Bureaucracy...*

[153]See Kimberly, *The Organizational Llifecycle...*; Downs, *Inside Bureaucracy...*

[154] Kingdon, *Agendas, Alternatives and Public Policies...*;

[155] Downs, *Inside Bureaucracy...* pp. 5-23, for a discussion of the of reaching the initial evolutionary threshold.

rare.[156] As a result, the entrepreneur and the program leader are often different individuals. While Leo Szilard and Hans Bethe were the key individuals promoting the US atomic bomb program to Roosevelt, neither served in key leadership roles. It was neither Von Braun, nor the scientists at RAND, who administered the US ICBM development, but Gen. Schriever. Only in the Soviet case did Sergei Korolev serve both entrepreneurial and administrative functions. However, administrative competence is insufficient for success of a program. An administrator may be able to manage relations with external agencies, develop appropriate organizational mechanisms and structures, and maintain discipline over suppliers, but an administrator cannot provide technical direction, or create a sense of mission among scientists, who tend to see administrators as mere paper pushers. Thus, Groves needed Oppenheimer, and Schriever needed Ramo and Woolridge. Korolev, able to perform in both spheres, needed no one.

Effective organization at the scientific level is likely to be a key variable in the success of a program. An organization that is able to transform informally organized scientists, instrumental in the early development of the science for a program, will result in a more effective program. Much of the effectiveness of program organization lies in the informal organization which exists well in advance of any decisions to develop a specific weapon system. No single type of scientific organization is uniquely suited to

---

[156]See Kimberly *The Organizational Llifecycle...*

programmatic innovations. Instead, what emerges is a combination of formal and informal organizational mechanisms. The Manhattan Project was fairly centralized, while the U.S. manned space program was dispersed across literally thousands of different organizations. [157] The US fleet ballistic missile program was in between, with the Special Projects Office serving as the center of operations at a fairly low bureaucratic level, and Lockheed the prime contractor. But in all cases, decision making was decentralized to a low level. Rarely did program managers have to go up the ladder for approval of routine design changes. Such coordination often occurs informally and can be a key to successful innovation.[158]

Institutionalization of New Program

The process of innovation does not end with the decision to initiate a program.[159] In most cases it is only the beginning. Cases such as the US atomic bomb program, in which a single decision was made by the President and never revisited until the bomb was nearly complete, are the exception.[160] The US ICBM program remained mired in

---

[157] See Rhodes, *The Making of the Atomic Bomb...*; see also McDougall, *The Heavens and the Earth...*

[158] See Chisholm, *Coordination Without Hierarchy...*

[159] In spite of its importance, several authors have explicitly ignored the implementation side of the equation and ended their analyses at the point of decision. See for example, Evangelista, *op. cit.* who ends his sequence with a production decision; Greenwood, *op. cit.*, who flatly asserts that the development decision is almost always the deciding point, and ends his analysis there; and Allison, "Questions: About the Arms Race...

[160] See Rhodes, *The Making of the Atomic Bomb...*

bureaucratic infighting from the initial decision to develop an ICBM in 1950 until Trevor Gardner succeeded in getting reduced requirements for the system and streamlined procurement procedures in 1954.[161] The US space program was similarly hamstrung from 1954 until 1958.[162] Although the decision to produce the US ABM system was made in 1969, implementation was not vigorously pursued and the system was ultimately dismantled. These programs were initiated, the organizations established, yet failed to provide useful services and establish routinized relations with constituents. In short, they had difficulty becoming institutionalized.

The distinction between the organizational establishment phase and an institutionalized program is drawn from Down's definition of the early precarious phase of a bureau's existence. In his terminology, a bureau's existence is assured if it becomes "large enough to render useful services, and old enough to have established routinized relationships with its major clients."[163] Thus, it could be said that a *programmatic innovation*'s existence is assured once it begins to provide useful policy alternatives to the political leadership.

---

[161]See Beard, *Developing the ICBM*...

[162]See McDougall, *The Heavens and the Earth*...

[163]Downs, *Inside Bureaucracy*... p. 9.

As is the case during the organizational establishment phase, one of the key tasks for the scientists is to develop a constituency. But as the program increases in scale the need is to develop constituencies at higher levels of government. This creates a dilemma for the scientists. By currying the favor of higher authorities, they invite intervention. New technology programs are often choked by the excessive attention of an uneducated constituent. Early ICBM development was starved of funds because the Air Force demanded that the first generation of missiles be able to match the accuracy of manned bombers.[164] The development of the Fleet Ballistic Missile was similarly restricted due to concerns over rocket fuel on board a submarine.[165] The scientists must therefore do all they can to maintain their control over information, for as the program matures, the administrators become more educated in the relevant technologies, develop their own channels of communication with internal sources, and find a greater pools of outside expertise from which to draw critical judgments. Their urge to participate will be strong, and the scientists will not welcome their intervention.

Information control can be strengthened through organizational structure. By funneling all communication between the administrators and the scientists through a single, narrow channel, the scientists can control the flow of potentially adverse information, and condition the transfer of this information so that it is received in a more positive light.

---

[164]See Beard, ***Developing the ICBM...***

[165]See Sapolsky, ***The Polaris Program...***

Nowhere was this more successfully achieved than with the U.S. atomic bomb program in which all information had to be transferred through Gen. Groves or Robert Oppenheimer.[166] But organizational structure by itself is hardly enough to control information. Even with the best structure, leaks are inevitable.[167]

Organizational consensus may be more powerful tool at the disposal of the scientists at this stage. By establishing and maintaining a clear sense of mission and organizational identity the chief scientists can protect against unwanted leaks of adverse information to independent administrators.[168] The scientists position will be further strengthened, to the extent that the are able to develop a similar consensus among lower level constituents such as military users of systems.[169] Because complex technologies require a great deal of interdependence and information sharing, this consensus must include all of the scientific organizations involved with the program. The chief scientist must instill in his subordinate organization the same sense of mission so its members will not serve as sources of adverse information. This organizational culture is key:

> When an organization has a culture that is widely shared and warmly endorsed by operators and manager alike, we say the organization has a sense of *mission*. A

---

[166] See Rhodes, *The Making of the Atomic Bomb...*

[167] Ely Devons, "The Problem of Co-ordination in Aircraft Production," *Papers on Planning and Economic Management*, (Manchester: Manchester University Press, 1970)

[168] See, Wilson, *Bureaucracy...* p. 95.

[169] On this point see Evangelista, *Innovation and the Arms Race...*

> sense of mission confers a feeling of special worth on the members, provides a basis for recruiting and socializing new members, and enables the administrators to economize on the use of other incentives...having a sense of mission is the chief way by which managers overcome the problem of shirking in organizations that (like most governmental bureau) cannot make the money wages of operators directly dependent on the operators' observed contribution to attaining the goals of the organization.[170]

As information on a new technological field becomes more widely disseminated, scientists from other fields are better able to provide useful judgments to the leadership regarding the technical direction of the program.[171] In some cases an administrative agency may solicit second opinions from other, analogous programs. Thus one missile designer may serve as a source of expertise on the progress of another, and vise versa. The important advantage of appeal to outside expertise from competing scientists is that they not only understand the technology, and can therefore render well founded opinions, but they also have a clear motive in discovering adverse information regarding a competing project.[172] Competing programs will be viewed by the original scientific group as a direct affront to their autonomy.[173] While it may be beyond their power to prevent

---

[170]See, Wilson, *Bureaucracy*... p. 95.

[171] For an excellent memoir account of the activities of post WW II advisory boards which commented on a broad range of topics see Herbert York, *Making Weapons, Talking Peace,* (New York: Basic Books, 1987).

[172] On the importance of monitoring sources with hostility towards the monitored see Downs, *Inside Bureaucracy*... esp. pp. 148-151.

[173] See Wilson, *Bureaucracy*...

the leadership from establishing such programs, the original scientific group will do all in its power to undermine the success of the competing program.[174]

In choosing to establish competing programs, the leadership often finds itself on the horns of a dilemma. On the one hand, competition can provide for better ideas; but on the other, the creation of competition may have the effect of diluting a small pool of scientific talent to the point at which nether competitor can produce the new technology. The early failure of the U.S. missile program is explained by the fact that there were several competing programs diluting both the resources of the government and the scientific talent pool.[175] But as the program matures and the pool of talent expands these concerns dissolve, and the leadership will strive to create competition as both a source of information, and as a means of insuring that the best technological path is chosen.

Another source of outside expertise comes from scientific advisors. These external advisors can become a powerful source of information for the leadership.[176] However, ill informed scientific advisors can be worse than useless prior to the institutionalization phase. Vannevar Bush, the preeminent US scientific advisor, for years maintained that

---

[174] Martin Landau, "Redundancy, Rationality, and the problem of Duplication," *Public Administration Review,* Vol. 29 (1969), pp. 346-358.

[175] See Beard, *Developing the ICBM...;* and, McDougall, *The Heavens and the Earth...*

[176] See York, *Making weapons Talking Peace...*; and Solly Zuckerman, *Nuclear Illusions and Reality,* New York: Viking, 1982)

ICBMs were impractical. His intransigence probably cost the U.S. years delay in developing an ICBM. Von Neuman's later recognition that the ICBM would be a decisive weapon proved to be critical in the institutionalization of the program.[177] At the same time, the leadership runs the risk that the advisors may be somewhat less than objective. Von Neuman, for example had a close relationship with the manager of the U.S. ICBM program, Gen. Shriever.[178] Similarly, the Vice President of the Soviet Academy of Sciences, Mystislav Keldysh developed a close friendship with the Chief Designer of the Soviet missile program, Sergei Korolev.[179] For both, their friendship, and in Keldysh's case, his institutional interests, may have biased their technical objectivity.

Relations between advisors and managers of emerging programs are often problematic. There are two means of managing problematic relations with advisors, co-optation and stacking. Co-optation is simply winning over opponents to your program. The Commander of the Redstone Arsenal and the Jupiter missile program, General Medaris, successfully worked this strategy, for a time at least.[180] Stacking is arranging for members who are sympathetic to your program to be appointed to advisory commissions. Sergei Korolev was the master at this. The State Commission appointed to approve the

---

[177] See Beard, *Developing the ICBM...*

[178] See Beard, *Developing the ICBM...*

[179] See case study below.

[180]See Medaris, Countdown to Decision,...

Sputnik launch contained a majority of members from his Council of Chief Designers.[181] Most members of the Central Committee directorate and the Military Industrial Commission (VPK), essential to the approval of space programs, also came from Korolev's design bureau.[182]

By the end of the institutionalization phase there is an established program. Initial projects have been successfully completed and a plan for the future development of the program has been approved for the future. The leadership has come to accept the program as a useful policy tool and incorporates it into its regular activities. At this point innovation has occurred.

THE DILEMMA OF INNOVATION RECONSIDERED

This chapter examined in some detail the issues associated with large-scale innovation -- *programmatic innovation*. Because the stakes are highest, and the opportunity for conflict between the scientists and the leadership are the greatest for *programmatic innovation*, it is likely to be organizationally distinct from less ambitious forms of government-sponsored technological innovation. For these reasons we have

---

[181]See *Pravda*, October 4, 1987.

[182]Interview with Iuri Biriukov and Boris Stroganov, Moscow July, 1991.

limited our discussion to this class of innovation. Yet we have to conclude that despite the theoretical arguments of principal agency, there is a strong case to be made that it is very unlikely that *programmatic innovation* will occur under conditions of leadership direction. It is much more likely that the scientists will be able to manipulate the leadership to develop the program which is in their interests first, and the leadership's second. It is only fortuitous that the interests of the two have coincided in many cases.

Scientists have a wide variety of powerful bureaucratic tools at their disposal in programs involving new technologies and missions. If they act opportunistically and strategically, scientists can use their virtual monopoly over critical information to gain the highest levels of support for projects they wish to develop. The leadership is at a distinct informational disadvantage which it is hard pressed to redress. Its only hope for gaining control over runaway technology is to establish knowledgeable independent administrative agencies, and to structure decision making process so that programmatic decisions are carefully considered using the best available information. Therefore, we are led to consider the hypothesis that: *programmatic innovation is most likely to occur where there is a high degree of scientific autonomy.*

In the end, we must wonder, how can innovation occur under leadership direction? Answering this question requires digging deeper. Some of the existing case study material provides a convincing argument for scientific autonomy, but none really addresses the question. Furthermore, it has been argued that the United States provides optimal conditions for scientific autonomy.[183] Therefore, if we really want to test the proposition that scientific autonomy is necessary for *programmatic innovation*, we should look to a governmental environment in which the conditions are ***least likely*** to allow scientific autonomy. The Soviet Union under Stalin's dictatorship presents such an environment. Development of the Soviet missile and space program provides the only clear case of Soviet innovation, as contrasted with emulation (of which there are several examples). Considering the limited number of available case studies, in order to contribute to development of theory such a study must be carefully constructed. The following chapter develops a research design which can lead to generalizable observations regarding innovation, the scientists, and the leadership.

[183] This is the basic argument in Evangelista, *Innovation and the Arms Race...*

CHAPTER 2

The mainspring of science is the conviction that by honest, imaginative enquiry we can build up a system of ideas about Nature which has some legitimate claim to "reality."

Stephen Toulmin (1961)

RESEARCH DESIGN

This study considers the means by which states engage in large scale technological innovation, and conflicts inherent in such enterprises. Problems arise because there is a fundamental conflict of interest between the state leadership, which wishes to control the innovative process, and the scientists, who wish to have the greatest possible independence from the leadership.[1] For most high profile, expensive policy programs, the leadership is able to maintain control through monitoring agencies. However, the preceding chapter indicated that the leadership will be hard pressed to monitor highly

---

[1] For this study, the term "scientists" includes all scientists engineers and industrial concerns involved with conception, design and production of new technological hardware. The "leadership" refers to the members of the government having the right to initiate, terminate, or substantially alter new programs. As discussed in chapter 1, for programmatic innovation, the leadership would be at the highest levels of national government. Thus, for example, a service chief did not have the ability to initiate the atomic bomb program, that decision could only be made at the presidential level.

original, large scale technology programs. Examination of the theoretical literature, and historical cases of programmatic innovation, suggests that scientific autonomy may be a necessary condition for programmatic innovation. This is, naturally, a disquieting conclusion for policymakers in governments around the world, and not one which should be arrived at without rigorous, systematic, and observable hypothesis testing.

What is the best means of examining the relationship between the scientists and the leadership in programmatic innovation? Survey research and statistical analyses are inappropriate for this topic. Theoretical understanding of the process of programmatic innovation is not sufficiently well developed to permit the distillation of several cases into a small number of surveyable data points which can be statistically compared. Such qualitative studies of innovation yield contradictory and confusing results.[2] Given our limited understanding of innovation, the case study is the most appropriate methodology. Eckstein argues that case studies

> are valuable at all stages of the theory building process, but most valuable at that stage of theory building where least value is generally attached to them: the stage at which candidate theories are "tested." Moreover, the argument for case studies as a means for building theories seems strongest in regard to precisely those phenomena

---

[2] Steven Rosen perhaps best summarized the confusion through reference to another study noting: "One survey published in 1971 stated that academics had come up with thirty-eight different propositions about innovation, and that they disagreed about thirty-four of these. The four that were not the subject of controversy were the four which had not yet been discussed by academic experts." See E. Rogers and F. Schoemaker, *Communications of Innovations,* (New York: Free Press, 1971) cited in Rosen, *Winning the Next War,* pp. 4-5. See also George W. Downs and Lawrence B. Mohr, "Conceptual Issues in the Study of Innovation," *Administrative Sciences Quarterly,* Vol. 21 (December 1976) pp. 700-714; and James Q. Wilson, *Bureaucracy: What Government Agencies Do and Why They Do It,* (New York: Basic Books, 1989), p. 227

with which the subfield of "comparative" politics is most associated: macropolitical phenomena i.e. units of political study of considerable magnitude or complexity...[3]

With careful controls, much can be accomplished using these techniques.[4] George provides a useful framework for integrating case studies into a theory building study. The tasks are as follows: 1) specification of the research problem and objectives; 2) specification of dependent, independent, and intervening variables; 3) selection of case studies; 4) consideration of the way in which variance can best be described to further the assessment or refinement of the existing theory; 5) formulation of data requirements.[5]

The most productive result, for theory development, can be achieved with a single, crucial case study in which the proposition being tested appears to be least likely to hold true. For this study, an instance in which the leadership has a preponderance of authority in relationship to the scientists and a strong interest in exercising that authority would fit the bill.[6] If, through a detailed process tracing case study, it can be

---

[3] See Harry Eckstein, "Case Study in Political Science," pp. 79-137 in Fred I. Greenstein and Nelson W. Polsby (eds.) *Handbook of Political Science, Volume 7,* (Reading MA: Addison-Wesley, 1975), p. 80.

[4] I am, of course, mindful of the limitations imposed by utilization of a case study methodology. In particular the problem of many variables and a small number of observations. For a discussion of the shortcomings of case studies for theory development see Christopher H. Achen and Duncan Snidal, "Rational Deterrence Theory and Comparative Case Studies," *World Politics,* vol. 41 (1989) pp. 143-169, see also Eckstein, "Case Study in Political Science," ...

[5] George calls out five tasks which need to be performed during the research design phase of a project incorporating cases studies. See Alexander George, "Case Studies and Theory Development," paper presented to the Second Annual Symposium on Information Processing in Organizations, Carnegie-Mellon University, October 15-18, 1982.

[6] See Eckstein, "Case Study in Political Science," ...

demonstrated that programmatic innovation depended upon scientific autonomy in such a case, then a strong argument would be presented that the autonomy of the scientists from the leadership was a necessary (but almost certainly not sufficient) condition for successful programmatic innovation.[7] There are three steps to this process. The first is to observe scientific autonomy within the case study. The second is to make a causal connection between scientific autonomy and successful programmatic innovation. Finally, we should conduct a counterfactual analysis, asking the basic question: if the leadership ***did*** control the program, would it have made an important difference in the results? In the long run, it may be more important to understand ***how*** it is that the scientists exercised control over their program, rather than the mere fact that that they did, and that their control was necessary for success. The preceding chapter provided some clues as to how this might occur, but actual observation of these events and activities is an equally important part of the analysis. In this way, this case study might serve as a means of ferreting out critical hypotheses which disembodied theories would miss.[8]

---

[7] Process tracing has been hailed by Alexander George as the most powerful deductive method for single, or comparative case studies. See Alexander George, "Case Studies and Theory Development," ...

[8] Both George and Eckstein assert that hypothesis generation is one of the most powerful applications of the case study method. See George, "Case Studies and Theory Development,"...; and Ekstein, "Case Studies and Theory Development..."

The Theoretical Question

Chapter One uncovered a critical question with regard to the sources of state innovation in large technology programs. The basic dilemma posed is whether the leadership or the scientists are better administrators of technological innovation. The general consensus whicharose over the past two decades argued that the leadership could and should control innovation through the use of well educated, well intentioned, powerful administrative agencies.[9] Principal-agency theory provides the intellectual foundation for understanding how strong monitoring provides the closest approximation of an optimal relationship between the scientists and the leadership.[10] However, organization theory suggests that the leadership will be hard pressed to exercise control over a process about which it understands very little.[11] Historical experience furthermore indicates that innovation is often the result of a ***lack*** of leadership control. This generates two mutually exclusive propositions. Either: ***the leadership must control innovation in order to be successful;*** or ***the scientists must control innovation in order to be successful.*** Theoretical arguments aside, there was little evidence to support the former proposition,

---

[9] See Stephen Peter Rosen, *Winning the Next War: Innovation in the Modern Military*, (Ithaca: Cornell University Press, 1991).

[10] This issue is discussed in some detail in chapter one, but see in particular Michael W. Lawless and Linda L. Price, "An Agency Perspective on New Technology Champions," *Organizational Science*, (1992) 3:3 pp. 342-355; see also Jonathan Bendor, Serge Taylor, and Roland Van Gaalen, "Stacking the Deck: Bureaucratic Missions and Policy Design," *American Political Science Review*, Vol. 81 No 3, (September 1987) pp. 873-896.

[11] See in particular Jeffrey Pfeffer, *Power in Organizations*, (Cambridge: Ballinger, 1981)

while historical experience and organizational theory provided substantial support to the latter proposition. Consequently, the latter is the proposition to be tested in this study.

But methods of scientific inquiry impose limitations. At most, hypothesis testing can disprove a hypothesis; it cannot be used to prove a hypothesis to be true. The most this inquiry can prove is that it is not necessary for the leadership to control innovation for it to be successful. However, we shall strive to draw a strong inference that the scientists must have independence in order for programmatic innovation to be successful.

Specification of Variables

The first step in George's process is the specification of dependent and independent variables. The literature on innovation suggested that an important part of explaining innovation is to be very specific about the type of innovation being explained.[12] Accordingly, this study considers only a narrow range of innovations. The preceding chapter designated the dependent variable of this study as programmatic innovation; defined as the creation of a new technology program which represents a new mission for the state leadership. The point at which an innovation is deemed successful is the point at which the leadership applies it. Thus, the atomic bomb program was not successful until Truman approved its military use. If Truman had decided that it was too terrible a

---

[12] See George W. Downs and Lawrence B. Mohr, "Conceptual Issues in the Study of Innovation," *Administrative Sciences Quarterly,* Vol. 21 (December 1976) pp. 700-714; Rosen, *Winning the Next War...*; and James Q. Wilson, *Bureaucracy: What Government Agencies Do and Why They Do It,* (New York: Basic Books, 1989), p. 227

weapon to use and had discontinued the program after the successful test at Alamogordo, by this definition it would not be successful. Programmatic innovation is not successful until the leadership begins to use the new technology for clear policy purposes.[13]

The independent variable examined to determine if it is causally linked to successful (or unsuccessful) innovation is the relationship between the scientists and the leadership as defined in terms of *scientific autonomy.*[14] The preceding chapter explored this relationship in some detail. The inherent interests of the scientist and the state leadership are often at odds with each other, and it is almost unavoidable that they will come into conflict on endeavors as large in scale as programmatic innovation.[15] The

---

[13] Even this definition leaves logical loopholes. For instance, though by most estimates the SDI program of the Reagan administration failed to reach its objectives, it could be argued that it did achieve the objective of spending the Soviet Union into submission. There is no indication that the program was intended only to serve as a bluff, and every indication that it failed to meet its technological goals. Therefore, it must be judged to be a failure. In an endeavor such as this, such judgments of "gray area" cases are unavoidable.

[14] Scientific autonomy was defined as: the ability of a scientific organization to again and maintain a monopoly over a program with sufficient political support to undertake their research agenda without interference.

[15] This conclusion was developed through examination of principal agency theory. See For some the early work see Michael C. Jensen, and Willian Meckling, "Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure," *Journal of Financial Economics,* Vol. 3 (October, 1976) pp. 305-360; Eugene Fama, "Agency Problems and the Theory of the Firm," *Journal of Political Economy,* Vol. 88 (April, 1980) pp. 288-307; Eugene F. Fama and Michael C. Jensen, "Separation of Ownership and Control," *Journal of Law and Economics,* Vol. 26 (June, 1983) pp. 301-325. On the application of principal agency theory to politics see Terry Moe, "The New Economics of Organization," *American Journal of Political Science,* Vol. 28 (November, 1984) pp. 739-777; Terry Moe, "Politics and the Theory of Organization," *Journal of Law, Economics and Organization,* Vol. 7 (1991 special edition) pp. 106-129; Mathew D. McCubbins and Thomas Schwartz, "Congressional Oversight Overlooked: Police Patrols versus Fire Alarms, *Political Sciences Quarterly,* Vol. 28:1 (1984) pp. 165-179. and Barry Weingast, "The Congressional-Bureaucratic System: A Principal-Agent Perspective," *Public Choice* Vol. 44 (1984) pp. 147-192. For an application of the principal-agency framework to defense procurement see Tracy Lewis, "Defense Procurement and the Theory of Agency," in Jim Leitzel (ed.) *Economics and National Security,*(Boulder CO: Westview Press, 1993) pp. 57-72. For application of

challenge is to develop observations and measurements which characterize the relationship as being either dominated by the scientists or the leadership. That is, having high or low levels of scientific autonomy.

Case Study Selection

There are two basic approaches which could be taken toward case study selection. The first is to examine several cases using the techniques of structured, focused, comparative case studies.[16] The second approach is to develop a single, more detailed "crucial" case study.[17] For this subject matter, the latter approach seems more attractive for several reasons. First, given our rather poor understanding of innovation, even in the narrow sense considered here, there is much to be said for a rich examination of as many variables as possible related to programmatic innovation. Such detail is precluded in structured, focused comparative case studies. Second, the number of available cases of programmatic innovation is limited and expanding the set of applicable cases risks moving into a different type of innovation which might, to borrow Wilson's metaphor, behave like

---

the theory to problems related to R&D see Michael W. Lawless and Linda L. Price, "An Agency Perspective on New Technology Champions," *Organizational Science,* (1992) 3:3 pp. 342-355; see also Jonathan Bendor, Serge Taylor, and Roland Van Gaalen, "Stacking the Deck: Bureaucratic Missions and Policy Design," *American Political Science Review,* Vol. 81 No 3. (September 1987) pp. 873-896.

[16] See George, "Case Studies and Theory Development," ...

[17] This technique was most explicitly described in Eckstein, "Case Study in Political Science," ...

a completely different disease.[18] Consequently, limiting the scope of investigation will be important for developing useful theories of innovation.[19] Finally, there is a clear candidate for a crucial case study.[20] The Soviet missile and space program presents an instance in which leadership control, because of the nature of the society, over the process of innovation appears most likely. Thus, if the case study demonstrates that the scientists held control over the program, there are strong grounds for rejecting the hypothesis that there must be leadership control for programmatic innovation to succeed, and instead accepting the proposition that scientific autonomy is necessary.[21]

Throughout this discussion we have referred to historical cases of programmatic innovation. (See Table 1.1, chapter 1.) Of these cases, two stand out as the most clear cut instances of programmatic innovation--the U.S. atomic bomb program and the Soviet missile and space program. Both exhibited the highest levels of scale and originality. The atomic bomb program has been exhaustively researched elsewhere, and the clear conclusion was that the scientists exercised a preponderance of control over that program

---

[18] Wilson noted "innovations differ so greatly in character that trying to one theory to explain them all is like trying to find one medical theory to explain all diseases..." See. Wilson, *Bureaucracy...*

[19] See in particular George W. Downs and Lawrence B. Mohr, "Conceptual Issues in the Study of Innovation,"...; and Rosen, *Winning the Next War...*

[20] Eckstein notes that for many propositions it may be impossible to develop a crucial case study, either because the case doesn't exist or because of data collection problems. See Eckstein, "Case Study and Theory..."

[21] See Eckstein, "Case Study and Theory..."

and that their independence was critical to the success of the program.[22] However, the argument has been made that this was more likely a product of the American style of R&D than of innovation in general. In fact, Evangelista contrasts the "bottom-up" American style of research with the "top-down" style of research which characterized the Soviet style of development.[23] This suggests that we should look for cases of Soviet programmatic innovation to test the proposition.

Of the instances of programmatic innovation referred to in the previous chapter, the Soviet missile and space program stands out as the best case for examining the relationship between the scientist and the leadership. The launch of Sputnik was a watershed in the history of the Cold War. Yet this case has not been examined in any detail since the release of information in the wake of the Soviet Union's collapse. New sources of information allow us to rigorously explore this critical development in history for the first time. Historical reasons alone would make this is a valuable case study.

More importantly for this study, the creation of the Soviet missile and space program plays an important theoretical role. The most obvious factor which sets this case apart from other cases of programmatic innovation is that it occurred in the Soviet Union under Joseph Stalin. The post 1917 Soviet Union is recognized by political scientists as

---

[22] See Richard Rhodes, *The Making of the Atomic Bomb,* (New York: Simon and Schuster, 1986).

[23] See Matthew Evangelista, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies,* (Ithaca NY: Cornell, 1988)Evangelista, *Innovation and the Arms Race...*

being among the strongest states to have emerged in this century.[24] According to Freidrich and Brzezinski, as a formal organizational structure the Soviet governmental system had several notable features. First, the USSR was characterized by extreme hierarchy and a proliferation of oversight institutions. Second, the leadership sought to centralize decision making to the highest levels of the government.[25] Following from this, the vast majority of scholars have concluded that scientific progress results from leadership direction rather than scientific initiative. Samuel P. Huntington concluded:

> In the United States, pressures for change tend to bubble up continually...In the Soviet Union, in contrast, innovation tends to have a stop and start, trial and error quality. Major changes are initiated from the top.[26]

David Holloway adopts a similar perspective, noting,

> If left to themselves the design bureaux would no doubt carry on designing weapons and the factories would keep on producing them; but there is nothing to suggest that they would be very innovative. It is the political leadership and the armed forces that have created the conditions for innovation in the defense sector and directed its activities into innovative paths.[27]

---

[24] See Stephen Krasner, *Defense and the National Interests: Raw Materials Investments and U.S. Foreign Policy,* (Princeton NJ: Princeton University Press, 1978) p. 56; Evangelista, *Innovation and the Arms Race*...pp. 22-49; and Matthew Evangelista, "The Paradox of State Strength: Transnational Relations, Domestic Structures, and Security Policy in Russia and the Soviet Union," *International Organization,* Vol. 49:1 (Winter 1995) pp. 1-38.

[25]See Carl J. Freidrich and Zbigniew K. Brzezinski, *Totalitarian Dictatorship and Autocracy,* (New York: Praeger, 1956, pp. 9-10.

[26]Zbigniew Brzezinski and Samuel P. Huntington, *Political Power: USA/USSR,* (New York, 1972) pp. 228-229.

[27]David Holloway, "Innovation in the Defense Industry" in Amman and Cooper *Industrial Innovation in the Soviet Union,* (New Haven: Yale, 1983), p. 319.

And the Central Intelligence Agency asserts

> The Soviet system lacks the technological entrepreneurs who in the West respond to new market opportunities without being directed--the self-generating `Silicon Valley' microelectronics industrialists.[28]

This work by a broad range of scholars provides a clear assertion that the Soviet Union was the ***least likely*** case in which one would expect to observe control by the scientists of programmatic innovation. This is perhaps the most important of Eckstein's criteria for a crucial case study.[29]

A second, related reason that the Soviet missile and space program offers an attractive case study is that the Soviet governmental system was, by its very nature, *not* very innovative. In fact, the missile and space program offers the only clear case of programmatic innovation for the Soviet Union.[30] Berliner, who first began to make the connection between the Soviet political/economic system and the lack of innovation at the lower levels, argued that enterprise managers faced powerful disincentives and very weak incentives to undertake innovation of either products or processes.[31] Thus, there was almost unanimous agreement among students of the Soviet system that it was not very

---

[28]Central intelligence Agency, *The Soviet Weapons Industry,* (Washington D.C.: GPO, 1986) p. 15.

[29] See Eckstein, "Case Study and Theory..." especially pp. 118-120.

[30] Obviously, the Soviet Union has initiated many new program, but as discussed n the preceding chapter, there is an important distinction between innovation and emulation. The long range missile program and ultimately the space programs are the only cases in which the Soviet Union was clearly ahead of the United States.

[31]See Joseph Berliner, *The Innovation Decision in Soviet Industry,* (Cambridge: MIT, 1976).

innovative, and innovation would only occur through administrative fiat. But even under administrative fiat, the Soviet defense economy was not inclined to be innovative. Evangelista concluded that the Soviet system of military R&D, suffers from: 1) a high degree of centralization; 2) a low quality of technical workforce; 3) a high degree of formalization of processes; 4) poor connections between R&D institutions; and, 5) a low degree of organizational slack.[32] All of these contributed to the low innovativeness of the Soviet Union.

Other scholars have approached the issue of Soviet innovation from the perspective of organization theory.[33] Rigby noted that the Soviet government was basically similar to an "ideal type" of organizational structure which Burns and Stalker referred to as "mechanistic."[34] A mechanistic organization is one which is well suited to performing repetitive production in a stable environment. It is an organization which is, in short, unable to innovate, or even adapt to environmental changes.[35] The characteristics of a mechanistic system will strike the student of Soviet affairs as remarkably familiar.

---

[32]See Evangelista, *Innovation and theArms Race...* pp. 49.

[33]Alfred Meyer, was perhaps first and certainly most explicit in describing "USSR Incorporated" in terms similar to those used to describe the Western firm. See Alfred Meyer, "USSR Incorporated," *Slavic Review*, October 1961. It was however T.H. Rigby who provided reference to perhaps the most fruitful line of inquiry. See T.H. Rigby, *The Changing Soviet System*, (Brookfield VT.: Edward Elgar, 1990); Others included Allen Kassof, "The Administered Society," *World Politics*, (July, 1964); and Maria Herszowicz, *The Bureaucratic Leviathan*, (Oxford: St. Martin's, 1980).

[34]See T.H. Rigby, "Stalinism and the Mono-organizational Society," in Robert C. Tucker, *Stalinism: Essays in Historical Interpretation*, (New York: W.W. Norton, 1977)

[35]See Tom Burns and G.M. Stalker, *The Management of Innovation*, (London: Tavistock, 1961).

a) the specialized differentiation of functional tasks into which the problems and tasks facing the concern as a whole are broken down;

b) the abstract nature of each individual task, which is pursued with techniques and purposes more or less distinct from those of the concern as a whole; i.e. the functionaries tend to pursue the technical improvement of means, rather than the accomplishment of the ends of the concern;

c) the reconciliation, for each level in the hierarchy, of these distinct performances by the immediate superiors, who are also, in turn, responsible for seeing that each is relevant in his own special part of the main task.

d) the precise definition of rights and obligations and methods into the responsibilities of a functional position;

f) hierarchic structure of control, authority and communication;

g) a reinforcement of the hierarchic structure by the location of knowledge of actualities exclusively at the top of the hierarchy. where the final reconciliation of distinct tasks and assessment of relevance is made.

h) a tendency for interaction between members of the concern to be vertical i.e. between superior and subordinate;

i) a tendency for operations and working behavior to be governed by the instruction and decisions issued by superiors;

j insistence on loyalty to the concern and obedience to superiors as a condition of membership;

k) a greater importance and prestige attaching to internal (local) than to general (cosmopolitan) knowledge, experience and skill.[36]

While each point in the formulation by Burns and Stalker accurately describes a feature of Soviet government, Rigby argues that it is not a complete description. He further argues that their mechanistic formulation is not sufficiently rigid -- particularly during the Stalinist period -- to describe the Soviet system, because it fails to sufficiently describe the degree

---

[36]*Ibid.* p. 120.

of centralization in the office of the General Secretary of the CPSU (point "g" above), and the degree of coercive enforcement through terror (points "i" and "j" above).[37]

There were many instances of programmatic innovation in the United States in the post war period, but the Soviet missile and space program offers the only obvious case of programmatic innovation for the Soviet Union.[38] This alone would suggest that in a society characterized by leadership direction the only time it was able to innovate (as opposed to emulate its competitor) the innovation would be the result of scientific independence and the ability of the scientists to manipulate, if not circumvent leadership direction. If it can be demonstrated that this success was traceable to scientific autonomy then there is an additional argument which can be made for the productivity of this single case study.

It should be noted that this is a case which has been examined by several scholars. Most, if not all, of these examinations have concluded that the ICBM program was little different than other emulative Soviet development programs. Holloway noted that

> a crucial feature of the ICBM program is that ever since the decisions to undertake development of the atomic bomb and long-range rockets it has enjoyed the highest priority. The top party leaders have place great importance on the creation of strategic power, and have devoted time, energy and resources to ensuring the success of ICBM development. Stalin's role in the decisions of the mid-40s has already been noted. Khrushchev's memoirs suggest that when he was First

---

[37] See Rigby, "Stalinism and the Mono-organizational Society..."

[38] A thorough review of post-war innovative programs can be found in Evangelista, *Innovation and the Arms Race...* In all programs, with the exception of the ICBM, the Soviet Union trailed behind the United States in developing a new technology.

Secretary of the Central Committee he too played the dominant role in the Politburo.[39]

Galagher[40] and Evangelista[41] have also found the ICBM case to be consistent with this top-down orientation.

In the absence of information, these analysts have operated on assumptions about the Soviet system tracing back to Huntington and Brzezinskii. They assumed that when orders were given, administrators followed them, and that the research and development system worked according to formal rules. Yet even before the breakup of the Soviet Union, there were reasons to question these assumptions. Berliner found in a pathbreaking series of interviews, that factory managers often worked outside the formal planning system, relying upon informal coordination with other factories to ensure supply lines, and deliberately distorted their production capabilities to maximize bonuses.[42] Dunmore found that, even under Stalin, ministers often ignored orders from leadership.[43] In spite of these indications, analysts of Soviet military production erroneously adhered to

---

[39]See Holloway," The Defense Sector..." p. 401.

[40]See Karl F. Spielmann, *Analyzing Soviet Strategic Arms Decisions,* (Boulder Colo.: Westview, 1978) pp. 109-145.

[41]Matthew Evangelista, *Innovation and the Arms Race...*

[42] See Joseph Berliner, "The Informal Organization of the Soviet Firm," in Joseph Berliner, *Soviet Industry: From Stalin to Gorbachev,* (Ithaca: Cornell, 1988) pp. 221-46.

[43] See Timothy Dunmore, *Soviet Politics 1945-53,* (London: Macmillan, 1984).

the assumption that the military was a strong, well educated customer which set exacting standards and ensured that scientists met them.

A great deal of additional information has been released since this case has been seriously examined. Recent memoir accounts, brief histories, and limited documentary sources make a compelling argument that the scientists, specifically "Chief Designer" Sergei Pavlovich Korolev, controlled much of the developmental process and managed to co-opt the administrators into supporting the development of a space program, while selling the leadership on the notion that they were only building strategic rockets. In the end, Korolev's rockets were nearly useless as ICBMs but proved to be ideal space launch vehicles.[44] Since very little of this material has been made openly available in the West, this study goes into considerable detail in order to bring the new evidence to light in a fashion which not only contributes to our understanding of innovation, but to historical knowledge as well.

Observation and measurement

Observation and measurement of the relationship between the scientist and the leadership is both crucial and difficult. There are cases in which one observer has found evidence of leadership control while another apparently finds that the scientists dominated

---

[44] A basic derivative of the first ICBM continues to be used as the workhorse of the Russian space program today.

the process.[45] Ideal observations would be those events in which the scientists and the leadership had clearly divergent interests leading to mutually exclusive outcomes.[46] The best example of such an instance would be a case in which there was a clear divergence over the characteristics of a new project and the end result clearly conformed to one side's preference. In practice, there are many such instances, but they tend to be one sided. Scientists propose projects and are routinely rejected.[47] The sheer numbers of these cases indicate that leadership control is the rule. Examples in which the leadership proposes a project and the scientists refuses to take up the leadership are much less common.[48] It may be possible to find cases in which the leadership ordered one thing, and ended up with something very different. In some cases, the leadership might order something, but the scientists refused to build it.[49] These latter two cases offer the clearest observations of

---

[45] For example, Beard found that it was the autonomy afforded Bernard Shriever in the U.S. ICBM program which proved decisive. See Edmund Beard, *Developing the ICBM: a Study in Bureaucratic Politics*, (New York: Columbia University Press, 1976). With respect to the same program Rosen found that the military's ability to reign in the scientists was the most important factor. See Rosen, *Winning the Next War...*

[46] As Pfeffer notes we can only understand the disposition of power by observing the conditions under which it is exercised. See Jeffrey Pfeffer, *Power in Organizations*, (Cambridge: Ballinger, 1981).

[47] Virtually any discussion of successful R&D programs includes some comment on the numerous proposal which were rejected by the leadership which did not understand their merit.. See in particular, Rosen, *Winning the Next War...*; and Evangelista, *Innovation and the Arms Race...*

[48] To be sure there are cases in which one contractor, or another will chose not to bid on a contract, but I can think of none in which all contractors failed to bid. Perhaps the most interesting case of a scientists refusing to do the work ordered by the leadership occurred in the German atomic bomb program in which the lead scientist is alleged to have purposefully failed to produced a bomb. See Thomas Powers, *Heisenberg's War: the Secret History of the German Bomb*, (Boston: Little Brown, 1993).

[49] As the ensuing chapters will show, the creation of the Soviet space program was the result of just such a process.

scientific autonomy. Furthermore, just because the leadership ended up with the project it originally approved, does not mean that the scientists did not have a great deal of autonomy. We will therefore need to develop a more comprehensive set of tools for observation of scientific autonomy. The following discussion will trace through the stages of innovation outlined in the previous chapter, looking for instances in which an observable divergence in the interests of the scientists and the leadership occurs.

1. **Conceptualization and Initial Approval:** There are two distinctly different paths to innovation. In a top-down process, the leadership initiates a program by issuing a requirement for a new system. The scientists respond with their proposals, and the leadership chooses one and a new program begins. In the scientist dominated process, it begins with an idea. The concept becomes a proposal. The proposal is taken through administrative agencies to the leadership for approval or funding, and an innovative program is borne.

    In reality, the process is seldom so straightforward. Both top-down requirements and scientific proposals are subject to negotiation, often to the point where they are virtually indistinguishable from the original. The leadership may sharply constrain the creative control of the scientists by narrowing the scope of the initial contract, or requiring that the entire program be to subject many *de novo* reviews. The initial phase of a program is critical for determining the balance of power between scientist and the leadership, but observation is not simple. The following factors should be considered:

a) **<u>Technological possibilities or new mission origin:</u>** New program usually arise out of one of two factors. Either state leadership has embarked on a new policy direction (e.g. flexible response from massive retaliation) or a new technological possibility has presented itself during the course of scientific work. But both the scientists and the state leadership prefer working from their own draft. The initiator of a program holds the advantage of understanding the connection between the technology involved and the ultimate goals of the program. The first indicates leadership initiation, the latter of scientific initiative. Both however can be mitigated by the negotiation process.[50]

Observation: The initiator of a program holds an advantage. If the original proposal was submitted by the scientists without a specific request then they hold this advantage. If the proposal was a response to a new requirement issued by the leadership, then the leadership holds the advantage.

---

[50] For a discussion of the confusion which often occurs in the early phases of concept development see Edwin A. Deagle, Jr., "Organization and Process in Military R&D," in Franklin A. Long and Judith Reppy, *The Genesis of New Weapons: Decision Making for Military R&D,* (New York: Pergamon Press, 1980) pp. 161-181.

b) **Negotiation of initial work statement:** Often the leadership will issue a poorly defined requirement which the scientists will refine, perhaps to the point where the original requirement is nearly unrecognizable.[51] In such cases, it is inaccurate to say the leadership generated the requirement. By the same token, the scientists may bring a proposal to the end user or the state leadership only to have that proposal radically changed, often due to budget stringency's.[52] What is critical for this observation is the process of negotiation.

Observation: If there is a significant difference between the initial proposal and the final version, then the leadership is demonstrating control. If there is substantial modification of the requirement issued by the leadership, then the scientists are exerting control.

c) **Scope of work statement:** Does the initial work statement provide only performance specifications or design parameters? The leadership gains control through highly specific designation of performance as well as

---

[51] For example the final requirement for the F-111 bore little resemblance to the original specification. The changes in specification were due, in part at least to the inability of the contractors to meet the technical specifications. See Robert F. Coulam, *Illusions of Choice: The F-111 and the Problem of Weapons Acquisition Reform,* (Princeton: Princeton University Press, 1977).

[52] The U.S. space station is a particularly strong example of this. For a discussion of the early phase of the design see Howard McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice,* (Baltimore: Johns Hopkins, 1990).

design details. The scientists, on the other hand want to have only the most general sort of work statement.[53]

Observation: Highly specific requirements, particularly engineering requirements demonstrate leadership control while very general performance specifications indicate scientific autonomy.

d) **Review and funding schedule:** The scientists gain autonomy by getting a single decision to fund the entire project, (all or nothing funding). The leadership on the other hand can achieve a great deal of control by providing many programmatic milestones which must be achieved before the leadership will again consider *de novo* the decision on whether the program should be continued.[54]

Observation: Incremental funding schedules indicate leadership control while all or nothing decisions demonstrate scientific autonomy.

1. **Establishing Organizational Structure:** Once a decision has been made, an organization must be put into place to actually do the work. This organization will

---

[53] See James E. Webb, *Space Age Management: The Large Scale Approach,* (New York: McGraw-Hill, 1969); and Carl Kaysen, "Improving the Efficiency of Military Research and Development" in Edwin Mansfield, *Defense, Science, and Public Policy,* (New York: Norton, 1968)

[54] See Paul R. Schulman, *Large Scale Policymaking,* (New York, Elsevier, 1980); and McCurdy, *The Space Station...*

consist of scientific organizations performing the engineering and production, and administrative agencies to ensure both that work is being performed at an acceptable rate and cost, and that the work meets the initial requirements. Here too there is the potential for conflict between the scientists and the leadership.

a) **Organizational structure:** To be objective, it is important that the administrative agencies have no vested interest in the success or failure of a program.[55] In order to accomplish this the leadership should assign monitoring functions to administrative agencies that oversee different alternative programs to accomplish the same mission. The leadership will attempt to proliferate administrators.[56] The scientists, on the other hand, will prefer a few administrators who are tied specifically to their program.

Observation: The leadership's position will be strengthened by establishment of many administrative agencies with multiple program oversight. The scientists' will be strengthened by single program oversight agencies.

---

[55] See, Anthony Downs, *Inside Bureaucracy*, (Boston: Little Brown, 1967)

[56] Downs notes that multiple channels of information may be the most effective means of monitoring. See Downs, *Inside Bureaucracy*...

b) **Scientists-end user relations:** In formal terms, end users of systems act as administrators.[57] Informally however, they often become a captive audience of the scientists.[58] The end-users, with their own narrowly defined interests, often see new programs as a way to increase the scope of control of their department, and therefore become willing captives of the technological ideas of the scientists.[59] For the leadership, the objectivity of the administrators is particularly critical as the end-users have the best understanding of the true capabilities and performance of the administrators.

Observation: The position of the scientists is strengthened if they have established a working alliance with end-users for development of a new program prior to project approval and organizational creation/assignment.

c) **Competing scientific organizations:** In an uncertain, emerging technological area, the state leadership often finds scientific organizations which are competing with each other to be a powerful source of information on the capabilities and performance of each other. In the

---

[57] See Tracy Lewis, "Defense Procurement and the Theory of Agency," in Jim Leitzel (ed.) *Economics and National Security,*(Boulder CO: Westview Press, 1993) pp. 57-72.

[58] See Wilson, *Bureaucracy...*

[59] Evangelista contends that this is the dominant mode for innovation in the United States. See Evangelista, *Innovation and the Arms Race...*

absence of such competition, the scientists have a virtual monopoly over information which might be used as a powerful source of autonomy.[60] Naturally, the scientists would prefer monopoly while the leadership would rather have competition.

Observation: If there is only a single scientific organization which is working in the key technological areas, or if all scientific organizations are working together on a single program, then the scientists will enjoy greater autonomy than if there is competition among scientific organizations.

d) **Familiarity of administrators with new technologies and missions**: It is unavoidable that administrators will not have as good an understanding of the missions and technologies involved in the programmatic innovation as will the scientists. However, there are both degrees and types of ignorance. For the leadership, the worst case is when the administrators have a very poor understanding of both mission and technology. In this case they are most likely to be dominated by the scientists.[61] From the leadership's perspective, it is probably better if the administrators have at least some understanding of the mission, as this gives them at least some

---

[60] Wilson refers to the absence of competition as being an essential condition for autonomy. See Wilson, *Bureaucracy...*

[61] The classic example of this was the U.S. atomic bomb program during which General. Groves was forced by technological ignorance to accede to many of the scientists wishes. See Rhodes, *The Making of the Atomic Bomb...*

means of evaluating whether the scientist's activities have a reasonable chance of meeting their mission requirements.

Observation: If the background of the staff of the monitoring agency is non-technical, or unrelated to technology of the new program, then the scientists will have some autonomy from the administrators. This autonomy will be strengthened if the administrators also have a limited understanding of the new missions to be performed.

2. **Institutionalization of program:** Making the decision to go ahead with a project and setting up the organizational structure can take place in matter of weeks or months. The real business of implementation – development of the project – takes years. It is during this period that formal relations are modified, and informal procedures come to be preeminent. Relationships between administrators and scientists are established; formal procedures are modified to suit the real world situation rather than the formally envisioned process. The leadership can either control this process, or exercise benign neglect.

   a) **Technological deviations:** New technologies are invariably uncertain. During the course of development, new possibilities may arise. Pursuing these alternatives is likely to deviate from the original requirements, particularly if the requirements are rigid, engineering specifications.[62] At a

---

[62] See Kaysen, "Improving the Efficiency of Military Research and Development"...

minimum, such deviations will require some reallocation of funds, at a maximum, a reorganization of the project. Both are anathema to the leadership. Ultimately, these deviations may make the final project virtually indistinguishable from the original requirement.[63] ***This represents the clearest indicator that the scientists have exercised control over a project.***

Observation: If the scientists are able to make a significant technological deviation, this should be taken as evidence of scientific control over the program.

b) **Informal vs. formal coordination:** Top- down programs are characterized by extremely hierarchical decision making processes. Many seemingly routine decisions involving the coordination of scientific activities require approval from large number of officials throughout the hierarchy. The typical program requires concurrence of all, and therefore may be held up by a single veto. To gain control over their programs, scientists must develop formal an informal means of circumventing such processes and restricting decision making groups for routine technical

---

[63] The clearest example of this phenomenon is the Soviet space program which was presented to the leadership by the scientists as a *fait acompli*. The original missile program was never completed by Korolev's scientific group. This case will be explored in detail in the following chapters.

decisions to the scientists. The leadership will resist such attempts to circumvent established procedures.[64]

Observation: If we observe that a large number of decisions must be ratified by many higher level agencies then this provides an indicator of leadership control over the program. If scientists are able to manage the program through informal channels it will be an indicator of scientific control.

c) **Evolving interests of administrators:** Administrative agencies are at the center of the competition between scientists and the leadership for control over a program. The scientists will attempt to establish the administrators as constituents for the program while the leadership will establish incentives to maintain the administrators' independence and thus leadership control.[65]

Observation: Observation of strong support and lack of serious programmatic criticism from the administrative agencies, in particular threats to cancel the program, are a strong indicator that the scientists have

---

[64] See Donald Chisholm, *Coordination Without Hierarchy: Informal Structures in Multiorganizational Systems,* (Berkely, University of California Press, 1989).

[65] See Downs, *Inside Bureaucracy...*

been able to co-opt the monitoring agencies. By the same token, constant threats of cancellation are an indicator of monitor independence.

d) **Transmission of adverse information:** Intermediate failures are inevitable. But it is often up to the discretion of the monitor whether, and how, the information is reported to his superiors. In some cases administrators will protect the scientists, buffering the transmission of adverse information or not transmitting it at all. In other cases, the information will be faithfully transferred to the suitable authorities.

Observation: Faithful transmission of adverse information indicates leadership control, while cases of protection indicate scientific autonomy. In practice, the former will be difficult to validate, but the latter may be readily observable.

Naturally, all these observables will not tally up to a single figure. Some aspects of any program will be under the control of the leadership while others will demonstrate scientific autonomy. We must also be careful to avoid a simplistic comparison of the number of observables on one side or the other. All observables are not created equal. The most important variable may be whether or not the final program was similar to the original agreement, and the reasons for this deviation. Other issues which seem of intrinsic interest would be the alignment of the monitor's interest; informal coordination and the ability of scientists to make technological deviations. The significance of other issues will become clearer in the course of the individual case studies. The point here is that measurement of scientific autonomy, or leadership authority must be analytic, not simply arithmetic.

We should also devote special attention to the dynamics of control. Power ebbs and flows. While the leadership may control a project during a certain period of its development, it may lose control in others. Furthermore, the flow of control may prove to be consistent across projects and emerge as an important part of the explanation.

Data Requirements

The preceding questions pose an ambitious set of data requirements. It is only through the detailed examination of the interplay of leadership, administrators and scientists in a detailed process tracing case study that we can gain a greater understanding of how programmatic innovation occurs. The preceding section defined the basic processes to be traced and the issues which should be addressed within each in chronological phases of programmatic innovation. But it is also important to understand that there are processes which must be traced within each level of government. At the leadership level, we are primarily concerned with the political leadership's ability to overcome its inherent informational deficiencies by reducing the decision making load, developing a consensus over goals, and reviewing the program's progress. At the level of the administrators, the fundamental process is how administrative agencies develop in relation to the program. Organizational structure, staffing, and availability of outside expertise, may lead an administrate agency to become the captive of the program it is intended to monitor. The scientists have a great many means of manipulating information to their advantage. But this is a delicate and dangerous game. We should seek to understand how these tools are utilized, and which prove to be most (and least) effective.

In the end, any useful theory must be parsimonious. But in the study of innovation, we have a long road to travel before we can construct truly supportable theories. Scholarship in this area remains in the stage of hypothesis generation. While this study advances a tangible theory, within a very specific class of cases, it remains general, and there is little question that if it to prove ultimately useful it will have to be modified to some extent. In order to tease out the additional hypotheses which might be generated, it is almost imperative that a relatively comprehensive historical case study be constructed.[66]

Many of the issues posed in the preceding section can be addressed through a fairly cursory examination of the historical record. For instance, if available, the initial requirements will tell us the original intent of the program and this can be easily compared with the end results of the development program. Even for secretive programs in the Soviet Union, sufficient fidelity of such data can usually be obtained through openly published accounts. Naturally, official requirements documents would be more precise,

---

[66] Relatively, in this case to the focused, structured, comparative case studies George discusses. See George, "Case Studies and Theory Development," ...

but they may not be necessary. Other questions may not be so easily answered. For information on such issues as reporting of adverse information, we may have to rely on the memoir literature or interviews with participants.

Interviews, in fact, promise to provide the richest source of information for this study. In spite of *glasnost* and the late Soviet rhetoric of openness, documents on Soviet military, or even quasi-military programs remain difficult to obtain even in Russia today. More importantly, even though several of the key participants in the early Soviet missile and space program have died, many important participants are still alive today and willing to openly discuss all aspects of the program. Interviews with these sources can provide a level of detail and insight unobtainable in official documents, and difficult to find in memoir accounts. Moreover, virtually all of the relevant participants have long since retired, and the revolution of 1991-1992 allows these people to speak without fear of reprisals from current employers, or the former security service. For this study, these will prove to be the most valuable sources.

Accordingly, interviews were conducted with as many of the participants of the early missile and space program as was practical. Interviewees were selected who would cover the range of government agencies and scientific organizations. Interviews were conducted in Russian, primarily in the Moscow region over the period of 1990-1994. A total of 22 interviews were conducted with 18 different participants, coming from government monitoring agencies, the military, the industrial ministries, the academy of sciences, and the design bureaus. Questions were open-ended and focused upon the participants direct experience with the early missile and space programs. In all cases the interviews included discussions of the personal backgrounds of the participants, education, career paths, their participation in specific decisions, and the relationship of their organizations with other participating organizations and agencies in the missile and space programs. Particular attention was devoted to the relationships between leadership, administrative agencies, and scientists. Table 2.1 lists the interviewees, times and the organizations they represented. The interviewees represent four basic groups.

The top seven names all came from high level administrative agencies (the Central Committee, the Main Administration for Space of the Ministry of Defense (TsUKOS), the Ministry of Armaments, the military scientific research institute for missiles and space (NII-4), and the Academy of Sciences institute with oversight for the missile and space programs (The Keldysh Institute). These interviews were included to provide information on how effectiveness of leadership direction and control of the missile and space program.

The next five interviewees (Mishin, Feoktistov, Vetrov, Chertok, and Mozhorrin) all worked within the lead scientific organization for the missile and space program. In the early period this was known as NII-88. OKB-1 later split off from NII-88, and subsequently had its name changed to OKB-EM. The following interviewee (Sheremetevskii) worked in organization which served as subcontractor to Korolev's design bureau. The following four interviewees (Budnik, Semenov, Gubanov, and Efremov) worked in the design bureaus which emerged as the chief competitors to Korolev in both the missile and space fields. The final interview listed was the Deputy

Director of the institute which was responsible for developing the nuclear warheads used on Soviet missiles. His inclusion was due to specific questions over the connections between the nuclear industry and the early missile program.

NAME	INTERVIEW DATES	ORGANIZATION	POSITION
Boris Stroganov	7/91	Central Committee	Instructor
Gen. Kerim Kerimov	7/91	TsUKOS	CinC
Viktor Piskaraev	12/94	Ministry of Armaments	Department Chief
Gleb Maksimov	7/91	NII-4, OKB-1	Designer
Iuri Bazhenov	7/91	NII-4, NII-88	Designer
Timur Eneev	5/93	Keldysh Institute of Applied Mathematics	Deputy Director
Efim Akim	5/93	Keldysh Institute of Applied Mathematics	Department Chief
Vasiliy Mishin	5/90, 9/90, 2/91, 5/93	NII-88, OKB-1	1st Deputy Director, Director
Konstantin Feoktistov	9/90	OKB-1	Dep. Chief Designer
Georgi Vetrov	5/93	NII-88, OKB-1	Designer
Boris Chertok	8/94	NII-88, OKB-1	Department Chief
Iuri Mozhorrin	9/90, 7/91	NII-88	Director
Nikolai Sheremetevskii	9/93	VNII-EM	Director
Gerbert Efremov	7/91	Chelomei-OKB	Director
Vasiliy Budnik	5/93	OKB-586	Dep. Chief Designer
Iuri Semenov	10/91	OKB-586, OKB-1	Dep. Chief Designer
Boris Gubanov	7/91	OKB-586, OKB-1	Dep. Chief Designer
Igor Golovin	8/94	Kurchatov Institute	Deputy Director

Table 2.1 -- Interviews Conducted for Case Study

Particular notice should be given to the interviews with Vasiliy Mishin, who served as the First Deputy to Sergei Korolev from 1946 to Korolev's death in 1966. Mishin's participation actually preceded Korolev's. He possesses the greatest direct knowledge of any surviving participant in the early Soviet missile and space programs. Mishin was interviewed on several occasions and often served fill in gaps left by other interviewees.

It was impossible to gain access into the official archives of either the government, NII-88 (now TsNIIMash) or OKB-1 (now NPO-Energiia). However, I was provided with retyped copies of several of the more important documents by Timur Eneev of the Keldysh institute, and Georgi Vetrov, of NPO-Energiia. Other documents were reproduced and published in collections in the Soviet Union. Together they provide a useful, if incomplete, documentary record.

Interviews and documentary sources may not be necessary for understanding most aspects of leadership politics of the period from 1944-1958 in the Soviet Union. Literally hundreds of accounts of the Soviet leadership have been published in English and Russian. Such secondary accounts provide a great deal of insight into leadership agendas, decision making processes, and governmental processes necessary for this study.

Analysis and Implications

The steps outlined above basically set forth the mechanistic aspects of the study. But analysis of the case study must go beyond simple measurement of dependent and independent variables. A simple correlation of variables is clearly insufficient even considering the crucial nature of this case. A causal connection must be made and defended in the light of competing explanations. It is the final analysis which permits us to draw generalized conclusions and hypotheses. Two basic points need to be made in this analysis: 1) scientists enjoyed considerable autonomy in the creation of the Soviet missile and space program; and, 2) scientific autonomy was the most important reason for the success of this program.

George asserts that the best technique for attributing causation to an independent variable in a case study is through process tracing, a technique "that attempts to identify ***the intervening steps or cause-and-effect links*** between an independent variable and the outcome of the dependent variable."[67] Thus, at the end of each section of the case study the effect of scientific autonomy (or lack thereof) will be examined in terms of its contribution to the advancement of the program. By considering this issue at each stage of the process, we might develop phase specific conclusions which contribute to a deeper understanding of the relationship between innovation, the scientists, and the leadership.

In addition to process tracing, we should also consider other counterfactual questions at the end of the case study which may lead us to more supportable conclusions. The first issue is whether the program would have succeeded if the leadership *had* controlled the program. Specifically, could the Soviet Union have developed a space

---

[67] See George, "Case Studies and Theory Development..." emphasis in original.

program before the United States if the program did not have considerable scientific autonomy? While such a question is speculative, and may not be entirely, it can provide valuable insight if it can be plausibly demonstrated that innovation could not have occurred under conditions of leadership control. Following from this we should consider whether, in the event of leadership control, were there other variables which could have led to a successful outcome? For example, if the Soviets had succeeded in acquiring all of the German rocket scientists, would they have beaten the United States into space in spite of Stalin's control? In the end, through the use of process tracing and counterfactuals we can establish whether scientific autonomy was a necessary an sufficient condition.

PUTTING THE SOVIET MISSILE AND SPACE PROGRAM IN THEORETICAL CONTEXT

In the preceding chapter, we considered the problem of leadership control over programmatic innovation and developed a means for systematically using a single crucial case study for the proposition that programmatic innovation may require a high degree of scientific autonomy from the state leadership. History, however, seldom flies into theoretical pigeon holes without putting up a struggle. No case fits perfectly into any theoretical framework, and the Soviet missile and space program is no exception. Given the difficulty of fit, there is the danger of falling into one of two traps. Either the theory gets hammered into a shape into which fits the historical case study, or history gets twisted until the case study fits into the theoretical framework. In this study both history and the analytic framework will be protected. Instead, some flexibility must be extracted from the readers, who will have to follow an analysis which doesn't always follow the linear chronology.

Even the title "missile and space program" hints that this was no simple linear program. In the United States, great efforts were made to ensure that these were two distinct programs. There was one program for missiles, another for space.[68] The Soviet missile and space programs were bureaucratically intertwined throughout their history.[69] In fact, the ensuing case study will show that it is even difficult to distinguish whether the space program grew out of the missile program or the other way around. It depends a great deal upon perspective. From the standpoint of the leadership, the space program grew out of the missile program. But from the perspective of the scientists the missile program was only a means of supporting their dreams of space travel; thus, it could be argued that the missile program grew out of the space program. Clearly the case study will have to consider both programs. In the following case study we will begin by tracing

---

[68] In fact, there were two space programs. The military space program under the Air Force was bureaucratically separated from the civilian space program under NASA from the very beginning. See Walter A. McDougall, *The Heavens and the Earth: a Political History of the Space Age,* (New York: Basic Books, 1985); and, Paul B. Stares, *The Militarization of Space: U.S. Policy, 1945, 1984,* (Ithaca, Cornell University Press, 1985).

[69] Both the missile and space programs were under the same industrial Ministry until the fall of the Soviet Union, and were responsible to the same branch of the military until 1982, when the Space Units of the Ministry of Defense were broken off as a separate branch.

the development and institutionalization of the missile program, and then return to consider how the space program was developed out of the organizational foundations of the missile program. In so doing, the formal decision to initiate a space program will be treated as an organic part of the institutionalization process. Since the case being made is that the leadership was presented with a *fait accompli*, embedding the initiation decision is well suited to history, the case study, and the reader.

A second problem emerges with respect to the relationship between organizational formation and the decision to initiate a missile program. In the typical program there is an initiation decision, then organizational creation, followed by institutionalization. The Soviet missile and space program was not nearly so tidy. The organizational heritage of the program went back to the 1920s, and most of the organizational team established itself and its inter-relations well in advance of any formal decision to begin a Soviet missile program. This presents the problem of where to begin. The problem is that our theoretical framework treats organizational formation and the initiation decision as discrete processes. Rather than jump around in history, we will treat the initiation of the Soviet space program as a seamless process, including the organizational origins, decision making processes and the formal organizational assignments in a single chapter. Again, we are attempting to retain as much data as possible with respect to process tracing.

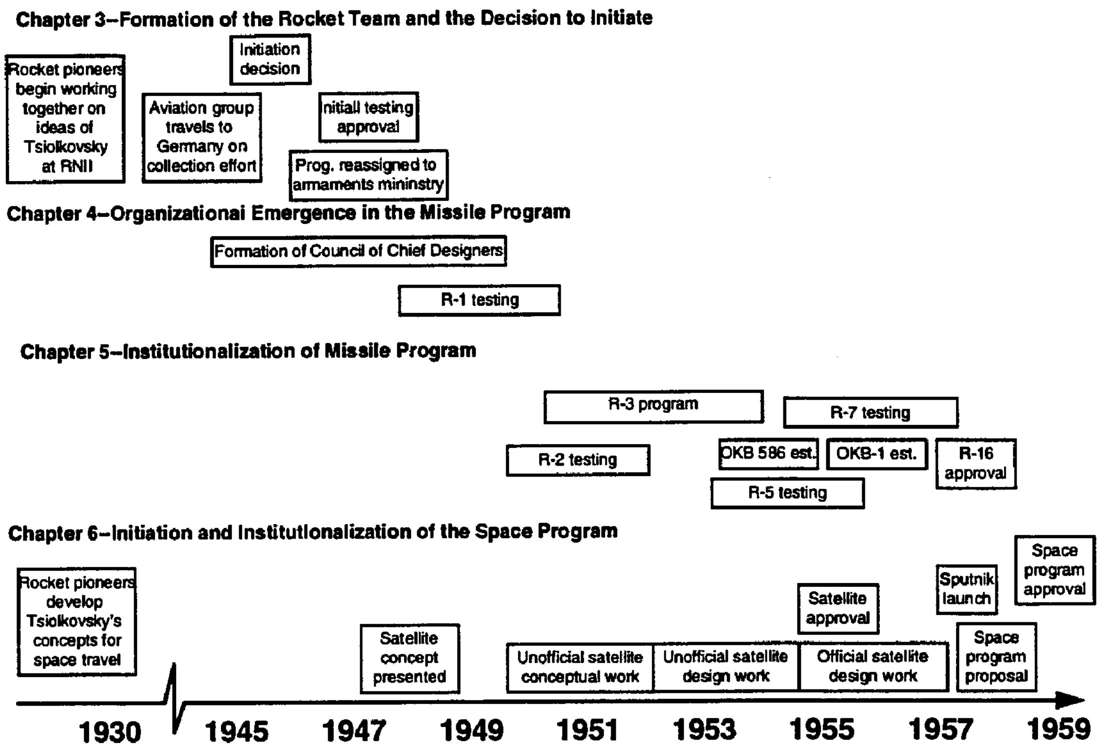

Figure 2-1 Overlapping Chronologies of the Soviet Missile and Space Programs

Figure 2-1 illustrates the organization of the case study. In the first chapter we will begin by examining the organizational antecedents to the modern organization of the Soviet rocket program, consider the leadership decision making processes, and trace the development of the early organizational structures. In the opening section we will see how the early pioneers established relationships in particular, between the two leading scientists, Sergei Korolev and Valentin Glushko, well in advance of the war at the jet propulsion scientific research institute (RNII). These close relations continued in spite of the internment of several of key scientists, including Korolev and Glushko, in labor camps during the war. The closeness of these relations was cemented by the belief in the cosmic ideology of the early Russian theoretician of space flight Konstantin Tsiolkovsky. When Korolev and Glushko were able to obtain their release, they quickly became the informal leaders of a group of Soviet aviation engineers and rocketeers from RNII. The Ministry of Aviation Production, however, was uninterested in Korolev's proposals for developing rocketry. The orphan program was ultimately foisted upon the Ministry of Armaments under Dmitry Ustinov. When Stalin finally made the commitment to rocketry in May 1946, it was hardly the forceful reorganization one might expect for a high priority program. The program was divided up amongst six reluctant ministries. Nevertheless, the program survived its precarious early days, largely on the strength of an informal organization conceived by Korolev, and based on the informal relationships established at RNII and in Germany--the Council of Chief Designers.

The second chapter of the case study picks up where the first left off covering the phase of organizational emergence. It begins with the first trip of Korolev's rocket team to the flight test range and the solidification of the relationships and authority of the Council of Chief Designers, and moves through the progressive development of ballistic rockets. During the early institutionalization of the rocket program Korolev used the personal relationships he was able to establish with his Chief administrator, Dmitry Ustinov, to survive the difficult early days of the program's existence. While technical success on the testing range was limited, Korolev was able to establish a strong organizational foundation built upon the Council of Chief Designers. During this phase

Korolev concentrated on orgnizational development to a greater extent than technical achievements.

In the institutionalizatzation phase of the missile program, Korolev established a close working realtionship with the Vice President of the Academy of Sciences, Mstislav Keldysh, and used this to fend off competing technological approaches. The relationship between Korolev and his chief monitor Ustinov developed into one of almost complete interdependence. By the end of 1956, Ustinov was able to wean himself of Korolev by creating a competing missile design center. By this time however Korolev had surreptitiously moved the competition into another arena--space. In the conclusion of this chapter, we will see that Korolev and the other members of the Council of Chief Designers were able to defend, and even expand their autonomy primarily by developing strong constituencies with the Academy of Science and the leadership of Ministry of Armaments. Without this autonomy, it is doubtful that Stalin would have allowed continuation of a program which offered limited prospects for success and which faced competition from other programs which appeared much more likely of achieving the ultimate mission of delivering a nuclear bomb to the United States.

From their early 20s Korolev and Glushko dreamed of space flight. The fourth chapter of this case study examines how Korolev used his institutional base as the premier rocket designer to fulfill his dreams of space flight. Whether it was a grand deception or simply opportunism, it was clear that Korolev optimized his rocket for space launches rather than delivery of atomic weapons. This was a dangerous game under Stalin.

Exposure under Stalin could be fatal. Until Stalin's death, Korolev concealed his space plans from the political leadership. Korolev carefully managed the requirement generation process to ensure that they would be consistent with his satellite plans. His emerging partnership with the Vice President of the Academy of Sciences, Mstislav Keldysh, was a critical part of this process. The death of Stalin gave Korolev the opportunity to bring his space program into the open. Capitalizing on the technological ignorance and political turmoil of the new leadership, Korolev pushed his plan through. With the phenomenal political success of Sputnik, Korolev was then able to convince the political leadership that his proposal for manned space exploration should take precedence over the military' desire for photoreconnaissance satellites and a space program was borne. In the end, the events themselves demonstrated both the autonomy of the scientists and the fact that without this autonomy the Soviet Union would have arrived in space well after the Americans.

While it is clear that the Soviet missile and space program was a product of scientific autonomy, the connection between this case and other instances of innovation is not immediately obvious. The final chapter of this study will put the Soviet space program into the larger context. Were there similarities between the Soviet case and other cases? The U.S. atomic bomb program is clear enough, but its autonomy was dictated by the need for secrecy. Was the intentional scientific autonomy of that program really comparable to the autonomy for which Korolev fought in the Soviet case? The development of the U.S. ICBM provides us with a particularly interesting comparison in that this program was at first stifled by oversight, only to flourish when it was released from many of the bureaucratic constraints in 1953.

Conclusion–The Soviet Missile and Space Program as a Crucial Case Study of the Relationship Between the Scientist the Leadership and Programmatic Innovation

In the preceding chapter we determined that a lack of rigor and specificity has contributed to the limited progress we have achieved to date in understanding innovation in the leadership. The Soviet missile and space program offers us a rare opportunity to contribute significantly to our knowledge of an important phenomenon with a single case study. The ensuing case study will show that the Soviet missile and space program was not only characterized by scientific autonomy, but that the independence of the scientists was the most important factor contributing to the success of this program.

In order to be productive, we must be rigorous and systematic in our examination. We have therefore formulated specific points of observation which apply not only to this particular case, but to all cases of programmatic innovation. Thus, the results of this study can be readily compared with other cases. Furthermore, we have formulated questions which will measure the relationship between the scientists and the leadership over time, permitting us to observe the ebb and flow of power within a program. This observation may generate new hypotheses.

But it will not be the mechanics of measurement which will make this a productive case study, but the rigor of analysis. Causal links between scientific autonomy and successful programmatic innovation will be established through careful process tracing and validated through reference to counterfactuals. In this way we can establish that scientific autonomy not only occurred, but was necessary.

Ultimately though, we should recognize that the most useful output from this case study may be unknowable. It behooves us therefore to keep an open mind to the emergence of unforeseen variables and hypotheses in the ensuing case study. Indeed, the uncertainty and unmanageability of scientific investigation is one of the fundamental tenants on which this study is founded.

CHAPTER 3

The most important thing was not that we learned rocket technology,

but that we closed ranks as a collective.

S.P. Korolev (1947)

1944-1947: ORGANIZATIONAL ANTECEDENTS AND THE DECISIONS TO INITIATE A MISSILE PROGRAM

The Soviet space program began at different times for different individuals and organizations. For Sergei Korolev and many of the emerging rocket scientists, it started in the mid 1920s when groups of space enthusiasts began working together on the ideas of the Russian space pioneer Konstantin Tsiolkovskii. As their work progressed, the rocket scientists' journey into space took a detour to the prison camps of Siberia during the purges of the late 1930s. Throughout the war, rocket scientists remained in exile, performing small tasks in support of wartime aviation. Soviet rocketry was reborn in the rubble of abandoned German rocket factories and launch ranges following the Allied victory in Germany. Bringing in new members from the aviation industry and young military officers, a stronger rocket team was formed under Korolev's leadership in Soviet occupied Germany. In 1947, this group returned to Russia to become the foundation upon which the Soviet missile and space programs were built.

The political leadership showed little interest in rocketry after the war. Only after repeated prodding by the scientists, it finally respond in 1946 by creating an organizational structure for the development of rocketry. However Stalin's initial decision did not provide for a development program, not even the launch of captured German V-2s. The structure of the program itself was ill-suited for development of a new complex technology. Rocketry was put under the management of both an industrial ministry which had little understanding of the technology, and military leaders who were openly hostile toward using missiles as military weapons. Even within the institute charged with the development of rocketry (NII-88), long range rocketry remained a distant second-order priority behind anti-aircraft missiles. Korolev would have to overcome these organizational obstacles in order to build a missile program.

Analytic and Substantive Issues

Two issues are of fundamental importance in the conceptualization and decision-making phase of programmatic innovation: the organizational pre-history; and the decision-making process. There is an organizational pre-history to every program.

Decisions do not come out of the blue sky. The concept may come from either leadership foreseeing a strategic change, or the scientists who may have been working on an idea for years prior to a decision. Scientists may be either an atomized smattering of individual researchers and ideas, or a coherent group within a single institute. Their cohesiveness will have an important effect on the ability of scientists to push a new idea through the administrative agencies to leadership. The decision itself, may be either a highly incremental approval for a small project, or complete approval of the entire program. The leadership's ability to comprehend the technology and rationally choose a program with a high probability of meeting clearly understood goals will also play a role in the development of programmatic innovation. Before discussing the prehistory and early decisions of the Soviet missile program, we will briefly consider these issues.

Leadership decision-making capacity

When a decision is made to initiate a new program, the leadership *appears* to hold a preponderance of authority. It controls the funding, and must make a positive decision in order for a program to begin formulation. However, for dramatically new technologies, it possesses little understanding of the realistic costs and possibilities for programmatic success. It may not even have a clear understanding of the objectives. Time constraints, imperfect understanding of technology, conflicts over basic goals, and the limited attention the leadership is able to devote to consideration of technically complex issues, are weaknesses of the leadership that scientists may be able to exploit.[1]

The Soviet political leadership made two important decisions in the 1944-1946 period: 1) to begin the collection of German missile technology, and 2) to bring German technology back to the Soviet Union to possibly serve as the basis for development of a Soviet missile industry. But what was the nature of these decisions? Most analyses to date have argued that these decisions, particularly the 1946 decision to create a missile industry, were conscious efforts to establish a Soviet long range missile program to deliver nuclear weapons to the United States.[2] However, at the time these decisions were being made, the Soviet leadership was besieged by a huge number of more pressing issues. It had a very poor understanding of the capabilities of ballistic missiles, and there was no indication that it had any knowledge of the potential use of missiles as nuclear delivery vehicles. The ensuing discussion will show that leadership decision-making closely resembled a "garbage can" process. The scientists advancing the missile program were a solution looking for a problem and a decision-making opportunity. In the end, they were coupled with a problem (shooting down American aircraft) which had little to do with

---

[1] See in particular John W. Kingdon, *Agendas, Alternatives, and Public Policies,* (Boston: Little Brown, 1984).

[2] See David Holloway, "Innovation in the Defense Sector: Battle Tanks and ICBMs," in Ronald Amann and Julian Cooper, *Industrial Innovation in the Soviet Union,* (New Haven: Yale University Press, 1982); Karl F. Spielmann, *Analyzing Soviet Strategic Arms Decisions,* (Boulder: Westview Press, 1978); David Holloway, *The Soviet Union and the Arms Race,* (New Haven: Yale University Press, 1984); and Ronald D. Humble, *The Soviet Space Programme,* (London: Routledge, 1988).

their solution (ballistic missiles), but the decision-making opportunities created by the end of WW II made it difficult for the leadership to refuse to initiate the program.[3]

Incrementalism versus single-point decisions

A leadership may limit its exposure to the risk of wasting resources on useless technologies by resorting to highly incremental decisions and frequent reporting requirements.[4] It may gain control over a new program by establishing detailed, inflexible requirements, and by closely monitoring their implementation.[5] Through learning, the leadership may eventually redress its informational deficiencies. However, some programs require a single-point decision. There is an initial threshold of resource commitment the leadership must make in order to even understand the possibilities for success.[6] Scientists will push for such a decision first, while reserving a strategy for completing the program on an incremental basis.[7]

---

[3] See Michael D. Cohen, James G. March and Johan P. Olsen, "A Garbage Can Model of Organizational Choice," *Administrative Sciences Quarterly*, Vol. 17 (1972) pp. 1-25, more recent and detailed accounts appear in James G. March and Johan P. Olsen (eds.), *Ambiguity and Choice in Organizations*, (Bergen Norway: Universitetsforlaget, 1976); and James G. March and Roger Weissinger-Baylon, *Ambiguity and Command: Organizational Perspectives on Military Decision Making*, (Marshfield MA: Pitman Publishing, 1986).

[4] See Stephen Peter Rosen, *Winning the Next War: Innovation in the Modern Military*, (Ithaca: Cornell University Press, 1991)

[5] See Downs, *Inside Bureaucracy*...

[6] See Paul R. Schulman, *Large-scale Policymaking*, (New York, Elsevier, 1980)

[7] See Howard McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice*, (Baltimore: Johns Hopkins, 1990).

The decisions to initiate the Soviet missile program were made on a highly incremental basis. In part, this was a product on the "garbage-can" decision-making process noted above. It was also due to the extreme apathy expressed by the leadership toward the development of a missile program. Stalin's decision was to allow the research to continue, as long as he did not have to provide significant additional resources. Consequently, the scientists were not in a position to push for an all or nothing decision. They would save this strategy for later.

Building scientific consensus

The development of scientific communities prior to the conception of a new program can play a decisive role in the relationship between the scientist and the leadership. A coherent, well organized scientific community is able to define the technical issues, and valid means for resolving technical disputes, and measures of effectiveness.[8] These are powerful tools in the hands of the scientists giving them control over the research agenda.[9] A united scientific community is capable of pushing its agenda through

---

[8] See Thomas Kuhn, *The Structure of Scientific Revolutions,* (Chicago: University of Chicago Press, 1969).

[9] See Bruno Latour, *Science in Action,* (Cambridge: Harvard University Press, 1987).

an uncertain leadership.[10] Consensus does not occur unaided, however. It requires effective scientific leadership to create a sense of organizational mission.[11]

Informal organizational formation preceded the decision to initiate the Soviet missile program by almost two decades. Most of the rocket scientists who presented the possibility of constructing long range missiles to the Soviet leadership had worked together before the war and found themselves reunited in Germany. Informal ties developed through a common belief in rocketry and space travel. Years of working together enabled the scientists to quickly settle upon the leadership of Sergei Korolev, and to trust him in advancing their cause. These proved to be powerful tools in organizing the scientists and maintaining consensus.

Locating and building a constituency

Scientific consensus and organization mean little if the scientists are unable to find an established bureaucratic agency which values their program. Finding a constituency is the single most important activity of the scientists in the early phase.[12] Without it, the scientists have little hope of getting their proposal before the leadership. Difficulty

---

[10] See James Q. Wilson, *Bureaucracy*, (New York: Basic Books, 1989); and Jeffrey Pfeffer, *Power in Organizations*, (Cambridge: Ballinger, 1981).

[11] See Anthony Downs, *Inside Bureaucracy*, (Boston: Little Brown, 1967); Wilson, *Inside Bureaucracy...*; and, Jameson W. Doig and Erwin C. Hargrove, *Leadership and Innovation: a Biographical Perspective on Entrepreneurs in Government*, (Baltimore: Johns Hopkins University Press, 1987).

[12] See Wilson, *Bureaucracy...*

generating support is compounded for programmatic innovations in which the scientists must convince potential constituents of the validity of not only the technology, but also of the basic objectives.

Developing a constituency was the single greatest obstacle facing the early Soviet rocket scientists. The problem was exacerbated by two factors. First, the Soviet R&D administrators were generally conservative due to an intense fear of failure.[13] Second, during the decision opportunity, the Soviet rocket scientists were located in Germany. Therefore, lobbying efforts were conducted from afar. The most obvious administrative home for the technology, the Narkom (Ministry) for Aviation production, rejected the program. Other potential constituents resisted. Finally, the Narkom for Armaments, under Dmitry Ustinov, reluctantly accepted the program. Once Korolev was able to establish a relationship with Ustinov, he was able to develop a strong constituency even while the scientists remained in Germany.

<u>Actors</u>

According to the socialist economist Kornai, "the key to an understanding of the socialist system is to examine the *structure of Power*, which receives little or no attention in many comparative studies of economic systems. In my opinion, the characteristics of the power structure are precisely the source from which the chief regularities of the system

---

[13] See Kendall E. Bailes, *Technology and Society Under Lenin and Stalin: Origins of the Soviet Technical Intellgentsia, 1917-1941*, (Princeton: Princeton University Press, 1978)

can be deduced."[14] After WW II, the Soviet bureaucratic structure was in a state of transition. Administrative agencies and the scientists involved with the development of the missile program remained inchoate until 1947. Only the highest levels of political power were showing signs of stability.

At the pinnacle of the Soviet state stood Stalin alone, his authority unquestioned. During the course of the WW II, he closely watched virtually all troop activities and actively participated in planning strategic offensives in its latter months. This was a particularly busy time for the Soviet leader. From 1944-1945, the Red Army was advancing at an amazing pace across central Europe and Germany. On the foreign policy front, Stalin also monopolized policy making, personally deciding the issues which would shape the post-war world. By the end of the war, Stalin was exhausted and increasingly came to rely upon his colleagues in the Politburo to manage the daily affairs of state. Authority for decision-making on many issues grew unclear in late 1945, and by the end of 1946 the leadership settled into a pattern in which ad hoc groups would gather in the late night and early morning hours over bottles of vodka and appetizers to determine the future course of the world's second most powerful nation.[15]

---

[14] See Janos Kornai, *The Socialist System: The Political Economy of Communism,* (Princeton: Princeton University Press, 1992) p. 33. Emphasis added.

[15] See Werner Hahn, *Post-War Soviet Politics: The Fall of Zhdanov and the Defeat of Moderation 1946-53,* (Ithaca: Cornell University Press, 1982); Timothy Dunsmore, *Soviet Politics 1941-53,* (London, Macmillan, 1984); Strobe Talbott, N.S. Khrushchev, *Khrushchev Remembers: the Last Testament,* (New York: Little Brown, 1971); Jerry Hough and Merle Fainsod, *How the Soviet Union is Governed,*(Cambridge: Harvard University press, 1979); and Milavan Djilas, *Conversations with Stalin,* (New York: Harcort, 1962)

The massive German industrial technology collection effort was officially under the direction of the Chairman of the Council of Ministers, Georgi Malenkov. However, during the entire time the Soviet rocket scientists were in Germany, there was no indication that Malenkov was even aware of the missile technology effort. In the midst of the technology collection program, Malenkov was attacked by Politburo contender Andrei Zhdanov for failing to instill sufficient ideological direction in the German collection effort. The collection program was curtailed as a result of Zhdanov's attacks.

In the Soviet socialist structure there were no private companies. All productive activity was under direct control of the People's Commissariats (Narkoms). In the immediate post-war period, the Soviet economy was reorganized to a peacetime footing, creating a tremendous amount of administrative confusion.[16] Many of the defense-oriented ministries, such as the Narkoms for the Tank Industry, and Mortar Industry, were disbanded. The rocket scientists in Germany came from five different Narkoms. Until 1946, there was no missile program which could be assigned to a single Narkom. After some debate and avoidance by several Peoples' Commissars, the missile program was reluctantly adopted by Dmitry Ustinov's Narkom for Armaments (NKV). Ustinov's Narkom was completely unprepared for management of a missile program. In the early

---

[16] For an in-depth discussion of the organization of the Soviet Post-war economy see Alec Nove, *An Economic History of the USSR: 1917-1991*, (Middlesex UK: Penguin Books, 1993); Hough and Fainsod, *How the Soviet Union is Governed...*; and, Dunmore, *Soviet Politics...*

years, management fell upon him and one of his deputies, Sergei Vetoshkin. Through 1947, there was no administrative section within his department assigned to rocketry.

The industrial ministries were only half of the administrative equation, representing the producer. The customer was the military.[17] In Germany, missiles were assigned to the Artillery Troops of the Ground Forces under Marshal Iakovlev. Initially, Iakovlev was merely disinterested in missiles. Disinterest soon grew into distaste, and ultimately contempt. Iakovlev's views were hardly surprising, considering that missiles were alien to the culture of artillery troops. The military was accustomed to being at the battle front, providing close artillery support for advancing troops. Mobility was valued above all else. Missiles were seen as immobile, inaccurate, unreliable, and very expensive fantasies. However, from their time in Germany, a small group of officers began to share in Korolev's dream. They would become the future military customers for the Soviet missile and space programs.

The scientists were at the bottom of Soviet hierarchy. They were an amorphous group of scientists and engineers from five different industrial narkoms who had no clear tasking. During their time in Germany, the missile program was not subordinate to any narkom. While the lack of oversight permitted them a great deal of freedom, it also rendered the existence of their program highly precarious. The group rallied around the organizational talents of Sergei Korolev and Lev Gaidukov, a General assigned to manage

---

[17] For a more in-depth discussion of the overall organization of the Soviet Military see Harriet Fast Scott, and William F. Scott, *The Armed Forces of the USSR,* (Boulder: Westview Press; 1979).

the program in Germany. Korolev's and Gaidukov's first task was to find a Narkom to serve as an administrative home for their program. After several rejections, they found Ustinov in the Narkom for Armaments which agreed to at least sponsor the lead institute (NII-88). When the German collection effort was called off, the rocket scientists returned to their respective institutes, scattered among five industrial narkoms.

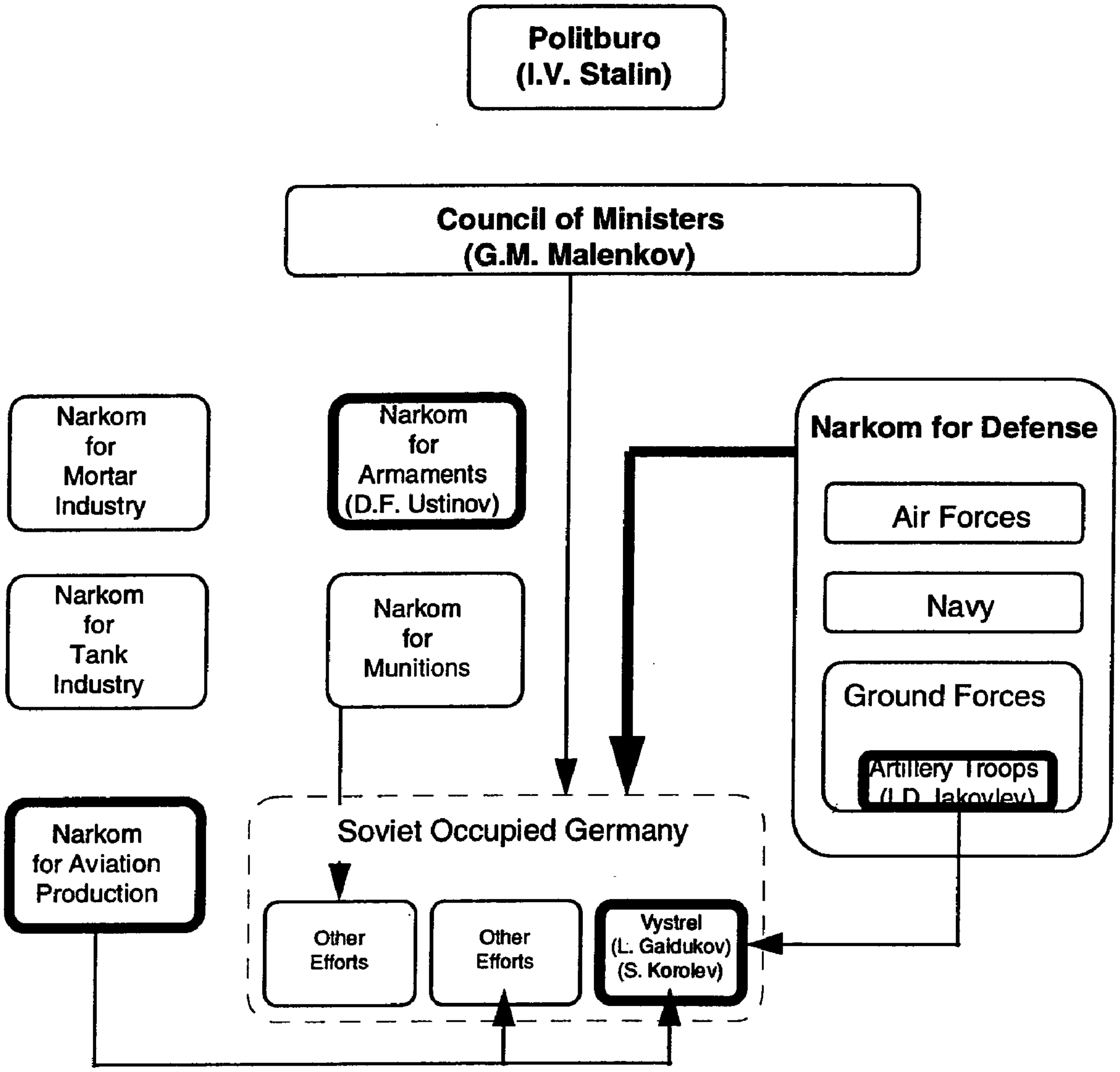

Figure 3.1 -- The Administration of the Missile Program in 1945

A basic schema of the organization of the Soviet missile effort in Germany is provided in Figure 3.1. Several of the Narkoms lobbied by Korolev and Gaidukov are depicted, as well as those which had other major technology collection efforts in Germany. The missile technology collection effort was certainly among the smallest of many dozen. Ultimately, over 12,000 trainloads of German equipment were brought back to the Soviet Union, only three of which were involved with missile technology. As indicated in this organization chart, the majority of the scientists involved in the collection of rocket technology came from the Narkom for Aviation production. Only a small contingent of junior officers came from the artillery troops, and no one from the Narkom for Armaments. Without clear subordination within Germany, the scientists were able to operate with a great deal of autonomy. Defying their original orders to look for jet aircraft technology, the scientists spent their entire time searching out the riches of the German V-2 program. This autonomy allowed the scientists the time and freedom to collect sufficient evidence to convince reluctant administrators that there was potential value to a missile program.

THE ROCKET SCIENTISTS IN THE PRE-WAR PERIOD

There is an almost theological character to the history of the Soviet space program. Lenin said that "science is the religion of Communism," and missiles were the pinnacle of science. The "theological" roots of the Soviet space program went back to the "prophet Tsiolkovskii," a Russian, and later Soviet, theorist of space flight who produced a great deal of truly visionary work in the late 19th and early 20th centuries. All past, present and future plans, projects and accomplishments of the Soviet space program had their genesis in the visions of Konstantin Eduardovich Tsiolkovskii around the turn of the century. To understand this point, one need only briefly consider Soviet literature on space exploration. It is unusual to find a Soviet book about the Soviet space program which does not begin with Tsiolkovskii.[18] Each year, from 1957 until his death in 1966, Korolev delivered a lecture on the anniversary of Tsiolkovskii's birth, in which he described the future of Soviet space exploration in terms of Tsiolkovskii's plans.[19] Concentration on the theoretical developments of Tsiolkovskii created a common vision of the future course of space exploration among Soviet space enthusiasts.[20] This contributed to the creation of a closely knit group of rocket scientists who believed in a single mission and dominated the early Soviet space program.[21]

---

[18]The remarkable depth and breadth of Tsiolkovskii's work, as well as the slavish adherence of Soviet scientists, is well documented in a collection published by the Academy of sciences *Idea K. E. Tsiolkovskogo i Sovremennie Nauchnie Problemi,* (The Ideas of K. E. Tsiolkovskii and Current Scientific Problems) (Moscow: Nauka, 1984).

[19] The last of these speeches given under Korolev's actual name was in *Pravda,* September 17, 1957 from that time on his annual speeches were given under the pseudonym Professor K. Sergeev.

[20]The similarity of views for the development of space between the rocket scientists and Tsiolkovskii is evident in all early writings and seems to carry to this day. For a brief discussion of Tsiolkovskii's plan see *Pravda,* September 17, 1957. A good discussion of this also appears in MacDougall, *The Heavens and the Earth...* For the most detailed description of Korolev's near slavish adherence to Tsiolkovskii, see Georgi S. Vetrov, *S.P. Korolev i Kosmonavtika: Pervie Shagi,* (S.P. Korolev and Cosmonautics: the First Steps), (Moscow: Nauka, 1991).

[21] The importance of a common sense of mission is discussed in James Q. Wilson, *Bureaucracy,* (New York: Basic Books, 1989). Downs discusses the importance of mission in the early phases of a bureau's life in Anthony Downs, *Inside Bureaucracy,* (Boston: Little Brown, 1967); and Pfeffer considers organizational consensus as a source of power in Jeffrey Pfeffer, *Power in Organizations,* (Cambridge: Ballinger, 1981).

Soviet rocket scientists, (or, at this time they might be more appropriately referred to as enthusiasts) began to voluntarily collectivize in the early 1920s.[22] In 1921, the Laboratory for the Development of N. I. Tikhomirov's Inventions was formed in Leningrad. In 1928, this laboratory was expanded to become the first Test and Design Bureau (OKB) devoted specifically to rockets, the Gas Dynamics Laboratory (GDL-OKB).[23] In Moscow, a Central Bureau for the Study of the Problems of Rockets (TsBIRP) was created in 1924. While there has been very little discussion of the function of TsBIRP in Soviet sources, it appears to have been a modest effort to provide a central clearing house for published materials on rocketry. There is no evidence that any research was performed at TsBIRP, but it provided an early means for establishing informal connections between emerging rocket scientists. This is a critical thread which runs through the early history of the Soviet missile program.

In April 1924, a "Section for Interplanetary Communications" was voluntarily formed within the Military Science Society of the Academy of the Air Force (now the Zhukovskii Air Force Engineering Academy.)[24] Later the same year, the section was expanded to become the All-Union Society for the Study of Interplanetary

---

[22]In fact, very few of the early Soviet rocket pioneers had any formal post-graduate training.

[23]V. P. Glushko, *Rocket Engines: GDL-OKB*, (Moscow: USSR Academy of Sciences Press) p. 6. In a later book, *Razvitie raketostroeniia i kosmonavtika v SSSR*, (Moscow: Mashinostroenie, 1987) p. 23, Glushko notes that GDL-OKB was the first "state organization" devoted to rocket propulsion although in the later book he commingles the OKB with Tikhomirov's laboratory.

[24]SeeGlushko, *Razvitie raketostroeniia* ...pp. 35-36.

Communications.[25] The Society attracted approximately 200 members, including Tsiolkovskii himself as well as Fredrich Tsander, who was to become the first Soviet scientist to launch a liquid-fueled rocket. Other groups devoted to the study of space flight were formed across the Soviet Union. In 1925, a group of Kiev Academicians organized under D. A. Grave "for the study and conquest of space." Significantly, this group included E. O. Paton, founder of the Paton Welding Institute of the Ukrainian Academy of Sciences.[26] Sections for interplanetary communication were established in the most terrestrial of enterprises, such as what is now the Leningrad institute for railway engineers.[27]

In September 1931, at Korolev's initiative, the Group for the Study of Reactive Propulsion (GIRD), was created and attached to the Central Council of Osaviakhima.[28] The most notable rocket scientists at GIRD, aside from Korolev, were Tsander, from the Central Institute for Aviation Materials (TsIAM), Iuri Pobedonostsev from TsAGI, and his chief engineer, Mikhail Tikhonravov.[29] A former co-worker of Korolev's at GIRD aptly described the closeness and sense of purpose that characterized the members of GIRD:

---

[25]*Ibid.* p. 22.

[26]*Ibid.*

[27]*Ibid.*

[28]Iu.A. Ishlinskii, *Akademik S.P. Korolev: Uchenyi, Inzhener, Chelovek*, (Moscow: Nauka, 1986) p. 152.

[29]Both Pobedonostsev and Tikhonravov would go on to be key players in the later space program. Tsander would die before the war. *Ibid.*, p. 152.

> In 1932, young aviation designers arrived at GIRD from TsAGI[30] and TsKB[31]... Four construction brigades and a small group of laboratories brought into the management of GIRD a united, enthusiastic-single-minded family putting all of their force, knowledge and energy into the achievement of the main goal—creation of the first liquid-fueled rocket.[32]

GIRD also presided over a similar group in Leningrad appropriately titled, LenGIRD.[33] In 1933, GIRD attained its primary goal with the launch of the first liquid-fueled rocket under the direction of Tsander.

GDL-OKB was formed in 1921 under Nikolai Tikhomirov. It concentrated on rocket propulsion, beginning with gunpowder powered engines, and progressing to more powerful liquid-fueled rocket engines by the end of the decade. The leading figures of this group were Tikhomirov, I.T. Kliemenov G.E. Langemak, and Valentin Glushko, who became the designer of most of the Soviet booster engines after the war. Noting the importance of these groups, Glushko commented that,

> in the first Soviet rocket organizations—GDL and GIRD—lay the foundations of native (Soviet) rocket-building. From the stands of GDL and GIRD came the important cadres, growing as a creative collective, which guaranteed their further development.[34]

Almost from the inception, the leaders of GDL and GIRD urged the creation of a single rocket institute. In 1932, a series of proposals from both groups were directed to

---

[30] The Central Aero-Gasdynamics Institute.

[31] The Specislized Design Bureau under the direction of the noted Soviet aviation designer Tupolev.

[32] See *Ishlinskii, Akademic Korolev...* p. 152

[33] Glushko, *GDL-OKB...*

[34] Glushko, *Razvitie...* p. 42, emphasis mine.

the Chief of Armaments of the Red Army, Marshal Tukhachevskii.[35] Responding to this request, Tukhachevskii recommended that "a Reaction Propulsion Institute should be established immediately."[36] On October 21, 1932, General Efimov, the Deputy Chief of Armaments, wrote to a Secretary of the Central Committee that, "the Reaction Propulsion Institute should be the guiding body responsible for the integration of reaction in the various branches of the national economy where the reaction engine can find a diverse and fruitful application."[37] Apparently, the most compelling appeal for reorganization came from Korolev. His proposal was addressed through Tukhachevskii to Stalin and was brought directly to the Central Committee. In his letter, Korolev perhaps overstated his case claiming that

> in the very near future it will be possible to anticipate the realization of projectiles being hurled on the order of several thousand kilometers, with not only combat usage but also humanitarian applications."[38]

To support his argument, Korolev noted that there was ongoing secret work on rocket propulsion which would be used in future wars. Finally, his letter discussed "difficulties which impeded the work of GIRD and the necessity of accelerating the creation of an institute."[39] In September 1933, Tukhachevskii established the Scientific

---

[35] Marshal Tukhachevskii was at the time the Chief of the Armaments Directorate of the Red Army.

[36]Glushko, *GDL-OKB*... p. 14.

[37]*Ibid.*, p. 15.

[38]V. S. Lel'chuk, *Nauchno-Tekhnicheskaia Revolutsiia i Promyshlennoe Razvitie SSSR*, (The scientific-technological revolution and industrial development of the USSR), (Moscow: Nauka, 1987), p. 73.

[39]B.V. Raushenbakh, *Iz Isororii Sovetskoi Kosmonavtiki*, (Moscow: Nauka, 1986), p. 210.

Institute for the Study of Jet Propulsion (RNII), with Kliemenov as its head and Korolev as a deputy.[40]

RNII combined most of the staffs of GDL-OKB and GIRD, as well as scientists from numerous volunteer societies, design bureaus, and institutes across the Soviet Union.[41] Korolev also recruited other rocket scientists who had been working individually to come to RNII.[42] Additional, rocket scientists -- notably, small-rocket engine specialist A. M. Isaev -- maintained working relations with RNII from their existing institutes.[43] The creation of RNII, therefore, put most of the major rocket scientists under one roof under the direction of Kliemenov and with the military patronage of Tukhachevskii.[44] Under these conditions, rocket science flourished in the Soviet Union -- for a time at least.[45]

---

[40]Glushko, *Razvitie...* p. 15.

[41]David Holloway, *Innovation in the Defense Sector: Battle Tanks and ICBMs,* in Amman and Cooper *Industrial Innovation in the Soviet Union,* (New Haven: Yale, 1982) p. 387.

[42]Ishlinskii, *Akademic Korolev...* p. 162 recounts how Korolev asked if Iu. V. Kondratiuk was interested in coming to work at RNII, indicating that he could arrange to have Marshal Tukhachevskii request his reassignment, but only with Kondratiuk's approval. Kondratiuk declined on the grounds that he wanted to work on a wind-powered electric generator in Siberia. Although he was one of the most creative minds among the early rocket scientists, Kondratiuk apparently did no more work on rockets after this meeting.

[43]"Tvorcheskie idea i pervie dvigateli A. M. Isaeva,"... p. 28.

[44] Other rocket scientists who went on to become luminaries of the Soviet missile program included G.A. Tiulin, who went on to become the senior military officer with direct responsibility over the missile and space programs, M.V. Tikhonravov, the theorists who later developed the conception for the "packet" system of clustering rocket engines, and who was the prime mover behind the satellite efforts, B.V. Raushenbakh, a guidance specialist, Iu. A. Pobedenotsev, a rocket engine specialist; and Boris Chertok, a guidance specialist.

[45]During its rather short lifetime, RNII produced several liquid-fueled rockets as well as prototypes of rocket planes. See Raushenbakh, *Iz Istorii Sovetskoi Kosmonavtiki...* pp. 211-222.

In 1937, Stalin began the infamous purges of the CPSU, effectively eliminating all potential political opposition. The majority of the Soviet high command was executed including Tukhachevskii. Millions of alleged "enemies of the people" were arrested and either sent to prison or shot. The scientists at RNII were at risk as a consequence of the institute's connection with Tukhachevskii. Kliemenov, the director of RNII, was swept away in Tukhachevskii's wake, as well as his successor, Langemak.[46] In November 1937, Korolev and Glushko were arrested. Korolev was interned under the horrific conditions of the gold mines at Kolyma in Siberia, while Glushko drew the somewhat less onerous conditions of the Kazan Aviation Works, a *sharaga* under the famed Soviet aircraft designer Tupolev.[47] In 1939, Tupolev and Glushko succeeded in getting Korolev transferred to their design group.[48] For the next five years, Korolev and Glushko worked together on a series of minor aviation projects, most involving small rocket engines to be used for takeoff assist for Soviet bombers.[49] Nevertheless, Korolev's and Glushko's dream of space flight remained alive. Unofficially, they continued to work on rocket-powered aircraft, the first step in Tsiolkovskii's pathway to the stars.[50]

---

[46]Mariia Pastukhova, "Iarche liuboi legende" *Ogonek*, #49, (December 1987) p. 18 asserted that both Kliemenov and Langemak were interned in the OTB and died there. Holloway, *op. cit.*, p. 388. notes that they were purged in 1937 and 1938 and speculates that they were shot.

[47] Sharaga was a term used to describe prison-design bureaus created by Stalin during the purges.

[48] See Glushko, *Perviy v Mire...*

[49] See Raushenbakh, *Iz Istorii Sovetskoi Kosmonavtiki...*

[50] Korolev's working notes "Regarding work of the bureau on aircraft rockets at OKB-RD attached to Factory No. 16" archives of the Cosmonautics memorial museum, Korolev's home museum, f.1 ed. Xp. KP 135, ll. 16-21. Document provided to author by Georgi Vetrov. See also, M. Rudenko, "Uskol'znyvshaia luna," (The Moon stolen away) *Ekonomika i Zhizn*, No. 40 (October 1991) pp. 10-11.

Some work on long range rocketry continued through the early phases of the war, but there is no evidence that this work attracted the attention of the political, military, or industrial leadership of the Soviet Union.[51] RNII was converted to design and produce mortars and reassigned to the Ministry of the Mortar Industry. In Fall 1940, Korolev sent several letters to Beriia regarding German rocketry and the possibility of greatly increasing their range. But these letters went unanswered.[52] Chertok went so far as to observe: "Normally Stalin reported on all types of new weapons. But up to 1941 Stalin did not even have any information regarding rockets for the ground forces."[53]

Early Development of Organizational Cohesion and Informal Coordination

During WW II, a group of rocket scientists was able to form close working relationships. By laboring together under the difficult conditions of the sharaga, many of the rocket pioneers developed strong personal ties. Theorists like Tsander and Tikhonravov, as well as designers like Korolev and Glushko, worked for several years under the same roof, informally linking science with production. Furthermore, the rocket scientists were motivated by a single vision of space exploration, promulgated by

---

[51] See A.N. Poliarin, "K 50-letiiu organizatsii konstruktorskogo biuro #7 po raketam na zhidkom toplive," (Towards 50 years of the organization construction bureau #7 for liquid-fueled rockets,) *Iz istorii aviatsii i kosmonavtikii*, (Moscow: AN SSSR, 1986) pp. 24-59. See also Glushko, *Razvitie Raketostroeniia...*, , p. 42.

[52]See N.L. Anisimov, and V.G. Oppokov, "Proisshesvie v NII-3," *Voenno-Istoricheskii Zhurnal*, 11:89.

[53] See Boris Chertok, *Raketi i Liudi*, (Moscow, Mashinostroenie, 1994) p. 35.

Tsiolkovskii. This combination of tightly-bound theorists and practitioners driven by a single goal proved to be an important source of power for the rocket scientists.[54]

The core group of Korolev, Glushko, and Tikhonravov established the basis for informal coordination. In the years to come, the three would be sent to different institutes under different administrative agencies. Glushko, the engine builder, would return to the Narkom for Aviation Production; Tikhonravov, the theorist, would go to the Narkom of the Armed Forces' institute for rocketry, NII-4; and, Korolev, the integrating designer, would end up in the Narkom for Armaments. But because the three shared a vision of space travel, and had cemented their working relations under the cruel conditions of the sharagi, they were able to find ways to work together in spite of the bureaucratic barriers between them. In the future, they would be served well by this ability to work around hierarchical channels of authority.[55]

---

[54] See Wilson, *Bureaucracy...*; Downs, *Inside Bureaucracy...*; and, Pfeffer, *Power in Organizations...*

[55] On the importance of informal coordination in promoting innovation see Chisholm, *Coordination Without Hierarchy...*

THE DECISION TO COLLECT GERMAN ROCKET TECHNOLOGY

During the war, the State Defense Committee (GKO) supplanted the Politburo as the primary organization of the Soviet leadership.[56] The overriding issue for the leadership was, of course, winning the war with Germany. This occupied the vast majority of Stalin's time. Stalin also had to concern himself with winning the peace. He devoted a great deal of time to meetings with leaders of other governments, and strategizing about shaping the post-war world. This too, occupied an inordinate amount of time. Given the high degree of decision-making centralization, all indications are that there was little time for Stalin and the GKO to consider issues related to the development of rocketry.

After the Soviet victories of Kursk and Stalingrad, the Red Army began its inexorable march to Berlin, and the leadership began to think in terms of post-war recovery. Slowly the Soviet rocket program re-emerged from its deep slumber during the war. In late 1943, the state planning agency (Gosplan), the Academy of Sciences, and the Narkoms began to develop plans for post-war development of the economy. These early plans focused on development of a broad range of technologies including atomic energy, radar, jet engines, electronics, semiconductors, calculation devices, theories of combustion and rocketry. They were incorporated into the first post-war five year plan in 1946. GKO participation in this process appears to have been limited to initiating planning activity and

---

[56]The membership and functions of the GKO were essentially those of the Politburo. Membership in the GKO consisted of Stalin as chairman, Molotov as vice-chairman, and Voroshilov, Beria, Malenkov Mikoian, and Voznesensky. On November 22, 1944 Voroshilov was replaced by Bulganin.

acceptance of the final plan.[57] There is no indication that Stalin had a personal interest in including rocketry in the post-war plans. Rather, it was simply part of a long-list of technologies that the Academy of Sciences wanted to develop as part of the post-war recovery.

Interest in rocketry was generated from an unexpected source -- Winston Churchill. German series production of V-2s, which began in 1943, did not escape the attention of the Soviet intelligence agencies.[58] However, there was nothing to suggest any special interest by the Soviet leadership in German rockets.[59] In June 1944, however, Churchill began a correspondence with Stalin regarding German rocketry with reference to the German launch facility at Blizna, Poland. The first three letters from Churchill described the V-1 (an unmanned, jet powered, winged bomb) with no particular alarm, but requested that Stalin forward intelligence information regarding these systems gathered during the Soviet advance across Poland. On July 13, Churchill sent a letter to Stalin revealing far greater concern over the development of the V-2 ballistic missile, noting "It is possible that they have 1000 rockets of this type with a weight of around 5 tons. If this is correct, this would become a serious issue for London..." Churchill stressed the

---

[57]See Bruce Parrot, *Politics and Technology in the Soviet Union,* (Cambridge: MIT, 1983) p. 114.

[58]See G.A. See G.A. Tokaty, "Soviet Space Technology" *Spaceflight,* Vol. 5, No. 2 (March 1963), pp. 58-64..

[59]This is the conclusion drawn by one of the early participants in the German collection effort as well as the development of Soviet rocketry since that time, B.E. Chertok. See the first in a series of articles drawn from Chertok's recollections, Boris Konovalov, "U Sovetskikh raketnykh triumfov bylo nemetskoe nachalo" *Izvestiia,* March 4, 1992 pp. 1,3. Four more installments of the same article appeared in the four succeeding issues of *Izvestiia.*

importance of intelligence information from the Russians: "We have learned much from rockets which have fallen in Sweden, and not been returned, but vestiges of experiments in Poland will provide invaluable additional data."[60] Prompted by Churchill's interest, in the second half of July, Stalin ordered an investigation into the German rocket base at Blizna Poland. He asked Georgi Malenkov to the effort with the remaining rocket specialists at RNII. Tikhonravov responded to Malenkov's inquiry by asserting that indigenous talent was capable of greater accomplishments.[61] Nevertheless, Malenkov sent a delegation to Poland to investigate the German test range on August 5, 1944.[62]

While Churchill's letter aroused Stalin's curiosity, the investigation remained a low priority on his agenda. This was an extraordinarily busy time period for Stalin and the GKO. In summer 1944, Stalin was occupied first and foremost with the progress of the largest Soviet offensive of the War, Operation Bagration, which began on June 22, 1944. After the debacle at the beginning of the war, Stalin personally maintained very close contact with the conduct of military operations. It was customary for him to contact his frontal commanders every night, elicit their reports on activities during the preceding day, and offer his advice. Stalin also participated in all planning activities, and his approval was mandatory for virtually all troop movements. In the final year of the war, as the Red

---

[60]Letters from Churchill are from *Correspondence Between I.V. Stalin and the President of the USA and the Prime Minister of England 1941-1945,* (Moscow, 1957) pp. 232-235, 282-283, as cited in G.S. Vetrov, *Sekrety Ostrova Gorodomliia* (mimeo) pp.. 14-17.

[61] See Golovanov, *Korolev*...p. 334.

[62]Among the delegation only M.K. Tikhonravov, and Iu. A Pobedonostsev had any expertise in rocketry.

Army moved rapidly westward, Stalin's insistence on knowing where each of his 12,000,000 troops were located at any given time was an extraordinarily difficult, and time consuming task in itself.[63] In the week that Stalin received the correspondence from Churchill, the Ukrainian front began its portion of the offensive. Moreover, planning for this offensive had not gone smoothly: there was a heated dispute between Stalin and the commander of the Ukrainian front, Marshal Koniev over the basic thrust of the attack.[64] Consequently, Stalin was watching these operations with even closer attention than usual.

The Belorussian front, which began its offensive on June 22, also attracted Stalin's attention, if only for the dramatic success it was enjoying. By the end of July, the Belorussian front had obliterated between 25 and 28 German divisions, capturing or killing over 350,000 soldiers. In late July, Stalin was also concerned with planning operations to the south through Rumania which began on August 2.[65] From June through August, the Red Army made decisive movements across Soviet territory and into the countries of East Europe, covering several hundred kilometers on all fronts.

Stalin also faced diplomatic issues which overrode any consideration of German rocketry. Foremost among these was the struggle for control of Poland between the exile government in London and the Polish Committee of National Liberation (the Lublin

---

[63]The most detailed English language account of WW II from the Soviet side is to b found in the three volume set by John Erikson. Of particular relevance to this study is the final volume. See John Erikson, *The Road to Berlin: Continuing the History of Stalin's War with Germany*, (Bolder Col.: Westview, 1983).

[64] *Ibid.*

[65]*Ibid.*

government), which was sympathetic to the Soviet Union. There was no issue more important to Stalin in the post-war structure of Europe than the disposition of Poland. July-August 1944 was a period of very high activity regarding this issue including: the Warsaw uprising, which began on July 29, as well as visits by the Polish Committee in the last week of July, and the leader of the London Poles, Stanislav Mikolajczyk, in the first two weeks of August.

All indications were that Stalin's decision to send a team to Poland to investigate the German V-2 test range was little more than a perfunctory response to Churchill's letter. Stalin delegated the matter to Malenkov, and did not revisit the issue until mid fall.

In October, Churchill wrote to Stalin thanking him for his assistance in locating and collecting German rocket components in Poland.[66] The letter was somewhat premature. When the crates of "rocket parts" arrived in London, British engineers discovered that the fragments of V-2s had been substituted with old Soviet aircraft parts.[67] By this time, Stalin's attitude toward Churchill had noticeably hardened, particularly regarding the issue of the London Poles. Stalin probably ordered the substitution of components to frustrate Churchill, rather than to retain something he truly valued. If the rocket components were of any value to Stalin, he did not demonstrate this to the rocket

---

[66]Vetrov, *Secrets of Gorodomliia Island...*

[67]See Fredrick I. Ordway III and Mitchell R. Sharpe, *The Rocket Team,* (Cambridge MA: MIT Press, 1979) pp. 157-158. In an interview Chertok claimed that they had faithfully loaded the components into boxes for shipment. But he didn't know what happened to them afterwards.

scientists. They never saw the components again.[68] There were no orders to accelerate the collection of German rocket technology. The issue of German rocketry was not raised again before the Soviet leadership until the explosion of the atomic bombs at Alamogordo, Hiroshima, and Nagasaki.

In the waning months of the war, Stalin again demonstrated a lack of interest in German rocketry. In February 1945, the Red Army literally passed within 100 km of the main German rocket development and launching facilities at Peenemunde as they raced across the eastern parts of Germany toward Berlin. Stalin had an opportunity to pursue the German rocket scientists and their technology, but instead chose to put the protection of his troops above pursuit of rocketry.[69] Von Braun remained at Peenemunde through the end of the month, launching the final salvos on February 19th.[70] Chertok's intelligence gathering team did not arrive in Peenemunde until June, a month after the fall of Berlin.[71] If German rocketry was important to Stalin, he certainly did not reveal it. In the end,

---

[68] In an interview Chertok claimed that they had faithfully loaded the components into boxes for shipment. But he didn't know what happened to them afterwards.

[69] There is some debate over the intentions regarding the Red Army's intentions to capture the German rocket center at Peenemunde. Walter MacDougall imputed a great deal of interest by the Soviet leadership. However, there is little to substantiate his claim "that the Kremlin's desire to reach Peenemunde before the Americans before the Western Allies influenced Red Army operations." See Walter A. McDougall, *The Heavens and the Earth...* p. 42. John Erickson's account of Red Army operations directly contradicts MacDougall's assertion. See, Erickson, *The Road to Berlin ...*, p. 521.

[70] See Sharpe and Ordway, *The Rocket Team...*

[71] See *Izvestiia,* March 4, 1992

Stalin's disinterest allowed Von Braun and his colleagues to slip out of the Soviet occupied zone and into allied protection.[72]

Stalin and the German Rocket Program--Decision-making by Omission

With prodding from Churchill, during the latter stages of the war Stalin sent a small group of aviation specialist to investigate the vestiges of the disintegrating German missile program. However, this was not a high level effort. His deputies were unconvinced of the value of missiles, and the effort was discontinued. Why did Stalin show so little interest in missiles? The Americans were vigorously pursuing German rocket scientists. With some intelligence planning, the Red Army could have easily intercepted Von Braun's group before they had the chance to leave Peenemunde.

Decision-making at the end of the war was confined to the upper levels of the military hierarchy and the GKO, and Stalin was fixed upon reaching Berlin before the Western allies. No one in the leadership had any interest in missiles, nor any connections with the small group of aviation designers who did. The leadership of the Narkom for the Aviation Industries had already rejected the notion of rocketry twice. It was not about to reconsider his decision in the face of Stalin's determined advance to Berlin. Stalin did not immediately seize upon rocketry as a way to leapfrog over the American monopoly of nuclear bombers. In fact, he probably never thought about it. This was the risk of over-

---

[72]Chertok notes that his group was in fact pursuing Von Braun, but this activity was performed without official sanction or knowledge. See *Izvestiia,* March 4, 1992; and interview with Chertok.

centralization of decision-making.[73] A centralized bureaucracy can only make a limited number of decisions. Those decisions falling outside their control tend to be passed through without review.[74]

Despite Stalin's indifference, in Soviet occupied Germany a group of enthusiastic scientists was organizing which would take decision-making matters into their own hands.

THE SCIENTISTS 1944-1946--COLLECTION OF GERMAN TECHNOLOGY BEGINS

Following Allied bombing of the Peenemunde facility in 1943, Von Braun had established a secondary test facility in Poland that was out of range of British and American bombers. Soviet troops had pushed the German Army out of the area during the late spring. In early August 1944, a delegation headed by Air Force Col. Fedorov was hastily assembled to travel to the German rocket test facility at Blizna, Poland. Among the Soviet delegation sent to Poland only M.K. Tikhonravov, and Iu. A. Pobedonostsev had any expertise in rocketry. The majority of the delegation was composed of soldiers

[73] See Downs, *Inside Bureaucracy...*

[74] This is a basic conclusion of "garbage can" theories of decision making. See Cohen (et. Al) "A Garbage Can Model...;" March and Olsen, *Ambiguity and Choice...;* and March and Wessinger-Baylon, *Ambiguity and Command..*

who had no knowledge of rocketry, and little desire to wade into rivers and walk through muddy farm fields looking for twisted chunks of metal.[75] The Soviet team was met by the British delegation. They divided the bits and pieces of rockets remaining from unsuccessful tests and sent them back to their respective capitals, agreeing to exchange components after each had a chance to examine the original shipment. The technological harvest was meager; the retreating Germans had taken most of the intact components with them.

The delegation did not remain long in Poland. Later in August they returned to Moscow with the German rocket components to undertake further study at NII-1 of the Ministry of Aviation Production (NKAP).[76] The group of engineers at NII-1 who studied the German components included several of the future pioneers of Soviet rocketry. It was headed by V.P. Mishin (later Korolev's First Deputy), and included guidance specialists, N.A. Piliugin, and B.E. Chertok, and rocket engine specialist A.M. Isaev. Although they returned with only a small fraction of the parts needed to build a V-2, Soviet rocket engineers were greatly impressed by the accomplishments of the German rocket program. Boris Chertok recalled walking for the first time into the building where the parts were being held:

In deep thought on a stool sat V.F. Bolkhovitinov.

---

[75]The account of the first Soviet intelligence gathering team to Poland is based upon the recollections of one of the participants in the delegation, M.K. Tikhonravov. See Vetrov *Secrets of Gorodomliia...* See also Iaroslav Golovanov, *Korolev: Fakty i Myfy* (Moscow: Nauka, 1994),pp. 337-338.

[76]Up until 1944 NII-1 was known as RNII. See *"U Sovestkikh..."* Regarding the ministerial affiliation of NII-1, a matter which will prove to be of some significance, see *"Proisshesvie v NII-3..."*

I came up to him and posed the question: What is this?

It is something which cannot be.

You understand, one of the most talented of aviation designers simply did not believe that that such a powerful rocket engine could be created under wartime conditions.[77]

After a month of study, the group of engineers at NII-1 assembled the fragments of the V-2s, and proposed to the Ministry of Aviation Production that an improved version of the V-2 with a range of approximately 600 km should be developed. Deputy Commissar, P.M. Dementev, rejected the proposal, noting that "rocket technology was outside the Narkom for Aviation Production's range of competence."[78] Many of the components transferred from Poland to Moscow were packed for shipment to England for further analyses by British specialists.[79]

In August 1944, the sentences of Korolev and Glushko were commuted by the secret police (NKVD). Remaining in Kazan, they launched their own assault of NKAP, independent from the group studying the German technology. In late September, Korolev wrote to Dementev outlining two proposals. The first was to create an independent design bureau based upon the group in which Korolev and Glushko worked (Group 5). Korolev argued that "given the current conditions, Group 5 could not longer work

---

[77]Bolkhovitinov was one of the leading Soviet aircraft designers of the era. See *Izvestiia,* March 4, 1992, p 3.

[78]See Interview with V.P. Mishin; and "Iz Germanii v Kapustin Iar," *Izvestiia,* April 6, 1992 p. 3.

[79]Chertok asserted that his group passed components on to London. See *Izvestiia,* March 4, 1992, p. 3. However, Sharpe and Ordway assert that the components which actually arrived n London were just miscellaneous bits and pieces of aircraft. See *The Rocket Team...* p. 158.

effectively." He asserted that "completion of the group's 1944 plan is only possible in the presence of necessary conditions, in the first place, legalization or recognition of the group as an independent technical unit, guaranteeing for it a production base along the lines of the NKAP and carrying out the corresponding organizational measures." In practical terms Korolev was asking that Group 5 be given the status of an independent design bureau (KB-RD), under Glushko's direction. Second, Korolev proposed that KB-RD's first work be directed toward completion of two missile designs on which he and Glushko had been working, the D-1 and D-2. While these missiles were limited in range to 76 km, Korolev's letter held promised that completion of these projects would lead to systems with a range of 200-to 400 km by using new engines that were already in the process of . development.[80]

Dementev was quick to respond to Korolev's first proposal, bestowing Group 5 with the status of an independent design bureau KB-RD within Aviátion Factory No. 16.[81] However, he strictly limited their activities to "completing flight testing of the Pe-2 aircraft, and equipment for the RD-1 rocket assist engines."[82] Consequently, Dementev explicitly rejected Korolev's proposal to develop missiles, and even implied that the independent status of KB-RD was only temporary.

---

[80]As quoted from Korolev's correspondences, in the Academy of Sciences Archives in Georgi Vetrov, *S.P. Korolev i Kosmonavtiki: Pervye Shagi,* (Moscow: Nauka, forthcoming) p. 270 of manuscript.

[81]Vetrov, *Secrets of Gorodomliia...* p. 24.

[82]As quoted in *Korolev i Kosmonavtiki...* p. 271.

Between September 1944 and spring of 1945, Chertok and the other scientists who went to Germany returned to their respective institutes. Korolev and Glushko remained in Kazan. The trip to Poland had no effect on either the leadership or administrative agencies. The initial launch of the Soviet rocket program had been effectively aborted.

In spring 1945, new intelligence-gathering teams were formulated to travel to Germany to gather information on German military technology behind the rapidly advancing Red Army. Among these teams was a group from NKAP, which left on April 23 with general tasking "to find and rescue the newest German technology and secret archives, first of all from ourselves."[83] The group generally followed behind the advancing Red Army, but did not reach Peenemunde until June 1, almost three months after the Red Army passed through the area, and three weeks after the German surrender.[84] Chertok and his comrades were the first technical specialists to reach the facility.[85] It was in shambles. Werner Von Braun had taken virtually all of the useful equipment with him when he fled for the South of Germany three months earlier. The Americans and British picked over whatever remained. The only item of value Chertok's group found was a folder containing descriptions of Sanger's plans for a winged spacecraft.[86]

---

[83] *Izvestiia*, March 4, 1992, p. 3.

[84] Chertok remarked that the Red Army "arrived in the region of Peenemunde on March 10." See Chertok, *Raketi i Liudi*...p. 98

[85] *Izvestiia*, March 4, 1992, p. 3.

[86] See Golovanov, *Korolev*... p. 354.

After spending time in Mittlewerk, where the German V-2s were constructed in an underground factory, Chertok's group settled in the German town of Bliecherode near Nordhausen.[87] There, Chertok and the engine designer A.M. Isaev formed a small institute which they named "Rabe." Chertok, posing as a major, was named the director of this institute. It was a very small group involving only a handful of Soviet engineers, as well as soldiers.[88] That it was lead by only a major indicated that it was not a high level effort. It was only one of many dozen Soviet technology collection efforts involving thousands of troops.

Chertok's group was specifically tasked with collecting information and technology related to jet engines and cruise missiles.[89] However, after seeing components remaining from V-2s, Chertok resolved to direct his efforts toward rocketry. He found it easy to circumvent orders from Moscow:

> With A.M. Isaev, we were assigned to the Narkom (Ministry) of Aviation Production, which was primarily interested in jet engines for aviation. By working on ballistic rockets we went beyond our mission as given by Moscow... We never received authorization from Moscow, we simply agreed upon our activities with the local military commanders.[90]

Given the large number of Soviet technology collection teams in Germany at the time, and the small size of the *Rabe* group, their disregard of Moscow's orders went

---

[87] This is the literal transliteration of the Russian spelling of the town.

[88] See Chertok, *Raketi i Liudi*...pp. 99-136.

[89] Interviews with Chertok and Mishin.

[90] See *Izvestiia,* March 4, 1992, p 3.

unnoticed.[91] Even the name of this institute "Rabe" was, in Chertok's words, "an innocent camouflage." It could be translated in German into "crow," but for Chertok and his nascent rocketeers, the name was an abbreviation for "rocket bay."[92]

While Chertok and his team were gathering data on German technology, Korolev and Glushko remained in Kazan working on boosters for aircraft. In June 1945, Korolev directed a revised, "more official" version of his proposal for the development of rocketry within NKAP to Dementev. The response was the same as that which he received a year earlier -- rejection.[93] He and Glushko remained in Kazan until August 1945.

By the Summer of 1945, Chertok realized that although he had many German specialists working for him, they were all "second class." The "first class" specialists had all retreated to the American sector of Germany before he arrived. Compounding his frustration was the fact that the first class specialists were sitting less than 10 kilometers away, only 3-4 kilometers beyond the boundary between the American and Soviet zones. Chertok and his group decided to send a team over to the American sector to recruit leading German specialists. His primary target was the technical leader of the German missile program -- Werner Von Braun.

When the Red Army advanced toward Berlin in February 1945, Von Braun gathered the most important specialists, the remaining rockets, and technical

---

[91] Interview with Chertok.

[92] See *Izvestiia,* March 4, 1992, p 3.

[93] *Korolev i Kosmonavtiki...* p. 271-273.

documentation and took them to the south of Germany. After safely stashing a trainload of documentation and rockets in a tunnel in the Hartz mountains, Von Braun went in search of the American Army -- to surrender to them. Von Braun's brother, Magnus, described the logic of this move: "We despise the French; we are mortally afraid of the Soviets; we do not believe the British can afford us; so that leaves the Americans."[94]

Chertok learned through a secretary working with Von Braun that many of the German rocket scientists might be interested in going over to the Russian side -- including Von Braun. Von Braun's interest proved to be illusory. Chertok was unsuccessful in locating, much less recruiting, Von Braun, despite his best efforts. However, he was able to recruit Helmut Gottrup, who would later lead the German group of rocket scientists in Russia.[95] This was yet another action undertaken by Chertok without official sanction.[96] Chertok ultimately gathered what he described as a "bunch of second class technicians and factory workers," with a handful of mid-level specialists and Grottrüp as the only leading engineer. In total there were several hundred Germans working with the Soviets at various Nordhausen facilities.[97]

In early August, General Kuznetsov of the Main Artillery Directorate (GAU) paid a visit to the Rabe institute to inform them that GAU had been assigned responsibility for

---

[94] See *The Rocket Team*...p. 271

[95] See *Izvestiia*, March 5, 1992, p. 5.

[96] Interview with Chertok.

[97] See Chertok, *Raketi i Liudi*...

their activities within the military sphere and that he would be the officer directly responsible for Rabe's activities. After the initial shock, Chertok's team of aviation specialists agreed that this assignment would not create any serious conflicts. In practice, the rocket group probably benefited from the total unfamiliarity of GAU leadership with long-range rocketry. Up to this point, GAU's primary responsibility was for the production of munitions, and organizing the relocation of industry from Western Russia to the Ural mountains. It had virtually no experience with research and development, and the most sophisticated weapon system with which it had dealt was the small, solid-fueled rocket known as the "Katiusha." For the rest of their stay in Germany, the young rocketeers were treated by GAU with benign neglect. Kuznetsov never visited again, even though he stayed in a comfortable villa in Bleicherode, less than an hour away.[98]

There was one notable exception to the general unfamiliarity and disinterest which characterized GAU's attitude toward rocketry. Col. G.A. Tiulin spent his formative intellectual years working under the tutelage of Sergei Korolev at RNII.[99] While he was an obvious choice among the GAU staff to serve as the military's conduit to the rocket group, he could hardly be expected to act as a stern taskmaster to his former teacher. Tiulin arrived on August 9 with a team containing all of the future members of the Council of Chief Designers (with the exception of Korolev) including: V.P Glushko, V.P. Barmin,

---

[98] Chertok, *Raketi i Liudi*...pp. 123-136.

[99] See "G.A. Tiulin," in Iuri A. Mozhorrin *Dorogi v Kosmos Vol. 1*, (Moscow: Moscow Aviation Institute, 1992)

N.A. Piliugin, M.S. Riazanskii, V.I. Kuznetsov and V.P. Mishin. Upon his arrival at Rabe, Tiulin made no attempt to conceal his admiration for Korolev and Glushko.[100] From this time until his retirement in the 1980s, Tiulin unstintingly supported the Soviet missile and space programs.[101]

Korolev arrived late in October with General L.M. Gaidukov. During their journey from Moscow, they witnessed a successful British-sponsored test launch of a German V-2.[102] Korolev reacted to the launch with mixed emotions. For his entire career, he had pursued the concept of winged rockets flying into space. The V-2 clearly demonstrated that there was another way into space. Moreover, its success could not be concealed from the state leadership. After the rejection of his proposals by the Ministry of Aviation Production, Korolev understood that it would be difficult to sell his concept of winged rockets to other ministries. This disturbed the future Chief Designer. On the other hand, Korolev was mightily impressed by the accomplishments of the German rocket designers. The rocket test gave him encouragement that space travel was indeed possible and that German technology could provide a needed boost to Soviet efforts.[103] Setting his emotions aside, Korolev made the most of the opportunity presented by the German rocket program.

---

[100] Interview with Chertok...

[101] Interview with Mozhorrin...

[102] See *Izvestiia*, April, 6, 1991, p. 3.; March 5, 1992, p.5.

[103] These observations are drawn from Golovanov, *Korolev...pp. 350-351.*

Upon returning from the launch, Gaidukov and Korolev proposed to Moscow that similar test launches be conducted in the Soviet sector in Germany. Without waiting for a response, and at Korolev's urging, Gaidukov commandeered the Vystrel rocket testing facility and effectively took control of Rabe. Vystrel was then headed by Aleksei Isaev and contained test stands essential for testing rocket engines. Korolev's working partner, Glushko, had already gone there to conduct his work.[104] By itself, Rabe was capable only of dealing with the on-board systems of the V-2. Combined, the two institutes gave Gaidukov and Korolev the material base they needed to build and test V-2s which had been constructed from leftover components. By this time, Korolev had unofficially taken technical control of all rocket work, while Gaidukov assumed the task of external relations with local authorities as well as Moscow.[105]

Moscow was not so easily converted to rocketry. The scientists were well along in construction of V-2s when the response finally came from Moscow: all equipment was to be gathered up and transferred to the Soviet Union, and the launches would take place on Soviet territory.[106] Korolev was accustomed to rejection, but the others were incredulous. They had only begun to scratch the surface of German rocket technology, and now they were being sent home![107] What they didn't know was that their return was being hastened

---

[104] See Chertok, *Raketi i Liudi*...p. 135.

[105] Gaidukov's early conversion to rocketry is discussed in Golovanov, *Korolev*...pp. 358-363. Also interviews with Mishin, Mozhorrin, and Chertok.

[106]See "G.A. Tiulin," in *Dorogi v Kosmos*...p.156.

[107] Interview with Mishin.

by political intrigues at home.[108] Whatever the reasons, Korolev and Gaidukov understood that their operation would have to be moved to the Soviet Union, but they had no idea where. Since they had no destination, in terms of an institute or even a test range, they contracted with a German rail car firm to produce a special train for transport of all necessary equipment to remote locations for launching. This train contained not only cars for carrying missiles and components, but also all of the laboratories, command centers, and sleeping quarters which would be necessary for conducting launch operations anywhere the train could travel.[109] It was a stroke of genius by Korolev. The self-contained, mobile, rocket team could continue their operations unabated, no matter where Moscow sent them. Korolev would have to depend upon the leadership for very little. He did not need them to build a test range, an institute, or even sleeping quarters. He could take them with him. Moreover, the train ensured that the entire team would have a common point of reference. As events would reveal, these would be very important factors in promoting the scientists' early autonomy from the political paralysis then developing in Moscow.

The search for an administrative home for the missile program predated Korolev's arrival in Germany by almost a year. On September 30, 1944, Korolev wrote to the

---

[108] Georgi Malenkov, who was in charge of the German collection effort, was under attack for ideological laxity by Andrei Zhdanov. As a result, Malekov's policy of developing German technology on German soil and then returning to replicate it in the Soviet Union was repudiated, and orders were given that German equipment and scientists would simply be loaded up on trains and sent back to the Soviet Union where ideological purity could be maintained.

[109] The best published discussion of Korolev's motivations appears in Golovanov, *Korolev...* Interviewees Chertok and Kerimov also made this point.

Deputy Minister of NKAP requesting that the group of rocket specialists from Plant 16 (including himself, and Valentin Glushko), recently released from the Peoples Commissariat for Internal Affairs (NKVD) systems of *sharagi*, be transferred to the People's Commissariat for Aviation Production (NKAP).[110] His proposal was rejected.[111] Korolev resubmitted the proposal in June 1945, only to be rejected again.[112] The Ministry of Aviation Production was not merely disinterested in development of rocket technology, it was afraid of it.[113] The German accomplishments were considerable, and Deputy Peoples Commissar, Dementev, justifiably feared that production of Soviet versions of the V-2 would involve considerable technological as well as personal risk.[114] Failure to successfully assimilate the technologies involved in the V-2 could easily lead to charges of sabotage, and the ministry was already faced with the difficult task of absorbing the technologies involved in reproducing the German V-1, as well as the American B-29.[115] As events turned, the NKAP was unable to avoid charges of mismanagement. In early 1946, the Peoples Commissar, Novikov, was jailed for his mismanagement of the B-29 program.[116]

---

[110]Correspondence from Korolev, Archives of the Cosmonautics Memorial Museum/ Memorial of Korolev's house, F.1, ed. xp. kp 135, ll. 16-21.

[111]Vetrov, *Secrets of Gorodomliia Island...*

[112]Georgi Vetrov, *S.P. Korolev i Kosmonavtiki: Pervye Shagi,* (Moscow: Nauka, forthcoming) p. 270

[113]Interviews with Chertok, Mishin, and Golovanov.

[114] Interview with Chertok.

[115]See Steven Zaloga, *Target America: the Soviet Union and the Strategic Arms Race, 1945-1964,* (Navato: Presidio Press, 1993) pp. 69-80.

[116]See *Target America,...* p. 70.

It is not surprising, therefore, that no one in Moscow was willing to take responsibility for the new, risky, high technology venture proposed by Korolev, despite the findings of a year's research. Clearly, additional persuasive power was needed. To this end, Gaidukov studied the organizational details of pre-war Soviet rocket technology under Korolev's tutelage. He prepared a sales pitch based on the long Soviet rocket history, and emphasized the opportunity provided by the collected German technology for the Soviet Union to advance beyond the rest of the world. Armed with this narrative, Gaidukov and Korolev renewed their search for an administrative home in January 1946. Traveling from Germany to Moscow, they were greeted with resistance. They went first to the Peoples' Commissar for Aviation Production, Shakyurin, who not only rejected the program again, but also recalled all the specialists from NKAP working on rocketry.[117] The Peoples' Commissar for Munitions, Boris Vannikov, initially accepted Gaidukov's offer, but changed his mind after two weeks, arguing (somewhat disingenuously) that he had *just* been given another program.[118] Gaidukov and Korolev also paid visits to the Peoples' Commissariats for the Mortar Industry and Heavy Industry only to be rejected there as well.[119] Korolev and Gaidukov also considered the idea of setting up an entirely new narkom to manage rocketry.[120] The scientists favored this option, arguing that rocket

---

[117] Gaidukov was successful in preventing the departure of all but two specialists, rocket engine designer Isaev, and one of his co-workers. See Chertok, *Raketi i Liudi...* p. 139.

[118] Vannikov was actually tasked with the atomic bomb program several months earlier, but did not disclose this to Gaidukov. Therefore, his excuse was somewhat disingenuous.

[119] Interview with Chertok.

[120] See *Secrets of Gorodomliia...*

technology could not be developed within any of the existing Narkoms (with the exception of the Narkom for Aviation Production.)[121] As a last resort, Gaidukov went to the Peoples' Commissar for Armaments, Dmitry Ustinov. While Ustinov expressed interest, he refused to accept the program immediately, agreeing only to send his first deputy, Vasilii Riabikov, to examine Gaidukov's rockets.[122]

Riabikov's only industrial experience had been at the Bolshevik naval artillery factory in Leningrad. However, his work there was in party organization; not design, or even production. He was not suited to judge the value of this new technology. Upon Riabikov's arrival in Germany, Korolev guided him through the captured underground factories at Mittlewerk and Montana, various design bureaus, and finally to the test stands. Riabikov seemed unimpressed. Even the rocket engine tests drew the disheartening response from Riabikov that he thought the one minute test had lasted for hours. A banquet was prepared, offering their best vodka and cognac, but Riabikov was virtually a teetotaler, and remained silent. Finally, however, Riabikov broke his silence and announced to the assembled rocketeers:

> Well comrades, everything that you have shown me is very interesting. I believe that our narkom should take up this work. I will speak to Dmitry Fedorovich (Ustinov) about this...[123]

---

[121] Interview with Chertok...

[122] See Golovanov, *Korolev*.. pp. 361-362..

[123] See Golovanov, *Korolev...*, p. 363.

Ustinov considered the program further. He determined that he must go to Stalin with this information in an effort to apprise Stalin before the Chief of the secret police, Beriia, had a chance to do the same. This tactic was necessary to diminish the possibility of an inquiry from Stalin as to why Ustinov had not taken up this promising new technology.[124] Ultimately, Ustinov agreed to take responsibility for the program only after an implied threat of reprisal from Stalin. On May 13, the Council of Ministers issued a decree assigning all missile programs to the Narkom for Armaments, but there were no immediate tangible effects of this decree to the rocket scientists in Germany. While Korolev recognized that there were few other possibilities, the other scientists feared that this was a mistake. The Narkom for Armaments knew nothing about missiles. Mishin later proclaimed "that this was the single biggest mistake the Soviet government made in the entire missile program."[125]

In August 1946, a high-level delegation including Ustinov, Chief Marshal of Artillery Iakovlev, several deputy ministers, and members of the Central Committee staff traveled to Germany.[126] The delegation did not come to Germany specifically to examine rocket technology; its primary objective was to accelerate the transfer of German hardware and technicians to the Soviet Union. This was an almost incomprehensibly

---

[124] See Golovanov, *Korolev...*, p. 363. It is also interesting to note that during the late 1930s many R&D managers were accused of stifling inventors' initiative by rejecting proposals without thorough investigation. See Bailes, *Technology and Society...*

[125] Interview with Mishin.

[126] See Golovanov, *Korolev...* p. 362.

massive effort concentrated in the fall of 1946, involving the coordination and transfer of as many as 12,000 trainloads of equipment, and 10,000 scientists and technicians from Germany to Russia.[127]

Korolev's missiles were only a very small part of this effort. Nevertheless, Ustinov and Iakovlev were particularly impressed with Korolev's self-contained train for launching V-2s. Iakovlev ordered that a second train be built for the Ministry of Defense. Korolev cleverly ordered a third, to insure that the rocketeers, rather than the military, would acquire the most modern version. Ustinov formally ordered that the *Rabe* institute be placed under his jurisdiction, expanded, and renamed *Nordkhausen.* The entire enterprise was put under Gaidukov's control with Korolev as his deputy.[128]

Ustinov named Korolev as Chief Designer of Long-Range Ballistic Missiles. While Ustinov appreciated Korolev's skills, another designer in Moscow, Sergei Sinel'shikov, was his favorite. Indicating the higher priority placed upon anti-aircraft systems, Sinel'shikov was appointed Chief Designer for Anti-aircraft rockets.[129] A further indication was that the Chief Designer of the design bureau for ground systems, V.P

---

[127]See Antony C. Sutton, *Western Technology and Soviet Economic Development, 1945-1965,* (Palo Alto: Stanford University Press, 1973) p. 31.

[128]See "G.A. Tiulin," in *Dorogi v Kosmos Vol. 1...* p.156; *Izvestiia,* April, 6, 1991, p. 3.; *Izvestiia,* March 5, 1992, p.5.

[129]Interview with Mishin.

Barmin, was assigned to work on anti-aircraft rockets. His deputy was sent to work with Korolev.[130]

At the end of his short, visit Ustinov took Korolev aside and asked whether Korolev understood everything about the German rockets. Korolev replied: "No, we do no yet have a complete understanding. I understand how it works, but several aspects connected with technology need to be solved. All of our shortcomings, though, are because we have no technical documentation." Korolev then went on to explain that he needed the rest of the year to complete his work in Germany and return with at least ten rockets. This was, of course, contrary to Stalin's orders that everything be returned to the Soviet Union as soon as possible. Zhdanov's attacks on the ideological laxity of the German operation increased the pressure to return Korolev to Moscow.[131] Nevertheless, Ustinov acceded to Korolev's wishes, allowing him to stay until the end of 1946 to complete his work in Germany.[132] This exchange was an early indicator of the relationship that developed between Korolev and Ustinov. Korolev quickly gained the trust of his superior through ostensibly honest assessments of his own capabilities. In return, Ustinov was willing to protect Korolev and his young rocket team from capricious leaders, and allowed them a great deal of autonomy. It was an exchange which would be repeated many times over the coming decade.

---

[130]See *Izvestiia,* March 5, 1992, p. 5.

[131] See *Soviet Postwar Politics...* pp.. 19-66.

[132] See Golovanov, *Korolev...* p. 366-367.

While Korolev managed to gain a one year reprieve from transfer to Moscow, the same would not be granted to the German specialists working with him. The secret police demanded that they either be transferred to Moscow in the fall of 1946, or remain in Germany apart from the Soviet missile program. Though the German specialists were not the most qualified, Korolev understood that they would be needed for at least launching the initial V-2s. With Grottrup's help, Korolev provided a list of Germans to be offered positions in the Soviet missile program, and submitted the list to the NKVD. The deputy director, Ivan Serov, returned in October to inform Korolev and Gaidukov that his revised list of Germans would be taken to the Soviet Union whether they wanted to go or not. The date was set, and a huge banquet was staged for the German specialists on the night of October 22. As the Germans returned to their homes, they were collected by Soviet troops, put on a train, and taken to Moscow. In total, 188 German specialists were "voluntarily" taken to Moscow for assignment.[133]

Korolev developed close relations with the military using slightly different tactics than he had with the administrators from the industrial Narkoms. He assigned, junior military officers to work alongside Korolev's civilian engineers.[134] Approximately half of the sections within the institute were headed by military personnel, the rest by civilian engineers. Capt. Kerim A. Kerimov, who would later become the commander of the

---

[133] See Golovanov, *Korolev...* pp. 370-372; Chertok, *Raketi i Liudi*...pp. 176-178.

[134]As a formality, even the civilian personnel were assigned temporary military ranks. Korolev, for example, was a Col. Mishin was a Lt. Col. This discussion distinguishes between these temporary military personnel and those with permanent military affiliation.

military space program, headed the telemetric section, sharing a building with Chertok's guidance group. Lt. Col. G.A. Tiulin, who would later become a deputy minister in charge of missiles and space, directed construction of the trains, and translation of documents.[135] Sections on engines, test stands, and guidance, were headed by civilians Glushko, Voskressenskii, and Chertok, respectively. Within each group there was a fairly even distribution of military and civilian personnel. This arrangement was borne of necessity.[136] There simply weren't enough civilian engineers to perform the tasks at hand and, given Zhdanov's campaign against ideological laxity in Germany, it was unlikely that any more civilians would be transferred. It was also true, as a matter of practice, that the political leadership wanted the military to monitor the activities of all civilian personnel in Germany. Whatever the motivations, the result was that a group of lower ranking military officers became socialized into the missile program, working alongside the engineers whom they would be assigned to monitor in the coming years. A bond between the military and the civilian pioneers of Soviet rocketry formed at an early stage -- it would be an important characteristic of the program in the years to come.[137]

In this fashion, Korolev established close working relationships with many of the state and military officials who would later administer the development of missiles in the

---

[135]See "Iu.A. Mozhorrin," in *Dorogi v Kosmos Vol. 1* ... p.139.

[136] Interview with Kerimov.

[137] See Chertok, *Raketi i Liudi*...; and interviews with Mozhorrin and Kerimov. On the effect of personal attachments on the ability of monitors to effectively discharge their responsibilities see in particular Anthony Downs, *Inside Bureaucracy*... pp. 132-157.

Soviet Union. Included in this group was were a Col. G.A. Tiulin, who returned from Germany to head the military directorate within GAU in charge of ballistic missiles and who later became a Maj. General, as well as head of several state commissions for various missile systems, and a deputy minister in charge of the development of rocketry. Another figure was Captain Kerim A. Kerimov, who later advanced to become the head of the military space program.[138] Captain Smirnitsky, who became the Chief Operating officer at the missile test range and Deputy Chief of the Strategic Rocket Forces, also began his career in rocketry in Germany.[139] For the rest of their careers, these men, and many others in the state administration, would look to Korolev to advance them professionally. In return, he could look to them for support for his projects. Such support would prove crucial in the difficult years ahead.

By the time they left Germany, Korolev had created a tightly knit collective which would prove to be capable of overcoming the obstacles placed before it. He reunited almost all of the members of RNII who survived the war and the prison camps. This group established Korolev as their leader, and reached a strong consensus over organizational mission. This was Korolev's primary goal in Germany. [140] Even at its peak, however, the total number of Soviet engineers, technicians, and workers analyzing and gathering German missile technology was small, never exceeding 250. By January 1947,

---

[138]Interview with Kerimov...

[139]See *Dorogi v Kosmos, Vol. II...*

[140]As quoted from Korolev's personal archives in *Secrets of Gorodomliia...* P. 37.

their work in Germany was finished, and the specialists of the *Nordkhausen* institute returned to their respective design bureaus and scientific research institutes in the USSR. During their time in Germany they were able to piece together only 29 complete rockets, but they did manage to collect a nearly complete set of V-2 documentation.

At the expedition's conclusion, Chertok summed its achievements simply: "We came as aviation designers, we returned as rocketeers."[141] But the Chief Designer of Long Range Ballistic Rockets (Korolev) proved most prophetic: "the most important thing was not that we learned technology, but that we closed ranks as a collective."[142]

Consensus-building and the Emergence of Scientific Leadership

Every veteran of the Soviet missile program interviewed for this study who spent any significant time in Germany believed that this was the most important period in the program's history. Unanimously, they felt that the organizational cohesion and consensus developed in Germany was the only thing that enabled them to endure the difficult years ahead.[143] More than anything else, their impetus was their belief in Korolev and his vision of space travel. Focusing upon Korolev and his vision created a sense of mission among a disparate group of scientists, engineers, and low ranking military officers which would

---

[141]Interview with Chertok.

[142]As quoted from Korolev's personal archives in *Secrets of Gorodomliia...* P. 37.

[143] Interviews with Mishin, Chertok, Kerimov, Maksimov, and Mozhorrin.

unify the Soviet missile program for decades to come.[144] For more than a decade, Korolev's leadership of the Soviet missile program would go unquestioned.

In addition to overall leadership, the basic task assignments of the future Soviet missile industry were established in Germany. Glushko would be responsible for engines; Nikolai Piliugin for inertial navigation systems; Viktor Kuznetsov would be responsible for gyroscopes and control mechanisms; Viktor Barmin--launch structures; and Mikhail Riazanskii--radio telemetry and control. Korolev would be in charge of overall system integration. Not only did Korolev's group learn how to put rockets together in Germany; they also learned how to put an organization together which could function both as six separate entities, *and* as a unified collective.

While isolated in Germany, the rocket scientists discovered that in the absence of direction from Moscow, they could take matters into their own hands. They began to explore the limits of government control. Often, they openly defied orders from the political leadership. It is doubtful that there would have been any Soviet missile program had Chertok not ignored his instructions from the NKAP to limit his search to jet engine technology. This envelope would be pushed for the next two decades.

---

[144] On the connection between leadership and creating an organizational mission, see Wilson, *Bureaucracy...*; and, Doig and Hargrove, *Leadership and Innovation...*

Locating a constituency

The most difficult task facing Korolev and Gaidukov was finding someone of consequence within the Soviet administrative structure who believed in their missile program. For the better part of a year, the missile program existed in a state of bureaucratic limbo, without an administrative home. Ustinov became the patron administrator of the program not because he saw great potential, but because circumstances dictated his sponsorship. He needed some strategic program to maintain his position as one of the preeminent Narkoms, and the more important atom bomb and long-range bomber programs were given to other agencies. His support of the missile program was at best tepid. Korolev would have to nurture and develop this relationship.

Conversely, Korolev enjoyed greater success developing a constituency from the ground up in the military. He had developed a strong core of adherents to his program among junior officers. This core of officers believed in Korolev's vision, and continued to provide support for Korolev as their careers advanced. However, the higher reaches of the military were uninterested in missiles. Resistance at this level would continue to trouble Korolev for the next five years.

There was no constituency within the political leadership. Neither Korolev nor Ustinov made any attempt to convince Stalin of the efficacy of a missile program. At this stage of the program, there was no indication that Stalin gave any consideration to missiles beyond his correspondence with Churchill. It was clearly not a leadership driven program.

THE DECISION TO INITIATE A ROCKET DEVELOPMENT PROGRAM

Stalin emerged from WW II victorious, but exhausted and in ill health. In the months to follow, he suffered a minor stroke, but nevertheless carried on the affairs of state. From the end of 1945 until at least mid 1946, decision-making suffered from perhaps the greatest uncertainty since Stalin consolidated his rule in the late 1920s.[145] Without the discipline imposed by the conduct of war, decision-making quickly fell into a series of "decision-making parties," combining movie going, dining, drinking, and affairs of state. Only a few high ranking members of the GKO were consistently included. Over the years, this decision-making process yielded a certain efficiency, but initially it must have been difficult for the participants, including Stalin, to distinguish between the affairs of state and those of society.

Uncertainty of process was heightened by questions regarding the basic direction of the nation which had to be resolved over this period. In foreign affairs, the Soviet Union had established an uneasy alliance with the United States and, to a lesser extent, Britain during the war, but there were increasing conflicts in relations concerning the

---

[145]On Stalin's post war condition, see Robert Conquest, *Stalin: Breaker of Nations,* (New York: Viking Books, 1991) pp. 269-300.

disposition of Eastern Europe. The basic question of accommodation or conflict was unresolved. On the domestic front, the Soviet leadership faced the question of how to rebuild the nation. Was the country to be rebuilt on the backs of the peasantry, as it had been in the 1930s at such enormous costs? Or was a more moderate course, allowing increased consumption, to be pursued? The questions of the day were enormous and unrelenting. Between almost nightly celebrations of victory, each day demanded decisions that would determine the future course of not only the Soviet Union, but the entire world.

With the exception of WW II, political intrigue was first on Stalin's agenda. Shortly after his return from the Black Sea, he undertook a significant reorganization of the Soviet leadership in the first months of 1946. Andrei Zhdanov was brought to Moscow from Leningrad to serve as Second Secretary, displacing Viacheslav Molotov. Malenkov and his political ally, Beriia, were brought into the Politburo as full members in March. For the next two years, Zhdanov and Malenkov were locked in a bitter political battle. By June, Zhdanov generated charges of incompetent management of the aviation industry and the German collection effort against Malenkov. Within a year, Malenkov would be removed from the Politburo and sent to Central Asia, only to be returned in early 1947.[146] In mid January, Beriia was forced to resign as head of the NKVD.[147] By

---

[146]See Roy Medvedev, *All Stalin's Men,* (New York: Doubleday, 1985) pp. 147-148.
[147]See *Beriia...* pp. 140-143.

any measure, strategic political calculations occupied a great deal of the attention of the Soviet leadership during the early months of 1946.[148]

The post-war reconstruction of Russia also had to be considered by the leadership. Twenty million Soviet citizens perished during the war, and the entire Soviet industrial infrastructure west of Moscow was decimated. Defense industrial facilities located in Moscow prior to the war had been relocated to the Ural Mountains and eastward. Overall production declined by more than half. In August 1945, the State Defense Committee (GKO) formally began discussions of the 1946-1950 five year plan.[149] This plan was almost incomprehensibly immense. Incremental planning was impossible; there were virtually no baselines. Almost the entire productive capacity of the Soviet Union during the war had been devoted to production of military equipment and materiel. Each individual factory had to develop a plan for peacetime production from scratch. It fell upon the political leadership to mediate the inevitable disputes between ministries (the dispute over the location of rocketry being only one example), and make final decisions on plan approval. While there is no open record, the time required for meetings alone was more than enough to fill the schedules of Stalin and the rest of the political leadership during late 1945 and early 1946.

---

[148]On the battle between Malenkov and Zhdanov in particular see, Hahn, *Postwar Soviet Politics....*
[149]See Timothy Dunmore, *Soviet Politics...*

A major shift in foreign policy from accommodation to confrontation with the West was also taking place during this time. Consolidation of the Soviet position in Japan was of immediate concern for the GKO in the middle of August. The results of the Potsdam summit were also being digested by the Soviet leadership.[150] While Poland had been effectively absorbed into the Soviet fold by August 1945, battles for political control of Hungary, Bulgaria, and Rumania peaked during this period. Soviet positions in Yugoslavia and Czechoslovakia were also being solidified.[151] The United Nations had only recently been created, and the Soviet leadership was attempting to discern their role in a body clearly dominated by American interests. Stalin was jousting with the British and Americans over the fates of Iran and Greece. Stalin and Molotov, and to a lesser extent, Beriia, were aware that a fundamental restructuring of the balance of power in the world was taking place. Events in this arena also competed successfully with rocketry for a place on the leadership agenda.

It is against this backdrop that the decisions which led to the development of rocketry must be considered. Every decision the Soviet leadership made was important, but it had very little time to make decisions, and was almost completely isolated from sources of information necessary for well-informed choices. Decisions which today seem to be of the utmost importance and which would require months -- if not years -- of

---

[150]See, for example, Adam Ulam, *Expansion and Coexistence: Soviet Foreign Policy 1917-1973,* (New York: Holt, Reinhart and Winston, 1974).

[151]For a discussion of the process of Soviet digestion of Eastern Europe see Zbigniew K. Brzesinski, *The Soviet Bloc: Unity and Conflict,* (Cambridge MA: Harvard University Press, 1960).

careful analysis in "normal" governments, were made between shots of vodka. There was little time to consider alternatives and even less time to weigh the merits of competing alternatives. As the decisions regarding the future of Soviet strategic forces show, the tendency was to choose "all of the above."

For the previous three years, Soviet intelligence had closely tracked the development of the American atomic bomb and had informed Stalin the scheduled test date some time in advance.[152] Nevertheless, the actual test seems to have caught him by surprise. Perhaps Stalin was not so much caught by surprise as he was doubtful of intelligence reports regarding the strong likelihood of American success.[153] Consequently, it was not until after the successful detonation that he became alarmed over the emerging American nuclear monopoly. In mid-August 1945, Stalin directed the Chief Scientist of the nuclear weapons program, Igor Kurchatov, and the Minister of Munitions, Boris Vannikov: "Comrades, a single demand of you. Get us the atomic weapon in the shortest time possible. As you know, Hiroshima has shaken the whole world. The balance has been broken. Build the bomb, it will remove a great danger from us."[154]

The obvious means of delivering a nuclear weapon to the United States, or at least Western Europe, was the long-range bomber. On July 29, 1944, a U.S. B-29 bomber was

---

[152]At the last minute the test date was changed due to weather conditions and Stalin criticized the NKVD for being faulty in its prediction of the exact date. See *Target America...* pp. 11-28.

[153] This is the point made by Holloway in *Stalin and the Bomb...* p. 115.

[154]As quoted in *Target America...* p. 29.

forced to land at Vladivostok, in the Soviet Far East. Shortly thereafter, buttressed by the fact that a similar bomber had dropped the atom bombs on Hiroshima and Nagasaki, Stalin ordered that the bomber be copied, bolt for bolt, by the Tupolev design bureau for use as the first Soviet strategic bomber.[155] Soviet intelligence was able to monitor the progress of the extensive U.S. long-range bomber programs. Therefore, Stalin did have a clear idea of the organization, technology and mission for at least one of the strategic delivery options.[156] Stalin naturally gravitated toward the option with the greatest certainty.[157]

Although German accomplishments in developing the V-2 greatly impressed Soviet aviation designers, the range of the German missile would have to be increased by 50 times to serve as a delivery vehicle to the United States. The technological hurdles involved in developing a guidance system capable of delivering an atomic bomb within 10 miles of its target over these distances were even more formidable. Soviet missile designers knew this, and Stalin had no available Western systems to emulate. The Soviets would have to develop ICBMs on their own -- that is, they would have to innovate. Further complicating the matter, there was no clear bureaucratic home for this innovative program. To be sure, there were eager engineers who wished to further develop the

---

[155] See Steven J. Zaloga, *Target America....*

[156] The terms organization, mission and technology correspond closely with March's notion of leadership goals and means as used in garbage can theory. The original work describing this phenomenon was in Michael D. Cohen et al., "A Garbage Can Model ..." ; March and Olsen (eds.), *Ambiguity and Choice in Organizations...*; and, March and Weissinger-Baylon, *Ambiguity and Command....*

[157] See James G. March, and Herbert Simon, *Organizations,* (New York: Wiley and Sons, 1958)

German system, but there was no industrial ministry ready to assume the challenge. A new institutional structure would have to be created to develop these systems. Given the high uncertainty of the missile program relative to the bomber program, its future was tenuous.

There is no record that Stalin held a meeting with personnel involved with the development of rocketry, as he did on the subject of the atomic bomb. During the same time as he was initiating the priority development of the atomic bomb, Stalin, or more likely Malenkov, directed at least some attention toward the development of the missile program.[158] As noted in the preceding section, on August 8, 1945 Malenkov ordered another small group of aviation engineers and military personnel under Gen. Gaidukov and Korolev to fly to Germany to assist Chertok's group.[159] However, in this case, the group's mission was specifically defined as the collection of rocket technology, though there were no specific recommendation made regarding ballistic versus anti-aircraft missiles.[160]

---

[158] Malenkov was in charge of the German technology collection effort, and at this point it the missile program was not of sufficiently high priority for Stalin to have directed any of his personal attention to the matter, beyond approving Malenkov's directive.

[159]There is no precise record of this decision, but by late August another group of rocketeers and military officials had been formed to travel to Germany to accelerate the collection of German rocket technology. Due to bureaucratic conflicts among ministers, it took at least several weeks to determine which ministry would be in charge of this effort. Therefore, the decision rendered by Stalin could not have occurred much later than mid August.

[160] Interview with Mishin.

A decision was made during early August 1945 to begin collecting German rocket technology, but there was no clear idea of what to do with it either administratively or technologically. Over the next eight months, management of the missile program was transferred among several defense industrial ministries. None of the ministers were anxious to take on such a risky technological endeavor.

The issue of where to place the missile program was neither trivial nor obvious. Liquid-fueled missiles represented completely new technologies for Soviet administrators. Rockets did not blend conveniently into any of the existing defense industrial ministries at the end of WW II. Since construction and technologies involved were similar to those of aircraft, the argument could be made that rocketry should be assigned to the Ministry of Aviation Production. This was the best apparent fit. On the other hand, liquid fueled missiles were vaguely similar to smaller solid fueled rockets such as the *Katiushas,* which were assigned to the Ministry of the Mortar Industry. Furthermore, case could also be made that missiles were simply another form of artillery shell, and therefore should be assigned to the Ministry of Munitions.

Not only did rocketry defy easy placement into existing ministries, it required technological competence which spanned several Narkoms: sophisticated fabrication of fuselages, a competence of Narkom for Aviation Production; autonomous gyroscopes, best built by the Narkom of Shipbuilding; launch structures from the Narkom of Heavy and Industries; rocket engines from the Narkom of Aviation Production; and telemetry and guidance systems from the Narkom of the Instrument Industry.

Institutional uncertainty associated with the development of rocketry was increased by the dual-purpose nature of rocketry. Rockets could be used for both defense against penetrating American bombers and (possibly) as a delivery vehicle for conventional munitions. The types of rockets required for these missions differed substantially.[161] Of the two, the concern foremost in Stalin's mind was defense against American bomber attacks.[162]

If the industrial Narkoms were reluctant to take on rocketry, the military leadership was hostile to the idea. Nevertheless, in August 1945, development of missiles was preliminarily assigned to the Main Artillery Directorate (GAU) of the Ground Forces under Marshal N.D. Iakovlev.[163] From its perspective, because of their poor accuracy, V-2s had absolutely no military utility.[164] Worse, the noise, clouds of smoke, and immobility of missiles made them an easy target for enemy bombers or artillery. At the highest levels of the military, assimilation of rocketry into the military was a slow and painful process. The activities of Korolev's and Gaidukov's group were virtually ignored by GAU during the entire stay in Germany. The GAU representative in Germany visited their facility only

[161] Anti aircraft missile must have very high acceleration and maneuverability. Ballistic missiles on the other hand put a high premium on range, payload, and guidance.

[162] Interview with Chertok, Golovanov.

[163] See Chertok, *Raketi i Liudi...*

[164] Interviews with Mishin, Kerimov.

once, to announce that it was under his control. He never returned, despite the fact he was based only minutes away.[165]

On May 9, 1946 (the first anniversary the German surrender -- Victory Day), the Politburo approved the decree on the development of rocketry in the Soviet Union. On May 13 the Council of Ministers issued a broad-ranging decree calling for:

1. priority development of rocketry;
2. established a high level monitoring organization—*Spetzkomitet-2*, under the direction of Georgi Malenkov;
3. designated the Ministry of Armaments as the responsible ministry; and,
4. designated the design bureaus and scientific research institutes, from the MV as well as other ministries, which would be participants in the missile development programs.[166]

The primary organization was designated as NII-88 under the direction of A.D. Kalistratov. Prior to the decree, NII-88 was a poorly equipped factory scheduled for conversion from production of artillery pieces to oil drilling equipment. Because there were a great many more important issues which the political leadership in late 1945 and early 1946, there were few other details provided for in this decree.

There were four rocket programs approved in the 1946 decree. Three of these were for the *Taifun, Shmeterling,* and *Vasserfal* anti-aircraft rockets. The fourth was Korolev's long-range ballistic missiles (BRDDs).[167] Among the rocket programs, anti-

---

[165] Three detailed accounts show only two brief visits by ranking military officers. See Chertok, *Raketi i Liudi...*; Golovanov, *Korolev...*; and Vetrov, *Sekrety Gorodomliia...*

[166]Interviews with Chertok, Golovanov.

[167]See Vetrov, *Secrety Gorodomliia...*

aircraft systems were Stalin's highest priority. Even among long-range missiles, it is far from clear that Korolev's program was the most important. There were two other programs for unmanned missiles in the Ministry of Aviation Production. The Chelomei Design Bureau was developing primitive cruise missiles based on the captured remnants of V-1 cruise missiles.[168] There may have been another rocket-plane project within NKAP based loosely upon the Sanger space plane concept involving a three stage booster with a winged re-entry vehicle. [169] Given the relatively limited information available on the Tokaev project, and questions over its existence, it is difficult to establish its institutional stability. If it did exist, it was assigned to NKAP. That much is beyond question. However, it is unclear whether Tokaev represented a distinct design bureau or some design group within some other organization, or possibly even the Soviet Air Force (VVS).

---

[168]See "Zhizn' i tvorchestvo Akademika V.N. Chelomeia" *Iz Istoriia Aviatsii i Kosmonavtiki,* No. 60 (1990) p. 72.

[169]Some caution must be used in discussion of the Tokaty project. The existence of this project revolves around the recollections of a single man G.A. Tokaty-Tokaev who defected to England in 1948. In the voluminous literature on the history of Soviet rocketry there is not a single reference to this person and none of the participants who were interviewed for this study have any recollection of his existence or the existence of his project. However, in other respects his accounts of the post-war history of the Soviet rocket program are remarkably consistent with information which was only released some 40 years after his defection. It is entirely possible that his story is correct, but that the project was closed down and all traces removed after his defection. See G.A. Tokaty, "Soviet Space Technology" *Space flight,* Vol. 5, No. 2 (March 1963), pp. 58-64; and G.A. Tokaty, "Foundations of Soviet Cosmonautics," *Space flight,* Vol. 10, No. 10, pp. 335-343.

Gerhardt Sanger was a German rocket engineer who developed a spaceplane concept for delivering a bomb to the United States from Germany. The project was never approved nonetheless he managed to flesh-out the general concept in considerable detail. For a more detailed description see Ordway, *The Rocket Team...*

The decree issued by the Central Committee and the Council of Ministers only elaborated on points made in the fourth five year plan (1946-1950). This plan reflected the overall trend to increase the level of defense preparedness after the war. In 1941, the R&D budget was 1.6 billion rubles. By 1945, it increased to 2 billion. In 1946, it shot up to 6.3 billion rubles, and increased to 9 billion by 1950.[170] There was also a specific reference to rocketry in the document of the Chairman of Gosplan of the USSR, N.A. Voznesenski. He emphasized that it

> is necessary for us to guarantee work on development of new branches of technology and production. To this it is referred...work on development of *reactive technology*, utilizing new types of engines, creating new speeds and capabilities; work on research in the interest of producing and transporting internal atomic energy.[171]

Similar decrees for the organization of the nuclear and aviation programs were also issued in the same year.[172] Viewed in this context, the missile program, which involved no more than hundreds of engineers and technicians, was probably the most trivial of the post-war development programs.

Ustinov did not revisit the issue of rocketry until a spate of decrees in August 1946 after returning from Germany. On the 9th, he named E.V. Sinel'shikov as the Chief

---

[170]Parrott, *Politics and Technology*...pp. 100-101. Reactive technology was the Soviet term for rocket propulsion. Emphasis mine.

[171]A.P. Romanov and V.S. Gubarev, *Konstruktori*, (Moscow: Politizdat, 1989) p. 301. See also, Avduevskii, V.S. and Grishin, S.P., "Razvitie raketnoi tekhniki v SSSR v period 1946--1957 gg." in D'ianenko, S.M., *Issledovaniia po istorii i teorii razvitiia aviatsionnoi i raketno-kosmicheskoi nauki i tekhniki, Vol. III,* (Moscow: Nauka, 1984), p. 9. for a reference to the same information.

[172] See Steven J. Zaloga, "The Soviet Nuclear Bomb Programme--The First Decade," *Jane's Soviet Intelligence Review,* April 1991, pp. 174-181.

Designer for Zenit rockets and Korolev as the chief designer for BRDDs. A week later, Ustinov fired A.D. Kalistratov as the Director of NII-88, and appointed L.P. Gonar. On the 26th, another decree defined the internal structure of NII-88.

Most of the leading rocket specialists were still in Germany the time during which the basic function of NII-88 was being defined, in the summer of 1946. Two of the leading specialists on Zenit rockets, Sinel'shikov and Isaev, stayed in Moscow to assist in the organization of NII-88. Sinel'shikov took the lead in most of the organizational work.[173] V.P. Mishin appeared on Korolev's behalf representing the interests of the BRDD program.[174] A talented engineer and thinker, Mishin was, unfortunately, a poor organizer, and the structure which emerged favored Zenit rockets over BRDDs. Ustinov left the finer organizational details to be worked out within the structure of NII-88.

Decision-making conditions

In theoretical terms, the decision-making process was very nearly a classic "garbage can," featuring time constraints, high uncertainty for participants in the decision-making process, and unclear understanding of technology and missions.[175] Garbage can theory predicts that under such conditions, decisions tend to come from the bottom up,

---

[173] Isaev spent a period of time in Germany, but returned to Moscow in mid 1946. There was no indication that Sinel'shikov had spent any time in Germany.

[174] Interviews with Mishin and Chertok...

[175] See Cohen (et. Al) "A Garbage Can Model...;" March and Olsen, *Ambiguity and Choice...;* and March and Wessinger-Baylon, *Ambiguity and Command...*

decisions tend to be avoided, and trivial issues will pass through without review.[176] This decision-making environment presented the rocket scientists with opportunities push their program through the leadership, but it also presented a problem. Garbage can theory predicts that decision-making under these conditions will be highly incremental. The actual decision to initiate a missile program did little more than assign missile development to administrative agencies. There were no provisions for further development, nor commitments of national resources. The only decision was to bring three trainloads of equipment back to the Soviet Union and place them within the confines of a dilapidated factory.

This was mixed blessing for the scientists. They would have preferred that the government make a single decision, appropriating full funding for a developmental program, and then leave the scientists to their own devices.[177] The initial decision may not have provided a critical mass of resources, below which the program cannot survive; but at least the decision created some administrative foundation from which to build.[178] Korolev, and the rest of the rocket team, would have to fight long and hard to maintain their autonomy and keep their program alive. Stalin would not give it to them in a single stroke.

---

[176] This point is elaborated on in somewhat more depth in Kingdon, *Agendas, Alternatives and Public Policies...*

[177] See Latour, *Science in Action...*

[178] See Schulman, *Large Scale Policymaking...*

CONCLUSIONS

The Soviet missile program emerged from a combination of the dreams of Soviet scientists dating before the war, opportunity for advancement presented by German rocket technology, and the leadership recognition that this was a sufficiently interesting project to pursue. However, despite the leadership's decision to initiate a long-range missile development program in May 1946, the survival of the program was far from assured. The leadership was not willing to commit to a large scale program, and was perhaps not convinced that there was any value to the program at all. More so than most bureaucratic endeavors, the missile program's early days would be difficult.[179]

[179] This draws from Down's concept of bureau lifecycles. See Downs, *Inside Bureaucracy*...pp. 5-24.

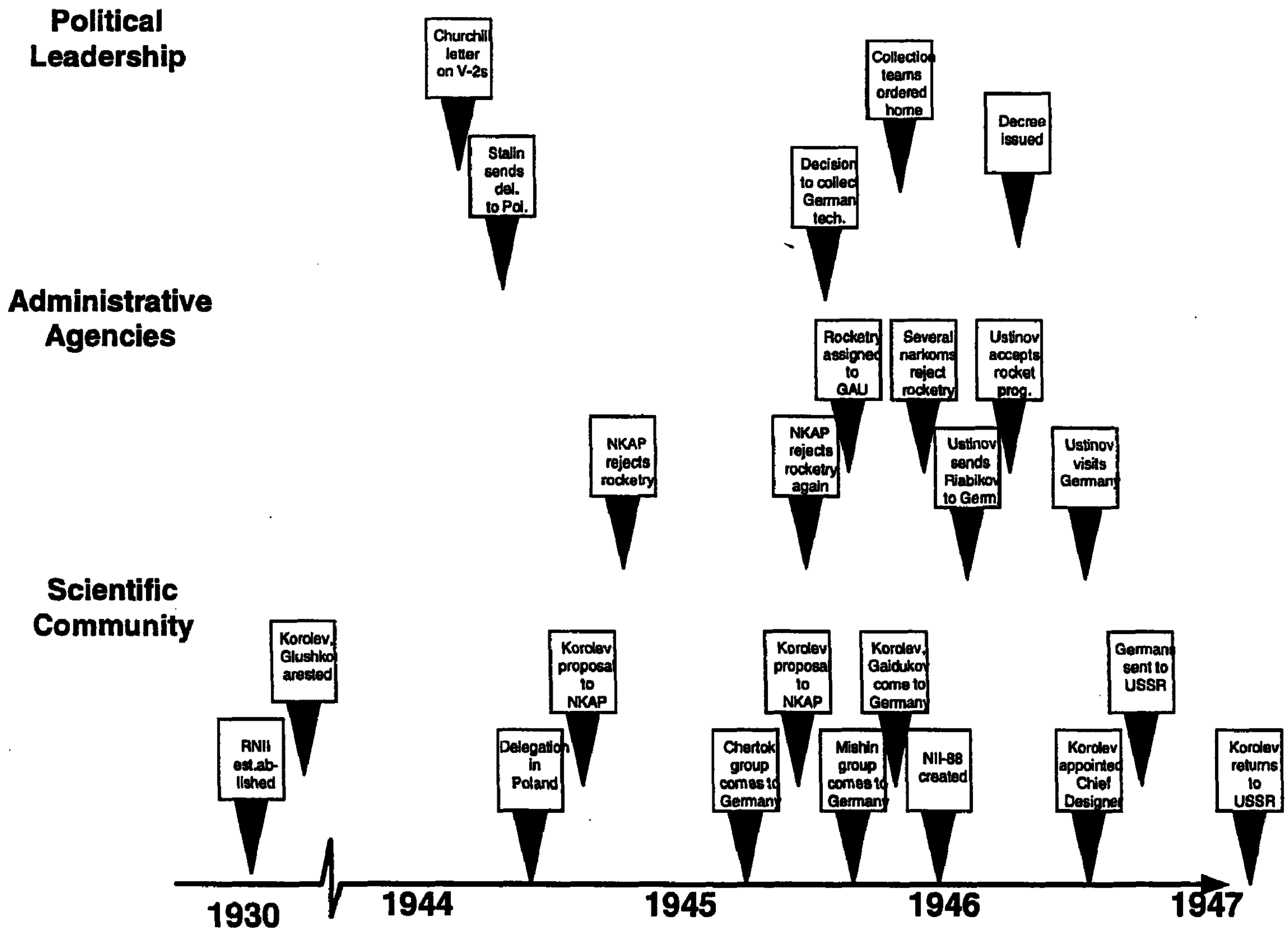

Figure 3.2 –Soviet Missile Research 1920-1947

Figure 3.2 provides a schematic of the Soviet missile program in the years leading up to the May 1946 decision and for a short time thereafter. Activities are divided among the three basic actors considered in this study: the leadership, the administrative agencies, and the scientists. The figure illustrates the early activities of the scientific community and the combined resistance of administrative agencies and the leadership. Repeatedly, both avoided opportunities to initiate a missile program. Despite their resistance, the scientists continued developing an informal program in Germany.

Observations of Scientific Autonomy

Chapter 2 identified observable events which pitted the interests of the scientists and the political leadership against each other. These observations provide a basis for judging the degree of autonomy the scientists achieved from the political leadership. For the phases of the initiation decision and the organizational prehistory, I posited the following observations:

Technological possibilities or new mission origin?

The conceptualization of ballistic missiles was a synthesis of the dreams of Korolev and his cosmic comrades, and the opportunity presented by the German success in design and construction of the V-2. Korolev and Glushko based their concept of rocketry on Tsiolkovskii's notion of rocket-powered planes flying through the stratosphere into space. These were not ballistic missiles. Nevertheless, Korolev recognized the power of the German accomplishment, and that he would have a far better chance selling an already proven idea to the leadership.

It was abundantly clear that the idea for rocketry did not come from the leadership. Repeatedly, Stalin and other Soviet leaders were prodded by rocket scientists, and even by Churchill, with little response. In fact, most of the leadership was directly hostile to the idea of rocketry. There was no evidence indicating that rocketry was originally conceived as a means of delivering atomic weapons to the United States. Korolev's relationship with Ustinov demonstrated the power of controlling the initial drafting process. Ustinov, not understanding what the real obstacles were in rocketry, simply accepted Korolev's word on schedules and performance, allowing Korolev to remain in Germany a year longer than he preferred.

Review and funding schedule

Stalin ensured that the program decision-making would be highly incremental: the initial decision only permitted Korolev to return with German rockets, and to begin constructing test facilities. Korolev did not even have approval for conducting test launches. Such incremental decision-making gave Stalin the ability to redirect the program at any point or to simply close it down. He was not convinced of the efficacy of the program, and used incremental decisions to allow him to control the progress. Intentional or otherwise, incremental decision-making processes guaranteed that the leadership *could* maintain control over at least the growth, if not the direction, of the missile program.

Organizational structure

Once bureaucratic authority over the missile program was established, it was clear that Ustinov would have a vested interest in the successful development of missiles. He saw the missiles as his only opportunity to participate in an important strategic program. Following the war, there was little need for his Narkom to produce more artillery pieces. The problem was that his vision of the program (anti-aircraft missiles) was different from Korolev's. The fact that Ustinov had little choice but to support Korolev contributed to the scientists' autonomy.

Scientists-end user relations

While Korolev was successful at co-opting lower level military officers, he did not enjoy much success with senior military leaders. At best, missiles were a cumbersome new technology they did not want to absorb. At worst, they could prove to be a threat to the artillerists' core technology. But since the military had no role to play until flight testing began, they could not prevent Ustinov from initiating the program. During the early period, therefore, the military leadership was disinterested, and neither attempted to impinge on Korolev's autonomy nor provided support.

Familiarity of monitors with new technologies and missions

The agencies charged with monitoring Korolev's missile programs were completely unfamiliar with both the missions and technologies being developed. Consequently, the leadership and monitoring agencies were forced to rely upon the scientists' assertions regarding costs, schedules, and technological capabilities. Moreover, the military did not understand the basic mission of long-range bombardment. This could cut two ways. the military might be willing to accept Korolev's definition of mission requirements, but it might also impose inappropriate requirements drawn from its own experience. In the ensuing years, the military would adopt the latter approach. Nevertheless, Korolev was able to teach his future administrators the new technologies, and at least argue with them as equals over basic mission definition. Both would prove to be important sources of autonomy.

Scientific autonomy considered

Did Korolev and his scientists have independence from the leadership? In Germany, their independence was clear. They repeatedly contravened Moscow's orders and never suffered retribution. Without such circumventions, the Soviet missile program might never have lifted off the ground. More importantly, this independence permitted the rocket scientists to establish personal connections amongst themselvesr and toestablish their own means of coordination. Similar informal coordination was important to the development of the U.S. atomic bomb[180] and the German V-2.[181]

However, that autonomy was sharply constrained once they returned to Moscow. The political leadership was unconvinced of the efficacy of ballistic missiles, and provided only incremental support. What little support there was from administrative agencies was misdirected. Korolev was placed within an institute which was hostile to his projects. His colleagues from Germany were in five different industrial ministries. He would have to build his autonomy from the ground up, but at least he had a strong informal organizational foundation, established in Germany, from which to build.

Analysis of Opening Phase of Soviet Missile Program

The process by which the missile program began is best described in terms of garbage can decision-making. The basic components of garbage can decision-making were all present: ambiguous lines of authority, lack of consensus over missions or technology, and severe time constraints.[182] Decision-making bounced from one minister to another, from the military to the industrial ministries. The highest ranking member of the leadership involved with rocketry, Georgi Malenkov, was exiled to Kazakhstan during the critical decision-making period. Lines of authority, generally blurred under Stalin,

---

180 See Rhodes, *Making the Atomic Bomb...*

181 See Sharpe ad Ordway, *The Rocket Team...*

182 See Cohen (et al.) "A Garbage Can Model..." March and Olsen, *Ambiguity and Choice...* and Kingdon, *Agendas, Alternatives and Public Policies...*

were particularly confused during Zhdanov's ideological campaigns of the immediate post-war period.

In addition, the leadership did not have a clear understanding of either missions or technologies in the post-war world. By the end of 1946, it was clear that the United States and the Soviet Union would be involved in a strategic competition, but few understood how that competition would be waged. The military leadership assumed it would be conducted on the same terms as WW II. Stalin was concerned that nuclear weapons might change the face of warfare; few others in the leadership gave the matter much consideration. There is no hard evidence to suggests that the leadership had any understanding of how long-range rocketry would evolve in the post-war world. Moreover, the military, political and industrial leadership was completely ignorant of the technology behind rocketry. They were forced to rely upon the judgments of a small group of space enthusiasts.

Gaidukov and Korolev were a solution looking for a problem and a decision-making opportunity during their trip to Moscow in early 1946. That opportunity was forced by Ustinov's realization by that if he did not accept responsibility for the program, he might be implicitly accused by the NKVD of concealing vital information from Stalin. Ustinov did not take the program because he wanted it, he took it because he had to take it.

If the leadership decision-making process can be described in terms of a garbage can, the early organizational structure of the scientists was the beginnings of a stone edifice. The Soviet rocket scientists had developed a common technical ideology decades before they began their work in Germany. In Germany, Korolev and Glushko were able to quickly gain control over technical aspects of the program and almost immediately began building a constituency in the military from the ground up. When they returned to the Soviet Union, they had already established friendships and close working relations with many of the officers who would later be charged with monitoring their activities. Even before they returned to the Soviet Union, there were indications that the military would quickly be co-opted by Korolev at the lower levels. A foundation was established; the task ahead, was to expand that constituency to higher levels.

By the end of 1947, there were no formal administrative agencies capable of dealing with missile technology. The military units established to oversee the scientists in Germany were slow to reconstitute themselves in the Soviet Union. The military leadership had yet to even establish a launch range for the new missiles. Indeed, it was not clear until the spring of 1947 whether or not there would be any launches at all. On the industrial side, although Ustinov had designated Riabikov as his deputy with responsibility for rocketry, it is hard to imagine a man less qualified to monitor the technical progress of a completely new technology. Administrative agencies to oversee the missile program would not be established until the next phase - organizational emergence.

It is obvious that Korolev and his group of scientists established a significant degree of autonomy while in Germany. They used this freedom well and established a closely knit organization. This consensus would be severely tested in the near future, as Korolev built an organizational foundation for his program. His primary problem was building a constituency. While he appeared to have won over Ustinov, he would have significant problems building his constituency within both the military and industrial sides of the Soviet administrative structure. This was a battle he would wage for the next decade.

Whatever challenges that lay ahead, the fact that the missile program survived leadership resistance and disorganization through the period in Germany testifies to Korolev's early autonomy. Without independence, Chertok would have resigned himself to looking for bits of Messerschmidts or V-1s in Germany. Chertok took it upon himself to defy orders form Moscow and work through the local commandánts. However, Korolev, Chertok, and the other rocket scientists could not have done it by themselves. They needed a patron. It was Gaidukov who had the connections within the Central Committee to force a decision on rocketry and who had the authority to unite the various rocket programs in Germany. It was Korolev who was able to quickly win over Gaidukov and spur him on to extraordinary measures. Together, they established the early autonomy of the missile program. Their formal partnership, was however, short lived. Upon his return to Moscow Gaidukov went to the Central Committee, and Korolev took his place in NII-88.

CHAPTER 4

What are you doing?!? You put more than four tons of alcohol in a rocket. If you give my division this alcohol it could take any town. But your rocket could not even hit the town. Who needs it?

Unidentified Red Army Marshal (1948)

1947-1951--ORGANIZATIONAL EMERGENCE

In early 1947, the rocket engineers and their accompanying military personnel returned from Germany to face a series of organizational challenges which threatened the survival of the infant missile program. The May 1946 decree created a skeletal organizational structure for the Soviet missile program which was poorly suited for the development of long-range ballistic missiles (BRDDs). The missile program was assigned to the Ministry of Armaments, which had previously developed nothing more sophisticated than artillery pieces, held little familiarity with missile technology. Within the ministry, BRDDs were an organizational stepchild; the formal structure of the ministry strongly favored the anti-aircraft (ZUR) rockets. The various technological components of the BRDD program were strewn about five industrial ministries, and the Soviet economic system did not provide for an efficient means of coordination across ministerial boundaries. Neither the political nor the military leadership were anxious to support the development of long range ballistic missiles. The Chief Designer of Long Range Ballistic Missiles -- Sergei Korolev -- would be in a constant struggle for survival for the next four years.

Analytic and Substantive Issues

A program's survival is most precarious during the period immediately following initiation.[1] Constituents are skeptical of the value of new technologies. Leadership is reluctant to commit large sums of money to fundamental research with no concrete promise of results. New scientific groups must emerge which are capable of cooperating to develop completely new technologies.

Grim as the picture may be for programmatic innovations under the best of circumstances, the obstacles the path of the Soviet rocket scientists loomed even larger. During the organizational emergence phase, the following issues were of particular salience to Sergei Korolev and the developing Soviet missile program.

[1] This notion draws from Downs' concept of the lifecycle of a bureau. See Anthony Downs, *Inside Bureaucracy*, (Prospect Heights Ill.: Waveland Press, 1994)

Developing a constituency and maintaining information control

In the early phase of institutionalization, no process is more important than developing a constituency for the program.[2] An established agency must develop an interest in a program in order for it to survive. At the same time, the scientists must maintain informational control.[3] They must simultaneously allow their constituent an institutional stake in the program in order to gain support, and preventing the constituent from interfering in the research agenda. It is a delicate balancing act for the leader of a scientific organization. The chief scientist may confront this problem by creating a tightly woven organizational structure, but such a rigid organization will restrict the flexibility to innovate.[4] A more effective structure features informal coordination among a flexible cast of participants.[5] Control over information leaks can be assured by establishing a strong sense of organizational mission.[6]

How did Korolev manage this complex interaction? The key to his strategy was the Council of Chief Designers--an informal organization of the six Chief Designers of the major components of a missile (i.e. engines, launch systems, guidance, telemetry, instrumentation, and vehicle integration), allowing rapid coordination across ministerial

---

[2] See James Q. Wilson, *Bureaucracy*, (New York: Basic Books, 1989); Downs, *Inside Bureaucracy...*

[3] See in particular Arthur L. Stinchcombe, *Information and Organizations*, (Berkeley CA: University of California Press, 1990); and, Jeffrey Pfeffer, *Power in Organizations*, (Cambridge: Ballinger, 1981).

[4] See Tom Burns and T.M. Stalker, *The Management of Innovation*, (London: Tavistock, 1961)

[5] See Donald Chisholm, *Coordination Without Hierarchy: Informal Structures in Multiorganizational Systems*, (Berkeley: University of California Press, 1989).

[6] See Wilson, *Bureaucracy...*

boundaries without interference from administrative officials. Without a formal mandate, the cement holding this group together was a common belief in the basic mission of the organization.

Korolev built a close alliance with his chief administrator, the Minister of Armaments (MV) Dmitry Ustinov. Capitalizing on Ustinov's unfamiliarity with missile technology, Korolev established his own research agenda without Ustinov's interference. To provide further institutional support for his program, Korolev trained and staffed the departments of the MV responsible for the missile program. However, Korolev's relations with the military were much more difficult. Marshal Iakovlev, who was the customer for Korolev's missiles, was openly hostile to his program. Since Iakovlev could not be won, Korolev built his constituency within the military from the ground up, personally selecting and training the future operators and customers for his systems. It was an effective strategy allowing Korolev's program to survive its most precarious stage.

Leadership capacity

The political leadership of a nation also faces difficult choices during the early stages of a technological program's existence. Having made the decision to initiate a program, now the issue becomes how much freedom the scientists should be allowed. The scientists will clamor for unlimited budgets with no state interference. Naturally the political leadership prefers to maintain a close watch on how money is spent, and will insist that its goals be reaffirmed with every step of incremental funding.[7] Does the state jeopardy the success of the program by insisting that it closely conform with its political goals?[8] Does the leadership really understand what those goals are? How does the state find monitors who are both sufficiently expert to understand the new technology, but still independent enough to render critical judgments? All these questions must be addressed by the political leadership if it is to effectively manage new technology developments.

As 1947 dawned, the Soviet political leadership was in the midst of a power struggle over the successor to Stalin. In spite of its preoccupation with internecine conflicts, the Soviet leadership was forced to make pivotal decisions shaping the post WW II world. Domestically, it was faced with the Herculean task of rebuilding a country which had been ravaged by the most destructive war in history. Complicating matters, the political leadership descended into a decision making pattern which isolated it from the rest of government, leaving it without reliable information regarding the risks, costs and benefits of technological and other programs. Decisions were made hastily, without careful analyses of the alternatives. This was not a leadership well suited to initiating and managing new technology programs.

---

[7] See Stephen Peter Rosen, *Winning the Next War: Innovation in the Modern Military*, (Ithaca: Cornell University Press, 1991); and, Howard McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice*, (Baltimore: Johns Hopkins, 1990)

[8] The foremost proponent of the notion that the state could not manage science without restricting science was the President's advisor on science, Vannevar Bush, *Modern Arms and Free Men*, (New York: Simon and Schuster, 1949); see also, Bruno Latour, *Science in Action*, (Cambridge: Harvard, 1987); and, Martin van Crevald, *Technology and War: From 2000 B.C. to the Present*, (New York: Free Press, 1989)

Organizational structure

The assignment of a new program within an administrative bureaucracy has important consequences for the relationship between the scientific community and the state leadership. Several alternatives can be considered. Scientists prefer an autonomous, independent administrative structure with little or no hierarchical control, such as the Manhattan District structure which was so important to the American atomic bomb program. In practice, however, such structures are rare, and limited to high priority programs.

A second alternative is to assign the new program to an agency which is familiar with the technologies. However, a well qualified agency may also have competing interests. Such was the case in the United States when the early ICBM program was assigned to the Air Force. However, the ICBM program was in direct competition with the Air Force strategic bomber program. This seemingly logical assignment delayed the development of missile in the United States for several years following WW II.[9]

A third alternative is that a new program can be assigned to a bureaucracy which has little familiarity with the technology or mission. This arrangement, while it defies conventional bureaucratic wisdom, does afford the scientists the greatest informational

---

[9] See Edmund Beard, *Developing the ICBM: a Study in Bureaucratic Politics,* (New York: Columbia University Press, 1976).

advantages. Consequently, it may provide the best conditions for programmatic survival during the difficult stage or organizational emergence.

Korolev's missile program was placed within an administrative structure which was unfamiliar with the technology also possessed a competing program -- the ZUR. The Ministry of Armaments possessed little understanding of rocket technology. During the period of organizational emergence, there was not a single staff member with any prior knowledge of missiles. Korolev held a complete informational monopoly. He used this monopoly to compete with other programs within the ministry. The original intent of the MV was to concentrate on the development of anti-aircraft (ZUR) missiles. BRDDs were only an ancillary program. However, given the lack of success of the ZUR program and the ***perceived*** success of Korolev's BRDDs, by 1950, the MV narrowed its focus to a single missile program under Korolev. As a result, Ustinov was effectively a captive of Korolev's program. His career, and perhaps his life, was dependent upon Korolev's success. This only increased Korolev's autonomy.

Scientific coordination

In programmatic innovation, scientists are developing new technologies, often requiring combinations of scientific fields which have not worked together before. Given the high technological uncertainty of programmatic innovation, it is impossible to know in advance precisely the combination of talents which will be necessary for programmatic success. Therefore, informal mechanisms of coordination among individual scientific institutes are the most effective form of organization.[10] Rigid hierarchies only serve to fix the final design configuration at a premature stage due to the institutional pressures to include only members of the existing hierarchy.

Though he would have preferred a hierarchical arrangement, Korolev was forced by circumstances to develop informal coordinative mechanisms. The May 1946 decree spread his missile program across five different ministries, and Korolev developed the Council of Chief Designers specifically to deal with this problem. As events turned, the Council proved to be an extraordinarily effective mechanism. It permitted a great deal of organizational flexibility, while sharply limiting the ability of administrative agencies to interfere.

Actors

The phase of organizational emergence is marked by instability in the cast of bureaucratic actors. In the case of the emergence of the Soviet missile program, the instability was even greater than for most programs. While the May 1946 decision defined the organization of the Soviet missile program, it created more questions than answers. The program was assigned to the Ministry of Armaments and the Artillery troops of the

---

[10] See Chisholm, *Coordination Without Hierarchy...*

Ministry of Defense. How would those agencies manage a program that was so unfamiliar to them? By the same token, the decision defined the lead agency as NII-88, but it did little to resolve the question of how missiles would be produced given the fact that most of the subcontractors were located in different ministries. The only area of apparent certainty was at the level of government leadership. Stalin was in firm control of the nation, and would remain so until he died.

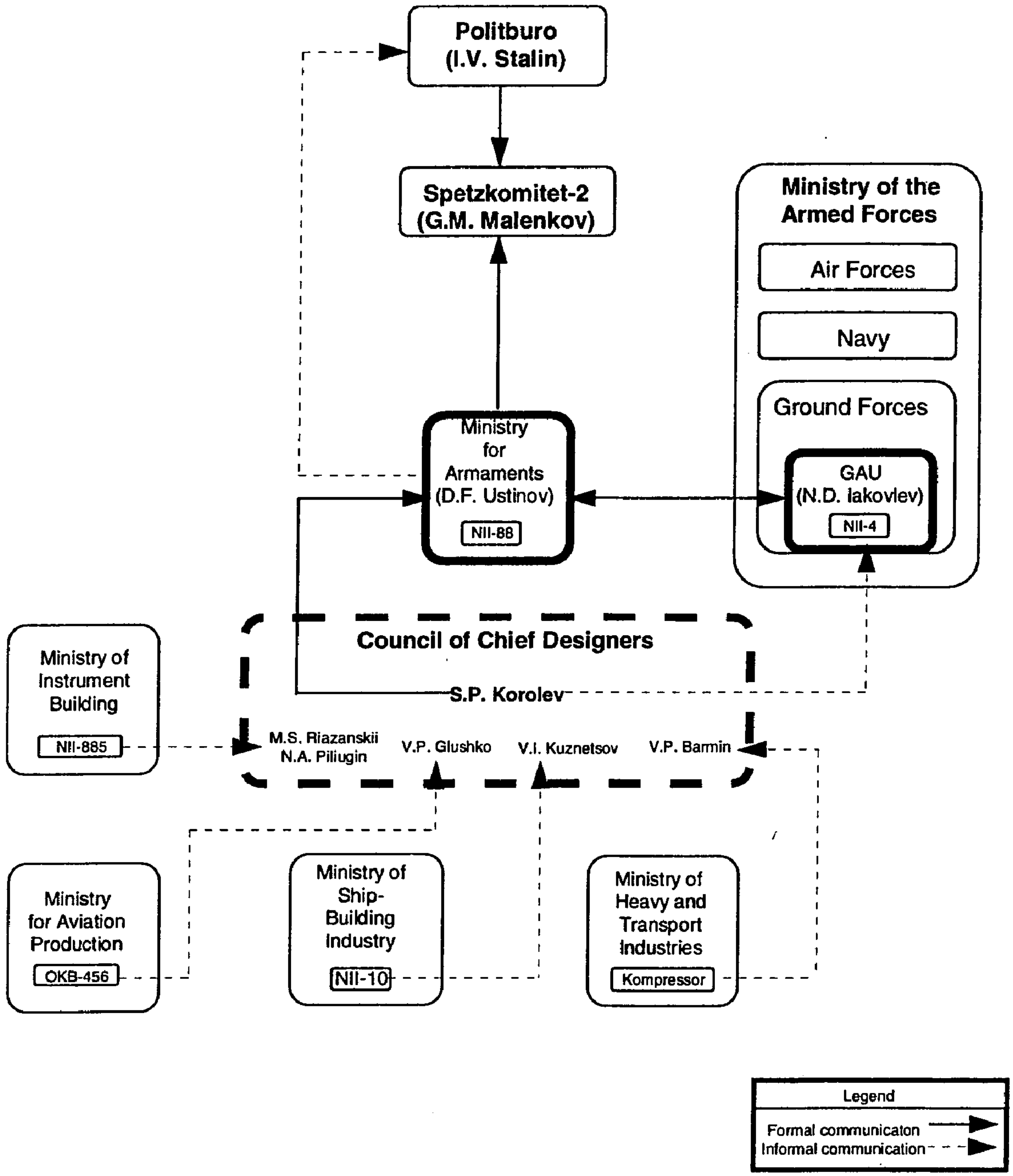

Figure 4.1 -- The Organization of the Soviet Missile Program in 1950

The basic organizational structure as it existed in 1950 is depicted in figure 4.1. The most important point illustrated in this diagram is the difference between formal and informal channels. Formally, the program was under the direction of Georgi Malenkov, a leading member of the Politburo, who headed *Spetzkomitet-2* (Special Committee-2). In practice, Malenkov was seldom involved. Dmitry Ustinov, the Minister of Armaments, had informal channels of communication with Stalin which circumvented Malenkov. Similarly, the Council of Chief Designers itself was an informal structure. Formally, the institutes were completely separate. Informal coordination between Korolev and the military at NII-4 served to build his constituency in the military from the ground up.

Stalin was seemingly capable of exercising complete control over administrative affairs in the Soviet Union from 1944 to 1953. His decision on any issue was final. Through the widespread use of terror, he ostensibly maintained a high level of compliance from his administrators. "Sabotage," or the failure to implement CPSU policies, was the crime for which many R&D managers were shot during the purges of the late 1930s.[11] Perceived omnipresence of the secret police created the impression that Stalin was capable of knowing everything. Therefore, once Stalin made a decision, there was a high perceived cost associated with failure to faithfully implement that policy.

---

[11] See Kendall Bailes, *Technology and Society Under Lenin and Stalin: Origins of the Soviet Technical Intellgensia, 1917-1941*, (Princeton: Princeton University Press, 1978)

However, the gap between potential and actual control was great during the post WW II Soviet Union.[12] Because of the tremendous concentration of authority in the hands of a single individual, Stalin's ability to control the Soviet Union as a whole was severely circumscribed.[13] Therefore, question becomes one of how decision making was actually performed and policies actually monitored under Stalin. Which programs really received his attention? In the post war years, Stalin's ability to manage affairs was compromised by his ever decreasing attention span. As Stalin aged, and became increasingly incapable of managing such a large bureaucracy, the government settled into a sort of political paralysis. Hough and Fainsod note that "there were very few striking policy innovations taken in these years, and in one policy area after another, one gains the clear impression of petrifaction."[14]

In 1947, there were only hollow administrative agencies for monitoring and managing the development of missiles. By the end of 1954, both the Ministry of Armaments (MV) and Ministry of the Armed Forces (MVS) had their own research institutes as well as a variety of administrative organizations to monitor missile development. A directorate for the missile program was formed within the MV (the 7th Directorate) under the direction of Sergei Vetoshkin. During the period from 1949 to 1953, it was staffed primarily by engineers trained by Korolev. Within the MVS, missile

---

[12] See Timothy Dunmore, *Soviet Politics 1945-53*, (London: Macmillan, 1984).

[13] This is Downs' "Law of Diminishing Control" See Downs, *Inside Bureaucracy...*

[14] See Jerry Hough and Merle Fainsod, *How the Soviet Union is Governed*,(Cambridge: Harvard University Press, 1979, p. 363.

programs were assigned to the Main Artillery Directorate (GAU) under Marshal N.D. Iakovlev. General Ivan Nestorenko was put in charge of a research institute (NII-4) created in 1947 with specific responsibility for monitoring the development of ballistic and ZUR missile programs. During the time that the German rocket scientists were involved, the secret police (NKVD) supervised some aspects of the program.

However, two factors diminished the ability of these organizations to act in the interests of the political leadership. First, the administrative agencies and institutes were populated with personnel who had developed far closer working ties to Korolev than they had developed with the leadership. Most of the personnel of these organizations owed their position to Korolev. Second, with the exception of the NKVD, there were no administrative agencies which supervised more than one of the strategic delivery programs. The primary task of the monitoring agencies was to ensure that Korolev's projects were successful, not to provide accurate information to the leadership regarding the progress of various alternatives. In fact, it was in their interest to distort information regarding the likely success of their programs. Thus, the administrative agencies developed interests which were consistent with those of the scientists, but at odds with those of the political leadership.

In formal bureaucratic terms, the scientists' position was improved relative to their position prior to the decision in May 1946 establishing the missile program. Informally they were in a more difficult position. Their program was divided among five industrial ministries, and their leader, Korolev, was only the head of a secondary department within an institute poorly qualified to execute his program. To deal with the bureaucratic atomization of his program, Korolev created a new organizational mechanism, the Council of Chief Designers, which permitted informal coordination among scientists in different ministries without the participation of ministerial officials. The key members of the Council were Sergei Korolev--Chief Designer of BRDDs; Valentin Glushko--Chief Designer of rocket engines; Viktor Kuznestov--Chief Designer of instrumentation; Nikolai Piliugin--Chief Designer of inertial guidance systems; Mikhail Riazanskii--Chief Designer of radio control and telemetry systems; and Vladimir Barmin--Chief Designer of launch structures. Through the Council, the scientists institutionalized the decentralization of decision-making for the Soviet rocket program. This was their primary tool in their struggle for autonomy.

THE STRUCTURE OF NII-88

While Korolev and many of the other rocketeers were still working in Germany, decisions were being made at lower administrative levels in Moscow regarding the future organizational structure of missile production. However, without a clear institutional sponsor, the process of organizing the program proceeded in fits and starts. On

November 30, 1945, the Narkom for Armaments issued a decree designating a department of Plant-88 as the location for the development of the missile program.[15] But while Ustinov had yet to accept permanent responsibility for the missile program, the decree at least provided Korolev's trains with a destination on their trip from Germany in February 1947.

In November 1945, Plant-88 was not much more than a destination. Ironically, the plant had been built with the assistance of German armaments specialists in the late 1920's. At the beginning of WW II, Plant-88 was one of the more qualified facilities, but as the German army approached Moscow, the equipment at the facility was evacuated to the Ural mountains. Only the most antiquated equipment remained. During the war, the plant was basically unused. Although engineers and workers returned to the half-empty halls of the facility toward the end of the war, there were no plans to return the evacuated equipment from the Urals.[16] In fact, in 1944, the facility was included on a list of enterprises to be converted completely to civilian production for the purpose of producing drilling rigs.[17]

---

[15]A history published by the successor to NII-88 noted that the institute was established by a decree from the Ministry of Armaments. However, other sources note that Ustinov did not accept responsibility for the program until May. It is possible, nevertheless, that the Ministry did provide the decree while deferring the question of long term responsibility. See *Progress,* May 23, 1991 p. 1.

[16]See Vetrov, *Secrets of Gorodomliia...* p.41.

[17]See *Progress: gazeta tsentral'nogo nauchno-issledovatel'skogo instituta mashinostroeniia,* May 23, 1991, p. 1.

From November 1945 until August 1946, the Plant existed in a state of bureaucratic limbo. It had been tentatively designated as a recipient for German rocket technology, but there had been virtually no change in the organizational structure and had received no additional equipment. Ustinov had yet to accept responsibility for the missile program. The May 13 Politburo decree renamed Plant-88 as NII-88, and designated it as the lead organization for missile technology. Even though the director (A.D. Kalistratov) announced on May 25 that there would substantial organizational changes, the NII remained in limbo for another three months.

On August 15, the changes began. Kalistratov was replaced by Major General of Artillery L.R. Gonar. From that point on, reorganization proceeded at a rapid pace. Although still in Germany, Iu. A. Pobedonostsev had already been named by Ustinov as Chief Engineer (the First Deputy Director). S.P. Korolev was named as Chief Designer of Long-Range Ballistic Missiles (BRDD) and head of design bureau number 3 (OKB-3) E.V. Sinel'shikov was named as the Chief Designer of anti-aircraft rockets (ZUR) and head of OKB-1 on August 9, 1946. On August 30, Gonar appointed K.I. Tritko as the head of the Central Design Bureau.[18] In September, functional departments were created for materials and fuel. A section for guidance was created under Chertok upon his return in late 1946.

---

[18] Tritko worked as Gonar's deputy at the Barikady factory in Stalingrad.

By the time Korolev and the remaining rocket specialists arrived from Germany in February 1947, the organizational outlines of NII-88 were established. The leadership of NII-88 consisted of Lev Gonar, as Director, K.I. Tritko as Chief Designer of the Central Design Bureau (TsKB), and Iu.a. Pobedonotsev as the Chief Engineer. Of the three, Pobedonotsev was the only member of the NII's leadership who had a substantial background in rocketry. He had worked with Korolev and Glushko as far back as 1932. Since that time however, he had concentrated on small, unguided, solid fueled rockets such as the *Katiusha.* He did not have experience with larger, liquid-fueled missiles, which were to be the basic line of research for NII-88. Gonar and Tritko had even less background in rocketry, having been the Director and Chief Engineer respectively of the *Barikadi* artillery plant, which was destroyed in the Battle of Stalingrad.[19]

---

[19] See. *Progress...* The *Tsentral'nyi Nauchno-Issledovatel'skii Institut Mashinostroeniia* was earlier named NII-88.

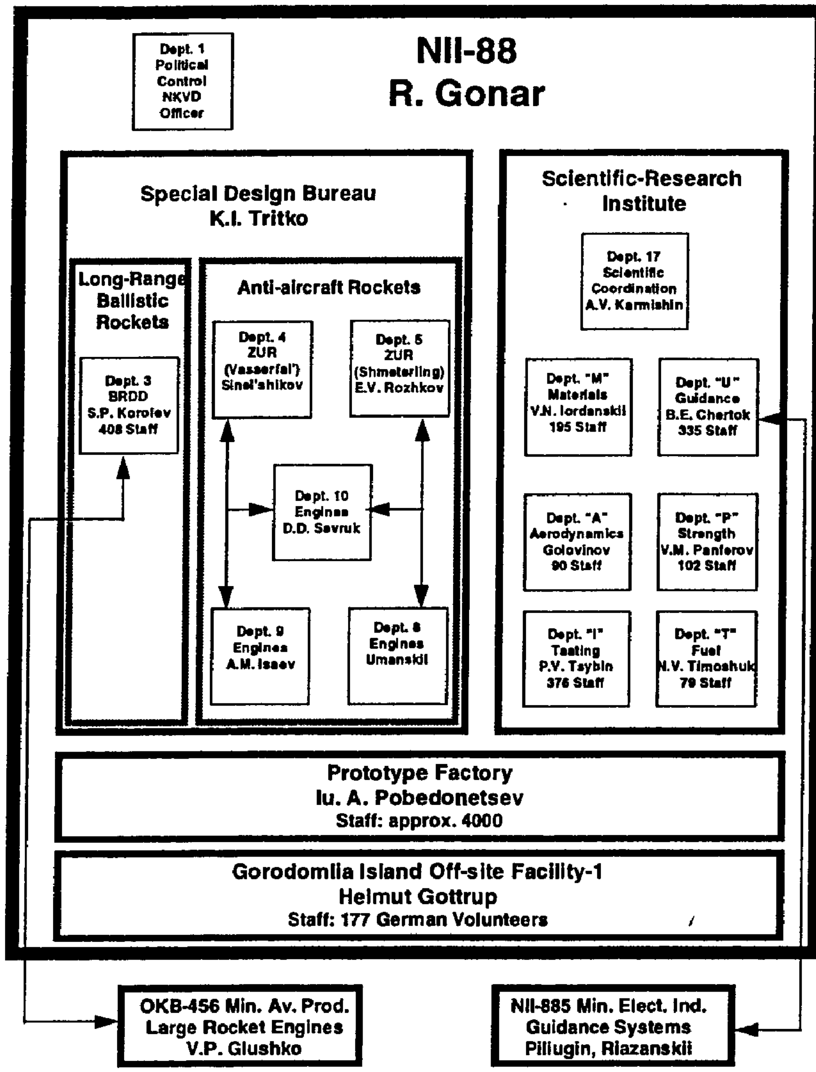

Figure 4.2 -- The Structure of NII-88 in 1947[20]

Although the factory was by far the largest structure within NII-88, it did not fit well within the future plans of the facility. Production of drilling equipment would be

[20] Sources: *Progress:...*; Vetrov, *Sekrety Ostrova Gorodomliia...;* and, Iu. A. Mozhorrin, "Tsentral'nye nauchno-issledovatel'skii institute..."

halted and the factory was to be retooled in order to support the scientific and engineering activities of the other two sections. The staff of the factory was an order of magnitude larger than it needed to be. Moreover, by the end of 1946, there was still no new equipment. After the specialists returned form Germany, the equipment deficit was critical. Heaters didn't work, the roof leaked, and workers pleaded with local CPSU officials for capital improvements so that they might "at least begin to work a little."[21] Social conditions were perhaps worse. There were shortages of everything bread, housing, water.[22] Boris Chertok described his impressions of the future home of the missile program:

> Frankly speaking, when we first arrived in Podlipki and saw the future rocket factory, we were horrified. Dirt, primitive equipment, one could even say it was pillaged. By comparison with the aviation industry from which we came, it appeared to us to be from the troglodyte era.[23]

These were not the conditions one would expect of the highest priority state sector. Nevertheless, the majority of the workforce remained in the factory and continued to produce drilling rigs at a huge deficit of 21 million rubles for 1946. At the end of 1946, however, 1832 of the factory workers were reassigned to other facilities.[24] In early 1947, the remaining workers stood idle, without a plan for the coming year.

---

[21]As quoted from Moscow Party Archives in Vetrov, *Sekrety Ostrova Gorodomliia*... p.43.

[22]See *Sekrety Ostrova Gorodomliia*... p.43.

[23] See Chertok, *Raketi i Liudi*... p. 186.

[24]See *Progress...*; and Vetrov, *Sekrety Ostrova Gorodomliia*... p.42.

The creative center of the facility was the Central Design Bureau. Although there are no available records of the total staff of the TsKB, Korolev's Department 3 had a staff of 87 in early 1947. Since it was significantly smaller than Sinel'shikov's department, but probably larger than others, the overall staff of the TsKB was probably between 400 and 500.[25] As originally formed in 1946, it contained six separate design departments. Five of these were dedicated to design and production of *zenit* missiles. The remaining department, under Korolev, was dedicated to development of BRDDs. Tritko and Gonar centralized all decision-making within the TsKB, and Korolev's work on long range missiles considered as secondary to anti-aircraft missiles. As a result, Korolev's department was be somewhat isolated from the rest of the TsKB. This isolation only encouraged Korolev to work more closely with his colleagues from other organizations.

The third structure within NII-88 was a series of functionally oriented laboratories; intended to support the activities of the TsKB. Initially, there were only three laboratories, for fuel (Department T), metallurgy (Department M), and guidance (Department U), with 183 scientists, engineers, and technicians divided among them. The work of these laboratories was coordinated through A.V. Karmishin.

The initial structure of NII-88 was primarily directed toward the design and production of three German anti-aircraft missiles. The simplest of these was the *Taifun*, a

---

[25] Viktor Kazanskii reported that Sinel'shikov's design bureau occupied two floors of the main building while Korolev had only one. See "Viktor Vasil'evich Kazanskii," in *Dorogi v Kosmos,... V. 1.* p. 73. Another historical account of the origins of NII-88 noted that in 1947 Korolev's department had a staff of 87. See *Progress...* p. 1.

small 9 kg. unguided liquid-fueled missile. This project was placed under the control of P.I. Kostin. The *Shmeterling*, a 2.5m guided missile, was initially under Rashkov, and after 1948 under E.V. Rozhkov.[26] By far, the most sophisticated ZUR project was the *Vasserfal*, under E.V. Sinel'shikov. The *Vasserfal* was 7.45 meters long, using two ground based radars for guidance and was designed to be capable of intercepting an aircraft traveling at 865 km/hr at an altitude of 20 km and a distance of 50 km. The missile used hypergolic fuel components (which ignited on contact with each other) and could be stored in the missile for long periods of time. While the Germans never made this system fully operational, it was clear to Stalin and the military leadership that it could fill the requirement for a system to defend against American bombers. In the initial years, most of the resources of NII-88 were directed at completion of this project.[27]

In contrast, resources for the BRDD were largely located outside NII-88. Although there were two engine design groups within NII-88, neither was assigned to BRDD work. Instead, Korolev worked with his long-time colleague V.P. Glushko, who headed OKB-456 within the Ministry for Aviation Production. Similarly, Korolev worked with organizations outside the Ministry of Armaments for guidance and instrumentation, although there were also departments dedicated to these activities within the NII. However, the fact that Korolev had to go outside the institute for support may have

---

[26]The Schmeterling used a rather strange maneuvering system consisting of plates which would extend, creating aerodynamic drag on one side causing the rocket to turn (hopefully) in the appropriate direction. See "Viktor Vasil'evich Kazanskii," in *Dorogi v Kosmos,... V. 1.* p. 73.

[27] Interview with Mishin.

proved to be a blessing rather than a curse. It enabled Korolev to create the Council of Chief Designers, which ultimately proved pivotal to the success of the ballistic missile program.

Centralization of decision-making with the Central Design Bureau was another source of difficulty. Even before Korolev's arrival, there were debates between Tritko and Korolev's deputy, Mishin, over staffing, equipment, and research directions. Relations with administrators outside the design bureau were also problematic. Aside from Ustinov, the administrators appreciated neither the importance nor the difficulties associated with design and construction of BRDDs.[28]

The organizational arrangement foisted upon Korolev's group can be explained in large part by the fact that most of the decisions were made at a time when Korolev and the vast majority of rocketeers were still in Germany. During 1946, the organizational structure of the future home of the rocketeers was decided by Ustinov, the few remaining missile specialists (primarily Sinel'shikov) and the future Director General of Artillery, Lev Gonar. Only V.P. Mishin returned from Germany to assist with organizational issues in September 1946. Mishin's participation was limited to definitions of the organizational structure within NII-88. A qualified engineer, Mishin was not the organizational genius that Korolev was.[29] Thus, by the time Korolev arrived in February 1947, he was

---

[28]Interview with Mishin and *Secrets of Gorodomliia...* p.43.

[29]Mishin's lack of organizational acumen was amply demonstrated after Korolev's death. After failing to complete the Soviet lunar program, Mishin was among the very few soviet Chief Designers to ever be relieved of his duties in the prime of his career.

presented with an organizational scheme which was not conducive to development of BRDDs. His program was clearly secondary to the zenit missiles. It was an organizational *fait acompli.*

Nevertheless, Korolev returned from Germany with a great many bureaucratic tools of his own. Ironically, one of these tools was the group of 177 German rocket scientist. Most of the scientists were engineers who had worked on the V-2 program. There was only one small group of less than twenty engineers who had worked on either the *Wasserfal, Taifun,* or *Shmeterling*. Furthermore, the only "first class" German scientist was Helmut Gottrup, who was familiar with only with the V-2 program. There was no corresponding group recruited for the Zenit missile programs.[30]

The main reason for the dearth of German anti-aircraft rocket scientists was that Soviet leadership interest in German rocketry did not become organized until August 1945. By that time, most of the leading German scientists had left for the United States. Furthermore, the official Soviet effort at recruitment was a mass effort, bringing 5,500 German specialists, from a variety of military and non-military disciplines, to the Soviet Union within the a few weeks. The problems of coordinating such an effort and implementing specific instructions were enormous. It is hardly surprising that anti-aircraft scientists fell were overlooked. In any case, there was clearly a disconnection between interests in Moscow and implementation in Germany. The recruitment which did occur

[30]See *The Rocket Team...*

was unofficially organized by Boris Chertok, who freely admits he was totally captivated by the German V-2 program and had little interest in anti-aircraft systems.[31] In this sense, the Russians were fortunate to get the 177 German rocket scientists they did manage to recruit.

Organizational Structure

Korolev arrived in the Moscow suburb called Podlipki to an organizational disaster. He was buried beneath an organizational hierarchy which was not receptive to his program. Moreover, it was a hierarchy with which he had to interact on a daily basis. His rocket team was now strewn about five different industrial ministries. The German workforce he had carefully trained was mistrusted by the leadership of the institute, and there were few technically qualified workers at the new facility.

On the other hand, Korolev did have a powerful set of organizational resources which he had developed not only in Germany, but in the years preceding the war and even during the war. Most importantly, he had a closely knit group of scientists who believed in his program. This organizational consensus was strengthened by the support of junior military officers who shared Korolev's vision.[32] He also held a virtual monopoly over

---

[31] Interview with Chertok.

[32] See Pfeffer, *Power in Organizations...*

technical expertise, as long as he kept the Germans under his control.[33] What remained to be seen was whether Korolev could utilize these resources to overcome the obstacles placed before him.

THE APRIL-MAY 1947 DECISIONS

The May 1946 decision to initiate a missile program merely set forth the organizational structure and authorized the transportation of German missile components to the Ministry of Armaments. It provided for no programmatic development. That was left to subsequent decisions. The first of these came in the spring of 1947.

Before they arrived at their assigned institutes, the military and civilian rocket specialists participated in a two week conference in late January and early February 1947 to prepare a plan for the further development of long range missiles. Korolev authored the final report, which was completed in February. The plan included:

1. testing the German V-2s,
2. developing a Soviet analogue, the R-1,
3. developing an improved version of the R-1, the R-2, with a range of 600 km, and,
4. developing the R-3 with a range of 3000 km.[34]

---

[33] See Stinchcombe, *Information and Organizations...*; and, Pfeffer, *Power in Organizations...*

Korolev's plan was ambitious. He was calling for no less than development of an entirely new industry. More detailed near-term proposals were also listed which delineated the transition from stage one to stage two of the above list. Thus, Korolev was simultaneously presenting an enticing vision of the future in which these weapons could be used against the likely Soviet adversaries in the West (setting aside for the moment the fact that the 3,000 km R-3 could not get close to America), ***and*** presenting an incremental plan for accomplishing this goal. It was a necessary tactic. Korolev required a means for generating leadership interest in missiles. At the time, the future of the long range missile program remained very much in doubt, as it had not yet been decided that the V-2s collected from Germany would be tested in Russia.[35]

The plan also demonstrated Korolev's informational monopoly. He had done considerable work on the R-1, which was an exact copy of the V-2, as well as the R-2, which involved improvements to the V-2. The R-3, however, was a complete fiction. The military members of the commission were duped by Korolev's assertion that this missile would be the next logical step. In reality, Korolev never intended to build this missile. Listing the R-3 was intended to demonstrate to the leadership that there was a future in missiles.[36] For the next four years, Korolev would use this project not only as a means for

---

[34] See *Sekrety Ostrova Gorodomliia...* p. 57.

[35] S.P. Korolev, "Zametki po raketnoi tekhnike," 1947, NPO Energiia Archives. I am indebted to Georgi Vetrov for making this document available to me.

[36] See Iaroslav Golovanov, *Korolev: Fakty i Mify*, (Moscow: Nauka, 1994) pp. 421-422.

maintaining the interest of the military and industrial leadership, but also as an umbrella project for pursuing a variety of research directions.[37]

Korolev and his group had to wait for two months before a meeting with Stalin and the military leadership could be arranged. On April 14, 1947, Stalin called a meeting of the leading figures associated with Soviet missiles to review the proposals. Accounts of this meeting vary, but there is general agreement that this was a large meeting including several dozen officials, scientists, and military officers.[38] However, little was decided at this meeting. It was apparently designed to serve as an official opening for the missile program, giving the participants an opportunity to become familiar with each other. A more serious meeting took place ten days later.

The Presidium of the Scientific-Technological and Academic Council of the Ministry of Armaments met on April 25, 1947. At this meeting, Korolev defended his second BRDD design--the R-2.[39] The outcome was never in doubt. Of the 22 members of the Scientific Technical Council (NTS), 8 worked directly for Korolev, and two others, Iuri Pobedonestsev and Mikhail Tikhonravov, worked with Korolev since the early 1930s

---

[37] Interviews with Mishin, Maksimov, and Chertok.

[38] The accounts of this meeting vary widely. Romanov and Gubarev asserted that Korolev met personally with Stalin. See Romanov and Gubarev, *Konstruktori...* p. 62; Tolubko, a biography of the military officer who would later become the Chief of the Rocket forces, asserted that Nedelin played a leading role. See V. Tolubko, *Nedelin: Pervyi Glavkom Strategicheskikh,* (Moscow: Molodaia Gvardiia, 1979) p. 47. Daniloff asserted that there were actually two meetings. See Nicholas Daniloff, *The Kremlin and the Kosmos,* (New York: Alfred A. Knopff, 1972). Golovanov considers these accounts and used several interviews to conclude that these accounts could not be true. My own interviews with Mishin support Golovanov's assertion. See Golovanov, *Korolev...* pp. 391-394.

[39]See B.V. Raushenbakh, *Iz Istorii Sovetskoi Kosmonavtiki,* (Moscow: Nauka, 1986), p. 226.

and were very sympathetic to Korolev's plans.[40] Ustinov's representative, E.A. Satel', and the director of the NII, Robert Gonar, did not have commitments to Korolev, but were probably inclined to support his proposal. Therefore, Korolev could count on the support of at least 10 of the 22 members. The remaining members were primarily came from the sections of the NII working on anti-aircraft missiles.[41] Their support was probably tepid at best. At worst, they saw Korolev as a competitor.

Korolev had been working on the design of the R-2 since shortly after arriving in Germany. Although the missile had a slightly larger diameter, and was more than 3 meters longer, it was basically a refinement of the V-2. The major innovation was that the warhead would separate from the rest of the missile during mid course. This solved many problems of accuracy and allowed the entire vehicle to be significantly lighter because it would not have to absorb the thermal loads of re-entry. The range was increased to approximately 600 km. Although there were some serious technical shortcomings with the design proposed at the NTS, Korolev's proposal sailed through without dissent. The project was approved for full-scale development.[42]

However, Stalin refused to approve the R-2's development. When this decision came down a month later in May, Korolev was disheartened to learn that the Soviet leader

---

[40] Both Tikhonravov and Pobedonostsev worked with Korolev at GIRD and RNII. They were clearly part of the original rocket team. In fact, upon his return to Moscow from prison, Tikhonravov was among the first people with whom Korolev met.

[41] List of members in NII-88 NTS comes from a display at the TsNIIMash museum.

[42] See Vetrov, *Sekrety Ostrova Gorodomliia...* pp. 57-66

would not even approve development of the indigenous version of the V-2 (the R-1). He would only allow the 11 fully intact V-2s, which Korolev collected in Germany, to be test launched at the newly created testing range at Kapustin Iar.[43] Stalin did not wish to commit to an expensive production program without first seeing the German missiles perform.

The issue of the missile program not a priority on the leadership's agenda. Events in Moscow during March and April 1947 were dominated by a conference of the foreign ministers of the victorious nations. The German issue was in the forefront of the Soviet leader's mind. Stalin kept close track of the conference and participated in several bilateral meetings with the attending delegations. In the end, the conference proved unproductive and served only to cement Stalin's impression that the Soviet Union would be forced to stand alone in the post-war world. American leaders had also lost their patience with negotiation. The conference ended with the Western allies pursuing their own course regarding Germany, and, for that matter, the rest of the world, leaving the Soviets to react as they might. The Americans were absolutely convinced of Soviet military and economic weakness, and believed that this gave them the opportunity to consolidate the Western position in Europe and Asia.[44] Secretary of State George Marshall resumed arms shipments to Chaing Kai Shek to oppose potential Soviet influence in China in March and April. In May 1947, the State department announced that aid to

---

[43] See *Sekrety Ostrova Gorodomliia...*, pp. 57-66.

[44] See Leffler, *Truman*...pp. 153-155.

nations "would be predicated on the exclusion of Communist from government."[45] The Marshall plan was announced in early June. Soviet leaders were disturbed to learn that their expansionist plans were being opposed on virtually all fronts. The extraordinary opportunities presented by the Soviet victory in WW II seemed to be slipping from their grasp. It was a time for serious consideration of future Soviet foreign policy options.[46]

Garbage-Can Decision-Making and Incremental Approval

If Korolev held any illusions regarding Stalin's interest in missiles, they were dashed by the May 1947 decision. Apparently influenced by skeptics within the military, Stalin did not regard missiles as the weapons of the future. For the next seven years, the vast majority of Stalin's Generals regarded missiles as a wasteful diversion. On the other hand, it is not clear that Stalin was making a rational decision regarding the missile program.[47] Given the leadership style, and the heavy decision making load, it appears that the missile program survived through classic "garbage can" decision making processes.[48]

---

[45] *Ibid.* p. 158.

[46] See Adam Ulam, *Expansion and Coexistence,* (New York: Praeger, 1974) p 440.

[47] Rosen, for example, might argue that Stalin was pursuing a rational course of action by developing the technology as far as possible without committing major funds to an inflexible project. See Stephen Peter Rosen, *Winning the Next War: Innovation in the Modern Military,* (Ithaca: Cornell University Press, 1991)

[48] See Michael D. Cohen, James G. March and Johan P. Olsen, "A Garbage Can Model of Organizational Choice," *Administrative Sciences Quarterly,* Vol. 17 (1972) pp. 1-25; James G. March and Johan P. Olsen (eds.), *Ambiguity and Choice in Organizations,* (Bergen Norway: Universitetsforlaget, 1976); and James G. March and Roger Weissinger-Baylon, *Ambiguity and*

Stalin had little time to understand the technology involved in the missile program, and there is no indication that he regarded the program as a means of delivering atomic warheads to the United States at this early stage. He did understand the politics of the decision -- on instinct alone. His decision to let the rocketeers take their train to Kapustin Iar was essentially a non-decision designed to offend the fewest. On one side he had the skeptical generals, while on the other was Ustinov, whom Stalin looked upon favorably.

Korolev and Ustinov attempted to present the missile program to Stalin as a large scale program involving simultaneous development of several missiles that would ultimately require development of an entirely new industry, test ranges, troop reorganizations, etc.[49] Stalin's response was to decompose Korolev's program into its smallest components. By authorizing only test launches of existing missiles, Stalin needed only to deploy a small contingent of troops to a remote part of the Soviet steppe (Kapustin Iar). There was no requirement to begin construction of a permanent test range. Korolev's only solace came in knowing that he now had the camel's nose under the tent.[50] Getting the entire beast admitted would prove much more difficult, but Korolev had developed an incremental strategy for advancing his program once he received approval for his first step.[51]

Command: Organizational Perspectives on Military Decision Making, (Marshfield MA: Pitman Publishing, 1986).

[49] See Paul R. Schulman, *Large Scale Policymaking,* (New York, Elsevier, 1980).

[50] See Aaron Wildavsky, *The Politics of Budgetary Processes,* (Boston: Little Brown, 1964).

[51] On incremental strategies, their strengths and limitations see McCurdy, *The Space Station Decision...*

TESTING THE V-2 AT KAPUSTIN IAR

The German V-2 underwent extensive testing during the summer of 1947: electrical systems were tested, engines were fired in test stands, and the overall missile structure was tested for strength. Finally, in August, the missiles were loaded aboard the "Special Train" and they began the journey to the State Central Test Range (GTsP) at Kakpustin Iar on the lower Volga in southern Russia. In 1947, the GTsP was little more than a collection of clay huts for officers, and tents for enlisted men. All equipment for testing and launching of the captured V-2s was contained within the "special trains." With the arrival of Korolev's train, there were now two at the test range. A contingent of junior military officers had arrived in their train a few months earlier.[52]

A high level State Commission was formulated to oversee flight testing, consisting of: Chief Marshal of Artillery Iakovlev as the chairman, and Dmitry Ustinov as the deputy. Another member was Beriia's deputy, Ivan Serov, who was sent because of his role in the German collection effort.[53] The rest of the commission was split evenly between representatives of the Ministry of the Armed Forces (MVS) and the Ministry of Armaments (MV). Korolev served as technical director, with the remaining Chief designers as the technical staff of the Commission. The technicians working at Kapustin Iar were primarily military personnel, but the management of the project was formally

---

[52] See Golovanov, *Korolev...*; and, Chertok, *Raketi i Liudi...*

[53] See Chertok, *Raketi i Liudi...*

divided between the Ministry of the Armed Forces and the Ministry of Armaments. Korolev's deputy, L.A. Voskressenskii, served as technical manager from the MV, and Engineer-Major Ia.I. Tregub was the launch commander from the military side.

Throughout October, the launch site was prepared for the flight test program. On October 18, the first V-2 rose from Russian soil and flew out of sight. Initial celebrations were short lived, however, as the missile fell 70 km short of the mark and 30 km to the left. The State Commission did not judge the flight to be successful. The ensuing meeting of the Commission was not short on solutions. Serov's experience with the secret police led him to take charge and solve the problem in the well practiced fashion of the NKVD, announcing to the rocket engineers that "You have shown us that the rocket can land on Saratov. I don't need to tell you, you can figure out for yourself, what will happen with all of you [if this occurs]."[54] Korolev pointed out that Saratov was several hundred kilometers beyond the range of the V-2. Nevertheless, Serov made his point. Ustinov, protecting his engineers, turned to the two representatives of the German rocket team and suggested: "It's your rocket, your instruments, fix them. Our specialists do not understand why it flew so far off course."[55] This approach proved more productive. The German scientists Magnus and Hoch discovered that an amplifier was creating distortion in the gyroscope and corrected the problem with a filter. Ustinov rewarded them with a prize of 15,000 rubles and a bottle of vodka each.

---

[54] As quoted in Chertok, *Raketi i Liudi...* p. 192.
[55] *Ibid.*

Eleven launches took place between October 18 and November 13. The flight test program concluded with two successful flights on the same day. However, only five missiles landed within the 1 km target radius. At the conclusion of the test series, a group of 20 specialists was formed to analyze and report on the results. The membership of this group consisted almost entirely of junior engineers, most of whom had been working together since late 1945 under Korolev's direction.[56] The committee reported that only 5 of 11 launches achieved their objectives, but that the fault was due to problems with the German construction of the missile.[57]

Following the tests, Korolev and the other Chief Designers returned to their respective institutes. Within a few weeks, a high-level delegation of industrial and military leaders was sent to visit NII-88 to judge for themselves the potential of this new technology. The delegation included the most illustrious Marshals from the Red Army victory over Germany: Zhukov, Rokossovskii, Meretskovii and Malinovskii. Serov represented the NKVD. As the Minister of Armaments, Ustinov chaired the delegation. One incident during their visit highlighted several aspects of the emerging relationship between the scientists and the high levels of the state leadership. Boris Chertok recalled the first demonstration which he gave to the military leadership on the "foolproof" launch system.

---

[56] See Vetrov, *Sekrety Ostrova Gorodomliia,...* p. 110.
[57] *Ibid.* pp. 109-116.

Ustinov began the explanation. It was difficult for me, standing behind the lectern, and for Gonar and Korolev, to lounge about. Both wanted to take over the reporting from Ustinov. But he unexpectedly said:

"And now our specialist Comrade Chertok will demonstrate the process of launching a rocket."

During the time of Ustinov's speech, the Marshals and Generals had already begun to get bored, so I immediately began the demonstration accompanying it with commentary.

"The launch system is automated. Notice! I put the key in the ignition. Now watch the light board, see what is happening. I control the process by radio, and, if I make a mistake, the system does not permit an accidental launch. It automatically goes back to its original state."

Actually, I'm afraid, I made some procedural mistake, and (my co-worker) did not correct me. The lights on the board went out.

"I have just demonstrated that the system contains 'defense against fools.' And now I will repeat my attempt to launch the rocket."

Then I got myself together, Brodsky understood the mistake and strictly followed my lead. On the light board the gas generator light up, the turbopump system light up, ignition, we had preliminary, we had main! With enthusiasm, I explained that contacts were working and now "look, the engine is putting out full thrust, flight begins! After 60 seconds, without our interference, the engine will be shut off." Everything went brilliantly.

Nevertheless, along with expressing his gratitude, with a cunning smile Rokossovskii loudly announced:

"Regarding your 'defense against fools' you were toying with us."

I was taken aback but Ustinov did not lose his head. "No Comrade Marshal, this was a demonstration without deception. I have reviewed everything more than once not only here but at the test range.[58]

[58] See Chertok, *Raketi i Liudi,...* p. 244.

That Ustinov took it upon himself to lead the delegation, make the reports, and defend the scientists when there was a mistake, indicates that he was not a neutral monitor of the program. He had taken sides and was investing a portion of the success of his career in the success of the program. This incident also suggests that the military leadership was blissfully ignorant of the details of the missile program. By all indications, this was their first experience with missiles, and they did not appear to be taking it very seriously. It is difficult to imagine that such mistakes would be treated so lightheartedly if they regarded the program as a matter of the highest military priority. Their primary concern seemed to be that that the scientists were "toying" with their technical ignorance.

Korolev and his rocketeers did not get off to an auspicious beginning. Their results met only the minimum standards. What success they had, might be credited by the leadership to the intervention of the German scientists, Magnus and Hock. Several months would pass before Korolev learned whether the leadership would allow him to continue with his program and produce an indigenous V-2 -- the R-1..

Developing a Constituency

In spite of the dubious success of the V-2 tests, Ustinov became an unstinting supporter of Korolev's missile programs. It was a symbiotic relationship between the Minister of Armaments and the Chief Designer. Ustinov was among Stalin's most favored ministers, and one of the few who could call on Stalin directly.[59] Ustinov wanted to play a role in the development of new systems. Korolev's BRDDs along with Tritko's ZURs presented that opportunity. Korolev now had a powerful constituency for his missile program, making a critical step toward establishing stability.[60] A considerable portion of his effort in the future would be devoted to building a closer relationship with Ustinov. At the same time, Korolev was always careful to control information regarding the true capabilities of his technology and his scientists.[61] It was a delicate balance which he would struggle to maintain during the next five years.

THE MANNED BOMBER PROGRAM

Throughout the early period of missile testing, the political leadership regarded the manned bomber as the primary means of delivering nuclear weapons. Initial post-war efforts focused on development of a Soviet copy of the American B-29. In late July 1944, an American pilot was forced to land on Soviet territory after being hit by flak while bombing Japanese held installations in Manchuria. Two other B-29's were forced to land

---

[59] Interview with Piskareev.

[60] See Wilson, *Bureaucracy...*; and, Latour, *Science in Action...*

[61] See Golovanov, *Korolev...* p. 479.

at Vladivostok in November of the same year. Gifts in hand, in 1946 Stalin directed the noted aviation designer Andrei Tupolev to build exact copies of the American strategic bomber. Highlighting the high priority for this project, not only was Lavrenti Beriia given direct oversight responsibilities, but the B-4, as it was initially called, was the only aircraft project ever to require Stalin's personal signature on key requirement and certification documents.[62]

The program was a caricature of what happens when technologically ignorant leaders are put in charge. They chose to dismantle and copy the oldest of the three B-29s that still had technological bugs that had been worked out in the other two aircraft. The two more refined versions were used for training exercises, and, according to Zaloga

> The duplication effort sometimes took on ridiculous dimensions. There was a tunnel running from the forward pressurized cabin to the aft pressurized gunners' stations. The interior of the tunnel was painted, partly in zinc-chromate green anti rust paint and partly in white, probably due to an oversight of the assembly teams at Boeing's Wichita plant. Tupolev ordered the paint scheme to be copied exactly.[63]

Another report held that Beriia had to check with Stalin before the Soviet red star was painted on to ensure that this did not deviate too far from the leader's specifications.[64]

The first copies were ready in July 1947, and flight testing was completed in 1948. The aircraft was designated the Tu-4. A refueled Tu-4 was capable of delivering an

---

[62] See A.I. Kandalov (et. al), *Andrei Nikolaevich Tupolev: Zhizn i Deatel'nost,* (Andrei Nikolaevich Tupolev: Life and Activities), (Moscow: TsAGI, 1991) pp. 265-276; see also Zaloga *Target America...* pp. 69-72.

[63] See Zaloga, *Target America...* p. 71.

[64] See Holloway, *Stalin and the Bomb...*

atomic bomb to most of the United States on a one way mission.[65] Consequently, by the time the Soviets had developed the atomic bomb in September 1949, they already possessed a rudimentary capability to deliver the weapon to the United States. Considering the primitive state of U.S. air defense at the time, the threat was credible. In October, the second Soviet atomic test was conducted using a bomb dropped from Tupolev's bomber.[66]

By 1951, an improved version of the Tu-4 was developed, the Tu-85, with a range permitting an unrefuled bomber to strike most of the United States.[67] The success of Soviet jet fighters in attacking U.S. B-29's over Korea in 1951, however, convinced Stalin of the need to develop a jet bomber. In the spring of 1951, Stalin issued a requirement to Tupolev to develop an intercontinental jet bomber. Tupolev refused, arguing that the state of Soviet technology did not permit such adventures.[68] Stalin then went to another, less experienced designer, V.M. Miasishchev, and gave him the project. Within 22 months, Miasishchev produced a prototype, dubbed the M-4. The initial versions were still incapable of striking the United States on a round trip mission, but they were entered into the armed forces in 1954. Subsequent versions incorporated the ability to conduct round trip nuclear missions with refueling.[69] At the same time, Tupolev proceeded with his plans

---

[65] This was not an incredible scenario considering that the United States was planning one-way missions of B-47 bombers at the same time.

[66] See Holloway, *Stalin and the Bomb...* p. 219.

[67] See Kandalov (et. al), *Andrei Nikolaevich Tupolev...* pp. 275-276.

[68] See Zaloga, *Target America...* p. 81.

[69] *Ibid.* pp. 81-84.

to build the Tu-95 (Bear), a turboprop aircraft capable of reaching all parts of the United States, but at a speed and altitude which made it vulnerable to jet fighters.[70] Thus, by the mid 1950s, the Soviet Union had several bombers capable of reaching the United States.

Technological Uncertainty and Leadership Priorities

The Soviet leadership clearly regarded the manned bomber as the only effective means of delivering their initial atomic bombs. The post war bomber program attracted more of Stalin's attention than the missile program ever achieved. Aviation designer Aleksandr Iakovlev reportedly met with Stalin almost weekly to discuss the latest developments in aviation, while Korolev logged only a single direct meeting with Stalin.[71] As the effectiveness of propeller driven aircraft came into question, Stalin's reaction was immediate and decisive: cancellation of the Tu-85 and concentration on jet bombers. It was an entirely reasonable reaction, to limit uncertainty by pushing ahead with technologies he understood better than missiles.[72] While Stalin's actual understanding of aviation technology has been criticized, there is little question that from the mid 1930's until the end of his career, he designated himself as the chief architect of the overall Soviet

[70] See Kandalov (et. al), *Andrei Nikolaevich Tupolev...* pp. 280-285; and, Zaloga, *Target America...* pp. 85-88.

[71] See Aleksandr Iakovlev, *Raskazy Aviakostuktyra,* (Moscow, 1964)

[72] On the importance of reducing technological uncertainty see in particular James D. Thompson, *Organizations in Action,* (New York: Macmillan, 1967).

aviation program, if not each individual system.[73] Until the time of his death, there was no indication that Stalin ever considered missiles as a viable means of delivery of atomic weapons.[74]

THE COUNCIL OF CHIEF DESIGNERS

The Council of Chief Designers was informally created on the test range of Kapustin Iar. Boris Chertok recalled the most important result of the first series of tests:

> The process of the first flight tests strengthened the informal organ--the Council of Chief Designers under the direction of Sergei Pavlovich Korolev. The authority of this Council as an interdepartmental, not administrative, but scientific-technical leadership organization played a decisive role for all our activities which followed.[75]

One of the early problems facing the scientists and engineers interested in ballistic missiles was coordinating the work of specialists working in different organizations under different jurisdictions. In the latter years of WW II, a vast number of engineers from various design bureaus and scientific research institutes traveled to formerly occupied areas of Europe looking for information on German technology programs. A group interested in surface to surface missiles coalesced around six Chief Designers, from five different ministries. In the Soviet system of industrial organization, crossing

[73] See Bailes, *Technology and Society...*,

[74] See Golovanov, *Korolev...*

[75] See Chertok, *Raketi i Liudi,...* p. 195.

interministerial boundaries was no easy task. Simple interactions required the signatures of all concerned ministries. This process was time consuming, and ministers were reluctant to commit their resources to projects in which they were unlikely to enjoy the rewards.[76]

To overcome these problems, a unique organization was created by Korolev which permitted the informal cooperation of organizations from disparate ministries without the interference of the ministers.[77] This organization was formally named "the Council of Chief Designers for Collective Resolution of Scientific-technical Problems in the Creation of Ballistic Missiles."[78] The Council was a "special organization of collective thought."[79] One member, guidance specialist N.A. Piliugin, noted:

> The Council of Chief Designers was not only the `splinters' from the various organizations which we all represented but also above all a qualitatively new collective, a specific form of management. The Council was necessary because rocket technology is very many-sided. One organization, one man—even of the scale of Sergei Pavlovich Korolev—could not encompass it.[80]

G.A. Tiulin, who throughout his career was in charge of the interface between the designers and the military users, recalled that "the Council of Chief Designers was formulated in Germany, all of its members represented different ministries: someone was

---

[76] See Janous Kornai, *The Socialists System: The Political Economy of Communism,* (Princeton: Princeton University Press, 1992)

[77] All of the early participants agreed that the Council was Korolev's idea. Interviews with Mishin, Chertok, Mozhorrin, and Maksimov.

[78]Raushenbakh, *Iz Istorii...* p. 225.

[79]Krasnaia Zvezda, April 8, 1989, p. 3.

[80]As cited in Holloway, op. cit., p. 392.

from aviation, someone from radio technical production. Even there were those, like Viktor Ivanovich Kuznetsov from the shipbuilding industry...We did not have interministerial barriers...[81]

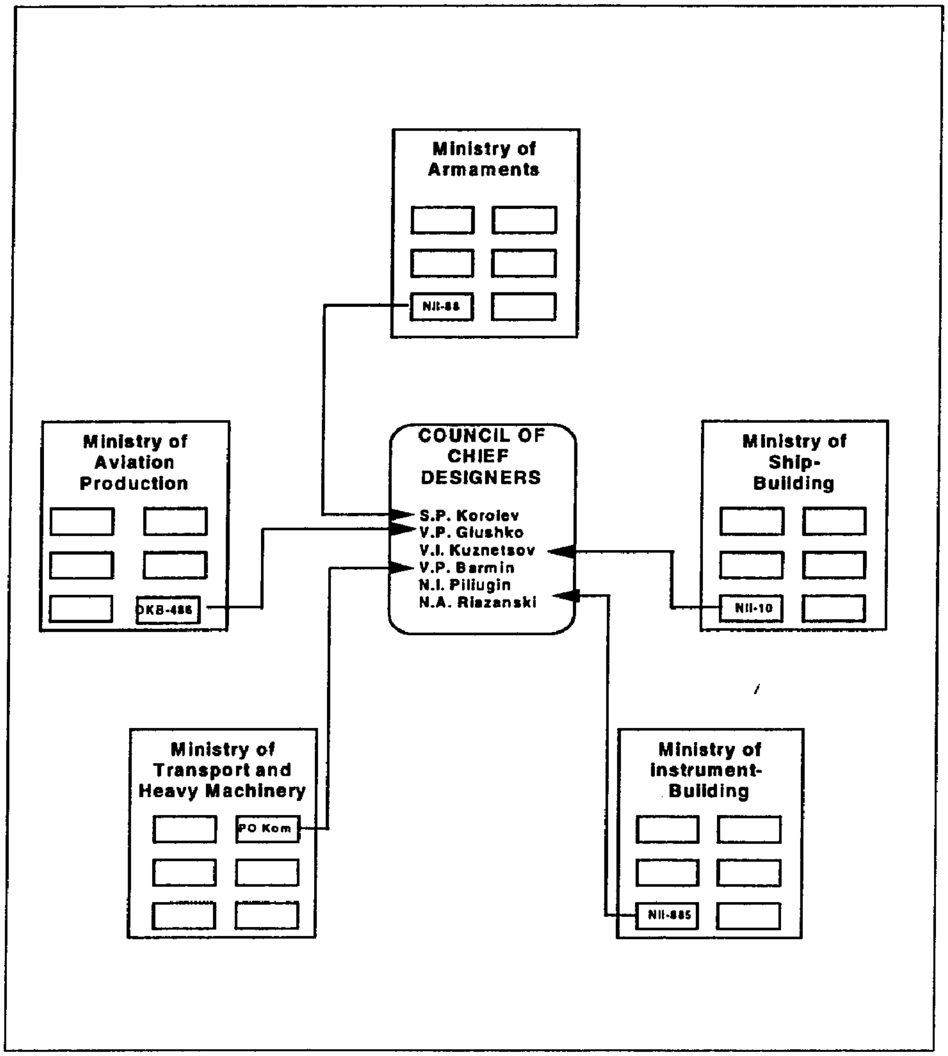

Figure 4.3 -- The Council of Chief Designers

---

[81]See "G.A. Tiulin" in *Dorogi v Kosmos, Vol. I.*, (Moscow: Moscow Aviation Institute Press, 1992, p. 160.

The center of activity was Korolev's design bureau (OKB-3), within NII-88, located in Podlibki, outside of Moscow. Other members were spread throughout the Moscow suburbs. Glushko re-established the GDL-OKB, as OKB-486, in the Khimky region of Moscow.[82] At the same time, V. P. Barmin was appointed as the Chief designer of launch facilities.[83] Mikhail Riazanskii and Nikolai Piliugin worked at NII-885, located near the Central airport in Moscow, with Riazanskii as director and Piliugin as head of the section for inertial guidance systems.[84] Riazanskii and Piliugin were appointed as chief designers of radio control and automatic control systems respectively. The Chief Designer for Instruments, V. I. Kuznetsov, headed a design bureau within NII-10, and was under the Ministry of the Shipbuilding Industry (MSP).[85] In turn, each of the "big six," as they were called, held responsibility for the activities of enterprises working on missiles within that ministry and functioned, for all practical purposes, as a mini-minister. By 1960, there were 200-300 organizations involved in this informal structure.[86]

There were several aspects of the operational procedures of the Council which made it an effective organization. Most importantly, the Council's decisions had authority

---

[82]See Glushko, *GDL-OKB*... p. 31.

[83]See *Trud,* April 12, 1987, p. 1.

[84]See, *Krasnaia Zvezda,* March 11, 1989 p. 3, for a biographical article on Riazanskii and *Krasnaia Zvezda,* February 25, 1989, p. 4, for a biographical article on Piliugin.

[85]See *Krasnaia Zvezda,* February 25, 1989, p. 4.

[86]See Ishlinskii, *Korolev*... p. 317.

over other agencies and ministries. An article originally written in 1958, but only recently published, recalls the significance of this aspect. "Creation of such an organ had decisive significance for the successful development of complexes. In the first stage, the authority of the Council permitted excluding the procedures of reaching agreement on technical solutions between departments."[87] V.P. Barmin recounted the ability of the Council to overcome ministerial resistance.

> Each of us headed a design bureau, had the authority in his own area, and could implement decisions. Of course, far from always did our ministry leaders like it, and there were conflicts. As a result, S.P. Korolev later succeeded in securing a resolution whereby the decisions of the Council of Chief Designers were binding on all ministries and agencies.[88]

Because the Council did not have to go through cumbersome interdepartmental coordination procedures, there was little opportunity for ministers, party officials, and military officers to interfere in its work. Since most proposals subjected to routine interdepartmental coordination procedures never survived the formal process of getting approval from sometimes dozens of state officials, the establishment of the Council was as much a matter of survival as expediency.[89]

---

[87]See Vetrov, *Sekrety Ostrova Gorodomliia...*, pp. 14-15.

[88]See *Izvestiia*, September 20, 1987, p. 3.

[89]Fyodor Burlatskii noted that in his study of the approval process, only 30% of the "zapiski" successfully obtained signatures from the necessary officials, sometimes numbering in the dozens. Seminar given by Fyodor Burlatskii at the RAND Corp. April 28, 1989.

Barmin also recalled how the members of the Council acted outside the Soviet planning system with flexibility and autonomy to develop their own schedules, and mechanisms to maintain them.

> The interrelationship and interdependence of the operations make missing a deadline in any section unacceptable. For that reason, every director and participant—from the Chief Designer to the shop master—in assessing the status of the work in his own area, considered the schedule above all as, by and large, the ultimate end and immediately sounded the alarm if there was a threat of a missed deadline. The feedback worked flawlessly. Any danger of missing a deadline went off like an alarm, immediately to the Council of Chief Designers, to the proper ministry or directing agency. In every serious instance, aid was rendered without delay. Depending on the circumstances, the aid might be people, equipment, finances, or additional production power.
>
> I think it very significant that the work deadlines, although tightly compressed, were realistic, because they were established by the equipment designers and makers themselves.[90]

The local autonomy afforded to the Council allowed them to create a flexible and informal working relationship between design bureaus, suppliers, and scientists. A co-worker of Korolev's, B.E. Chertok, recalled that "settling a complex question took simply a visit or even a phone call."[91] Another, Academician V.S. Avduevskii, described how this flexible relationship fostered productivity.

> I remember, in 1953, various heat-shield coatings that were to prevent spacecraft from severely overheating upon entry into the atmosphere were developed and tested. Our group of young research-institute associates came up with a new idea for facilitating the development of a heat shield. We immediately went to the design bureau headed by Sergei Pavlovich [Korolev]. And by chance, we met him on the plant grounds, as he was returning from a shop. We spoke as we walked—it took Korolev only about 5 minutes to get the gist of the idea and to make some

---

[90]See *Izvestiia*, September 27, 1987, p. 3.

[91]See *Izvestiia*, October 1, 1987, p. 3.

> observations on its development. Within a half an hour, the designers were already working on the idea. And that is how it always was. Nobody ever ran into any kind of bureaucratic delay with Sergei Pavlovich, and there were never any problems of 'implementation.' All ideas worth doing were snatched up instantly and were quickly converted into designs, and trust of and good will toward those enthusiastic about their own work was the rule. That was the primary incentive that inspired the participants in this collective work, and there were many of them. Industrial and academic institutes and enterprises did not solicit the decisions and resolutions of higher agencies—they went straight to the chief design bureau and performed complex theoretical and experimental operations within schedules that spanned only months.[92]

It was either a lack of interest or a lack of foresight on the part of the administrators which led to the creation of the Council of Chief Designers. If BRDDs were a high priority the leadership would have transferred the five key organizations into a single ministry when, in the immediate post-war years, there was a complete reorganization of the Soviet economy. The rocket scientists made their desire to be placed in a single ministry known to the Ustinov. That this was done suggests that Ustinov was not willing to force the issue among other ministerial officials, or to take it to a higher administrative level. Whatever his reasons, the creation of the Council, and Ustinov's support for the institution in the years to come, had far reaching consequences, both intended and unintended.

---

[92]See *Literaturnaiia Gazeta,* September 30 1987, p. 14.

Coordination Without Hierarchy

The Council of Chief designers proved to be a remarkable, though unusual, organizational structure. It was neither a formal hierarchy nor an informal coupling of individual organizations. In many ways, it combined the best of both forms of organization. The Council created the regularized procedures and lines of authority of a hierarchy while preserving the flexibility and autonomy of informal organizational coordination.[93] For Korolev, what mattered most was that the Council permitted him to coordinate activities across industrial ministries without having to go through the time consuming process of seeking ministerial approval for routine coordination. The Council also established the precedent of local autonomy which Korolev used to his advantage in the years to come.

THE GERMAN ROCKET SCIENTISTS

Korolev did not hold a monopoly over information related to missiles in the immediate post war years. He may not have even been among the most knowledgeable scientists in the Soviet Union. The German scientists who came to the Soviet Union in

---

[93] On the strengths of hierarchical relations in see Oliver Williamson, *Markets and Hierarchies: Analysis and Antitrust Implication,* (New York: Free Press, 1975). On the value of informal coordination see Donald Chisholm, *Coordination Without Hierarchy: Informal Structures in Multiorganizational Systems,* (Berkeley: University of California Press, 1989).

late 1946 had been working on V-2s for three years, and developed considerable experience. Even if they were not the most qualified German scientists, they held sufficient expertise in rocketry to provide a critical review of Korolev's proposals. A critical review was not what Korolev wanted at this time.

The German rocket scientists arrived for their "visit" to the Soviet Union in late October 1946. For a short time, they mingled freely with their Soviet counterparts as they had in Germany, but in spring 1947 almost all were relocated to Gorodomliia Island on Lake Selenger near Moscow. One hundred seventy-seven German specialists came to the Soviet Union, including: 24 Doctors of Science, 88 engineers, and 27 workers.[94] Korolev arranged that the German scientists would labor in relative isolation from Soviet scientists at NII-88.[95] Korolev argued to Ustinov that this move was necessary to insure that the German scientists would have creative independence. Korolev tasked them with development of an improved version of the V-2, requiring only that the missile have the same basic dimensions as its predecessor. Under Helmut Grottrup's directions, the German scientists began designing what was referred to as the G-1.

There were more sinister, or at least bureaucratically motivated, reasons for the Germans' isolation. Korolev was keenly aware that the Germans presented him with a

---

[94] The source does not make it clear what specialty the remaining 38 Germans held. See Vetrov, *Sekrety Ostrova Gorodomliia...* p. 48

[95] This pattern of isolating the German scientist was consistent with that practiced in the nuclear program. Therefore, Grottrup may have been isolated at the NKVD's urging. However, Chertok and Vetrov make it clear that Korolev at least encouraged this arrangement.

problem. There was a risk that Grottrup would eventually dominate the Soviet missile program. Korolev wished to be the unquestioned leader. By isolating Grottrup's group Korolev controlled the flow of information regarding their activities.[96]

Thus, Korolev could not only shape perceptions regarding the quality of the German work, but he could also use German technology without appropriate attribution. Korolev used both to his advantage. The arrangement also gave the Germans little access to the work of the Soviet scientists. Consequently, they could criticize neither Korolev's proposals nor his work.

In September 1947, Grottrup's group completed its preliminary plans for the G-1. As directed by Korolev, Grottrup's plan pushed the technological frontiers in several directions. By using radio guidance in place of an inertial system, Grottrup claimed to increase the accuracy over the V-2 by factor of ten. Through the use of aluminum, the weight was reduced by more than 100 kg. Given the lower weight, only minor improvements in the engine were required to achieve a range of 600 km. Additionally, as with Korolev's system, the most important innovation was the separation of the warhead from the rest of the missile.[97]

Grottrup and his colleagues made their presentation on September 25 at a meeting of the Scientific Technical Council (NTS) of the MV. Before the meeting Korolev made

---

[96] See Vetrov, *Sekrety Ostrova Gorodomliia...*; and Chertok, *Raketi i Liudi...*

[97] Korolev had independently developed a separable warhead during his stay in Germany and intended to use it on the R-2. See Vetrov, *Sekrety Ostrova Gorodomliia..*pp 67-91.

sure that he could control the outcome. The majority of the discussants worked directly under Korolev. Others had close ties to the Chief Designer. After the Germans' presentation, the first discussant, M.K. Tikhonravov, gave a fairly positive assessment of the concepts forwarded by Grottrup. He was one of a minority of discussants without direct institutional ties to Korolev.[98] But then came Korolev's deputy, Vasiliy Mishin, who noted that while there were several interesting ideas, Grottrup's project was not realistic, and that it made far more sense to pursue Korolev's plan for the R-2, which had already been approved by the NTS. Mishin was followed by several other members of Korolev's retinue. Glushko criticized the engines' turbo pumps. Riazanski questioned the claims of accuracy, and Piliugin simply announced that "he could never agree with the proposed system." By that time, the feeding frenzy was out of control. V.M. Panferov, the head of the reliability department of the NII, remarked: "It seems to me that the project is of a preliminary character. There are no basic assessments of the materials, and these were not calculated today. At the session we attempted to clarify several questions but were unsuccessful... I can only say the project may present some interesting thoughts for future design developments." Even Boris Chertok, who helped the Germans with their guidance system, criticized the proposal. In the end, Deputy Minister of Armaments E.A. Satel' concluded:

> Undoubtedly, this project presents some new technical thoughts... But at the same time, it seems to me that the materials as they are presented here cannot be

---

[98] It should be noted that even Tikhonravov was a longtime friend and colleague of Korolev, going back to their work together at GIRD and RNII in the early 1930's.

> supported as a draft project. The basic requirement for a draft project -- complete technical assessments, complete scientific analyses of questions are underdeveloped in the design elements. Unfortunately, in the materials presented, as we were able to observe at the concluding section, the defense of the design, sufficient assessments and scientific materials were not present in the proposed project.[99]

The Germans were sent back to the drawing board. Their project would be presented again in another year. Many things would change in the interim. Until then, Korolev could rest assured that the Germans would pose no serious threat to his program. Instead, he would incorporate their technical concepts in his own designs.

Grottrup presented a more refined version of the G-1 to the NTS of NII-88 in November 1948. In spite of the fact that Grottrup had responded to most of the earlier criticisms of insufficient theoretical work, the NTS remained unwilling to accept his design. Again, Korolev's deputies led the attack. Konstantin Bushuev asserted that "for an experimental system the sum of new design elements is too burdensome... all of these ideas cannot be put into a single vehicle at once."[100] Mishin was not nearly so kind in his assault on the proposal: "It amazed me throughout the proposal. The supplied data appears to be an advertisement. Instead of an engineering approach--a poorly executed essay..."[101] The Council concluded with the recommendation that further experimentation would be required before the project could be concluded, effectively killing the G-1 project.

---

[99] Stenogramma plaenarnogo zacedaniia NTS NII ot 28.12 Archives of TsNIIMash, f. 9, op. I No. 801. As quoted in Vetrov, *Sekrety Ostrova Gorodomliia, ...* p 84.

[100] *Ibid.* pp. 172-173.

[101] *Ibid.* pp. 173-174.

Nevertheless, Korolev held a certain interest in seeing that the Germans continued to serve as a source of productive ideas and theoretical work. There were many ideas, such as the separation of the warhead from the fuselage, and the extensive use of aluminum, which Korolev borrowed from the Germans without necessarily providing attribution. However, he did not want the German project to be approved thereby challenging his position as the leader of the long-range missile program. He surely had a hand in the rejection of Grottrup's proposals. Overall, the Germans contributed a great deal to the Soviet missile program, but it was all indirect knowledge.[102] Despite his attacks, Mishin later remarked in an interview that the Soviet rocket scientists "could not have accomplished anything without the Germans' help."[103] But that assistance was carefully controlled. Korolev made sure that the Germans did not become competitors.

In the end, however, the German program was a victim of Soviet leadership politics, not Korolev's bureaucratic intrigues. In early 1949, the so-called anti-cosmopolitan campaign began. All foreign science was condemned as "bourgeois science." Soviet scientists were careful to limit their ties with their foreign colleagues. The German scientists became casualties of Soviet politics.[104] In early 1950, the entire

---

[102] See Chertok, *Raketi i Liudi..;* Vetrov, *Sekrety Ostrova Gorodomliia,...* and Mishin.

[103] Interview with Mishin.

[104] Of course this campaign had little effect on the use of foreign intelligence for the development of Soviet systems, particularly in the case of the atomic bomb. See Holloway, *Stalin and the Bomb...* on the "anti-cosmopolitan campaign" see Hahn, *Andrei Zhdanov...*

research agenda of the German group was closed. The following year, the German scientists began to return to East Germany.

Competing Sources of Expertise

Competing programs provide a powerful source of information for monitors and the political leadership.[105] They can be used to validate the concepts, cost estimates, or expressed risks of a program. The German rocket scientists presented such a threat to Korolev's autonomy. Their proposal for the G-1 was technically more advanced than those being developed by Korolev's group at the time. Yet Korolev was able to discredit Grottrup's design by stacking the NTS with his own representatives. It was a highly successful technique and effectively eliminated Korolev's primary competition at the time.

PRODUCTION AND TESTING OF THE R-1

After the tests of the V-2, Korolev felt he had demonstrated the potential of the missile program, and wanted to move directly into production of an improved version of the V-2, called the R-2, with a range of 600 km. He spent the winter of 1947 promoting

[105] See Downs, *Inside Bureaucracy...*; Wilson, *Bureaucracy...*

this project. Stalin, and perhaps Ustinov, did not see matters in the same light. They wanted to be sure Soviet industry could duplicate the achievements of German industry. Korolev was in no position to argue. When the declaration approving the production of the R-1 was handed down in April 1948, Korolev and his group quickly began efforts to produce a copy of the German missile.[106] The work of 13 different scientific research institutes and 35 industrial enterprises was coordinated by the Council of Chief Designers which incredibly accomplished the production of 12 missiles in the space of ***five months***.[107] In comparison, it took almost a year and a half for the most capable of Soviet aviation designers to copy the U.S. B-29.[108] In September, Korolev was ready to return to the desolate reaches of the Kapustin Iar test range.

Korolev may have pushed too hard. Production problems led to 21 failed launch attempts, in comparison to three for the previous series of German missiles. Three missiles exploded on the pad. Tensions between the military and the rocketeers ran high. One general exclaimed:

> What are you doing? You put more than four tons of alcohol in a rocket. If you give my division this alcohol, it could take any town. But your rocket couldn't even hit the town. Who needs it!... The Germans built a thousand rockets. But who felt it? ...But if the Germans had a thousand tanks or aircraft instead of "Vs!" Now this we would still be feeling!

---

[106] See Vetrov, *Sekrety Ostrova Gorodomliia,...* pp. 117-118.

[107] See Romanov, *Konstruktori...* p. 63.

[108] See Zaloga, *Target America...*

Vetoshkin wryly responded with the toast: "Do not look at what is left in the pile of rubble, but look ahead"[109] This exchange would be repeated at higher levels in the months to come.

When the problems were finally resolved, tests showed the Soviet version to be somewhat more capable than the German missiles launched the year before. Range was 20 km. greater than the German version, and the percentage of missiles falling within the target zone was almost twice as high. Perhaps most significantly, all nine missiles that were finally launched reached their destination without breaking apart. Less than half of the German missiles were able to do this.[110]

Korolev also used this launch series to begin developing a constituency within the Academy of Sciences. Two specialists from Moscow's prestigious Physical Institute of the Academy of Sciences were allowed to place experiments studying solar rays on two of Korolev's missiles. They were also permitted to participate in the láunch tests. In later years, Academicians Vernov and Chudakov became powerful supporters of the space program.[111]

In the end, Korolev's group was fortunate to have been overseen by a State Commission which was far more accommodating than that appointed to supervise the

---

[109] See Chertok, *Raketi i Liudi,...* p 321.

[110] See Vetrov, *Sekrety Ostrova Gorodomliia...*

[111] See Chertok, *Raketi i Liudi,...* p. 313; and Golovanov, *Korolev...* pp. 406-407. Holloway claims that Vernov and Ivanov were sent to perform early research for the atomic program, but Golovanov's account seems to dispute this point. See David Holloway, *Stalin and the Bomb,...*

previous series of launches. The commission was chaired by Ustinov's deputy, S.I. Vetoshkin, as opposed to a military commander. Although the military was represented on the commission, it was represented by much lower level officers than the previous launch series. Also, there was no high level representation of the secret police (NKVD), which deprived the leadership of its primary source of information outside industrial and military channels.

The mixed success of the R-1 tests put the State Commission in a difficult position. If they rejected the test series, they might only call attention to the program. Most of the members of the commission would be without a job if the program was discontinued. If they supported Korolev, and his program ultimately failed, their fate might be worse still.[112] They could be accused by Stalin of sabotage, since they went along with the tests knowing that the weapon had no application. At least over the short term, they could conceal the failure. If Korolev was able to correct the problems in future missiles, they would become the leaders of an important new direction in military affairs. Whether out of fear of Stalin's irrationality or faith in Korolev's ability, they chose to support Korolev.

The Commission's principle conclusions were that:

1. The indigenous version of the R-1 was at least equal to the captured German missiles.
2. The principle questions of production of the R-1 from indigenous materials has been correctly solved.

---

[112] These points are made by Boris Chertok in *Raketi i Liudi,...* p 322.

3. The data from theoretical calculations was consistent with the flight characteristics.
4. The reliability of the construction of the R-1 throughout its flight regime met technical tactical requirements.

Incredibly, the conclusions of the State Commission report did not mention the launch failures. However, it did suggest a second series of tests be conducted before the missile was introduced into the Armed Forces.[113]

The Commission report was only buying time. Before departing the cosmodrome, Korolev convened a meeting of the Council of Chief Designers to suggest that the next series of tests should include no less than 20 missiles.[114] He wanted to leave no doubts in the minds of the military customers that his missiles could be a viable weapon. The major task for the coming year would be redesigning guidance and telemetry systems.

The Commander of the Artillery Troops, Marshal N.D. Iakovlev, refused to accept the conclusions of the Commission report. He wanted to kill the program. Ustinov fought him, and a meeting with Stalin was called to resolve the issue. Iakovlev, Ustinov, Korolev, several generals, and at least one other member of the Council of Chief Designers, Viktor Barmin, attended the meeting. It began with small talk between Stalin and Ustinov. Stalin then turned to Korolev and asked if he had anything to say. Korolev immediately took the offensive, attacking Iakovlev as being "short sighted and technologically stagnant." He then referred to Iakovlev's refusal to accept another missile

---

[113] See Vetrov, *Sekrety Ostrova Gorodomliia,...* pp.. 127-136.

[114] See Chertok, *Raketi i Liudi...* p. 322.

system, the "Katiusha," which proved to be a decisive weapon in the Soviet offensive against Germany.

> Was comrade Iakovlev right at that time? Yes he was. The Katiusha had some genuinely large shortcomings. He was correct then, as he is correct today, -- but correct only by today's technological standards. Fortunately for all of us, we did not listen to comrade Iakovlev then. I believe that today we will not be governed by only current information, and will again not listen to comrade Iakovlev...

Stalin thought for a moment and announced "I believe that the military is completely correct. We do not need a weapon with such characteristics." He walked around the room for a bit, and then continued

> But I estimate that rocket technology has a bright future. This rocket needs to be accepted into the military. Let our military comrades gain experience in the operation of the rocket. We shall ask comrade Korolev to make his next rocket more accurate so as not to offend our military...[115]

The issue seemed to be decided in Korolev's favor. In reality, very little was settled. Each side interpreted Stalin's decision differently. Korolev and Ustinov determined that they now had clearance to begin development of the R-2. Iakovlev refused to accept the R-1, and Korolev went back to Kapustin Iar for a second series of tests.

He had been working on a number of ideas and wanted to begin putting them into practice, with or without the military's support. One idea that Korolev had been working on for some time involved separation of the warhead from the fuselage of the missile after

---

[115] This conversation was recalled by Barmin, as published in Golovanov, *Korolev*, ...p. 398.

the booster was finished with the powered phase of flight.[116] By separating the warhead, much greater accuracy and range could be achieved. Rather than incorporate this modification in the second series of tests for the R-1, Korolev tested the concept as a scientific rocket (the R-1A) for geophysical research in May 1949, thus avoiding Iakovlev's scrutiny. The rocket was launched on a trajectory which maximized altitude, rather than distance, and separated the warhead (which had a scientific payload) at an apogee of 100 km, ultimately using a parachute to bring the warhead down to a soft landing.[117] This series of tests let Korolev develop the technically challenging system of separation without risking the wrath of a displeased military. At the same time, he further developed a constituency in the Academy of Sciences by inviting them to conduct tests on his scientific rockets.

The second series flight tests for the R-1 began in September, but Korolev was growing impatient. He wanted to get the R-2 project back on track. Again, choosing a risky course, he began testing of the R-2 concurrent with the second series of R-1 testing. As promised, Korolev launched 22 R-1s from Kapustin Iar. Two exploded on the pad. Of the 20 which were launched, 16 landed within the 16x8 km target area defined in the requirements document.[118] While these test results represented significant improvement

---

[116] Vetrov claims that in part at least Korolev borrowed this idea from the German scientists. See Vetrov, *Sekrety Ostrova Gorodomliia...*

[117] See Vetrov, *Sekrety Ostrova Gorodomliia...* p. 139; and Raushchenbakh, p. 228.

[118] This is a Russian term *tekhnicheskie takticheskie trebovannye* (technical tactical requirements). The TTT was a document agreed to by the representative of the service using the system, and the minister in charge of producing the system.

from the previous series, the military still refused to authorize series production. The reasons for their rejection were curious to Korolev. First, the scientists had not solved the problem of minor explosions at the time of ignition. While the explosions were reduced to the point where they did not interfere with the successful launch, they did unnerve the ground testing crew. Naturally, Korolev wondered why military troops which were trained to operate under enemy artillery, were afraid of the relatively harmless explosions of the R-1.[119] Second, the artillery troops rejected the systems because the caliber (diameter) was 1.5 mm larger than the specification.[120] In an artillery piece, a 1.5 mm variation in the size of a charge would be catastrophic, but the 1.5 mm difference had absolutely no bearing on the performance of a ballistic missile. This complaint was absurd, pointing to the disconnection between the culture of artillery troops and the missile industry. Korolev argued that these deficiencies were trivial and they could be remedied in the course of production. Iakovlev's deputy, General Mrykin, refused to budge and the matter was again escalated to the upper levels of government.

Chertok recalled the effect of this rejection:

> For Ustinov, Vetoshkin, Gonar, Korolev and all of us who developed the R-1, the initiation of series production under the formulation "accepted into armaments" was necessary for our self-affirmation of the new technology, for acceptance of the validity of the entire field. Over the course of four years of persistent work we had been unable to pass on rockets to series production which the Germans had already accomplished four years ago. This was a blow to our prestige.[121]

---

[119] See Chertok, *Raketi i Liudi,...* p. 326.

[120] See Vetrov, *Sekrety Ostrova Gorodomliia,...* p. 118.

[121] See Chertok, *Raketi i Liudi,...* p. 326.

In early 1950, Glushko succeeded in eliminating the ignition problems, but they did not proceed to the test range until June. Sixteen missiles were fired during the third series of tests. One hundred percent fell within the required target range. There was only a single launch delay. The tests were an unqualified success. Nevertheless, the military resisted acceptance claiming that the missile still had to be tested within the required temperature regime of +50 C to -50 C.[122] This was an impossible requirement! Even in Russia, such climatic conditions did not occur. At this point, Stalin intervened, issuing a decree accepting the R-1 into armaments on November 25, 1950. Still wishing to satisfy Iakovlev, the scientists traveled to Iakutsk in Siberia in January to test the system under the coldest possible conditions. Even then, the temperature never went below -26 C. At this temperature, the R-1 worked perfectly without further modification.[123]

The R-1 tests illuminated several points. They dispelled the notion that the military leadership had any interest in the missile program. They would fight the introduction of missiles tooth and nail. It was clearly a clash of organizational cultures. One Marshal remarked: "An artillery barrage is a symphony, a rocket launch--cacophony."[124] The differences between missiles and artillery could not have been greater. Missiles would be performing missions which were unfamiliar to the artillery troops, using technologies which were completely alien to them. The reaction of the leadership of the Artillery

---

[122] This converts to +122 F and -58 F. While neither was a record, both are exceedingly rare occurrences. See Vetrov, *Sekrety Ostrova Gorodomliia,...* pp. 110-114.

[123] See Vetrov, *Sekrety Ostrova Gorodomliia,...* pp. 110-114

[124] See Khrushchev, *Khrushchev Remembers: The Last Testament...*

Troops was simply to reject missiles. They imposed standards of design, construction, and performance that were completely inappropriate for missiles. When the missiles did not meet these standards, they were rejected. Even when the missiles did perform according to agreed upon requirements, the military imposed new unrealizable requirements. In the end, missiles had to be forced upon the military, and even then it took repeated interventions by the political leadership.

Decision Implementation--Leadership Ineffectiveness or Disinterest?

It is interesting that the political leadership had to intervene on more than one occasion in order to implement a decision. Was it a case of the incapacity of the leadership to implement decision, or a reflection of lack of interest? Almost surely both were at work. By all indications, Stalin's actual power was far from absolute. On a broad range of less important policy issues, his orders were often ignored by his ministers.[125] The missile program fell within this range of less important issues. He issued clear instructions in early 1948, which were not officially implemented until late 1950. The military seemed to be in open defiance. The reality may be more complex. Stalin's pronouncement at the meeting left room for interpretation. Given the opportunity presented by ambiguity, both sides chose to interpret the pronouncement in a way which

---

[125] This conclusion was reached in Dunmore, *Soviet Politics...*

suited their purposes.[126] It was not until 1950 that a clear decree was issued. The length of time that Stalin let the defiance persist is an indication that missiles were still not a high priority program for him.

INTERNAL ORGANIZATIONAL PROBLEMS AT NII-88--ESTABLISHING ORGANIZATIONAL CONSENSUS

Korolev had other problems to face much closer to home. Though he headed the entire Soviet ballistic missile effort, he was still only the head of a department within a badly divided institute. Despite the success on the test range, Korolev's effort remained a low priority within the institute, second to the anti aircraft missiles being developed under Kostin, Sinel'shikov, and Rashkov. Tritko, the Deputy Director of NII-88, and Sinel'shikov were openly hostile to and envious of Korolev, and Kostin was responsible for sending Korolev and Glushko to the Sharaga. [127] In order to survive on the test range, Korolev had to solve several problems within his own institute.

---

[126] See Vicki Eaton Baier, James G. March, and Harald Saetren, "Implementation and Ambiguity," in James G. March, *Decisions and Organizations,* (Cambridge: Basil Blackwell, 1988).

[127] On Tritko and Sinel'shikov see Chertok, *Raketi i Liudi...*; on the role of Kostin see *Voenno Istorichekhikh Zhurnal,* November 1991; and Golovanov, *Korolev...*

On December 14, 1949 Korolev gave Ustinov an unsolicited list of suggestions for reorganization of the Soviet missile program. It included the provisions for the reorganization of NII-88 to: "rebuild the work in the Head NII (NII-88) in order that the entire collective, and not just a few people and departments, will work on the creation of the R-3."[128] He also called for the creation of a department for engines and guidance design which would be dedicated to the "theme of the OKB."[129] Korolev's first choice was to establish his own organization for missiles outside the confines of NII-88, but failing this, he was willing to settle for the transfer of the ZUR program out of NII-88, thereby focusing the entire institute's efforts on his program. He had a compelling argument: During the previous three years, Korolev had demonstrated considerable success in developing long-range missiles, while the ZUR program had been unable to successfully test a single system.[130]

Korolev's attention was not confined to the NII. He proposed significant reorganization of the missile program at the ministerial level. Despite the creation of the Council of Chief Designers, Korolev remained troubled by the dispersion of organizations working on his program, which were spread across five different ministries. Therefore, he

---

[128] The reorganization proposal was submitted shortly after Korolev resubmitted the R-3 proposal. The R-3 project is covered in detail in the following chapter.

[129] Up to this point in time the engine and guidance departments of NII-88 were dedicated primarily to ZUR. Archives of NPO Energiia, No. 83 pp.. 195-204 document sent by Korolev to the Ministry of Armaments December 14, 1949. I am indebted to Georgi Vetrov for making a retyped version of this document available to me.

[130] See Chertok, *Raketi i Liudi...*

suggested "unification in one ministry of all specialized organizations working on rocket technology at the present time."[131]

Korolev timed his proposal to correspond with the planning-cycle for the next five year plan which provided an ideal window of opportunity for Korolev's reorganization.[132] There was already a growing movement to transfer the ZUR program to the Ministry for Aviation Production and Korolev's proposal only reinforced the political as well as technical problems faced by the ZUR program at NII-88.[133]

Anti-aircraft systems confronted Ustinov with a dilemma. They were of the greatest "personal interest to Stalin" as well as the head of the NKVD Beriia.[134] At the same time, however, Ustinov recognized that such visibility often proved fatal under Stalin. As early as 1948, Ustinov was distancing himself from ZURs, and the utter failure

---

[131] Archives of NPO Energiia, No. 83 pp.. 195-204 document sent by Korolev to the Ministry of Armaments December 14, 1949. I am indebted to Georgi Vetrov for making this document available to me.

[132] Iu. A. Mozhorrin, "Istoriia sozdaniia i razvitiia Tsentral'nye nauchno-issledovatel'skii institute mashinostroeniia" (The History of the Creation and Development of the Central Research Institute of Machinebuilding,) *Kosmonavtika i Raketostroenie,* Vol. 1, No. 1 (1993) pp. 28-38. On windows of opportunity see John Kingdon, *Agendas, Alternatives and Public Policies,* (Boston: Little Brown, 1984).

[133] In 1948 S.A. Lavochkin hired Beriia's son Sergei, to work at his design bureau. The younger Beriia brought with him a proposal for development of ZUR systems. Although the proposal itself was unsophisticated in the extreme, it did give Lavochkin a political means of wresting the ZUR program from NII-88. Given the total failure of the ZUR program up to that point, Ustinov was probably anxious to give the responsibility for this program to another minister. See Chertok, *Raketi i Liudi*...esp. pp. 270-273.

[134] The fact that Beriia's son graduated from Moscow Aviation Institute after writing his thesis on development of a new type of ZUR system, gave the program even greater visibility. See Chertok, *Raketi i Liudi...*

of Sinel'shikov only pushed him further in this direction.[135] Thus it was not surprising that Ustinov reacted favorably to Korolev's proposal.

In April 1950, a separate experimental design bureau (OKB-1) was established under Korolev's direction, but still under the organizational roof of NII-88.[136] As the director of a separate OKB, he was now effectively third in command at the NII, under Gonar and Pobedonostsev. For a time at least, the ZUR work remained at NII-88 under Tritko in OKB-2, which was ostensibly at the same level as OKB-1. In reality, OKB-2 was weakened in the reorganization. The most important project under Sinel'shikov was closed in early 1950; and the entire ZUR program was moved to the Lavochkin Design Bureau of the Ministry of Aviation Production on August 22, 1951.[137]

Gonar was arrested as part of Zhdanov's campaign against Jews and other "rootless cosmopolitans," and replaced by K.N. Rudnev on August 18, 1950.[138] Troubled at his departure, Korolev nevertheless found opportunity in Rudnev's inexperience. With Rudnev's arrival, Korolev effectively assumed the position of not only the Chief Designer of OKB-1, but also of the Chief Engineer to the production facility.[139] *De facto,* Korolev was in charge of the entire facility. Worried that Korolev was

---

[135] Chertok recounts that Ustinov was relieved when he rejected Beriia's proposal to develop his design at NII-88. See Chertok, *Raketi i Liudi*...pp. 293-294.

[136] G. Tiulin, "Godi, sversheniia, liudi," in G. Miranovich, *Otvaga Iskani,* (Moscow: Krasnaia Zvezda, 1989)... p 12.

[137] Mozhorrin, "Istoriia sozdaniia ..." p. 22.

[138] See Golovanov, *Korolev*...; Chertok, *Raketi i Liudi*...; and ,*Progress*...

[139] The Chief Engineer is a formal title which refers to the First Deputy of a factory director.

becoming "uncontrollable" Ustinov appointed a new Chief Engineer, Mikhail Riazanski, in 1951. However, Riazanski was, at the same time, the Chief Designer of radio telemetry systems under Korolev in the Council of Chief Designers. He could hardly be expected to control Korolev while he was simultaneously working as his subcontractor. In any case, they were both promoting the same programs.[140]

Korolev did not have much time to establish close working relations with Rudnev. In May 1952, Rudnev was promoted to serve as Ustinov's Deputy Minister for missile technology. Korolev would have an ally serving as his administrator, whom he had personally tutored in missile technology. In the future, Rudnev would prove to be a strong supporter of Korolev's program at the highest levels of government.

Since his arrival at NII-88, Korolev was troubled by the lack of qualified engineers and technical specialists. The problem was a result of the best technical specialists being siphoned into the ZUR side of the institute. Also, there was only a limited base of qualified engineers from which to in the Soviet educational system. Rocketry was a new field and the core group of rocket enthusiasts who worked on rocketry before the war were either working with Korolev, or had died in the purges. Korolev took matters into his own hands, and on the last day of 1947 he began teaching a course in missile design at the Bauman Polytechnical Institute.[141] It was the first course of its type in the Soviet

---

[140]See Chertok, *Raketi i Liudi...* pp. 347-349.

[141] See Raushchenbakh, *Iz Istoriia...*p. 227.

Union, and served as the basis for training most of the specialists who would either work on missiles in the near future, or who would go on to serve as administrators of the program.[142] For nearly a decade, the Bauman institute was the only school which provided a systematic education in missile development. Although Korolev soon delegated teaching responsibilities to others from his design bureau, he continued to act as director of the program. It was not until the mid 1950s that a competing set of courses was offered at the Moscow Aviation Institute. Thus, Korolev was assured three important benefits. First, he would have a cadre of adequately trained specialists from which to draw his staff in the future. Second, he could ensure that the staffs of the administrative agencies were trained to be sympathetic to his engineering techniques. And finally, Korolev positioned himself as the teacher and mentor for many of those who would later monitor his programs.

Organizational Consensus

From the beginning, the missile program suffered from an organizational culture which was badly divided. There were divisions between the military and the scientists, and even within the scientific organization itself. Many of the scientists within NII-88 were pulled in different directions by the split between the ballistic missile group and the ZUR

---

[142] See editorial note by Mstislav Keldysh, in M.V. Keldysh, *Tvorcheskoe Nasledie Akademika Koroleva,* (Moscow: Nauka, 1980), p. 208.

coalition, which had been dominant in the first years of NII-88. Capitalizing on his success on the test range, the growing relationship with Ustinov, and the dangerous position of the ZUR program, Korolev was able to prod the leadership to move the ZUR program out of the institute. Even though Korolev did not become the director of NII-88, he did assume the creative control of the institute. From that time forward, NII-88 would be solely dedicated to Korolev's missile program. It would have a single sense of organizational mission which it would maintain for a decade.[143] This consensus would be a source of power for Korolev and, by extension, the missile program in the years to come.[144]

In part, Korolev owed his success in gaining control over NII-88 to political mismanagement by the leadership. When Stalin and Beriia arrested leading engineers, plant directors, and administrators, they were invariably replaced with personnel based upon political reliability, rather than technical qualifications. The new directors and administrators proved to be easy targets for Korolev, who either co-opted them or attacked them on technical grounds. As long as he could maintain his informational monopoly, he could use this tactic. During the next five years, Korolev would use this and other tactics to fend off other sources of competition.

---

[143] On the importance of organizational mission see Wilson, *Bureaucracy...*

[144] See Pfeffer, *Power in Organizations...*

CONCLUSIONS

Four years passed between the time that Korolev returned from Germany, and the acceptance of the first BRDD by the military. Although accomplishments on the test range were modest, Korolev built a powerful bureaucratic structure for his program. During this time, his program grew from a few dozen enthusiasts returning from Germany to the wreckage of NII-88, to an effective, but informal, organizational structure consisting of five separate institutes. He used the challenge presented by the dispersion of his colleagues across ministries to develop an original organizational structure which gave his scientists complete independence from interference from any minister. The only administrator with the authority to influence Korolev's activities, Dmitry Ustinov, became the primary constituent for Korolev's program. He was dependent upon Korolev's success. Korolev had gone from the head of a secondary department in NII-88 to assume effective control of the entire institute. For the scientists, it was a long and painful period, but it established a strong organizational foundation for Korolev's missile program.

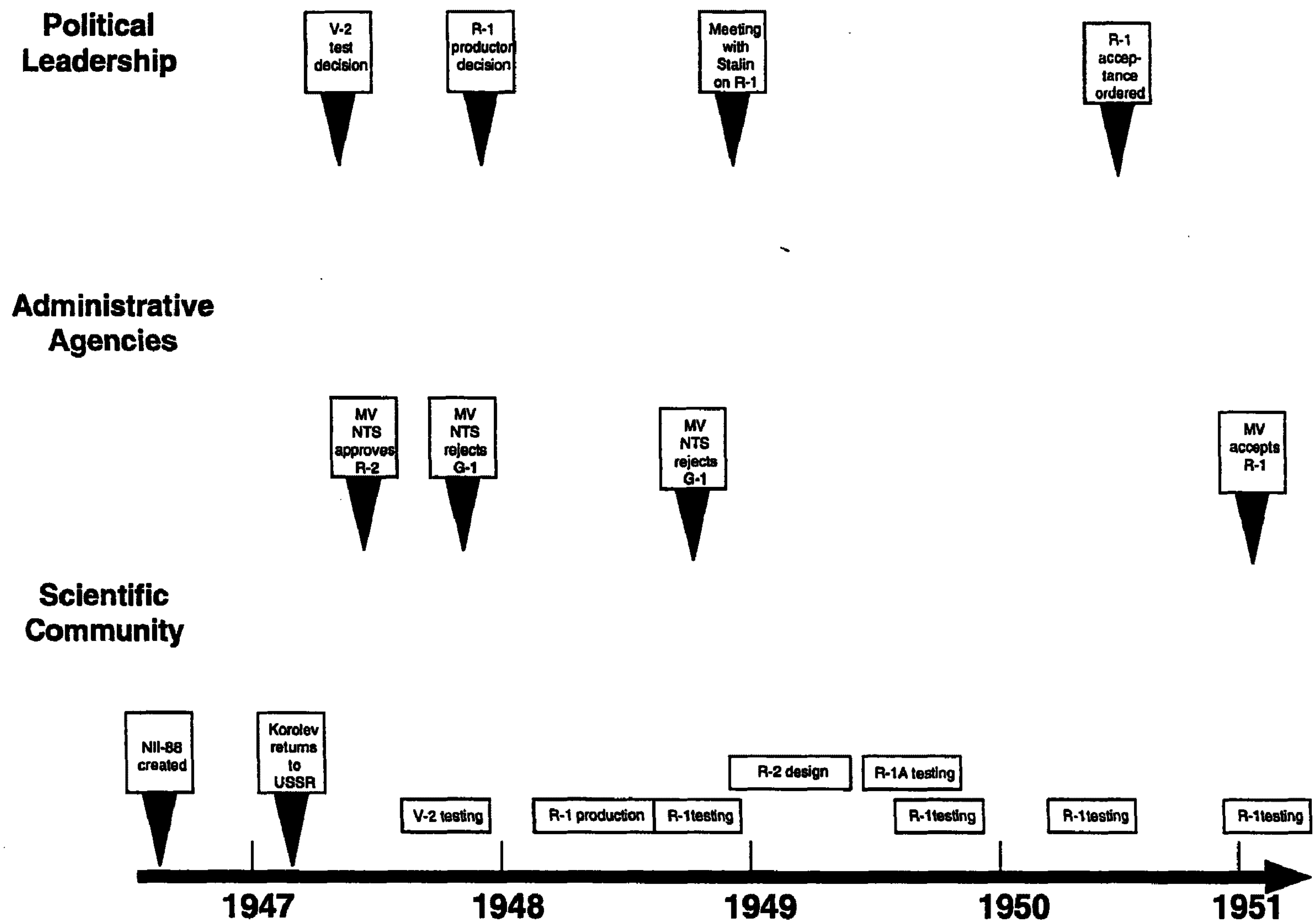

Figure 4.4 -- Major Events During Organizational Emergence Phase

Figure 4.4 depicts the major events during the phase of organizational emergence. From this, we can see that technological accomplishments were sparse during this period. Korolev was locked in a battle with the Artillery troops over acceptance of the first system -- the R-1. There was a great deal of activity during this period, but it was organizational rather than technological in nature. It was Korolev's focus on the organizational issues of: establishing a constituency; information control; and scientific coordination which proved decisive to survival in the precarious phase of organizational emergence.

Observation of Scientific Autonomy

Korolev was confronted with several challenges to his autonomy by the organizational structure dictated in the May 1946 decree. During the next four years, changes occurred in the original organizational arrangements which altered the relationship between Korolev and the political leadership. These observations will therefore be revisited to provide a more accurate picture of this relationship as it stood in 1951.

Scientists-end user relations

The end-user community was divided concerning the introduction of missiles. The leadership of GAU devolved from disinterest in the missile program in 1947 to outright hostility by 1950. However, at the working level, Korolev had built strong relations with many of the young officers. Furthermore, he introduced an educational course to train future officers in the field of missiles. Thus, he was building a constituency within the military from the ground up. It would be a slow process, however, and, at the end of 1951, the military remained more an opponent than an ally.

Competing scientific organizations

In 1947, the German rocket scientists presented a potential threat to Korolev's program. That potential became actual when the Germans proposed a more sophisticated missile program than Korolev's in late 1947. Korolev defeated the German program by appointing several of his own representatives to the evaluation committee. By the end of 1948, the German threat was removed, and Korolev incorporated many of their ideas into his own designs. From this point until 1953, Korolev retained an absolute monopoly over technological expertise.

Technological deviations

The military leadership attempted to keep a very tight rein on the development of Korolev's programs, offering only highly incremental approval. However, Korolev was able to circumvent their orders by creating a new program under scientific rather than military auspices. In the scientific version of the R-1, Korolev tested many components which had not been approved for testing. The R-1A was technically closer to the R-2 than to the R-1, and was therefore a clear violation of the approved military testing program. Such circumvention was only possible due to the ambiguity of Stalin's orders and the political leadership's inattentiveness to the missile program in general. So, while the R-1A program did provide a demonstration of scientific autonomy, it was the result of both Korolev's strategic behavior, and the ineffectiveness of the Soviet political leadership.

Informal versus formal coordination

Managing agencies do not readily sacrifice control. Yet with the institutionalization of the Council of Chief Designers, all ministers, with the exception of Ustinov, ceded control over enterprises under their jurisdiction to the Council. It was a unique organizational arrangement in the Soviet Union, providing the scientists a great deal of control over their own affairs. It provides us with a clear demonstration of scientific autonomy.

Evolving interests of administrators

In 1946 Ustinov embarked on the development of an anti-aircraft missile program, with a secondary ballistic missile program. By 1951, he had transferred the anti-aircraft program to another ministry and was concentrating his efforts on Korolev's ballistic missile program. His decision was motivated primarily by Korolev's ability to convince him that the ballistic missile program offered greater prospects for success than the ZUR program. The failure of the anti-aircraft program only strengthened Korolev's position. Therefore, Ustinov's shifting interests were as much a demonstration of the ineffectiveness of the designers of ZURs as they were a manifestation of Korolev's ability to influence Ustinov. Whatever his motivation, the fact that Ustinov was dependent upon the success of Korolev's program, was a source of autonomy for the scientists.

Transmission of adverse information

The primary function of a monitor is to provide an accurate depiction of the status of programs under his supervision. The distortion of the first R-1 test results indicated that Ustinov's ability to perform this function was severely constrained. Korolev was able to manipulate the information going to both Ustinov and Iakovlev. While Ustinov may have been a willing participant, Iakovlev was certainly not, and he challenged Korolev's report. Therefore, while Korolev was able to distort the initial report, he was not able to conceal his system's shortcomings over the longer term. Nevertheless, the fact that

Korolev was able to go as far as he did suggests that by 1951, he had already achieved a significant degree of autonomy.

Scientific Autonomy and the Early Phase of Institutionalization

From the above observations, it is clear that Korolev succeeded in achieving a great deal of autonomy from the political leadership. Through ineffective monitoring and general disinterest, the political leadership had almost completely lost track of the ballistic missile program by 1951. The military leadership remained implacably opposed to Korolev, but they were unable to exert any effective control. Korolev was able to circumvent most of the obstacles they placed in his path. Ustinov, on the other hand, had become a willing, if not dependent co-conspirator. He appeared to do whatever possible to support Korolev. Korolev appeared to be issuing more orders to Ustinov than the other way around. It was only at the end of 1951 that Ustinov realized that the program had spun out of his control. What remained to be seen in the next phase was whether or not Ustinov could regain control over Korolev.

Analyses

Organizational success may well be more important than technological success in the early phase of program development. The US long range missile program was very successful from a technical standpoint, but it stagnated until it was bureaucratically strong enough to advance.[145] Similarly, the success of the Polaris missile program was in large part due to the bureaucratic strength of the Special Projects Office.[146] It was clear that that Sergei Korolev was able to build an effective organization. By all indications, he was more concerned with constructing his bureaucratic program than the missiles during this early phase. The missiles appeared to be merely a means to an organizational end. During this early period, when Korolev was producing missiles with a range of only 200 km, and a success rate under 50%, it is hard to understand why the leadership kept his program alive. There were no indications that it understood the possibility of using Korolev's weapon for launching nuclear bombs, and Stalin in the processes of building a long range bomber force capable of delivering nuclear weapons to the United States.

It would be simplistic to assert that Korolev achieved scientific autonomy purely through effective implementation of a bureaucratic strategy. He needed help. Surprisingly, his greatest assistance came from the mismanagement of the program by the Soviet leadership. The fact that the missile program was placed within a ministry which

---

145 See Beard, *Developing the ICBM...*

146 See Harvey Sapolsky, *The Polaris System Development: Bureaucratic and Programmatic Success in Government*, (Cambridge: Harvard University Press, 1972)

was completely unfamiliar with the technology gave Korolev the opportunity to educate the personnel who would supervise him and act as military operators and customers. It assured him of an informational monopoly for the critical first years of the missile program.[147] Garbage can decision-making provided fertile ground for Korolev and Ustinov to continue gaining approval for their projects -- as long as they remained incremental.[148]

It was Korolev's bureaucratic acumen which proved decisive to the success of the Soviet missile program. His ability to capture and use constituencies in the Ministry of Armaments and the Academy of Sciences was critical to achieving autonomy. At the same time, Korolev was able to establish a flexible decision making structure composed entirely of members of the scientific community. Without these tactics, the Soviet missile program could not have survived. Without these tactics, Korolev would not have been able to go on to develop the Soviet space program.

---

[147] See Pfeffer, *Power in Organizations...*

[148] See Kingdon, *agendas, Alternatives and Public Policy...*

CHAPTER 5

Some people say we were technological ignoramuses. Well yes we were that, but we weren't the only ones. There were some other people who didn't know the first thing about missile technology.

Nikita Khrushchev

1951-1957 INSTITUTIONALIZATION OF THE SOVIET MISSILE PROGRAM

The 1951-1953 period was a watershed in the development of the Soviet missile program. Up to that point, the leadership refused to allow production of anything beyond copies of German missiles. On separate occasions, Stalin turned-down proposals to develop missiles with ranges of 600 km (the R-2), and 3,000 km (the R-3). Manned bombers were the focus of Stalin's attention for delivering atomic weapons, and anti-aircraft missiles (ZUR) were the highest priority program among missile programs. Since ZURs were being developed within the same institute as Korolev's ballistic missiles, Korolev's program was secondary within his own institute. Priorities shifted when the ZUR program was transferred to the Ministry of Aviation Production. Now Ustinov's ministry, as well as NII-88, had only one high priority program to support.

The log jam broke in late 1950. Over the next three years, the leadership would issue approvals for the R-2 (range-600 km) the R-3 (3,000), the R-5 (1500 km), the R-11m (600 km SLBM), and the R-7 (the ICBM which ultimately launched the first satellite). By the end of 1957, all of these systems were developed and the leadership had a useful policy program -- Korolev's missile program was institutionalized.

Analytic and Substantive Issues

In the phase of organizational emergence, the basic problem is one of finding a constituency and achieving a minimal level of support to establish a program. Building a strong organizational foundation should be the focus of the scientific leadership. Given a strong organizational base, the scientists can then move through the most difficult technical phase of a program, when considerable advances in science and engineering must be made. In the institutionalization phase, large amounts of resources must expended without guarantees that any single technological project will offer a concrete payoff. The organizational strength of the scientists will be most severely tested during this period, and their ability to resolve inherent dilemmas of innovation will determine the success of the program.

Balancing informational control with the need to maintain a constituency

The first dilemma facing the scientists is balancing information control and maintenance of a strong constituency. The more information the scientists give to the constituent, the stronger the relationship, but at the same time it means sacrificing control over their own program. In contrast to the earlier phase of organizational emergence where the focus was on locating a constituency, as the program matures the scientists have already established a constituency, the issue now is maintaining and strengthening that constituency without sacrificing control. Information control is even more important as administrative agencies gain a better grasp of new technologies.

After the ZUR program was eliminated, Korolev and Ustinov were dependent upon one another. The dilemma of control versus constituency was ameliorated for Korolev. He was irreplaceable.[1] He could concentrate his attention on maintaining information control. Korolev was able to accomplish this, by maintaining a strong organizational consensus, and attacking competing sources of expertise.

Developing a research foundation

Before any program can begin designing useful hardware, the scientists must conduct a great deal of research in order to understand the basic issues they face, the technological problems they must solve, and the potential configurations for the program.[2] Such research is invariably expensive and time consuming. Results appear only on paper.

---

[1] On Irreplaceability see Jeffrey Pfeffer, *Power in Organizations*, (Cambridge: Ballinger, 1981).

[2] See Donald Mackenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*, (Cambridge: MIT, 1990)

This is the most difficult stage both technically and bureaucratically for the scientists.[3] Successful negotiation requires organizational strength.

By 1949, Soviet scientists were faced with serious technological obstacles without clear solutions. The basic configuration of future long range missile remained in doubt. The possibilities ranged from multi-staged cruise missiles, to single stage ballistic missiles, with a variety of intermediate options. To answer the basic technological questions, the scientists needed time and money with no strings attacked. The Soviet leadership was ill disposed to do this. The early 1950s were a period of unusually high domestic political tension as another party purge was imminent. Administrators were unusually cautious of accusations of sabotage. To perform the research without putting the administrators in an uncomfortable position, Korolev put up the smoke screen of the R-3 project, claiming to be working on a 3,000 km single stage missile. In fact he was performing the fundamental research necessary to make a choice of the best missile configuration. He had no intention of building the R-3. His ability to shape the government's perception of this program was one his more important demonstrations of bureaucratic slight of hand.

Maintaining mission focus versus diversification

A second issue facing the scientists centers on the core mission of the program. As research proceeds, new technological possibilities emerge. Scientists must choose

---

[3] See Bruno Latour, *Science in Action,* (Cambridge: Harvard, 1987);

whether to focus on a single alternative, or attempt to maintain control over several options. This choice involves bureaucratic as well as technical judgments. Technically, the choice is straightforward: which of the options will be best suited to the intended mission(s)? The bureaucratic calculation of which option will put their organization in a strong position is more complicated. Wilson argues that most often bureaus chose to protect their core mission rather than attempt to branch out into new areas.[4] But, if they choose to focus on a single option, they must be sure that this option will prevail. It is an all or nothing gamble. If they choose to pursue several options: do they have sufficient staff to develop more than one option? What is the cost of failure of one of several options?

In the early 1950s Korolev was faced with a multitude of choices. After some trial and error, the solution he arrived at was novel and effective. As new technological developments opened the possibility for new systems and missions, Korolev would perform the initial development work, and then spin off a new design bureau, headed by one of his deputies, to design and develop new systems. This tactic permitted him to gain credit for the innovation, but retain both the focus on his design bureau's core technology, and informal control over the new design bureau. In this fashion, Korolev was able to develop a far flung empire in the Soviet missile and space industry, establishing an informal ministry within the Ministry of Armaments.

---

[4] See James Q. Wilson, *Bureaucracy*, (New York: Basic Books, 1989)

Leadership: organizational focus or competition?

A similar dilemma faces the state leadership. Should the state focus resources on the single, most promising alternatives, or should it risk diffusing technical expertise below a critical mass by attempting several alternative at the same time? Redundancy creates additional sources of information as well as providing assurances that one program would yield satisfactory results. However, early in the lifecycle of a technology the number of qualified experts is likely to be limited, and there may not be a sufficient quantity to maintain two competing programs. As a technology matures and more specialists are trained, money is the limiting factor.

After the departure of the German rocket scientists, Soviet efforts at rocketry were singularly focused on Korolev's program. But by 1954, Ustinov was concerned over Korolev's monopoly, and set up a competing design bureau in Dnepropetrovsk Ukraine under Mikhail Iangel. Iangel's technological approach differed significantly from Korolev's, and promised to lead to more effective military weapons. A competition ensued between Korolev and Iangel to develop the first ICBM. Korolev won the battle, but ultimately lost the war, as Iangel perfected his technology and went on to develop the first effective ICBMs for the Soviet Strategic Rocket Forces. By this time, Korolev was out of the missile business and had moved on to his real destination--space.

Actors

Over the period from 1952-1957 the institutional cast of characters involved with the Soviet missile program underwent few changes. There were considerable changes among individual actors, and the turnover of personnel presented opportunities which Korolev was able to use to his advantage. Figure 5.1 depicts the organization of the Soviet missile program in late 1953. The formal organizational structure was the same as that which existed prior to Stalin's death, with notable exception that *Spetzkomitet-2* was eliminated. In its place was an office within the Council of Ministers responsible for ballistic missiles, and under the direction of Grigorii Pashkov. The other change was that the Vice President of the Academy of Sciences Mystislav Keldysh was informally brought into the fold of the Council of Chief Designers, serving as the representative for institutes within the Academy which could provide mathematical and other theoretical support to Korolev's program.

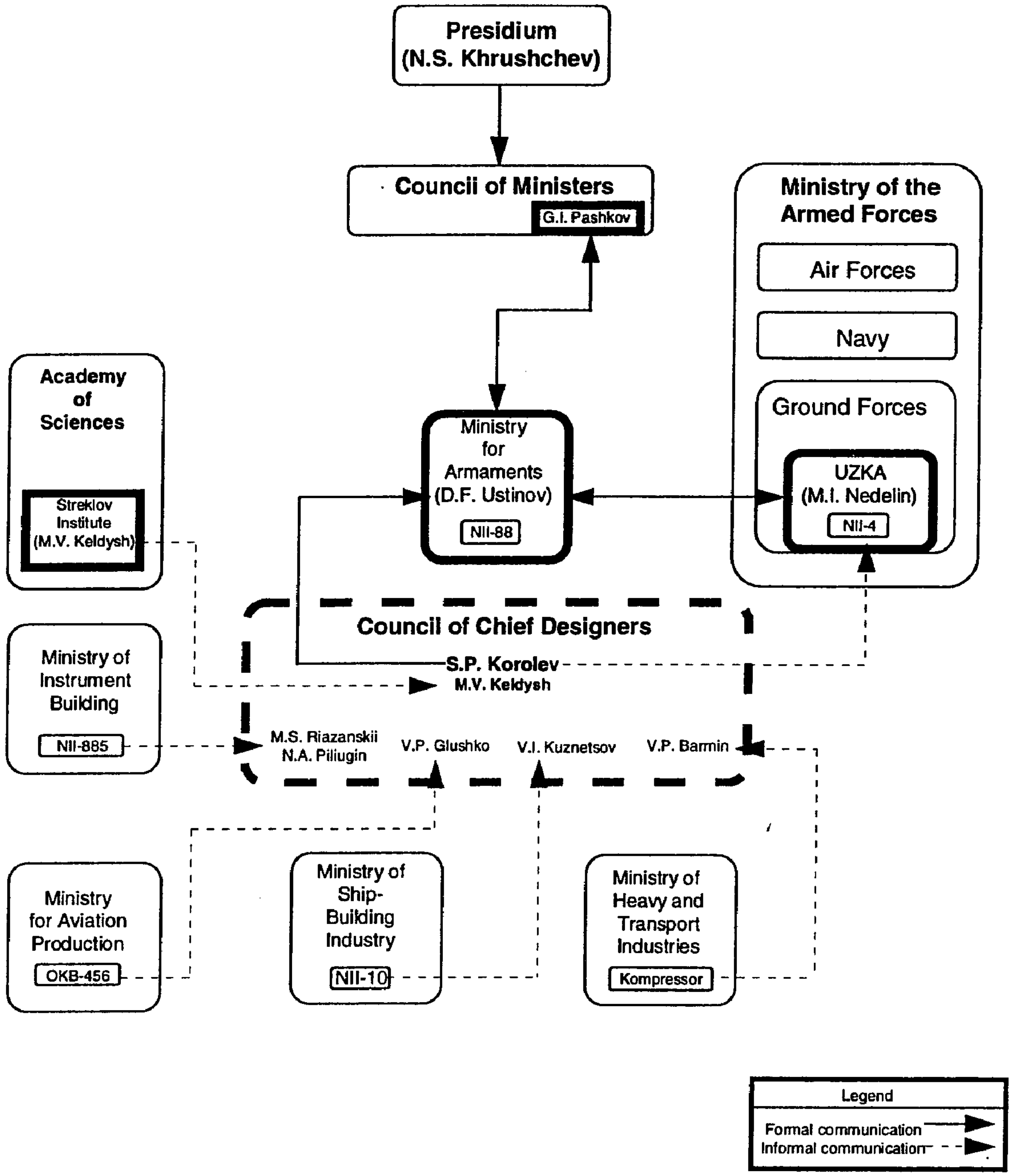

Figure 5.1 -- The Organization of the Soviet Missile Program in Late 1953

The last three years of Stalin's life were marked by increasing decrepitude and inattention. Nikita Khrushchev put the matter most vividly:

> Those last years with Stalin were hard times. The government virtually ceased to function...After the Nineteenth Party Congress, Stalin created among the new Presidium members some wide-ranging commissions to look into various matters. In practice these commissions turned out to be completely ineffectual because everyone was left to his own devices. There was no guidance. There was nothing assigned for the commissions to look into, so they made up their own assignments. Everyone in the orchestra was playing on his own instrument anytime he felt like it, and there was no direction from the conductor.[5]

Iosef Stalin died on March 3, 1953. With his death, there was a complete turnover of the leadership structure. From 1953 until the summer of 1957, there was a constant struggle among the political leadership over succession to Stalin's position. The two individuals having some understanding of missiles, the head of the secret police Lavrentii Beriia, and the Chairman of the Council of Ministers Georgi Malenkov were both eliminated from leadership responsibility over this period. Beriia was shot in 1953, and Malenkov demoted in 1955. The remaining members of the leadership, and perhaps most of all Khrushchev himself, were almost totally ignorant about missile technology, and were preoccupied with leadership succession for the entire period.

Dmitry Ustinov, the Minister of Armaments, was one of the few islands of stability in the Soviet administrative structure connected with the missile program. He remained in

---

[5]See Strobe Talbott, editor and translator, N.S. Khrushchev, *Khrushchev Remembers: the Last Testament*, (New York: Little Brown, 1971) p. 297.

his position until 1957, when he was promoted to head the Military Industrial Commission, but remained closely in touch with the missile program even after that date.

The Special Committee for Missile Technology *Spetzkomitet-2* was effectively replaced in the early 1950's with a much lower level group within the Council of Ministers apparatus under the direction of Grigori Pashkov.[6] But this change had little effect at the programmatic level, as Georgi Malenkov, the head of *Spetzkomitet-2*, had been completely ineffectual up to that time. The final years of Stalin's life saw the beginnings of another political purge that took several other significant members of the administration of the missile program. Marshal Iakovlev was dismissed as head of the Main Artillery Directorate and replaced by Marshal Mitrofan Nedelin in 1952. This single change made a huge difference, as Nedelin proved to be a much more pliable customer for Korolev.

Stalin's attacks reached as far down as NII-88. Robert Gonar was arrested in 1950 and replaced by Konstantin Rudnev. From that point on, the director's office at NII-88 was a revolving door. In 1952, Rudnev was promoted to become Ustinov's deputy for missiles, and was replaced as NII-88 Director by Mikhail Iangel. Iangel left to form his own design bureau OKB-586 in 1954, and was replaced by Nikolai Spiridonov. In 1956, Korolev's design bureau, which had come to dominate the institute, was finally separated as an independent design bureau OKB-1.

---

[6] See "G.I. Pashkov" in Iu. A. Mozhorrin, *Dorogi v Kosmos, Vol. II,* (Moscow: Moscow Aviation Institute, 1993)

In contrast to the turbulence above them, the cast of designers in the Council of Chief Designers remained consistent during this period. Their ability to operate outside the confines of the Soviet ministerial bureaucracy, and their informal cooperative style made them a strong-unified force in the face of a splintered administrative bureaucracy. Beginning in the mid 1950s, however, cracks began to appear in the edifice. A competing design bureau was set up by Ustinov under Mikhail Iangel in 1954 which offered competitive projects. By 1956, Korolev's informational monopoly was cracked. Within the Council, relations frayed between Korolev and the Chief Designer of Rocket Engines, Valentin Glushko. Beginning as a personality conflict, in later years it led to a rupture of the basic fabric of the Soviet space program. But at the same time, Korolev was extending the boundaries of his empire and strengthening the Council. In 1955, he began a program for Sea Launched Ballistic Missiles (SLBMs). Once he demonstrated the first successful prototype, he passed this program on to one of his deputies Viktor Makeev who opened up a new design bureau in the Ural mountains at Korolev's direction. Thus, Korolev created the first of what would be many bureaucratic satellites. In the early 1950s Keldysh was co-opted into the Council as the representative of the Academy of Sciences. He brought with him impeccable technical credibility which was used against competing scientific organizations, in particular, Mikhail Iangel.

THE R-2 PROJECT AND RESOLUTION OF PROBLEMS WITH MILITARY CUSTOMERS

Although development of the R-2 was approved by the Scientific Technical Council (NTS) of NII-88 three years earlier, the project was not approved by the leadership and remained in a state of bureaucratic suspended animation in 1950. All of the engineering work was completed, but the system was not approved for prototype production and testing. Even so, Korolev unofficially tested an "experimental" version of the R-2 in September of 1949 under the guise of the R-1A.[7] Official approval did not come until June 13, 1950.[8] In October, Korolev returned to the test range to begin official flight tests for the R-2. The first series of flight tests proceeded for two months yielding "good results." The second series of tests took place in July 1951. The tests were entirely successful, but Iakovlev still refused to accept the system.[9] The R-2 appeared destined to the same torturous acceptance process as the R-1.

The course of events took an abrupt change in 1952 when Iakovlev was arrested and replaced by Marshal M.I. Nedelin as CinC of GAU. Iakovlev had been a constant thorn in Korolev's side from the beginning of the post-war missile development program, refusing to accept any missiles into his services without serious resistance. Ironically,

---

[7] The R-2 NTS review is discussed in some detail in chapter 4. See also Bazhenov and Maksimov, ...p. 14.

[8] See *Progress: gazeta tsentral'nogo nauchno-issledovatel'skogo instituta mashinostroeniia*, May 23, 1991, p. 1.

[9] See Vetrov, *Sekrety Ostrova Gorodomliia...*

Iakovlev was arrested in 1952 for allegedly allowing the launch of a missile which was ill prepared for testing.[10]

Korolev and Nedelin immediately established good working relations, in large part because Nedelin was willing to admit his own technological ignorance.[11] Nedelin's background suggests that he was incapable of independently determining the technical merits of ballistic missiles. His educational training was limited to the political faculties of military academies.[12] His political training, combined with the arrest of Iakovlev, indicates that he was given responsibility for the artillery program more due to his political reliability than his technical competence.[13] Nedelin did not prove to be a particularly demanding military customer and Korolev aptly described the Marshal as "an experienced and benevolent advisor-consultant."[14] Final tests of the R-2 proceeded in September of 1952 "without failure." In contrast to the R-1, the R-2 was accepted by the Artillery troops without incident.[15]

---

[10] This probably involved anti-aircraft missiles, but there is no information to confirm this. See Iaroslav Golovanov, *Korolev: Fakti i Myfi,* (Moscow: Nauka, 1994), p 461.

[11] See Golovanov, *Korolev*...p 461.

[12]Nedelin's training was first in the Military-political courses in Turkestan (1923), and the Higher Komsomal Faculty (*Komsostav*) of the Dzerzhinskii Artillery Academy.

[13]Nedelin began his military career as a political commissar and only later became a fully fledged artillery commander, after the institution of political commissars was abolished. He had no engineering background.

[14]See V. Tolubko, *Nedelin* (Moscow: Molodaia Gvardiia, 1979) p. 176.

[15] See B.V. Raushenbakh, *Iz Istorii Sovetskoi Kosmonavtiki,* (Moscow: Nauka, 1986), p. 230.

Since before Nedelin, Korolev pushed for a separate branch of the military devoted to the missile program. Both he and the lower ranking military officers working on the program felt that they were being stifled by the rest of the artillery "ground pounders who refused to acknowledge the significance of the new technology."[16] In 1953 the Directorate of the Artillery Command for Special Technology (UZKA) was officially created under Nedelin's command to supervise the introduction of missiles into the Army. Unofficially, it had the effect of isolating the missile program from the rest of the Artillery program.[17] In 1955, after the first successful test of a nuclear armed missile, the management of the missile program was brought out of the artillery troops altogether and put under the command of Nedelin as the Deputy Minister of Defense for Special Weapons and Rocket Technology.[18]

Windows of Opportunity

Korolev once again reaped the benefits of Stalin's capriciousness. The arrest of Iakovlev removed a huge obstacle in his path. Nedelin was quickly co-opted and came to be an active, unabashed supporter of Korolev's program. By isolating Korolev's program from the rest of the Army, Nedelin ended up reducing his own ability to effectively

---

[16] Interview with Kerimov

[17] This was the conclusion of an official history of the military missile program. See Iu. p. Maksimov, *Raketnye Voiska Strategicheskogo Naznacheniia: Voenno-istoricheskii Trud,* (Moscow: RVSN, 1992) pp. 40-41.

[18] *Ibid.*, p. 41.

Since before Nedelin, Korolev pushed for a separate branch of the military devoted to the missile program. Both he and the lower ranking military officers working on the program felt that they were being stifled by the rest of the artillery "ground pounders who refused to acknowledge the significance of the new technology."[16] In 1953 the Directorate of the Artillery Command for Special Technology (UZKA) was officially created under Nedelin's command to supervise the introduction of missiles into the Army. Unofficially, it had the effect of isolating the missile program from the rest of the Artillery program.[17] In 1955, after the first successful test of a nuclear armed missile, the management of the missile program was brought out of the artillery troops altogether and put under the command of Nedelin as the Deputy Minister of Defense for Special Weapons and Rocket Technology.[18]

Windows of Opportunity

Korolev once again reaped the benefits of Stalin's capriciousness. The arrest of Iakovlev removed a huge obstacle in his path. Nedelin was quickly co-opted and came to be an active, unabashed supporter of Korolev's program. By isolating Korolev's program from the rest of the Army, Nedelin ended up reducing his own ability to effectively

---

[16] Interview with Kerimov

[17] This was the conclusion of an official history of the military missile program. See Iu. p. Maksimov, *Raketnye Voiska Strategicheskogo Naznacheniia: Voenno-istoricheskii Trud,* (Moscow: RVSN, 1992) pp. 40-41.

[18] *Ibid.*, p. 41.

monitor Korolev.[19] He was now in the same position as Ustinov, forced to rely upon the success of Korolev's program for the survival of his own institution. As was the case when Gonar was replaced as Director of NII-88 in 1950, Korolev used the "window of opportunity" presented by the introduction of a new, inexperienced manager to advance a major reorganization of the administration of his program, and isolate it from bureaucratic opponents.[20] He would maintain this uncanny sense of timing throughout his career.

THE R-3 PROJECT

In November 1949, Korolev presented his next set of concepts --the R-3-- to the NTS of NII-88. Korolev originally presented the technical proposal for the R-3, which would have a range of 3000 km, to Stalin in April 1947. Stalin put off a decision until Korolev could demonstrate that he could build copies of the V-2 with a range of 300 km. Proceeding without governmental approval, Korolev put together a group over 80 workers devoting over 190,000 man hours to the R-3 project between 1947 and 1949.[21] In December 1949, Korolev's group presented four variants of the system with differing configurations of boosters and winged or ballistic re-entry vehicles. The winged, multi-

---

[19] See Anthony Downs, *Inside Bureaucracy,* (Boston: Little Brown, 1967).

[20] On windows of opportunity see John W. Kingdon, *Agendas, Alternatives, and Public Policies,* (Boston: Little Brown, 1984). See Chapter 4 for a discussion of the reorganization of NII-88.

[21] See G.V. Vetrov, *Sekrety Ostrova Gorodomliia,* (mimeo) p. 181.

staged version had a calculated range of 4100 km with a three-ton warhead. Korolev did not stop there. Tying this project in with much grander visions of missiles with intercontinental range, he asserted:

> It is especially necessary to note when we speak of the furthest future that a range of 3000 km should only be examined as the first stage that makes it possible to solve to solve certain problems envisioned in the TTT for the R-3.[22]
>
> The costs and the whole complex of technical measures necessary for attaining the range of 3,000 km are so great that it would be unacceptable to isolate this work from the prospects for further development.
>
> Therefore for the following stage, capable of solving significantly greater tasks a range of the order of 8,000 km was projected with an increased payload.[23]

After hearing the report, "Ustinov and the military could not hide their satisfaction."[24] These were bold claims for a man who was still only the head of a section within a research institute, that was unable to convince the military to accept a missile with a range of only 300 km. The project was quickly approved by the leadership and a decree issued for Korolev to continue with full scale development.

The R-3 was not a single project, but a group of systems ranging from 1500 km to over 8000 km featuring winged ballistic missiles as well as more conventional ballistic

---

[22] TTT is the Soviet acronym for Technical Tactical Requirement. It is the official requirements document specifying system parameters.

[23] See M.V. Keldysh (ed.) *Tvorcheskoe Nasledie Akademika, sergeia pavlovicha Koroleva,* (Moscow Nauka, 1980), as cited in Holloway, *Stalin and the Bomb*...p. 292.

[24] See Golovanov, *Korolev*... p. 421; and, Vetrov, *Sekrety Ostrova Gorodomliia,*... pp. 188-198

systems.[25] The focal point was a single stage missile weighing 70 tons with a range of 3,000 km.

The program was deliberately amorphous. Korolev never intended to build the R-3.

Instead, the broad program was intended to serve two purposes. First and foremost, it was a means of both capturing the interests of the political leadership, and assuring skeptical members that Korolev would indeed produce a system which capable of frightening more than Poland. But the R-3, was also intended as a broad research program aimed at determining the optimal variant for long range ballistic missiles which might ultimately be capable of striking the United States.[26]

The first part of the R-3 project examined ballistic missiles. This work was broken into three research tasks. The first was development of single-stage missiles without aerodynamic stabilizers. Tail fins were ineffective for guidance and stabilization once the missile reached the upper levels of the atmosphere, and they also created aerodynamic drag. Thus, Korolev needed to develop the concept of gyroscopic stabilization if his longer range missiles were to be successful. Scientists from NII-88, Viktor Kuznetsov's institute (NII-10), and engineers from NII-885 under Nikolai Piliugin developed

---

[25] The scope of Korolev's work surrounding the R-3 project can be derived from a document produced by Mstislav Keldysh under Korolev's direction as part of the R-3 project. See "Ballisicheskie vosmozhnosti sostavnikh raket," (Ballistic possibilities of sectional rockets) in V.S. Avduevskii, *M.V. Keldysh: Raketnaia Tekhnika i Kosmonavtika,* (Moscow: Nauka 1991) pp. 30-140.

[26] This was the justification provided by Korolev's deputy V.P. Mishin; see also Golovanov, *Korolev...*; and, Chertok, *Raketi i Liudi...* for supporting accounts.

completely new gyroscopic guidance and stabilization systems for long range ballistic missiles.[27]

The second task was an examination of different components for missile fuels. The tradeoff was between the readiness of storable propellants, versus the increased energy of cryogenic components, in particular liquid oxygen and kerosene. Korolev conducted this work at his own institute.

In the third task, Korolev examined the possibilities for creating multistage intercontinental ballistic missiles. This work was performed by Korolev's institute in cooperation with Mstyslav Keldysh's Streklov Mathematics Institute of the Academy of Sciences.

The basic conclusions of Korolev's work were presented at annual session of the Scientific Technical Council (NTS) of NII-88 in a document titled "Thesis document on research results of future development of long range ballistic missiles (BRDDs)." This document provided the basis by which the military customer would choose future ballistic systems.[28] In it, Korolev developed three conclusions of consequence to the course of the missile program. First, he asserted that storable propellants were not capable of launching a 3 ton warhead further than 1000 km. and that these fuels would prove to be

[27] Interview with Chertok.

[28] S.P. Korolev, "Tezisy doklad po resul'tatam issledovanii perspectiv razvitiia ballisticheskikh raket dal'nego deistviia," (Thesis document on research results of future development of long range ballistic rockets,) in Keldysh, *Tvorcheskoe Nasledie...* pp. 319-327.

unproductive for use in ICBMs. Second, he concluded that a two-stage system with parallel burning engines was the most efficient option for future missiles with a range of over 10,000 km. This cleared the way for development on the "packet" system which was the only variant capable of launching a sizable payload into space. It was the variant which Korolev clearly preferred for this reason alone.[29] Finally, Korolev argued that a single stage missile was capable of reaching 7000 km. But only if an engine with 500 tons thrust could be developed. By contrast, a "packet" system could accomplish this with less than 150 tons maximum thrust.[30]

As a separate part of the R-3 project, Korolev considered winged long-range missiles which were essentially high speed, high altitude cruise missiles, launched either vertically or horizontally, and then glided to their targets during the terminal phase. In part, these ideas owed their heritage to the German scientist Sanger, but Korolev had done significant work on rocket planes earlier in his career.[31] Whatever the origins, this study concluded that there were serious problems with thermal regulation which effectively limited the warhead size to 500 kg. Furthermore, the demand for constant guidance would require either a radio-based system or astral navigation.[32] The first was technically feasible but politically impossible, since it required transmitting stations every several

---

[29] Interviews with Mishin, Chertok, Bazhenov, and Maksimov.

[30] M.V. Keldysh, *Tvorcheskoe Nasledie...* pp. 319-327.

[31] See Raushchenbakh, *Iz Istorii...*pp. 230-231.

[32] See Keldysh *Tvorcheskoe Nasledie...* pp. 328-341

hundred kilometers or so. It was unlikely, to say the least, that the United States would permit such deployments. Astral navigation on the other hand required major technological breakthroughs.

Despite the technological problems, Korolev believed that winged rockets could solve both the problems of delivering warheads to the United States and a man into space, and was therefore reluctant to give up on the idea. But there were powerful forces working against him. In the first place, Ustinov did not support the idea, reasoning that as soon as the plans appeared practical, they would be transferred to the Ministry of Aviation Production. Keldysh also understood this, and both convinced Korolev that he should stick to ballistic missiles.[33] The NTS recommended that the cruise missile project would be sent to Keldysh's institute in the Academy of Sciences for further study.[34]

Korolev never undertook hardware development of the R-3. Instead, he used the project as a justification for examining as many alternatives as possible for extending the range of rocketry. For four years, Korolev devoted a large portion of his resources to this project which could only be termed basic research. In the end, he unilaterally abandoned the 3000 km R-3 in 1951, and instead proposed the single stage R-5 which had a range of 1500 km. Korolev used this time and money to solve difficult technical issues.

---

[33] See Chertok, *Raketi i Liudi ...*

[34] See Keldysh, *Tvorcheskoe Nasledie...* pp. 328-341.

Irreplaceability and information control

The R-3 program demonstrated the degree of freedom Korolev established through his monopoly over technical information. He circumscribed orders from the Soviet government undertaking a research agenda which bore little resemblance to the original project. He knew it would be difficult to get such undirected research funded directly, so he used the R-3 as a smoke screen. It was a dangerous gambit, particularly in the early 1950s when several members of the missile program were being actively investigated by the Secret police.[35]

How was Korolev able to accomplish this? Since the departure of the ZUR program Korolev was irreplaceable for Ustinov as a strategic program.[36] If Ustinov wanted to participate in one of the high profile strategic development programs, he had to work with Korolev. Without sufficient expertise, Ustinov was unable to prevent Korolev from acting opportunistically. With the final report, Korolev solidified his position by defining the basic characteristics of future ballistic missiles. While the report did not eliminate competitive programs it did forestall competitive efforts looming on the horizon.[37]

---

[35] Between 1950 and 1952, the director of NII-88, Gonar, was arrested, as was Marshal Iakovlev. Chertok, was demoted, and Riazanskii was threatened. Ustinov himself was concerned that he would be arrested.

[36] On the importance of irreplaceability, see Pfeffer, *Power in Organizations*...

[37] As will be developed in more detail below, Iangel was already considering the possibility of developing his own missiles utilizing storable propellants.

THE STRUGGLE FOR CONTROL OF NII-88

In 1949 and 1950, NII-88 suffered from a serious case of organizational schizophrenia, performing two very different missions (i.e. anti-aircraft and ballistic missiles) for different customers. While Korolev managed to focus the mission of the institute on BRDDs in 1950, problems remained over the basic technology to be used for developing long-range ballistic missiles. The issue in dispute was they type rocket fuel to be used in the next generation of missiles. Korolev supported the use of liquid oxygen and kerosene, while the military supported the use of storable propellants. Korolev's missiles promised greater range but were cumbersome on the battlefield because liquid oxygen required refrigeration and could only be loaded immediately prior to launch. Missiles using storable propellants could remain fully fueled in their launchers for weeks prior to launch, but their range remained in question. The military made a powerful case against Korolev, and shortly after his arrival, the new Director of NII-88, Konstantin Rudnev, declared that storable propellants would be "the main direction of the institute."[38]

---

[38] Iu. A. Mozhorrin, "Istoriia sozdaniia i razvitiia Tsentral'nye nauchno-issledovatel'skii institute mashinostroeniia" (The History of the Creation and Development of the Central Research Institute of Machinebuilding,) *Kosmonavtika i Raketostroenie,* Vol. 1, No. 1 (1993) p. 23.

The dispute over technology manifested itself as a personality struggle. In August 1952, Mikhail Iangel was appointed as the new director of NII-88 replacing Rudnev, who went on to become Ustinov's deputy for missile programs. From the time Iangel arrived at NII-88 it was clear that he was very well connected politically. Iangel served as the scientific attaché in the Soviet Embassy in the United States during the war, and in Germany prior to that.

For his first year and a half at the institute, Iangel worked under Korolev as the head of the guidance department, in spite of the fact that he had no experience in either guidance systems or rocketry. In 1950, at the same time as Gonar was removed, Boris Chertok, then head of the guidance department, was subjected to similar accusations by the NKVD. Iangel's appointment as head of the guidance department served to ensure the political reliability of Chertok's department.

The appointment of a subordinate to serve as institute director irritated Korolev and the two developed a strong rivalry. The strain in personal relations was exacerbated by Iangel's support of storable propellants, and his opposition to Korolev's report of December 1951.[39] According to Chertok, the two only spoke to each other when it was absolutely necessary. Routine communications were conducted through intermediaries.[40]

---

[39] See Korolev, "Tezizy doklad..."; and, interview with Mishin.

[40] Interview with Chertok; see also Chertok, *Raketi i Liudi*, ..

An uncomfortable modus vivendi was established while Iangel was director, but it did not last.

Korolev understood it would be possible to achieve intercontinental ranges given further development of storable propellants.[41] But he knew it would be very difficult to make a missile powerful enough to launch a large satellite into orbit using these fuel components given the existing state of technology. He knew he could get into space using liquid oxygen and kerosene. It was necessary therefore, to stall the development of these systems at least until he could get his space program started.[42] To support his case, Korolev commissioned a study by M.V. Keldysh, who by then was a close colleague of Korolev, and an informal member of the Council of Chief Designers. Keldysh supported Korolev's position in a late 1953 report asserting that the practical limitation for storable propellants was 1000 km.[43] As a leading member of the Academy of Sciences, Keldysh's position was unassailable. The report was a political victory for Korolev over Iangel. On June 9, 1954, Iangel was sent to Dnepropetrovsk in the Ukraine to head the newly formed design bureau and factory (OKB-586). Their competition would continue from a distance.

---

[41] Korolev noted that the development of UDMH (hydrazine) as a propellant would greatly increase the range of storable propellants. See Keldysh, *Tvorcheskoe Nasledie*...Interview with Budnik, Dnepropetrovsk, Ukraine, August 19, 1992.

[42] Interview with Mishin.

[43] See Avduevskii, *M.V. Keldysh Izbrannye Trudy*... pp. 142-144.

Ultimately, Iangel would prove Korolev and Keldysh wrong, but by that time Korolev was well on his way to space.[44]

In another two years, Korolev would finally achieve his aim of gaining full control over his own design bureau. On August 14, 1956 Council of Ministers decree number 310 separated OKB-1 from the rest of NII-88, and an independent OKB-1 was established.[45] NII-88 went on to perform testing and analyses for the entire missile program, and Korolev went about developing his next missiles. In reality, the decree was only a formality, OKB-1 had already grown much larger than the rest of NII-88 and Korolev was operating quite independently from the rest of the institute.[46] There were essentially no changes in the operations or activities of Korolev's design bureau and prototype production facility.[47] The decree simply recognized the battle was won.

Refining Organizational Mission and the Appeal to Outside Expertise

Korolev's struggle for control over NII-88 seemed unending. But the final battle was fought with Iangel in 1953. To prevail, Korolev capitalized on his developing relationship with Keldysh whose technical competence was unquestioned. While there is

---

[44] In 1958 a research institute in Leningrad developed a means of producing hydrazine, a sufficiently energetic storable propellant which would be used in Iangel's missiles. In fairness to Korolev, he had noted that hydrazine would make a useful fuel, but he did not believe it would be developed soon. Interview with V.S. Budnik, Dnepropetrovsk, Ukraine.

[45] See Golovanov, *Korolev...* p. 464.

[46] Interview with Mozhorrin.

[47] See Golovanov, *Korolev...* p. 464.

no evidence that Keldysh intentionally distorted his report to support Korolev, in 1956, Iangel designed a missile capable of twice the range Korolev predicted using the same storable propellants. At the same time, Korolev and Keldysh were plotting the development of a satellite program, in which Keldysh figured prominently.[48] Therefore, he held many of the same incentives as Korolev to see that missiles with higher payload capacities survived long enough to begin a space program. Whatever the motivations, the result of Keldysh's report was clear, NII-88 would focus on Korolev's choice of propellants. The appeal to unquestioned outside experts proved unassailable.[49] The military, Ustinov, and Iangel had to go elsewhere. Korolev would never again be challenged for control of his design bureau.

THE DEATH OF STALIN AND THE TRANSITION TO NEW LEADERSHIP

Stalin died on March 3, 1953. It is difficult to imagine a situation in which a greater power vacuum was created at the pinnacle of national leadership. There were no formal mechanisms for political succession, and no less than six contenders for national leadership were removed from positions of power in the next four years. More than four years of political turmoil ensued. The leadership of the Soviet state was not settled until

---

[48] Interview with Eneev.

[49] On the importance of outside expertise see in particular James D. Thompson, *Organizations in Action*, (New York: McGraw-Hill, 1966);

the Summer of 1957. During this time, virtually all of the major decisions regarding the development of ICBMs and the initiation of a space program would be made by a leadership preoccupied by internal struggles.

The Soviet constitution made no explicit arrangements for political succession nor did the political institutions provide any informal arrangements for the succession, of authority, outside of an open competition for assumption of political power. Rush offers the following clarification:

> In the last analysis, the chief sanction for the dictator's rule in the Soviet system is the fact that he exercises it, and has placed it beyond the challenge of legitimate political activity. While this sanction may suffice for the incumbent, it has the defect that it provides no principle for establishing the legitimacy of a successor until he too has placed his rule beyond challenge by customary political means.[50]

As a result, several individuals and factions vied for leadership of the Soviet government following Stalin's death. Prior to his death, like Lenin before him, Stalin rendered his own, less formal, version of a last testament, describing his vision of the future of the Soviet leadership after his death. Much to the surprise to all those in attendance at the dinner at Stalin's dacha, Stalin pronounced that Nikolai Bulganin would be the next Soviet leader owing to his connection with the intelligencia. Khrushchev was not given any particular mention by Stalin. However, at the time of Stalin's death it

---

[50]See Myron Rush, *Political Succession in the USSR*, (New York: Columbia University Press, 1965) p. 74.

appeared that Malenkov and Beriia held the inside track to the leadership of the Soviet government.[51]

In sequence, Khrushchev and his supporters eliminated each contender to the throne, often using one to eliminate another, then, in turn eliminating the first group. One potential claimant, Lavrenti Beriia, was shot, and others such as Georgi Malenkov, Viacheslav Molotov, and Nikolai Bulganin, were dismissed from high positions and relegated to insignificant posts during this four-year power struggle. As a consequence, from 1953 to 1957 lines of authority were extremely unclear, and members of the leadership devoted most of their time to the struggle for succession rather than the business of running the country.

Beyond the general decision-making uncertainty, the Soviet leadership was especially immobilized on topics related to defense technology. Up to his death, Stalin confined information on defense systems to Beriia, and to a lesser degree Malenkov. Khrushchev remarked that he had been completely excluded from decisions related to military systems.[52] Consequently, with the execution of Beriia and the exclusion of Malenkov, the Soviet leadership had no one with any experience with military technology in general, let alone defense technology. Khrushchev himself commented on their lack of technological competence with respect to missiles:

---

[51]See Talbot, *Khrushchev Remembers....*

[52] *Ibid.*

> Not too long after Stalin's death, Korolev came to a Politburo meeting to report on his work. I don't want to exaggerate, but I'd say we gawked at what he showed us as if we were sheep seeing a new gate for the first time. When he showed us one of his rockets, we thought it looked like nothing but a huge, cigar shaped tube, and we didn't believe it would fly. Korolev took us on a tour of the launching pad and tried to explain to us how a rocked worked. We were like peasants in a marketplace. We walked around and around the rocket, touching it, tapping it to see if it was sturdy enough—we did everything but lick it to see how it tasted.
>
> Some people say we were technological ignoramuses. Well yes, we were that, but we weren't the only ones. There were some other people who didn't know the first thing about missile technology either.[53]

One of the first decrees of the new government was that governmental agencies should conduct their affairs during normal business hours, as compared with the Stalin era late-night policy-making parties.[54] All members who were in town participated in the Presidium's weekly Thursday meetings.[55] Policy differences were discussed among the full membership of the leading decisionmaking organization and a consensus could usually be achieved. Ironically, the need to include all leadership members in regularized decisionmaking was necessitated by political uncertainty.[56] Any member excluded from a particular decision might assume that a "palace coup' was being waged against him, and this might provoke a political reaction. Since the subgroup of Presidium member holding aspirations to the chairmanship was a large proportion of the overall membership, this

---

[53]*Ibid.* p. 46

[54]See Hough and Fainsod, ... p. 210.

[55]See Michael Voslensky, *Nomenklatura: the Soviet Ruling Class,* (New York: Doubleday, 1984) p. 264.

[56]*Ibid.* p. 250.

meant that the entire leadership needed to at least have the opportunity to participate in all meetings.

The actual meetings lasted around four hours, and considered an enormous number of issues, numbering over 50 or 60 per week.[57] One participant explains the logic behind the centralization of decisionmaking and the problems this creates.

> [T]here is a contradictory policy from the very top. On the one hand, the Politburo--or , for that matter, the Secretariat of the party, or the general secretary himself--wants to retain control over the most important issues. On the other hand, they realized and they understand very well that there is an enormous volume of proposals, of materials of absolutely different urgency, with different consequences. Either it's an economic problem or a social problem; but it's absolutely impossible for one body like the Politburo to deal with it all...
>
> I would say that eighty to ninety percent of the proposals are never discussed in the Politburo. If something is really important, then usually the [general secretary] has already moved on it, and the others have theoretically read all the materials that support the issue. By the time of the meeting of the Politburo it's a very routine procedure.
>
> The Politburo is not a place where they fight each other. Moreover, there always will be an established policy. Any [general secretary], would pursue the issue to be decided in the Politburo with as little debate and discussion as possible. First, for the simple reason [that] there is no time to do that. And, if the Politburo wants to retain its total control, its members have to adopt this procedure, Even if they approve of a given proposal, and even if they feel that this really shouldn't even be submitted to the Politburo, it's still better that it be submitted and everyone just goes along with [such a policy]...[S]ome of the decisions are adopted [by the Politburo] in blocks...[58]

---

[57]This was the general conclusion noted from a series of interviews with participants in high level decisionmaking in the governments of the Soviet Union and East Europe. See Uri Ra'anan and Igor Lukes, *Inside the Apparat: Perspectives on the Soviet Union from Former Functionaries,* (Lexington MA: D.C. Heath, 1990).

[58]This is the account from a former high-ranking Soviet diplomat, Arkedy Shevchenko. See Ra'anan, *Inside the Apparat....* 63.

Another participant in the Soviet decisionmaking process recounted how "voting" was conducted:

> [T] secretary general or second secretary says "Point number 25, the item is, you all have the documents, the draft decisions. Are there questions?" No. "Does anyone wish to present his opinion?" No. "Who is against it?" Nobody. If somebody says "No I have such opinion." Or if somebody says "I am against it," and explains why, then it is possible that there is a discussion. Then there would be a vote.[59]

Unable to deal with decisions at a high level of detail, the Presidium perforce relied upon the staff of the Soviet bureaucracy for support. This placed a great deal of authority in the hands of the bureaucrats who set the agendas for Presidium meetings, and those who prepared proposals for consideration. But even before Stalin's death, the *Spetskomiteti* system was dismantled, thus severing even this weak connection between the leadership and the missile program. Within the Central Committee, the Department for Defense Industries held no expertise over missiles.[60] Thus, from 1953 to 1955 there was nothing between the ministries and the leadership to assist in the management of missile technology. In 1957, the Military Industrial Commission was created to oversee all military technology programs. The first Chairman was Dmitry Ustinov.

Leadership Capacity and Decision-Making Uncertainty

Preoccupied with internal struggles, the Khrushchevian leadership was unclear on strategic goals, was totally ignorant of technological means, and given little time to devote

---

[59]These were the recollections of Michael Voslensky, in Ra'anan, *Inside the Apparat...* op. cit. p. 62.

[60] Interview with Stroganov; see also, Golovanov, *Korolev...*

to decisions due to formalistic decision-making processes. As was the case under Stalin, decision-making under these conditions tended to permit perfunctory review of mid-level decisions, but led to avoidance of the most important issues.[61] It was a leadership extraordinarily ill-equipped to effectively manage missile technology. It would have to rely heavily upon monitoring agencies to provide accurate information regarding missile programs. This was fertile ground for Korolev, who had already developed strong constituencies in both key administrative agencies.

THE R-5:

The R-5 was officially initiated sometime in 1952. Unofficially, it began as the "experimental BRDD R-3A" in 1951. With a range of only 1200, km it was not very useful as a strategic missile, since much of Europe remained out of range if the missile was launched from Soviet soil. However, it did demonstrate that useful ranges were achievable. Testing began on March 13, 1953, a little more than a week after the death of Stalin, and continued through April. The initial three launches were well off course, and for weeks the Council of Chief Designers argued amongst themselves regarding the causes. At a complete loss for answers, they broke for a short vacation on May Day.

---

[61] See Kingdon, *Agendas, Alternatives and Public Policies...*

During this short respite Korolev revealed his plans for the R-5 to his closest colleague among the Council, Nikolai Piliugin:

> Kolia, you know what I have been constantly thinking about? We must learn how to fly it! Understand, if we can learn to fly it, it is capable of carrying an atomic warhead. Understand? This is not a V-2--this is one thousand two hundred kilometers. And this is no a single ton of T.N.T., but a thousand tons, do you understand Kolia?[62]

The year before, Korolev paid a visit to the nuclear weapons research institute, NII-2 under Igor Kurchatov. There, Kurchatov and Korolev discussed the possibility of using Korolev's missile for an atomic bomb for the first time. Over the course of the next year, the idea slowly percolated through the atomic community.[63]

Returning to the flight test range, it did not take long for recriminations to begin. Most accusations centered upon the gyroscopes as the likely cause for the missile veering off course since they represented the most radical technological departure from past systems. Korolev recognized that it would be difficult to sort the problems out internally, so he brought in the Academician Vsevelod Fedosev to analyze the problem. After some fumbling with specious hypotheses, Fedosev was able to determine that the gyroscopes were not the problem. The real problem lay in the inertial guidance system. Fedosev and the Chief Designer for inertial guidance systems, Nikolai Piliugin, were able to sort these problems out before the next series of tests began in the Fall.[64]

---

[62] See Golovanov, *Korolev...* p. 426.

[63] Interview with Igor Golovin.

[64] See Golovanov, *Korolev...* pp. 431-433.

The second series of tests began in late October and lasted through the month of November.[65] Although the problem with guidance was solved, another problem appeared. Even though telemetry showed that temperatures were normal, the warhead shroud was burning up during the course of flight. This time Korolev went to Keldysh for assistance over the winter of 1954-1955. When they returned to the range for the third round of tests, the overheating problems persisted. Korolev called a general meeting to which he invited all interested researchers. Keldysh's best minds were sent to the test range but the problem was finally solved by a young major, whom Korolev defended even though his initial mathematical calculations had serious problems and were ridiculed by more prestigious scientists. It demonstrated Korolev's willingness to support junior staff from an outside organization, as well as his engineering intuition and ultimately led to resolution of the problem.[66]

During the second series of tests, Iangel was paid a visit at NII-88 by a high level delegation of defense industrial administrators including: Grigori Pashkov, from the Council of Ministers,[67] the Minister of Medium Machinebuilding (the atomic industry) Viacheslav Malyshev, Rudnev in his capacity as Ustinov's deputy, Malyshev's deputy Iuri

---

[65] See Raushchenbakh,...pp. 232-233.

[66] See Golovanov, *Korolev...* pp. 439-440.

[67] Pashkov headed a group within the Council of Minister which dealt with rocketry apparently serving as the staff for Spetzkomitet-2, and after the committed was disbanded, as the sole source of expertise on missiles in the Council of Ministers. He went on to serve as Ustinov's deputy with responsibility for rocketry after the Military Industrial Commission was created. See G.I. Pashkov, "G.I. Pashkov" in Iu. A. Mozhorrin, *Dorogi v Kosmos, Vol. II,* (Moscow: Moscow Aviation Institute, 1993)

Voronstov, and several nuclear scientists. Upon hearing of the visit from one of his deputies, rather than from Iangel, Korolev quickly returned from the test range to continue the discussions which he had initiated a year earlier. After viewing Korolev's missiles the group convened to consider the possibility of putting a nuclear warhead atop an R-5.

After some prodding by Malyshev and Korolev, who argued that if they "did not make a decision, no one will make such a decision for us upstairs" Pashkov, as the delegation's ranking member, decided to go ahead with the plan, without soliciting the opinions of the new Soviet leadership.[68] This was the first time that the missile program was explicitly tasked with delivery of an atomic bomb.[69] The operation was code named "Operation Baikal."

There was substantial resistance to Korolev's proposal from the Ministry of Aviation Industry. Tupolev, a General Designer of long range bombers, was naturally opposed to competition. He argued to the leadership that "The casualties would be catastrophic if the missile fell on our own territory!"[70] Korolev was sensitive to these concerns. Following the meeting with Malyshev and Pashkov, he embarked on a redesign of the R-5 to ensure that missiles armed with nuclear warheads would work exactly according to their flight plans. According to an historian of the program, "the R-5M was the first missile of Korolev, in which the duplication and even the triplication of several

[68] See Iaroslav Golovanov, "Operatsiia Baikal" *Poisk*, 7:42 p. 7.

[69] See Holloway, *Stalin and the Bomb...*

[70] See Chertok, *Raketi i Liudi*, ... p. 362.

most critical systems was used. The work on their development was performed in incredibly short time -- in approximately a year."[71] Korolev brought the modified version of the R-5 to Kapustin Iar for testing in August 1954. In January 1955, he began instrumentation tests for the nuclear warhead. Over the course of the next year they conducted 28 tests of the instrumented R-5. These tests were not encouraging: launch delays were common, there were several guidance failures, and at least one missile exploded in flight.[72]

Problems not withstanding, in February 1956, the State Commission traveled from Moscow to the test range to approve and witness the first flight test of a strategic missile with a live atomic warhead. The Commission was headed by Pavel Mikhailovich Zernov, from the Ministry of Medium Machinebuilding (the ministry of the atomic industry). Mitrofan Nedelin, Commander of the Artillery Command for Special Technology (UZKA), represented the military, along with three of his deputies Gen. Mrykin, Gen. Vozniuk (the commander of the launch facility), and Gen. Degtarev. Ustinov, Vetoshkin and Korolev represented the Ministry of Defense Industries, and the other Chief Designers (Barmin, Kuznetsov, Glushko, Riazanskii, and Piliugin) represented their respective ministries.

---

[71] See Iaroslav Golovanov, "Operatsiia Baikal" *Poisk*, 7:42 p. 7.

[72] See Iaroslav Golovanov, "Operatsiia Baikal" *Poisk*, 7:42 p. 7; and Raushchenbakh, *Iz Istorii Sovetskoi Kosmonavtiki,...* pp. 233-236.

While more experienced and qualified than most Commissions, the leadership of this State Commission was nevertheless capable of being deceived. As the missile was readied for launch, the temperature of the warhead began to drop dangerously. The Commission was summoned to diagnose and correct the problem. After they arrived, the temperature of the warhead mysteriously began to rise again to acceptable levels. The Commission pondered the matter for a short while and decided to go ahead with the launch. Unbeknownst to them, one of Vozniuk's technicians mistakenly disconnected the heater for the warhead. Vozniuk found out and ordered the heater reconnected without informing the leaders of the Commission. Two days passed with postponements due to low clouds at the test range. Anxious to conduct the launch before the conclusion of the 20th Congress of the Communist Party of the Soviet Union, Zernov grew tired of waiting and authorized the launch, despite the lingering fog.[73] On February 20, 1956, Operation Baikal was successfully completed.

Four days later, Khrushchev gave his secret speech condemning Stalin. Immediately following the Congress a delegation of Soviet leaders including Khrushchev, Molotov, Bulganin, Kirichenko, and Kaganovich visited Korolev's facility in Podlipki. Though Korolev did not have a completely constructed missile to show the political leaders, they were sufficiently impressed to award Korolev and his institute a Lenin Prize,

---

[73] The 20th Congress of the CPSU was notable for a speech which Khrushchev gave at the conclusion of the Congress broadly condemning Stalin for terroristic policies directed against the Soviet people. Officially, the speech was never made public, and it is therefore referred to as the "secret Speech."

and finally grant Korolev his own independent design bureau and prototype production facility.[74]

Achieving Autonomy

In February 1956, Korolev finally reached that stage at which he was providing a useful policy option to the Soviet leadership. In Downs' terminology the missile program had passed through the first, most dangerous stage. From the perspective of the political leadership, a missile program was borne. Up to this point, it was only the administrative agencies which were dependent upon Korolev. Now it was the political leadership. In the months following Operation Baikal, Korolev would be awarded the title of "Hero of Socialist Labor", the highest award bestowed upon Soviet citizens. More importantly though, he would be awarded his own design bureau. Korolev had finally achieved solid autonomy, now it remained to be seen what he would do with it.

One biographer recalled a conversation Korolev often had with one of his colleagues in the 1930s when working at GIRD. "Tsander would direct the conversation toward flights to Mars, Korolev always silenced him explaining: 'Its early, Fredrich Arturovich, its still not time...' Now Korolev could tell him: 'Its time!'"[75]

---

[74] According to Mishin and Vetrov, this was the first time Khrushchev and Korolev met. This is probably the time Khrushchev was referring to when he described the leadership as "technological ignoramuses." See Golovanov, *Korolev..* p. 464.

[75] See Golovanov, *Korolev...* p. 465.

THE R-11 AND THE WORLDS FIRST SEA LAUNCHED BALLISTIC MISSILE

Through 1952, the military remained unenthusiastic about Korolev's missiles. From a technical standpoint, the primary problem was that the fuel components could not be left in the missile for long. Liquid oxygen required constant refueling to replace the oxygen which was vaporizing. This made launching a tedious process, and left troops vulnerable for long periods of time while the missile was readied for launch. While the Artillery Troops accepted the R-1 and R-2, they did so only with reluctance. They wanted a missile which could be launched quickly.

In 1952 Korolev began work on the R-11 which utilized red fuming nitric acid (RFNA) as an oxidizer instead of liquid oxygen. The major disadvantage to these storable propellants was that they were far less energetic than oxygen and kerosene, which Korolev was using for the R-5. As a result, such a missile could only achieve a limited range of 200 km. Initially at least, Korolev was not eager to take this project on himself and assigned it to one of his deputies Viktor Makeev.[76]

Makeev teamed with the rocket engine designer A.M. Isaev, who had recently moved to NII-88, and produced the draft design later in 1952. The first tests of the R-11 began at Kapustin Iar in April 1953, at the same time as the initial R-5 tests were being conducted. This series of tests lasted through June. Over the winter Isaev redesigned the engines and the missile returned to the test range in April of the following year. In

---

[76] Interviews with Chertok, Budnik, and Mishin, see also Golovanov, *Korolev...*pp. 445-446.

December 1954 Makeev took his missiles to the range for state acceptance trials which were completed in February.[77]

While the R-11 clearly worked, it seemed to be another missile without a mission. With a range of only 200 km and accuracy no better than the R-1, it was still of little use to battlefield generals. The idea of stationing nuclear weapons so close to the front was unattractive to the few generals who knew of the missile's existence. In late 1953, Korolev came up with the concept of launching the missile from a submarine which could be deployed near the American coastline. The idea was endorsed by the Deputy Chairman of the Military Industrial Commission Pashkov, and Ustinov's Deputy Rudnev in October 1953 and was passed on to the CPSU leadership for approval.[78]

Korolev and Makeev teamed with the submarine designer Nikolai Isanin for the R-11 naval project. The R-11 MF as it was designated, was a primitive SLBM. It was to be launched from the deck of a floating submarine. Immediately after launch the submarine would then dive in the hope that it could avoid detection. N.A. Piliugin, Korolev's Chief Designer for guidance systems solved the thorny problem of developing a guidance system which would work from the surface of a rolling ship.[79] In May 1955, the first successful tests of the system from a rolling test stand took place.[80] On October 13, 1955, the

---

[77]See Raushchenbakh, *Iz Istorii Sovetskoi Kosmonavtiki,...* pp.. 232-234.

[78] Korolev's proposal came at the same meeting at which the project mating the R-5 to a nuclear warhead was advanced. See Iaroslav Golovanov, "Operatsiia Baikal" *Poisk,* 7:42 p. 7

[79] See Viktor Dygalko, "Sea-Launched Ballistic: the First Launchings" *Krasnaia Zvezda,* November 28, 1992, p. 5, as translated in JPRS-UMA-92-045, pp. 12-15.

[80] Raushchenbakh, *Iz Istorii Sovetskoi Kosmonavtiki,...* p. 234.

world's first SLBM was launched in the waters off Kamchatka. In spite of the successful test series, the system remained experimental and was never deployed for use in the fleet.[81]

Nevertheless, the Navy was intrigued by the idea, and wanted Korolev to develop more refined SLBMs for their use. Korolev recognized the importance of such a system, but did not share the Navy's enthusiasm for further development. In 1955, he recommended dispatching Makeev to the Urals mountains to establish a new design bureau dedicated to naval missiles.[82] The next year, Korolev passed on his design of a new SLBM to Makeev for production, and from that time on, Makeev was the focal point for SLBM development.[83]

The R-11 was clearly a preliminary design intended to demonstrate the military capabilities of ballistic missiles. It was not a mission which Korolev felt to be a core competency of his organization.[84] Ironically, the R-11 is the oldest missile still in use today. Now known as the "Scud," it is in limited deployments in the Russian Army, and has been more extensively used by other nations, most notably Iraq. However, the R-11 FM did put Korolev in charge of the early development of SLBMs. It was his choice whether to continue with this line or abandon it. Under his direction Makeev continued to develop missiles with long ranges which could be launched from under water.

---

[81] *Ibid.* p. 235; and, Dygalko, "Sea-Launched Ballistic..."

[82] Bear in mind that at the time Korolev was still only the head of a department within NII-88.

[83] See Golovanov, *Korolev...* pp. 446-451.

[84] See Wilson, *Bureaucracy...*

Maintaining Core Mission

This pattern of developing new mission areas but then spinning them off to his deputies would be repeated by Korolev several times over the next few years. In the future, as new ideas came along, he would pursue development for a time, but then spin off the new mission to another organization sending his own people along with the idea. Using this technique Korolev was not only able to maintain the focus of his organization, but continue to exert a certain amount of control over his spin-offs, building an empire which would later control the vast majority of the Soviet space program. As an organizational strategy it permitted him to retain his core mission (i.e. space) which was relatively uncertain, while at the same time hedging his bets by developing systems with more practical applications such as SLBMs, and tactical missiles. It was to prove effective at defraying military criticisms that Korolev was pursuing ideas which were pure fantasy, while permitting Korolev to do exactly that.[85]

[85] In 1959, Korolev sent D.I. Kozlov to Kiubishev to provide series production of his R-7 launch vehicle. Kozlov would later inherit the photoreconnaissance program from Korolev as well. In 1961 Babakin was sent by Korolev to the Lavochkin Design Bureau to work on interplanetary spacecraft. In 1965 Reshetnev was sent to Krasnoiarsk with the communications satellite portfolio.

COMPETITION FOR CONTROL OF THE MISSILE PROGRAM

By 1954, Ustinov had grown disenchanted with Korolev's independence.[86] Korolev demonstrated an uncanny ability to move the development of rocketry in his own direction, despite arguments by military and industrial leadership that his systems did not promise to be useful military systems. He was preoccupied with squeezing the greatest possible performance out of his systems at the expense of military effectiveness.[87]

From Korolev's perspective, Ustinov was replaceable.[88] Particularly after Operation Baikal, Korolev no longer had to rely on Ustinov for political support, his constituency was the political leadership, which was far more pliable in its ignorance. It was an amicable divorce. Ustinov continued to support Korolev, he just wanted to establish another design bureau which would be more reliable.[89] Iangel was an obvious choice. He was politically and bureaucratically reliable, and his ability to effectively govern NII-88 had been seriously undermined by Korolev's success.[90]

In 1954 Mikhail Iangel departed NII-88 to establish a competing missile design bureau, OKB-586, in Dnepropetrovsk, Ukraine.[91] OKB 586 grew out of the

---

[86] Interview with Mishin.

[87] Interviews with Iu. P. Mozhorrin, V.P. Mishin, and B.E. Chertok.

[88] Interview with Mishin. On replaceability see Pfeffer, *Power in Organizations...*

[89] Interview with Piskaraev.

[90] Interview with Mozhorrin.

[91] See V. Pappo-Korystin (et. al.) *Dneprovskii Raketno-kosmicheskii Tsentr,* (Dnepropetrovsk, Ukraine: POIu.Z., KBiuZ, 1994) p. 56.

Dnepropetrovsk Automobile Factory which had been rebuilt after the war. In 1951 the factory was charged with series production of the R-1 missiles developed by Korolev, and the name of the factory was changed to Plant 586 of the Ministry of Armaments. Serving as the series production facility for Korolev's designs, the plant went on to produce the R-2 and the R-5.

From 1951 to 1954, Plant-586 was strictly a production facility. But after the defeat of Iangel's proposals for storable propellants at NII-88, Ustinov needed a new design bureau to pursue this promising new technology. Many of the leading engineers for Iangel's design bureau came from NII-88. Prior to Iangel's arrival, Korolev was actively participating in staffing the new factory.[92] By 1954, Korolev was getting a steady stream of new engineers from the Bauman Institute.[93] NII-88, according to Korolev's Deputy Viacheslav Budnik, was well staffed, and Korolev could not locate suitable housing for more engineers, so many decided to go to Ukraine well in advance of Iangel. Therefore, Ustinov was not concerned that establishing a new facility would draw the quantity of experts at Korolev's institute to below a critical mass. There were plenty of rocket scientists to support two organizations.

Ustinov took a personal interest in setting up the new factory, often going there for weeks at a time to supervise production of missiles and installation of new equipment.

---

[92] Interview with Budnik.

[93] Interviews with Budnik, Feoktistov, and Maksimov.

During the time period that the R-1 was being produced, Ustinov "personally supervised the daily deliveries of components," and "held meeting with the chiefs of sections and departments nightly from 22.00 to 24.00."[94]

Iangel arrived in Dnepropetrovsk on June 9, 1954 and immediately began development of the R-12, a storable propellant missile which Ustinov specifically intended to act as a competing system to Korolev's R-5.[95] The R-12 relied upon the relatively inefficient fuel components of RFNA and kerosene. Nevertheless, Iangel managed to squeeze a 2000 km range out of the missile. The system was long in development however, and did not proceed to the flight test range until Spring 1957, more than a year after Operation Baikal. Flight testing continued for two years, leading to the deployment with the Strategic Rocket Forces (RVSN) in 1959.[96]

In 1956, Iangel received a proposal from an institute in Leningrad for development of a storable RFNA-unsymetric dimethyl hydrazine (UDMH) fuel. The development of hydrazine represented a watershed development, as it greatly increased the potential range of storable propellant rockets.[97] Iangel could design ICBMs using these propellants.[98] Ustinov and Nedelin were quick to seize upon the idea, and by late in the year a decree

---

[94] See Pappo-Korystin (et. al.) *Dneprovskii Raketno-kosmicheskii Tsentr...* p. 54.

[95] Interviews with Mishin, Mozhorrin, and Budnik.

[96] See Maksimov, *Raketnye Voiska...* p 62; and, Pappo-Korystin (et. al.) *Dneprovskii Raketno-kosmicheskii Tsentr...* pp. 58-63.

[97] Interview with Budnik.

[98] *Ibid.*

was issued for the development of the R-16, an ICBM which would carry a 1000 kg warhead. Development proceeded slowly, and in August 1958 a decree was issued accelerating the development of the R-16 and freeing the plant from further production of Korolev's missiles. Problems with the missile continued on the test range. In October 1960, the missile exploded on the pad before the first launch, killing Marshal Nedelin and several dozen engineers and rocket troops. The missile was successfully tested in the following year and was accepted for series production.[99]

The organizational culture at OKB-586 was very different from that at Korolev's design bureau. One designer, who worked at both organizations, remarked that there was a "much stricter regime at Iangel's design bureau. Military requirements were adhered to without deviation."[100] The engineers felt that they were developing the weapons which would defend the Soviet Union against capitalist aggression. Korolev rockets were flights of fancy. They summed up their feeling in the oft repeated slogan: "Iangel works us; Korolev works for TASS (the Soviet press agency); and Chelomei (another designer who appeared on the scene in the early 1960's) works for the toilet."[101] This culture was a product of the close watch which Ustinov kept on the activities of OKB-586. The

---

[99] Interview with Budnik; see also, Maksimov, *Raketnye Voiska...* p. 64; and, Pappo-Korystin (et. al.) *Dneprovskii Raketno-kosmicheskii Tsentr...* p. 59. It is important to not that the warhead requirement for this system was only 1000 kg. This was only sufficient for a conventional atomic warhead. Korolev's ICBM was designed to carry a thermonuclear warhead weighing 5,000 kg.

[100] Interview with Gubanov.

[101] The slogan was presented to me in unison by several engineers while riding in a van at the Iangel design bureau in 1990. The Russian transliteration is "Iangel rabotaet dlia nas; Korolev rabotaet dlia TASS; i Chelomei dlia tualeta."

contrast with the loose management of NII-88, and Korolev's independence is difficult to ignore.

Korolev had other competition from outside his ministry. In April 1953, two additional projects were initiated to produce intercontinental range missiles at the Lavochkin and Miasishchev OKBs in the Ministry of Aviation Industry.[102] Both projects were developed from the work of Korolev and Keldysh on two stage cruise missiles in the early 1950s.[103] Of the two projects, the Buria system under development by Lavochkin was the most serious competitor. The Buria was designed to be launched by a first stage missile booster which would be expended, the second stage would use an air breathing ramjet to fly at mach 3-5 to the target. The Buria pushed technological frontiers to a far greater extent than Korolev's missiles, making extensive use of titanium in the second stage, and relying upon astral navigation. While it began flight testing sooner than Korolev's ICBM, Lavochkin was never able to sort out problems with guidance and thermal regulation, and the system was canceled shortly after Korolev's successful ICBM launch.[104]

---

[102] See V.M. Petrakov, "O vklade OKB-23 V.M. Miasishcheva v prakticheskoe osyshchestvlenie idei K.E. Tsiolkovskogo" (On the contribution of the OKB-23 of V.M. Miasishchev in the practical realization of the ideas of K.E. Tsiolkovskii,) paper presented at the 25th annual Tsiolkovskii Lectures, Kaluga, Russia September 1991.

[103] See Avduevskii, *M. V. Keldysh...*; and Petrakov, "O vklade OKB-23..."

[104] See V.A. Serebrenikov, G.P Serov, M.L. Tarasenko, "O deatel'nosti KB Lavochkina v oblasti raketnoi tekhniki," (On the activities of KB Lavochkin in the field of rocket technology,) a paper presented at the 9th Moscow Symposium On the History of Aviation and Cosmonautics, June 1993, Moscow; see also Chertok, *Raketi i Liudi...*; and, interview with Mishin.

Korolev maintained a keen interest in Lavochkin's work, having only recently given up these ideas himself with great reluctance. He also made sure he had accurate information regarding Lavochkin's and Miasishchev's progress by providing assistance to the two competing designers. Thus, Chertok's work with Lavochkin on guidance served to keep Korolev apprised of his progress; and several other engineers from Korolev's bureau worked with Miasishchev. [105] Keldysh also served as an excellent conduit of information for Korolev.[106] In the end, however, neither project was successful. Both were closed following the successful launch of Korolev's ICBM. The stakes they were competing for proved to be higher still, as both design bureaus were closed down or absorbed into other organizations within the course of the next three years following the launch of Sputnik.[107]

Establishing Competitive Sources

In the early 1950s Ustinov was growing suspicious of Korolev's reliability. By early 1954, it was clear that Korolev had extraterrestrial intentions. Ustinov needed to create a competing center for missile development. Establishment of Iangel's center was crucial for the development of usable ICBMs. Tied to Korolev's systems, the Soviet

---

[105] Interviews with Mishin, and Chertok, see also Chertok, *Raketi i Liudi...*

[106] See Chertok, *Raketi i Liudi*...p. 291.

[107] The Miasishchev bureau was closed down altogether following another failed attempt at competing with Korolev for launching the first man into space. Lavochkin was absorbed into the Chelomei design bureau in the early 1960s.

Union would be hamstrung with ineffective missiles. Intentionally or otherwise, Ustinov waited until there was sufficient technical expertise resident at NII-88 to support development of a second center. He could then establish a competing center without depleting the first. It was a well-timed and effective policy move by Ustinov. Through close supervision, and Iangel's proven political reliability, Ustinov created a design bureau which would work for him, rather than for itself, as had become the case with Korolev.

THE WORLD'S FIRST ICBM -- THE R-7

The R-1, R-2, and R-5 were all single stage missiles. But it became apparent in Korolev's calculations for the R-3 project, that it would be difficult to achieve intercontinental ranges with a single stage missile. But even intercontinental ranges were not sufficient. Korolev wanted a missile capable of putting a man into space. A new type of missile was required for this endeavor -- a multistage missile.

The idea of building a multi-stage missile was not new. At the turn of the century, the Russian rocket pioneer, Konstantin Tsiolkovskii, theorized that a "rocket train" would be required to boost man into space. Tsiolkovskii conceived of a staged missile which would burn in series. From a theoretical standpoint a series burning missile was the most elegant solution. However, from a practical standpoint, the problem of igniting the second, and possibly third stages in a vacuum at negative acceleration was problematic.

Korolev worked on this problem for some time with Keldysh in the Streklov Institute of the Academy of Sciences, and Mikhail Tikhonravov of the military institute NII-4.[108] Several solutions appeared plausible, but testing presented obstacles. There was no easy way to test second stage ignition without putting them on top of first stages and launching them. This could an expensive and embarrassing process.[109] The solution which was ultimately adopted by Korolev was the packet system of rocket stages. The basic idea was that several rockets would be simultaneously ignited on the launch pad, but that one of them would burn at a relatively low thrust until the others had burned out and been discarded. The remaining rocket would then throttle up to full boost and carry the payload to its final destination.

---

[108] Interview with Eneev, see also Avduevskii, *M. V. Keldysh...*

NII-4 was hastily created in 1946 as part of the reorganizations which spun out of the decision to create a missile industry in Russia. The basic mission of the organization was to provide assistance in the utilization of rocketry for the artillery troops. The first Director of the Institute was Gen. Nestorenko. Nestorenko had no background in rocketry and at times exhibited a certain hostility towards the rocket scientist and the military men who supported them. According to one participant he only came to the position of director "because after the war there were many military generals without jobs, and they had to receive suitably high positions." But Nestorenko was surrounded by military men who had worked closely with the rocket specialists in Germany, several of whom worked with Korolev and Glushko before the war. Nestorenko's Deputy was Gen. Gaidukov, who had personally pushed Stalin for creation of a rocket program. Other leading figures, included Col. Tiulin, who headed a rocket research group in Germany and who worked with Korolev prior to the war, and Mikhail Tikhonravov. Mikhail Tikhonravov was a member of the original core group of rocketeers working alongside Korolev at GIRD and later at RNII from the late 1920's through 1938. When the group was disbanded by the purges of the late 1930s Tikhonravov was one of the fortunate few who were not sent off to the sharagi. Tikhonravov remained in Moscow working in various military research institutes. See Iaroslav Golovanov, "Start kosmicheskii ery," *Pravda,* October 4, 1987 p.3; and interviews with Bazhinov, and Maksimov.

[109] Interview with Eneev.

This idea was first considered in 1948, when Tikhonravov theorized that by combining a number of rockets, virtually any range or speed could be achieved. The original research on this topic involved very crude depictions of individual V-2s literally strapped together.[110] It was a purely theoretical piece of work which was well beyond the comprehension of most of those in the military. At the first presentation of the concept, he was roundly criticized "one after another, skeptics and critics came up to the lectern and pronounced that the Packet is a flying board, you can never bolt rockets together."[111] Korolev took the matter more seriously and encouraged Tikhonravov to continue with his research. During the most difficult times, Korolev even provided financial support.[112]

Korolev's design bureau spent 1952 and the early part of 1953 working on a draft design of a new missile, the R-6, with an intended payload of 3 tons and a range of 8,000 km. The R-6 was essentially four R-5s clustered around a single core stage. The program was presented for approval by the Council of Ministers in May of 1953. Soviet atomic weapons at the time were only 1,000 kg., and there was some question of requirement for the extra payload.[113] Malyshev, the Minister in charge of the nuclear program, was "deeply suspicious of Korolev's motives in suggesting the new missile and accused

---

[110] Tikhonravov's ideas were not openly published until 1980, and then in a classified journal of the missile industry. See M.K. Tikhonravov, "Puti ocushchestvleniia bolshikh dal'nostei strel'by raketami, Doklad v Akademii Artilerichekikh nauk, July 14, 1948)" *Raketnaia Tekhnika,* January 1980, pp. 10-19.

[111] See Maksimov and Bazhinov, ...pp. 16-17.

[112] "M.K. Tikhonravov," in Ishlinskii, *Korolev...*

[113] Interview with Golovin.

Korolev of "attempting to develop a space booster disguised as a military missile."[114] He was correct, but nevertheless, the project was approved.[115] Without notifying the rest of the leadership, and only weeks before his arrest, Beriia signed the decree authorizing development of the first ICBM.[116]

Malyshev returned in the fall with a very different story. Following the first successful test of a Soviet thermonuclear weapon on August 12, 1953, he wanted Korolev to increase the payload capacity of his missile to six tons, in order to deliver a thermonuclear weapon. Korolev's response a week later was that the existing design would have to be scrapped to achieve this payload. A new government decree would have to be issued. Malyshev suggested that Korolev himself write the decree. In the next several days Korolev wrote a decree calling for the full-scale development of a scaled up version of the R-6 -- the R-7 -- capable of delivering a 5.5 ton warhead 8,000 km with an accuracy of 5 km CEP.[117] This was the entire specification as written by Korolev. Even by Soviet standards, it was a very loosely structured requirement document.[118] Unofficial leadership approval came within a week.[119] The official requirement for the R-7 was not

---

[114] See Golovanov, *Korolev*...pp. 473-474; and Timothy Varfolomeyev, "Soviet Rocketry that Conquered Space," *Space Flight*, Vol. 38, January, 1996.

[115] Interviews with Mishin, Chertok, and Vetrov.

[116] In fact one of the charges leveled against Beriia was that he approved this program without consulting with that rest of the collective leadership. See Holloway, *Stalin and the Bomb*... p. 321.

[117] CEP or circle error probability is a term meaning that 50% of missiles launched will fall within the specified distance of the target.

[118] Interview with Mishin.

[119] Many veterans remarked that such a decree would take years under Brezhnev. See Golovanov, *Korolev*... pp. 473-475.

issued until May 20, 1954. On May 25th Korolev transmitted his acceptance of the requirements. On the following day made his first official request to use the R-7 for a satellite launch.[120] His secret was now out in the open.

In November his design team began working feverishly on the draft design for the R-7, completing the 15 volume study in July 1954.[121] The major issue emerging from this study was the necessity of developing engines with gimblable nozzles in order to steer the missile during the powered phase of flight. Glushko, the Chief Designer for rocket engines, argued that it would be too difficult to do this given the available materials.[122] Korolev proposed the use of several smaller vernier engines for steering. Glushko also rejected this idea, and Korolev resolved to build the engines himself.[123] It was the first skirmish in an escalating battle of nerves between Korolev and Glushko.

As was the case for the R-6, the basic construction of the R-7 featured four first stage boosters clustered around a single core. The four first stage boosters separated from the core stage mid-way through the powered phase of flight, and the central core would continue delivering thrust throughout the powered phase of flight. Design work proceeded through 1955. In 1956, individual component boosters were test launched

---

[120] The story of the use of the R-7 as a space launch vehicle will be covered in more detail in the following chapter. See Raushchenbakh, *Iz Istorii Sovetskoi*... p. 233.

[121] See Raushchenbakh, *Iz Istorii Sovetskoi*...p. 233.

[122] Interview with Mishin.

[123] Ultimately, Glushko relented and built vernier engines for later versions of the R-7. See Golovanov, *Korolev*... pp. 476.

separately.[124] Strapping the individual boosters together and separating them under power proved their greatest challenge. The engineers at OKB-1 worked on this problem for most of 1955 and 1956, but there was no way of testing the validity of their solution without launching the entire system.

In the spring of 1957, the Council, the State Commission, the missiles, and countless technicians proceeded to the new launch range at Tiuratam in Kazakhstan.[125] The first launch attempt ended in failure, when the R-7 blew up early in flight. The problem was traced to dirt in the vernier engines. In response, Ustinov sent one of his deputies to sit in Korolev's design bureau until the problem was corrected. How Karasev, who had no competence in missile technology, would know when the problem was corrected was unclear. Literally all he could do was verify that people were indeed working.[126] The second test on June 7 failed to ignite. A valve had been installed backwards by Korolev's technicians. The third missile launched a month later exploded as the strap-on stages were separating from the core stage. The State Commission temporarily halted the test series after the third failure.

---

[124] See Raushchenbakh, *Iz Istorii Sovetskoi...* pp. 234-235

[125] In 1955 a new launch facility was established at Tiuratam which is now referred to as the Baikonur cosmodrome. For a history of the facility see N.S. Narvolianskii, *Tak Nachinalsia Baikonur,* (Moscow: Promotei, 1991).

[126] See Golovanov, *Korolev:..* pp. 503-504.

The State Commission created by Ustinov to oversee the launches was headed by his deputy for rocketry Vasilii Riabikov.[127] His counterpart on the military side was Deputy Minister of Defense for Special Weapons and Rocket Technology, Marshal Nedelin, who was Deputy Chairman. As was the practice, the State Commission relied upon the technical staff of the Council of Chief Designers to produce reports and analyses. Korolev's deputies drafted the reports. Korolev provided the executive summary, which was the only part of the reports transmitted to the leadership. The results were predictable. Even in the case of the worst failures, his remarks were along the lines of: "It is a complicated business: there may have been some glitches, but these can't be traced to Korolev..." After one failure, Riabikov read Korolev's summary and remarked with a smile: "You're a clever man Sergei Pavlovich. [Korolev] You have resolved all problems with a magic wand, but your shit does not want to become cologne just to avoid offending your nose..."[128] And so it went. The political leadership was, no doubt, aware that there were launch failures, but blissfully ignorant of the depth of the problems, and never casting their suspicions upon Korolev as the culprit.

While the leadership may have been deceived their patience had limitations. Following the third test failure, Riabikov and Nedelin wanted to shut down the test series. Glushko agreed with them exclaiming: "You've already destroyed 40 of my wonderful

---

[127] Riabikov left the Ministry of Armaments in 1949 to oversee anti-aircraft systems. He returned to work with Ustinov sometime after Ustinov was appointed as head of the Military Industrial Commission in 1955.

[128] See Golovanov, *Korolev...* p. 506.

engines. If you keep going at this rate, my production cannot keep pace...Why should I suffer from someone else's mistakes?" Korolev screamed back:

> They are not someone else's. They are our mistakes!...
>
> In the end it is not "Korolev's rocket," it is our rocket! Exploded Korolev, Ours!! With your engines, with his instruments! Your basic principle of work must be discredited! The rocket can fail to fly as a result of breakage of launch facilities, as a result of a misfire of your engines, as a result of breakage of his instruments, or my valves, but in any case our rocket doesn't fly! And we must all be answerable![129]

Riabikov and Nedelin withdrew their recommendation to close down tests following Korolev's outburst, and decided to let the designers decide for themselves how to proceed.

This incident is among the more interesting in the early history of the Soviet missile program for several reasons. In the first place, it demonstrated that the State Commission was anxious to defer to the expertise of the scientists. Riabikov and Nedelin took their first opportunity to let the designers resolve problems for themselves, without outside interference. Second, it highlighted the widening rift between the two leading members of the Council, Korolev and Glushko. Problems between the two would increase in severity over the next three years leading to a complete split. Even Khrushchev was unable to force the two designers to work together after 1961.[130] Finally, even though Glushko may have been lost to the Council, the incident demonstrated that Korolev was able to use his

---

[129] *Ibid.* p. 508.

[130] See Talbott, *Khrushchev Remembers...*

charisma, and appeal to the shared sense of mission to maintain the consensus and cohesion of the rest of the group.

On August 21, the third test was conducted. The missile rose off the launch pad, successfully passed through staging, and continued on toward the target area in Kamchatka. The flight appeared successful. But, Korolev was immediately concerned with the quantity and quality of the telemetry. As it turned out, the warhead never arrived, breaking up in the atmosphere.[131] Korolev proclaimed in reports that the flight was only intended as a test of the missile, not the re-entry system. Almost a week later, the Soviet press agency TASS announced to the world:

> A launch of a super-long-range, intercontinental, multistage missile was conducted. The test of the missile was successful. It completely verified the design solution. The flight of the missile rose to previously unachieved altitudes. Traveling a very long distance in a short time, the missile fell in the designated area.

The failure of the warhead to survive did not surprise Korolev. He expected it. A department in his OKB had been working thermal protection since 1952, and was unable to come up with a workable solution. In part, the difficulty was that Korolev tasked them to devise means of protecting not only a warhead, but humans, from the thermal loads created by re-entry into the atmosphere. Because he maintained strict control over this department, there were few outside the design bureau who knew the full extent of this problem, until shortly before the launch when Korolev announced to the NTS of NII-88, that "it would be very bad if the warhead did arrive on target, as it would mean that all of

---

[131] See Golovanov, *Korolev*...p. 508.

our calculations of thermal loads were incorrect. We are testing a missile, not a weapon."[132]

A second test was conducted on September 7, with similar results. At this point the State Commission declared the test series successful, in spite of the fact that four more R-7s remained at Tiuratam. Korolev had other plans for these vehicles. Problems with the warhead re-entry were resolved in 1958, and the missile moved directly to series production in 1959. It was accepted into the service in the same year.[133]

Despite its quick acceptance into service, the R-7 was an extraordinarily poor ICBM: it took 20 hours preparation time for launch; it stood on an open, easily targetable launch pad; and required radio guidance for the initial phase of flight. It was hardly the "final weapon" Malyshev sought when the project was initiated. It was incapable of reaching most targets within the United States from the launch pads in Tiuratam. In 1959, an entirely new launch facility was constructed in northern Russia to ensure that the missiles would reach their targets.

These problems notwithstanding, the R-7 became the basis for the formation of the Strategic Rocket Forces (RVSN). On December 17, 1959, a new branch of the Soviet military was created under Marshal Nedelin which would have priority over all other branches of the Soviet military. It was the focal point of Khrushchev's "revolution in

---

[132] Interview with Mishin.

[133] See Varfolomeyev, "Soviet Rocketry..."

military affairs." Although in future years this program would be dominated by a competing designer's missiles, it was Korolev who must be credited with the impetus to this service. The Minister of Defense, Marshal Malinovskii clearly stated the significance in a 1963 article:

> In the last few years we have had a revolution in military affairs, thanks to outstanding successes in the development of the Soviet economy and science and technology... This has been caused, first of all, by the wide introduction of the nuclear rocket weapon and new equipment assuring its use. *Atomic and thermonuclear weapons now compose the basic firepower and striking power of our Armed Forces. Rockets, which in minutes can cover great distances and carry devastating blows to the enemy at any point in the world, are the main means of delivering these weapons of target.*[134]

Information Control

The R-7 was a monument to Korolev's ability to control vital information about his program. In the first place, he performed the bulk of the fundamental research necessary for the ICBM under the guise of the R-3 program. Korolev only took the R-7 proposal to the leadership after the research demonstrated the optimal configuration. Even before embarking on the project, Korolev knew that there were problems with warhead re-entry. But he was able to conceal these from the leadership and administrative agencies. Throughout the project, by controlling the reporting, Korolev was able to put a

---

[134] Rodion Ia. Malinovskii, "The Revolution in Military Affairs and the Task of the Military Press," as translated in William R. Kinter, and Harriet Fast Scott, *The Nuclear Revolution in Soviet Military Affairs,* (Norman, OK: University of Oklahoma Press, 1967). Italics in original. Original article written in 1963.

positive spin on the most disastrous failures. Thus, the leadership remained confident that their money was being spent wisely.

Window of Opportunity and Leadership Disarray

Korolev proposed the R-7 less three months following the death of Stalin, at a time when the leadership was in the greatest disarray. Was he taking advantage of a window of opportunity?[135] Given Stalin's general preoccupation with aircraft, and his thinly disguised intentions to initiate another bloody purge, it seems likely that Korolev wanted to wait until after Stalin's death to push his most ambitious program. It was up to Korolev to chose the time and place to advance his proposal. Beriia made it clear that he was not concerned with technical details, he wanted to know when something would be ready, and how much it would cost. Korolev knew he would not question the additional payload capacity of the R-7. Therefore, it is reasonable to conclude that Korolev pushed his proposal at the time when he knew leadership resistance was weakest. He used his window of opportunity to the greatest advantage.

[135] See Kingdon, *Agendas, Alternatives, and Public Policies...*

INSTITUTIONALIZATION OF THE SOVIET MISSILE PROGRAM: OBSERVATION, ANALYSES AND CONCLUSIONS

By 1950 Korolev had established a strong organizational foundation for the Soviet missile program. But he had little technical success to show for it. He had only completed two series of launch tests for an indigenous copy of the V-2. Literally thousands of these missiles had already been produced in Germany during the war. It would be an exaggeration, therefore, to say that the Russian rocket scientists had advanced the state of the art in rocketry by the end of 1949. This is not to say Soviet rocket scientists were in any way incompetent, the leadership simply stifled development. The few advances which had been made, namely the separation of the warhead from the fuselage, were done under the cover of experimental scientific programs. They were not part of the officially sponsored state program.

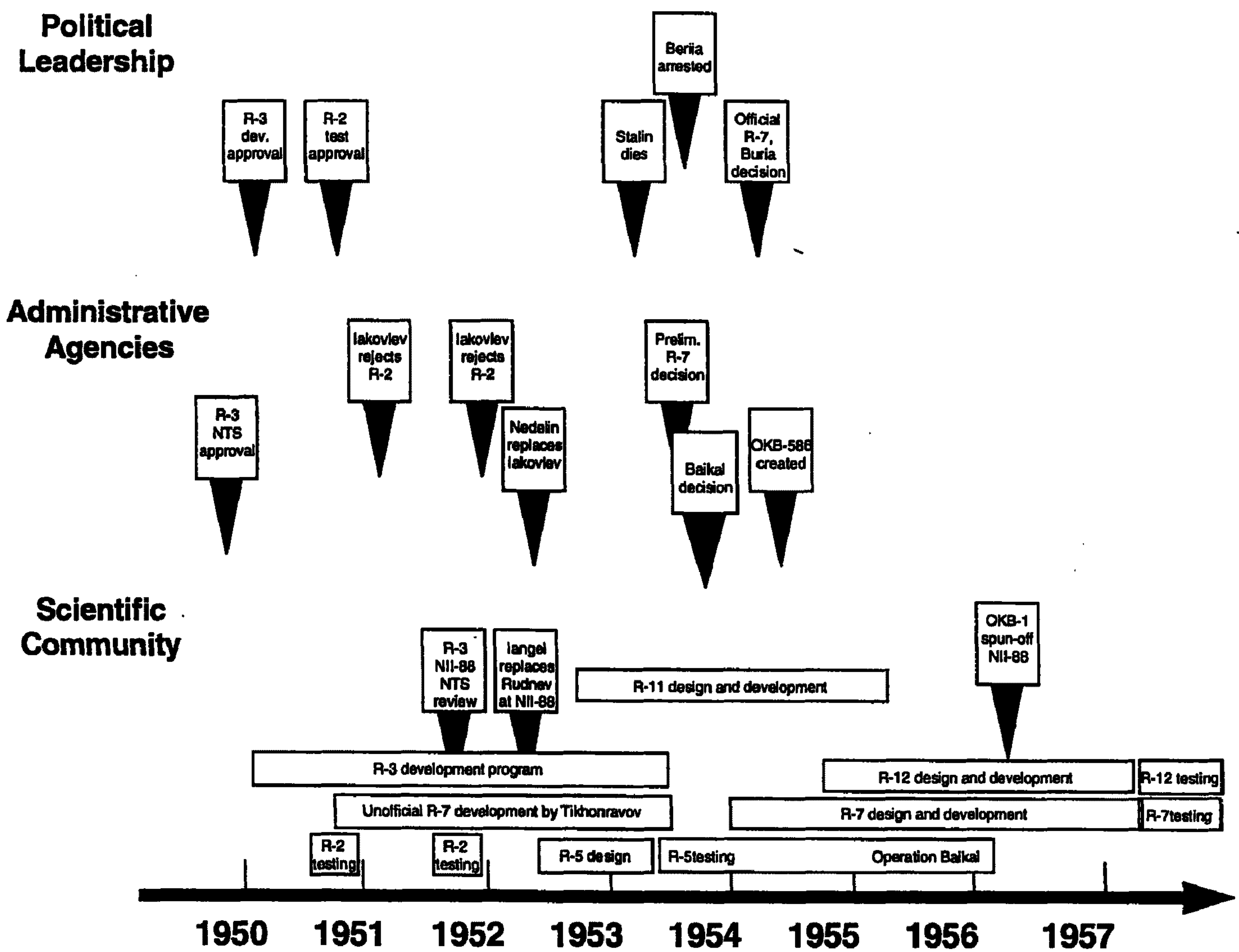

Figure 5.2 -- Major Events in the Institutionalization Phase

Figure 5.2 illustrates the major events during the institutionalization phase of the Soviet missile program. This period was characterized by much higher rates of development and testing, than the organizational emergence phase, with an incremental progression from the 600 km R-2 to the 1200 km R-5 (tested with an atomic warhead during Operation Baikal) to the R-7 with intercontinental range. This figure also shows the higher rates of activity following the dismissal of Marshal Iakovlev in 1952.

Over the course of the next six years, a single organization designed, produced and tested four new missile systems moving from the 600 km R-2, to the worlds first ICBM. In 1959, this ICBM became the basis for the formation of a completely new branch of the Soviet Military, the Strategic Rocket Forces. More than just another infant military organization, the RVSN was instantly placed at the top of the Soviet military hierarchy, clearly heralded as the most important component of the Soviet defense structure. At this point the missile program was a critical policy tool for the Soviet leadership. Programmatic innovation had occurred.

How did this happen? Did the Soviet leadership finally see the value of missiles in the early 1950s? No. The rocket scientists used their exceptional organizational strength to push their agenda through a resistant leadership, at times resorting to outright deception. Korolev's bluff was never called, and this alone was a strong indication of the autonomy enjoyed by the scientists. But we will go deeper to explore the depth and breadth of this autonomy with further observations.

Observation of Scientific Autonomy

There are several means of observing scientific autonomy during the late institutional phase. Certainly the most important and obvious measure is *technological deviations*, or the variation between the initial project agreement and the final result. If the variation is high, it is an indicator that the scientists were able to behave opportunistically. This is a strong indication of scientific autonomy. The degree of *informal coordination* among scientific organizations provides another important observation. If the scientists are able to take decisions out of the hands of administrator, and coordinate activities among themselves, they have gained autonomy. Scientist may also gain autonomy by managing the *transmission of adverse information* to avoid damaging reports to the leadership. These measurements are considered below.

Technological deviations

The feigned implementation of the R-3 provided a clear indication of Korolev's autonomy from the state leadership and monitors. The R-3 project occurred at the most dangerous stage of any R&D program, the point at which serious expenditures had to be made for highly uncertain results. Korolev's means of dealing with this problem was to use his informational monopoly to deceive the leadership. During the course of this project, instead of building a single stage missile capable of carrying a 1.5 ton warhead 3,000 km, Korolev conducted a broad range of research on rocketry in general. There was no intention to build an R-3. Korolev's actions were in clear contravention of leadership wishes. Neither Ustinov, Iakovlev, nor Stalin had any interest in such unguided research.

The technological deviations with the R-7 were less obvious but perhaps more important. To some extent, Korolev was circumventing requirements during the first test series in 1957. Well ahead of time, he was aware, that the warhead was not likely to survive reentry. Nevertheless, he proceeded with the test, without making the leadership aware of the shortcomings of the vehicle. Ultimately, of course, he developed a warhead which was survivable. What may be more important in this case are the reasons for the warhead problem. Korolev directed his scientists to solve the thermal regulation problem for both warheads and manned vehicles. The two created very different technical problems, and this additional requirement was responsible for much of the delay in warhead development.

Informal coordination

The ability of the scientific community to organize itself around the missile program provided another indicator of scientific autonomy. The Council of Chief Designers was a creation of the scientists to deal with the cumbersome organizational structure of Soviet industry. Though the Council did not achieve any official status until

1961, in the years from 1946 until 1961, its decisions on all technical issues were held to be binding on all five ministries involved in the missile program. This organization effectively left the vast majority of decision-making to the scientists themselves. Political leaders and administrative agencies are normally loathe to cede such authority to lower level participants in a rigid hierarchical structure. Korolev was able to secure this right by being irreplaceable.[136]

Transmission of adverse information

A key activity performed by administrators is to objectively report on the performance of programs under their supervision. The inability of Soviet administrators to meet this standard, provided another indicator of the autonomy of Korolev and the scientists. Failed missile launches would appear to be difficult to conceal. But since the documentation on vehicle tests was produced under Korolev's control, the final reports invariably put a positive spin on failed tests. Ustinov, faithfully passed these reports on to higher authorities.

Scientific Autonomy and the Institutionalization of Soviet Rocketry

From the above observations, it is clear that the rocket scientists enjoyed a considerable degree of autonomy from the Soviet leadership. But what did this autonomy mean for the advancement of the Soviet missile program? It was decisive. The basic

---

[136] See Pfeffer, *Power in Organizations...*

problem facing all programmatic innovations is how to get through the difficult early stages of research, when a great deal of resources must be devoted to highly uncertain technological paths. The scientists must either convince the political leadership that unconditional support for such endeavors is necessary; or they must deceive them. Korolev chose the latter. This required scientific autonomy.

For Korolev this may have been the only choice, as it seems highly unlikely that Stalin and Ustinov would have continued support for undirected research for much longer, given the problems with the R-1 and Iakovlev's opposition. Opening an uncertain research agenda has been a source of difficulty for other research programs. The early U.S. ICBM effort suffered from the lack of satisfactory technical guarantees of accuracy and readiness.[137] The space station suffered as well from a lack of technical specificity.[138] The Polaris program survived Congressional inquiries by developing an elaborate system of smoke screens (PERT) to demonstrate the program was following a well defined technological path.[139]

For other cases of programmatic innovation, the scientists were able to deal with the political leadership more openly. In the case of the atomic bomb program, Oppenheimer made it clear that it would be wasteful, but necessary to pursue several

---

[137] See Edmund Beard, *Developing the ICBM: a Study in Bureaucratic Politics,* (New York: Columbia University Press, 1976).

[138] See McCurdy, *The Space Station Decision...*

[139] Harvey Sapolsky, *The Polaris System Development: Bureaucratic and Programmatic success in Government* (Cambridge: Harvard University Press, 1972)

technical solutions simultaneously. The political leadership enthusiastically agreed.[140] The U.S. manned lunar program was approved without an agreed upon mission profile, and a great deal of time and money was expended determining whether the basic mission should feature a direct ascent to the Moon, and direct return to Earth, or Lunar rendezvous as was finally agreed upon.[141] But there does not appear to be a clear pattern.

Korolev was able to accomplish this deception by maintaining near complete control over critical information. By instilling a consensus over organizational mission, and maintaining a monopoly over expertise, Korolev was able to manage the information flow. All formal communications passed through his office. Informal communication, he controlled through organizational consensus. The scientists made all technical decisions among themselves, and presented a unified technical monolith to the leadership and monitors. It wasn't until the establishment of OKB-586, that the leadership was able to break Korolev's monopoly over missile technology.

While Korolev's autonomy was severely compromised by the establishment of a competing missile design bureau, the quality of the Soviet missile program was enhanced. Iangel's approach to design, in both technical and organizational terms, proved a much better match to the requirements of a developing missile force. This suggests that while scientific autonomy was necessary during the early phase of missile development, it proved

---

[140] See Rhodes, *Making the Atomic Bomb...*

[141] See MacDougall, *The Heavens and the Earth...*

to be counter productive as the program developed. Once there was sufficient scientific talent to support competing centers, the Soviet leadership was well advised to open the program to competition. By this time, administrative agencies were better educated and capable of closely managing a second R&D center. The leadership was in a much better position to manage the program. Administrative agencies had gained some understanding of technologies and missions. They could use one scientific organization as a means of testing the claims of another. At this point, the relationship between the scientists and the state underwent a fundamental shift in favor of the political leadership, and a new phase of the programmatic lifecycle begins involving routinization, rather than innovation.

CHAPTER 6

"Ministers come and ministers go, but we remain, a unified collective performing our own work."

Sergei Korolev's last words to his First Deputy, Vasiliy Mishin

CREATING THE SOVIET SPACE PROGRAM

The establishment of an ICBM program was not the fundamental goal of Korolev's scientific community. It was simply a necessary condition for embarking on the program of their true intentions. Since the 1920s, Korolev, and the group of scientists around him, dreamed of space travel. But, better than the rest, Korolev understood that these dreams were pure fantasy until they could establish a strong organizational basis for a space program. He knew that the political leadership would not agree to spend the enormous resources necessary for space travel. He suspected, however, that state resources might be dedicated to ICBM development. The difference between a rocket intended for use as an ICBM and one capable of launching objects into space was not large. If Korolev was clever, he could use the same rocket for both purposes. This was the plan. Implementing the plan entailed a fair amount of personal and professional risk.

If the leadership discovered his true intentions, Korolev feared a return to the Sharagas of Siberia, or worse.

Much of the organizational pre-history for the space program has been covered in previous chapters. This chapter will retrace that ground a different perspective to illustrate how the space program was borne of the missile program. The fact that the early Soviet rocket scientists had a plan for space exploration was relevant to the missile program because it demonstrated early organizational cohesion. For the space program, the plan itself acquires greater relevance. The preceding chapter covered the decision to develop the world's first ICBM -- the R-7. This chapter will retrace that decision-making process from the scientists' perspective, revealing how Korolev configured the R-7 to serve as a space launch vehicle, which would also meet the requirements of the ICBM. Such retracing is necessary for the reader to understand the significance of this overlap, and in order to make the basic argument of this study: that Korolev used the missile program to build the organizational foundation necessary for his true objective -- space travel.

Analytic Issues

The time period from initiation to institutionalization of the Soviet space program occurred over four years from 1955 to 1959. As contrasted with the missile program, which was institutionalized over the course of more than 14 years, the space program accomplished a lot in a relatively short period of time. Because the organizational foundations had already been laid well in advance of any proposals to the leadership, the program progressed rapidly once initial approval was granted. Consequently, this chapter will be concerned primarily with the phases of: conceptualization and decision-making, and institutionalization. Organizatonal emergence will treated as part of the phase of institutionalization.

Performing the fundamental research

Unlike missiles, there was no basic concept of a mission to be performed in space. The objective was to get into space -- but why? The scientists themselves did not have a clear idea. Therefore, development of a space program required theoretical research with far greater uncertainties than the missile program. They could hardly expect to convince the leadership to support such an expensive endeavor without having any idea of the basic goal. Today, the utility of satellites for communication, navigation, reconnaissance, observation etc., is perfectly obvious. But prior to 1953, few of these applications had been openly discussed in the Soviet Union.[1] Similarly, the technology of space travel was almost completely unknown. The basic mechanics of orbital motion were known, but almost nothing was known about the environment of space. The scientists did not even know where the atmosphere ended and space began.

Korolev's challenge was to find some means of solving these problems without having to go to administrative agencies or the leadership for support. He accomplished this by funding a colleague in another institute, Mikhail Tikhonravov, using his own

---

[1] In the United States, there had been considerable discussion of the utility of space flight begining with a reprot published bythe RAND corporation in 1946. See Walter A. McDougall, *The Heavens and the Earth: a Political History of the Space Age,* (New York: Basic Books, 1985)

reserve funds. With Tikhonravov's work, Korolev was able to present the leadership with a plan for space exploration defining a series of mission which could be performed using spacecraft.

Decision-making -- incrementalism or all or nothing

The decision to initiate the space program presented the same dilemma as any other programmatic initiation decision: the scientists wanted a single decision to embark on a range of projects, while the leadership wanted to maintain control over costs and program direction. Since the space program spun-off of the missile program, the differences between the scientists and the leadership were ameliorated, but the problem remained.

The first satellite was presented to the Soviet political leadership as *fait acompli.* Launching satellites from ICBMs involved very little additional effort. However, the leadership was concerned about the longer range implications of Korolev's program. It feared that the program could divert a substantial share of his design bureau's efforts toward an endeavor with questionable return. For the first three years, Korolev presented the leadership with incremental projects, beginning with a series of Sputniks followed by the Luna series. In 1958, he unveiled a single long-term programmatic proposal involving a one time approval for an entire space program.

Developing and maintaining constituencies

From the beginning, it was clear to Korolev that the military was not interested in a space program. Korolev had to find other constituencies, repeating the process he had performed with the military and the industrial leadership for the past decade. This time, however, he had only months, rather than years, to build support. Two obvious candidate constituencies were the political leadership, and the scientific community. However, these variant constituencies had differeing needs and goals. The Academy of Sciences wanted to conduct experiments in space. It wanted genuine scientific results. The political leadership wanted to demonstrate the superiority of the socialist system. It wanted to beat the United States into space. Korolev understood well what would serve the purposes of these communities. The problem were, first, that neither the Academy of Sciences nor the political leadership was convinced of the utility of a space program, and, second, that these interests were not necessariliy compatible.

Korolev began by building a constituency within the Academy. As he had with the missile program, early in the program Korolev established an important partnership. He had long-standing relations with the Vice President of the Academy Mstyslav Keldysh, and together they advanced the space agenda through the Academy. Once sufficient support was established, they went to the political leadership, offering a highly incremental research program. The task was then to convince the political leadership of the political value of putting the first satellite into space.

The Academy of Sciences represented a very different customer from the military. Korolev could not maintain a monopoly over critical information with the Academy. He relied upon several of their institutes for technical support. They were not so easily deceived, as was the military in the early years. Furthermore, while the Academy held a great deal of prestige, it did not command much in the way of financial resources. Korolev could not rely upon the Academy to finance his space program. It could be an important ally, but financing would have to come directly from the political leadership.

Actors

With one important exception, the bureaucratic cast of characters involved in the space program was the same as that for the missile program discussed in the preceding chapters. Figure 6.1 provides an overview of the relevant actors for the Soviet space program in 1957. The political leadership was unchanged; the scientific community was basically the same with a few additions. The major difference between the two programs was the near absence of administrative agencies with direct involvement in the space program. The Ministry of Armaments and the military were completely eliminated from the decision-making process. By 1957, Korolev had established direct, though informal, ties with Khrushchev, thereby circumventing even the higher levels of administrative agencies.

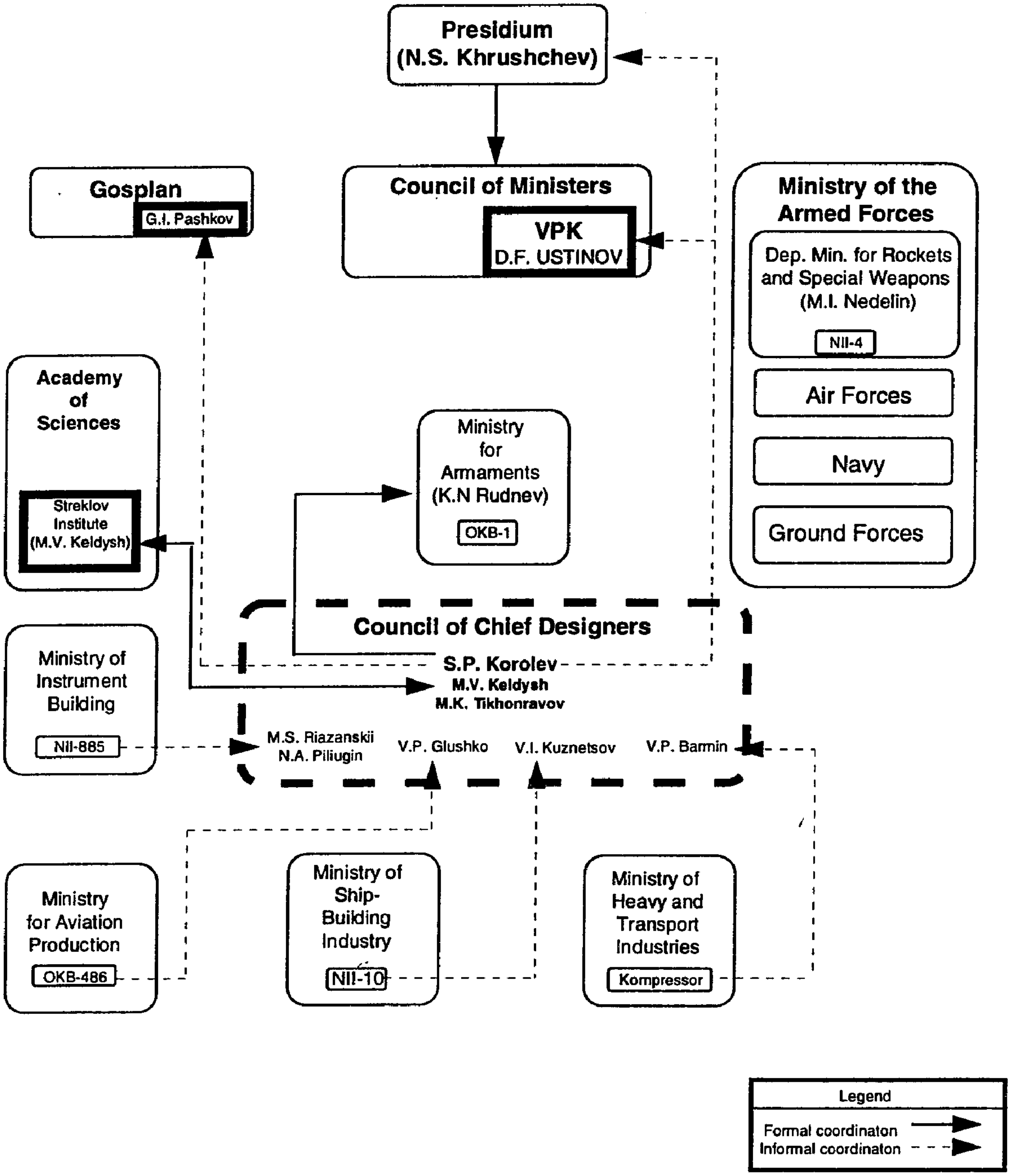

Figure 6.1 -- The Structure of the Soviet Space Program in 1957

At the level of the political leadership, the set of bureaucratic actors changed little from that which participated in the missile program following Stalin's death. Many were involved, but no one was in charge. The Khrushchevian leadership went to great lengths to provide the appearance of collective leadership. To the extent practical, every member of the Politburo was a party to decisions from 1953 until 1957. Following the defeated coup attempt in June 1957, Khrushchev's rule was increasingly autocratic.[2] Once the launch of Sputnik gave the space program center stage, Nikita Khrushchev assumed a personal interest in the advancement of the program. Khrushchev actively participated in the conception of at least one space mission. This was propaganda, and Khrushchev understood at least this much. Throughout his leadership, he would trumpet the success of the Soviet space program despite the fact that he possessed on the most limited understanding of space technology. Through his interest, direct lines of communication were established between Korolev and Khrushchev, obviating the need for much of the administrative bureaucracy between the two.

The greatest difference between the missile and space programs was at the administrative management level. The original satellite proposal was mired in the administrative decision-making bureaucracy for more than a year. The industrial manager for the missile program, Minister of Armaments, Dmitry Ustinov, refused to push the proposal through the expedited channels open to the missile program. Marshal Mitrofan Nedelin, the Deputy Minister of Defense for Special Weapons and Technology, and his

---

[2] In June 1957, Presidium members Bulganin and Voroshilov were defeated in an attempt to overthrow Khrushchev.following the attempted coup, Khrushchev exerted much greater, but not absolute control over the Soviet leadership. See George Breslauer, *Khrushchev and Brzhnev as Leaders: Building Authority in Soviet Politics,* (London: George Allen, 1982)

deputy, Gen. Mrykin, were openly hostile to satellites, but were unable to veto the proposal.

Literally overnight, on October 4-5, 1957, the space effort was transformed from one which was nearly buried by administrative decision making structure, to one which was almost completely free of it. Korolev could go directly to the political leadership. Ustinov's role became one of willing facilitator, to the extent that he participated at all. Nedelin and Mrykin disappeared from the State Acceptance Committees. Their only role was to provide troops necessary for launching the satellites. More importantly, the military did not serve as the customer for space systems. The formal customer for space systems was the Academy of Sciences but in reality, the customer was the political leadership itself. Intermediary monitoring organizations which were established to oversee missile programs were not assigned to the space program. Korolev dealt directly with the leadership. Over time, new administrative agencies were established to oversee space, but these were not created until the space program was well entrenched in the Soviet leadership.

The scientific community expanded to fill the needs of the space program. The primary new entrant was the Academy of Sciences. A Committee for Space Research was set up within the Academy under the chairmanship of Keldysh, which simultaneously served as customer for spacecraft and subcontractor to Korolev. The Council of Chief Designers remained the driving force on the industrial side. Its authority was at least as great as it was for the missile program.

CONCEPTUALIZATION AND PROGRAMMATIC INITIATION

The decision to go into space was preceeded by a long organizational prehistory of scientific coordination dating back to the turn of the century. Soviet rocket pioneers coalesced around the theories of space flight developed by Konstantin Tsiolkoskii and developed strong interporsonal ties which carried them through the difficult times of the war. Following the war they reestablished their working relations in the nascent missile program. While working on missiles, Korolev and his scientists surreptitiously developed theories and practical proposals for space flight. When a convergence of events presented the opportuity, Korolev pushed his proposal for a stallite launch through the administrative bureaucracy. Repeatedly thwarted, Korolev finally succeeded by stressing the political significance of beating the Americans into space, and that a launch could accomplished at a minimal cost.

1900-1940 Developing Theories of Space Flight

Konstantin Tsiolkovskii grew up in the town of Kaluga, 100 miles south of Moscow. Nearly deaf, he was largely self-educated, turning his intellectual curiosity to thoughts of space flight at an early age. Inspired by the work of Jules Verne, his early work was unsystematic in his obsession with space travel. At one point he convinced himself that he had devised a machine capable of conquering gravity. His machine and dreams crumbled in the face of his own mathematical calculations, but it provided an important lesson which would distinguish his work. Tsiolkovskii not only possessed the imagination of a dreamer, but he learned early on that he must fortify his ideas with serious mathematical calculations. It was the strength of his mathematical calculations which made his work enduring. Tsiolkovskii's independence from bourgeoisie science also made him an attractive symbol for the Bolshevik slogan that science is the religion of communism. In 1919, he was elected into the Socialist Academy of Sciences, and given a lifetime pension in 1921. From then, until his death in 1935, Tsiolkovskii was periodically paraded before the Soviet public to demonstrate the proletarian nature of Soviet science.[3] By the 1920s, his prominance provided the spark which set fire to minds of young Soviet space enthusiasts.

In addition to mathematical calculations and theories of rocket propulsion, Tsiolkovskii provided a 14 point plan for development of space which served as a developmental road map for the scientists who followed in his footsteps. The plan called for:

1. Development of a rocket plane with wings;
2. aircraft further developed with shorter wings;
3. aircraft developed to attain altitude of 12 kilometers;
4. wingless vehicles developed;
5. rocket developed that is capable of speed of eight kilometers per second (orbital velocity);
6. first flights into the cosmos;
7. development of regenerative processes in the cabin;

---

[3] See Nicholas Daniloff, *The Kremlin and the Cosmos,* (New York, Knopf, 1972) pp. 11-20; and, McDougall, *The Heavens and the Earth...*

8. space suits developed;

9. plants carried into space to aid regenerative systems;

10. space stations set up around the earth;

11. solar energy harnessed for space locomotion;

12. colonies established on asteroid;

13. colonies developed further;

14. human society and its individual members become perfect.[4]

Tsiolkovskii's writings were a magnet for an emerging community of space travel enthusiasts in the Soviet Union. Soviet rocket scientists, more appropriately referred to as `enthusiasts,' at the timebegan to voluntarily collectivize in the early 1920s.[5] While this period was covered in some detail in Chapter 3, it is important to briefly reconsider the origins of rocketry as it was connected to theories of space travel. Groups such as the Gas Dynamics Laboratory (GDL) in Leningrad, and the Group for the Study of Reactive Motion (GIRD) in Moscow were formulated with the basic mission of achieving space travel. Rocketry was only a means to that end; and Tsiolkovskii was their guiding light.

In the summer of 1933, Korolev convinced the Deputy Commissar for Defense, Marshal Tukhachevskii, of the necessity of uniting rocket scientists under a single organizational umbrella. The Reactive Scientific Research Institute (RNII) was created in September 1933. Korolev and Mikhail Tikhonravov worked together at RNII designing

---

[4] A.A. Kosmodemianskiy, *Konstantin Tsiolkovskii -- His Life and Work,* (Moscow, Nauka, 1960) as cited in Daniloff, *The Kremlin and the Cosmos...* p. 20.

[5] In fact, very few of the early Soviet rocket pioneers had any formal post-graduate training.

rocket powered planes. In 1934, Korolev published a book, *Rocket Planes in the Stratosphere*, which exemplified the first phase of Tsiolkovskii's plan for space development. While the book won widespread acclaim from all quarters, there was a group within RNII headed by A.G. Kostikov which was sharply critical of Korolev's work.[6] Nevertheless, Korolev included two rocket-planes in the 1936 work plan for RNII, one manned the other unmanned. Only the unmanned version was approved for full-scale development, while further research on human factors was directed for the manned version.[7] With the support of Tukhachevskii, Korolev was making progress, taking the first step along Tsiolkovskii's pathway to the stars.

In the late 1930's, the earlier debates with Kostikov turned ugly. In 1937, Tukhachevskii was purged and executed by Stalin. Anyone connected with the RNII was suspect as a consequence of the institute's connection with Tukhachevskii. Kliemenov, the director of RNII, was swept away in his wake as well as the following director, Langemak.[8] In November 1938, Korolev and Glushko were arrested as a result of accusations of sabotage leveled by Kostikov.[9] Korolev was interned under the horrific conditions of the gold mines at Kolyma in Siberia, while Glushko drew the somewhat less onerous conditions of the *Sharaga*, or prison design bureau, later known the Kazan

---

[6] See B.V. Raushchenbakh, *Iz Istorii Sovetskoi Kosmonavtik,* (Moscow: Nauka, 1986) pp. 214-215.

[7] For a collection of the work on rocket planes produced by Korolev from 1932-1938 see M.V. Keldysh (ed.) *Tvorcheskoe Nasledie Akademika, sergeia pavlovicha Koroleva,* (Moscow Nauka, 1980) pp. 147-163.

[8]Mariia Pastukhova, "Iarche liuboi legende" *Ogonek*, #49, (December 1987) p. 18 asserted that both Kliemenov and Langemak were interned in the OTB and died there. Holloway, *op. cit.*, p. 388. notes that they were purged in 1937 and 1938 and speculates that they were shot.

[9] See Raushchenbakh, *Iz Istorii Sovetskoi Kosmonavtiki...*; and Iaroslav Golovanov, *Korolev: Fakti i Myfi,* (Moscow: Nauka, 1994).

Aviation Works under the direction of the famed Soviet aircraft designer Andrei Tupolev. In 1939, Tupolev and Glushko succeeded in getting Korolev transferred to their design group.[10] For the next five years, Korolev and Glushko worked together on a series of minor aviation projects, most involving small rocket engines to be used for takeoff assist for Soviet bombers.[11] Nevertheless, Korolev's and Glushko's dream of space flight remained alive. Unofficially, they continued to work on rocket-powered aircraft.[12]

Developing the Basic Theories of Space Flight

The importance of Tsiolkovskii as an organizing force must be recognized. He provided the basic mathematical calculations demonstrating that space travel was possible. This is the first major step in any new technology. Believing that space travel was an achievable goal was a powerful unifying force in itself. But Tsiolkovskii's work went much further, providing a road map to the stars. Korolev, Glushko, and Tikhonravov found a mission in Tsiolkovskii's words. It was the mission which would unify the emerging cosmic collective through the difficult years of the war, and provide them with a vision of their destinationduring the test range failures of the limited range R-1. It would commit their conversations regarding space travel to the relative secrecy of their own collective.[13]

---

[10] See V.P. Glushko, *Perviy v Mire,* (Moscow: Nauka, 1981).

[11] See Raushenbakh, *Iz Istorii Sovetskoi Kosmonavtiki...*

[12] Korolev's working notes "Regarding work of the bureau on aircraft rockets at OKB-RD attached to Factory No. 16" archives of the Cosmonautics memorial museum, Korolev's home museum, f.1 ed. Xp. KP 135, ll. 16-21. Document provided to author by Georgi Vetrov. See also, M. Rudenko, "Uskol'znyvshaia luna," (The Moon stolen away) *Ekonomika i Zhizn,* No. 40 (October 1991) pp. 10-11.

[13] On the importance of mission to maintaining control over information see Wilson, *Bureaucracy...*

Thus, before the war began, there was an established community of scientists believing in space flight in the Soviet Union. With the possible exception of the German rocket community, the Soviet collective was the strongest of its kind in the world. Could it survive the ravages of Stalinism during the war? In a devastated nation, how would the rocket scientists reinvigorate their mission, and how would they find the money to do it?

Post-War Soviet Space Science: Developing the Technology Underground

Prior to their return to separate organizations in the Soviet Union, the group of Soviet rocketeers in Germany established close working relationships. Those who had not worked with Korolev and Glushko at RNII were quickly brought into the community of space flight advocates. A division of duties was established, and Korolev was accepted as their unquestioned leader.[14] Most importantly, Korolev devoted a great deal of effort to establishing a common set of goals among his workers which far exceeded those of simply launching rockets for use as long-range artillery.

The success of the German V-2 program presented Korolev with an uncomfortable proposition. The German rocket program was a departure from the agenda developed by Tsiolkovskii, which called for the development of winged, rocket powered aircraft for the opening forays into space. The German rocket scientists had essentially skipped this

---

[14] For a detailed discussion of the rocket scientists' activities in Germany see Chapter 3.

stage, moving directly to Tsiolkovskii's fourth stage.[15] Setting his previous conceptions aside, Korolev quickly adapted to the new agenda.[16]

From the time they arrived in Germany, Korolev made it clear to all within the scientific community that his destination was extraterrestrial.[17] He extended his vision beyond the scientific community, establishing adherents among the lower ranking military officers, and scientists from the Academy of Sciences.[18] One military engineer, arriving in Germany fresh out of school in 1946, recalled Korolev's response to his question regarding the future of rocketry:

> In his answer I first realized that basic idea, you might say his credo, to the realization of which he dedicated his entire life: a rocket—it is the only means to remove a person from his earthly cradle into space, the only means, the help of which might reveal the secrets of the Universe, which is hidden from us by enormous distances. Everything, which in the future would be created in the field of military rocketry, served, by stages in this path to space (including the semerka), from which he did not deviate his entire life.[19]

Korolev was guarded regarding his extraterrestrial ambitions in conversation with his superiors, however. Sergei Vetoshkin, the Deputy Minister of Armaments, noted that Korolev spoke about space "only very rarely, and with great caution. I had the impression that he was probing us: how would we react to such words...We would not react. We

---

[15] One German rocket scientist, Sanger developed plans for the A-10, a winged rocket which would be launched vertically, skip off of the upper layers of the atmosphere, and then "glide bomb" New York. The project never proceeded past the conceptual stage, however.

[16] Kosmodemianskiy, *Konstantin Tsiolkovskii...* p. 20.

[17] Interviews with Chertok, Mishin, and Mozhorrin.

[18] Interview with Kerimov. See also Golovanov, *Korolev...* p. 456.

[19]See "Kazanskii, Viktor Vasil'evich," in *Dorogi v Kosmos...V. I,* p. 70.

were not going into space."[20] Korolev understood that the leadership would not directly support the necessary basic research to develop more detailed theories of space flight. He would have to find more circuitous means of building a research base.

Such an opportunity appeared in 1948. An old colleague from his days at GIRD, Mikhail Tikhonravov, theorized that by combining a number of rockets, virtually any range or speed could be achieved.[21] It was a purely theoretical piece of work, but by mid 1948, he came to the conclusion that this concept could be used for propelling an object into outer space. Tikhonravov resolved to present these findings at the first plenary session of the Academy of Artillery Sciences (AAN).[22] The AAN was concerned primarily with the application of the experience of WW II to the further development of unguided short range solid fueled rockets such as the Katiusha. Anti-aircraft systems were of secondary concern and the lowest priority was long range rocketry.[23] Nevertheless, Tikhonravov and a group of his colleagues approached the President of the AAN with their idea, proposing to present a paper at the upcoming session. Gen. Anatolii Blagonravov initially rejected the proposal, noting that "the topic is interesting. But we cannot include your report. Nobody would understand why...They would accuse us of getting involved in things we do not need to get involved in..." But the rocket scientists

---

[20] See Golovanov, *Korolev*...p. 400.

[21] Tikhonravov's ideas were not openly published until 1980, and then in a classified journal of the rocket industry. See M.K. Tikhonravov, "Puti ocushchestvleniia bolshikh dal'nostei strel'by raketami, Doklad v Akademii Artilerichekikh nauk, July 14, 1948)" *Raketnaia Tekhnika*, January 1980, pp. 10-19.

[22] The Academy of Artillery Sciences was created in the wake of WW II to serve as a forum for discussing future warfare. It was far different from the Academy of Sciences in that it had no permanet institutes attached to it. Its only function, according to participants interviewed for this study was to serve a a meeting place for old Generals to rehash the battles fought in WW II.

[23] See K.V. Frolov, *Anatolii Arkad'evich Blagonravov*, (Moscow: Nauka, 1982) pp. 70-72.

were not dissuaded so easily. The next day Tikhonravov returned, and Blagonravov relented, cautioning: "Be prepared. We shall blush together."[24] Blagonravov's prediction proved prescient. After Tikhonravov's presentation, one high ranking military official remarked: "The institute must not have much to do. Has it decided to switch to the realm of fantasy?"[25] This was not isolated criticism. Another participant recalled that "one after another skeptics and critics came up to the lectern" criticizing Tikhonravov's presentation.[26]

One person who took Tikhonravov's report more seriously was Korolev, who sat on the Presidium of the AAN.[27] Keenly aware that Tikhonravov's packets presented the first possibility for putting objects into orbit around the Earth, Korolev was intrigued by Tikhonravov's report. Following the attacks, Korolev encouraged his old friend but cautioned him that such open discussions of space flight would be unproductive until they could produce a useful missile.[28]

Tikhonravov was chief of a small research group within a military institute -- NII-4 -- which was hastily created in 1946 as part of the reorganizations necessitated by the decision to create a rocket industry in Russia. The basic mission of the organization was to provide assistance in the utilization of rocketry for the artillery troops.[29] In the ensuing

---

[24] See Iaroslav Golovanov, "Start kosmicheskii ery," *Pravda,* October 4, 1987 p.3

[25] *Ibid.*

[26] See Maksimov and Bazhinov, ...pp. 16-17.

[27] *Ibid.*

[28] See Golovanov, "Start kosmicheskii ery"...

[29] The structure, personnel and purpose of NII-4 are discussed in greater detail in Chapter 5.

years, Tikhonravov's group became a think tank for Korolev's most ambitious schemes. Ironically, the group was partially shielded by the fact that they were under military control. The Director of the institute, Gen. Nestorenko, was not entirely cognizant of the work which was taking place within his own institute. According to one participant, he came to the position of director only "because after the war there were many military generals without jobs, and they had to receive suitably high positions."[30] Nestorenko had no background in rocketry, and at times exhibited a certain hostility toward the rocket scientists and the military men who supported them. But Nestorenko was surrounded by military men who had worked closely with the rocket specialists in Germany, several of whom worked with Korolev and Glushko before the war. Nestorenko's Deputy, Gen. Gaidukov, had personally persuaded Stalin to create a missile program and hadworked closely with Korolev in Germany.[31] Another leading figure and deputy to Nestorenko, Col. Tiulin, headed a missile research group in Germany, and worked with Korolev prior to the war at GIRD and RNII. Invariably, Nestorenko yielded in the face of presure from his deputies.[32]

The tepid support from Nestorenko not withstanding, Korolev understood that neither he nor Tikhonravov was likely to get support from the current military and political leadership for space flight.[33] In order to circumvent leadership approval

---

[30] Interview with Chertok.

[31] Gaidukov was the director of the Vystrel facility with Korolev as his deputy. His support was pivotal in gaining approval for initiation of the missile program in 1946. See Chapter 3 for an in depth discussion of the relationship between Korolev and Gaidukov.

[32] Interviews with Bazhinov and Maksimov.; Golovanov, "Start kosmicheskii ery"...; and Vetrov, "Mikhail Kladevich Tikhonravov..." pp. 40-41.

[33] Interview with Mishin, see also Golovanov, "Start kosmicheskii ery"...

processes, Korolev resolved to fund Tikhonravov's work at NII-4 outside of regular funding channels.[34] He told Tikhonravov: "Work, calculate, design in your institute; I will give you money and serve as the customer; I do not have any free people. They are all busy, no one can sit and do this work. Get agreement from your leadership so that I can order this work."[35] Tikhonravov received approval from the Deputy Chief of GAU, Gen. Mrykin, who commented: "It is good that Korolev should pay for this work." and G.N. Pashkov, the head of a group supervising rocketry in the Council of Ministers, who "wished him luck."[36]

Korolev maintained a reserve fund for just such purposes, but it was a closely guarded secret. No one within the design bureau was certain of how much money he had reserved in this account. Even his administrative officer, Sergei Okhapkin, claimed ignorance noting, "Korolev had a genuine reserve, he always did, how much, no one knew: not the people in his own design bureau, not his subcontractors, not the ministry. This secret Sergei Pavlovich [Korolev] never opened to anyone..." But he did not dispense of these funds readily.[37] They were set aside for critical tasks, such as those he wanted Tikhonravov to perform.

---

[34] See "M.K. Tikhonravov" in Ishlinskii...; and G.S. Vetrov, "Mikhail Kladevich Tikhonravov, k 80 letniu dnia rozhdeniia" *Zemlia i Vselennaia,* May 1980, p. 40

[35] See "M.K. Tikhonravov" in Ishlinskii...

[36] These accounts appear in the original version of "M.K. Tikhonravov" Iu.A. Ishlinskii, *Akademik S.P. Korolev: Uchenyi, Inzhener, Chelovek,* (Moscow: Nauka, 1986) but are ommitted in the final version. Maksimov and Vetrov confirmed that the original version was correct.

[37] See Golovanov, *Korolev...* p. 479.

For the next three years Tikhonravov and his group concentrated on using the packet system to launch an artificial Earth satellite.[38] Their research, performed in cooperation with Korolev's design bureau within NII-88, included examination of the guidance requirements for entering into orbit, means of correcting inaccuracies in orbital insertion, thermal protection, and optimal characteristics for the launch vehicle.[39] By late 1953, Tikhonravov prepared a report on artificial satellites which would be the basis for Korolev's ensuing proposal to the leadership. The basic premise of the study was that the R-7 was capable of propelling a one ton object in excess of 8 km per second, the speed necessary to achieve Earth orbit. It divided satellites into two basic types: stabilized and unstabilized. Unstabilized satellites, "the most simple satellites" (PS) weighed approximately1.1 to 1.4 tons, including 300-400 kg. of scientific instruments. Stabilized satellites weighing approximately 3 tons, were also examined with reference to the possibility of putting cameras on board. The study also included a discussion of projects involving manned spacecraft using existing rockets, manned space stations, and unmanned lunar flights, claiming all could be achieved in the near future.[40]

---

[38] The "paket" refers to the clustering of rocket boosters. This idea was developed by Tikhonravov at NII-4 under the guidance and sponsorship of Korolev. This project is discussed in more detail in chapter 5. Interview with Bazhinov, and Maksimov.

[39] See I.K. Bazhinov, "O teoreticheskikh isslecovaniiakh problem sozdaniia iskusstvennykh sputnikov zemli v SSSR v 1947-1956 gg." (Theoretical research on problems of the creation of articiacial Earth satellites in the USSR from 1947-1956) Separate publication Academy of Scientists Institute of the Natural Sciences and Technology, (Moscow: Nauka, 1981)

[40] M.K. Tikhonravov, S.P. Korolev, "Dokladnaia zapiska ob iskusstbennom sputnike zemli," (Report on artificial earth satellites,") in *Materialy po Istorii Kosmicheskogo Koroblia "Vostok,"* (Material on the History of the Spacecraft "Vostok"), (Moscow: Nauka, 1991)

Building a Research Base Without Spending Money

The early stages of research, in which the scientists must build a technological base, is the most difficult for a program. The scientists must determine first whether a concept is viable, and then develop a sufficiently specific plan for achieving that goal to convince the political leadership to provide the necessary financial support for full-scale development.[41] This stage was particularly problematic for Korolev. He was already involved with the R-3 project, which was performing technology development for ICBMs and space launch vehicles under its guise.[42] Thus, Korolev was already perpretrating one deception. Given the volatile nature of Soviet politics at the time, he could not risk another.[43] Performing the research in a military institute also removed it from Ustinov's oversight. Since he understood Korolev's programs better than any other administrator, this removed the greatest risk of detection and rejection. Korolev thus solved two problems by contracting for the work from another institute, and was able to perform the research without incurring the risk.

---

[41] See Downs, *Inside Bureaucracy...*; and Bruno Latour, *Science in Action*, (Cambridge: Harvard, 1987).

[42] TheR-3 program is covered in chapter 4. To briefly recapitulate, the R-3 was originally proposed as a 3,000 km medium range missile. However, Korolev never intended to build the missile. The project was used as a smokescreen to allow Korolev to perform necessary technology development which he could not get funded directly.

[43] In 1951-1952 several scientists and administrators involved with the rocket program were arrested in what appeared to be the beginnings of another party purge by Stalin.

The Decision to go into Space

A series of events converged in 1953 and 1954 which made it possible for Korolev to bring his cosmic agenda out into the open. Stalin died in March 1953. His deputy in charge of the secret police, Lavrentii Beriia, was arrested three months later, removing the most dangerous potential opponents to Korolev's space plans from the leadership. The rest of the leadership was composed of self-described technological "ignoramuses."[44] By late 1953, Korolev had completed preliminary design work of a rocket capable of launching a satellite into orbit. In 1952, a group of international scientists announced the celebration of the International Geophysical Year (IGY) which would last from July 1957 to the end of 1958, and invited the nations of the world to participate by launching artificial earth satellites to conduct scientific research. It was the official commencement of the space race. Korolev had a policy window; the task was to jump through it.[45]

In the 1930s Stalin expended a great deal of the state's effort establishing new world records for aviation achievements. Bailes, a historian of Soviet technology policy of the period, concluded:

> The need for political legitimacy and security led Stalin, in the period from 1933 to 1938, to stress a series of aviation stunts that had little relevance for the needs of Soviet defense and crippled Soviet military aviation unnecessarily in the early years of World War II. The particular way in which aviation technology was used by the Stalinists to emphasize the legitimacy of their regime was ultimately of less real use

---

[44] See Strobe Talbott, editor and translator, N.S. Khrushchev, *Khrushchev Remembers: the Last Testament,* (New York: Little Brown, 1971) p. 46

[45] See Kingdon, *Agendas, Alternatives and Public Policies...*

to the Soviet Union than a greater and earlier emphasis on air defense capabilities would have been.[46]

Throughout the tortuous process of fighting for approval of every step of the missile program, Korolev realized that Stalin would not easily be convinced of the value in returning to failed policies of the past. Stalin wanted a solid defense, not space spectaculars. Anything which detracted from that was sabotage. Given that Boris Chertok, Mikhail Riazanskii, Marshal Iakovlev, and Dmitry Ustinov were all under suspicion for sabotage over the previous three years, Korolev was reluctant to test his luck with Stalin by proposing that state resources be used for satellite launches.[47]

Stalin died in March 1953. Left in his wake was a confused, amorphous, political leadership. Beriia, who had the greatest cognizance of military technical affairs among the remaining leadership, was arrested in June and executed shortly thereafter. Georgi Malenkov, who was the political leader in charge of *Spetzkomitet-2*, was locked in a political struggle with Khrushchev arguing that the focus of the Soviet economy should be redirected from wartime priorities to those of a peacetime economy.[48] He argued that military-related production should be sharply cut back. Opposing him, Khrushchev argued for increased military modernization.[49] The political conflict was won decisively in

---

[46] See Kendall Bailes, *Technology and Society Under Lenin and Stalin: Origins of the Soviet Technical Intelligentsia, 1917-1941,* (Princeton: Princeton University Press, 1978) p. 405.

[47] Chapter 5 covers the beginings of Stalin's next purge in greater detail.

[48] *Spetzkomitet-2* was created in 1946 as a high level monitoring organization overseeing the missile programs. The committee was disbanded around 1951. See chapter 4 for a more detailed discussion.

[49] See for example Breslauer, *Khrushchev and Brezhnev as Leaders...*; and, Bruce Parrott, *Politics and Technology in the Soviet Union,* (Cambridge: MIT Press, 1985).

January 1955, when Malenkov was forced to resign as Chairman of the Council of Ministers, eliminating yet another potential opponent of the space program.

From Korolev's perspective, the primary result of the debate was decision-making paralysis. In the absence of decision-making at the top, lower level administrators made decisions without consulting the political leadership. During mid to late 1953, Korolev, Ustinov, and Minister of the atomic industry, Malyshev, decided upon: development of an SLBM (the R-11); "Operation Baikal" (the test of an R-5 with a live atomic warhead); and the R-7 (the first ICBM) with virtually no discussions at the leadership level.[50] Thus, by mid 1954, they were confident that decision making could be driven from the bottom up.[51]

In 1953, Korolev completed the conceptual and theoretical work for a missile capable of delivering nuclear weapons. In May, Korolev presented a proposal for the R-6 with an intended payload of three tons and a range of 8,000 km. Outwardly, it seemed to be a curious choice of vehicle size. Soviet atomic weapons at the time were only 1,000 kg., and thermonuclear warheads under development would be in the range of five tons.[52] In reality, Korolev arrived at the three ton figure methodically. A missile with a one ton

---

[50] For more detailed discussions of these programs see Chap. 5.

[51] For a discussion of the proposition that innovation tends to come from the bottom in public bureaucracies see John W. Kingdon, *Agendas, Alternatives, and Public Policies*, (Boston: Little Brown, 1984), Kingdon is basing his theory on the model of decision making developed in Michael D. Cohen, James G. March and Johan P. Olsen, "A Garbage Can Model of Organizational Choice," *Administrative Sciences Quarterly*, Vol. 17 (1972) pp. 1-25, more recent and detailed accounts appear in James G. March and Johan P. Olsen (eds.), *Ambiguity and Choice in Organizations*, (Bergen Norway: Universitetsforlaget, 1976); and James G. March and Roger Weissinger-Baylon, *Ambiguity and Command: Organizational Perspectives on Military Decision Making*, (Marshfield MA: Pitman Publishing, 1986).

[52] The First Deputy to the Director of the Atomic research institute reported that Korolev discussed warhead size with Igor Kurchatov, the Chief Scientists for the atomic program, in 1952. Interview with Golovin.

warhead was not large enough to launch a satellite into orbit, and a missile with a three ton warhead could be constructed from existing R-5 components, and would be large enough to launch a satellite into orbit.[53] The Minister of the atomic industry Viacheslav Malyshev, who was at the Scientific Technical Council (NTS) meeting, understood what Korolev was doing, and accused him of "attempting to develop a space booster disguised as a military missile."[54] Over Malyshev's objections, the project was approved. Only weeks before his arrest, Beriia signed the decree authorizing development of the first ICBM without notifying the rest of the leadership.[55] Korolev had approval for the rocket he needed to get into space.

Following the successful test of a thermonuclear weapon in the fall of 1953, Malyshev returned to Korolev requesting that he increase the payload capacity of the R-6 to six tons. Korolev agreed, but only after acknowledgment that much greater funds would be committed to development of an entirely new system.[56] Tikhonravov's calculations suggested that this new rocket -- the R-7 -- might be large enough to put a man into space.[57] Not only did Korolev now have a rocket capable of putting a satellite into space, but he could begin to think realistically of the possibility of putting a man into space. Tsiolkovskii's dreams were becoming reality.

---

[53] Interviews with Mishin, Chertok, and Vetrov.

[54] See Golovanov, *Korolev*...pp. 473-474; and Varfolomeyev, "Soviet Rocketry ...

[55] In fact one of the charges leveled against Beriia was that he approved this program without consulting with that rest of the collective leadership. See Holloway, *Stalin and the Bomb*... p. 321.

[56] This discussion is covered in greater detail in Chapter 5. See also Golovanov, *Korolev*... pp. 473-475.

[57] See Tikhonravov, and, Korolev, "Dokladnaia zapiska ob iskusstvennom sputnike zemli...

The third stream of events converging to open this policy window was the movement within the international space community to push for peaceful satellite launches. In 1950, an international group of scientists convened at the home of James Van Allen outside of Washington D.C. The topic of discussion was establishment an International Geophysical Year (IGY), coordinating international high altitude research during the unusually high solar activity predicted for 1957-1958. In October 1952, the IGY was officially announced, proposing satellite launches as the centerpiece. After open public discussion, on May 26, 1955, the National Security Council of the United States approved a program for orbiting a scientific satellite. The public announcement of U.S. participation was made on July 29th. There was no response from the Soviet Union.[58]

Korolev was aware of the IGY proposal, and in late 1953 began circulating the satellite idea within the Academy of Sciences, first building support within Keldysh's institute. The two scientists had informally discussed the idea of space flight for years, but their discussions took on a more serious note in 1953.[59] Korolev also held meetings with Academician Lavrov, astronomer, Academician Kykarkin, and the most famous member of the Academy, Petr Kapitsa. Together, Korolev and Keldysh proposed the idea that the first satellite should feature biological experiments on several types of living organisms. This supported Korolev's plans for manned space flight, and it quickly gained the support of the President of the Academy, A.N. Nesmeianov, a biologist. On May 25th, 1954, a

[58] See, McDougall, *The Heavans and the Earth...* pp. 118-121.

[59] Interviews with Eneev, Akim

meeting of the Presidium of the Academy approved Keldysh's proposal for creating an artificial satellite.

The same day, Korolev transmitted final approval of the specifications for the ICBM to Pashkov, at Gosplan, Riabikov, at the Council of Ministers, and Ustinov. This was the final stage in the formal approval process for the R-7. But the timing was no coincidence. On the following day Korolev sent another letter to the same list:

> For your consideration I present the report of Comrade Tikhonravov, M.K. "Artificial Earth Satellites," and also translated material on this subject coming from the United States. The development of the new article [the R-7] which is currently taking place raises the possibility of creating an artificial earth satellites in the nearest years.
>
> If we reduce the weight of the payload we may achieve the terminal speed of 8000 m/sec. The article [R-7] - satellite may be developed on the basis of the article currently under development; but requiring serious redevelopment of the latter [satellite].
>
> It seems to me to that now it is an opportune and expedient time to consider organizing a scientific department for conducting initial basic research on satellites and more detailed development of related issues.
>
> I request your decision.[60]

This letter was the first official communication with administrtors regarding satellites.[61] However, it did not catch Ustinov by surprise. Korolev discussed the satellite proposal with him for the first time in February, and he was willing to support Korolev's

[60] S.P. Korolev, "O vozmoshnosti razrabotki iskсstvennogo sputnika Zemli" ("The possibility of developing an artificial Earth satellite,") in Keldysh, *Tvorcheskoe Nasledie...* p. 343. Golovanov notes that the letter was sent to the same list as Korolev's acceptance of the ICBM specifications mailed a day earlier. See Golovanov, *Korolev...* pp. 519-520.

[61] *Ibid.* See also Golovanov, *Korolev...* p. 520; and, "M.K. Tikhonravov," in Ishlinskii, *Korolev....*

satellite provided it did not put more important missile programs at risk.[62] Consequently, the proposal was not considered a high priority, and was put on the slow track for approval. Given the unfamiliarity of the decision-making apparatus with space technology, this process would take many months.[63] The proposal probably never reached the Presidium, but stalled in the Central Committee decision making apparatus.[64] In the absence of official sponsorship, Korolev continued to fund Tikhonravov out of his own reserve.

Korolev's proposal was greeted with indifference by most, and hostility by some. The Deputy director of NII-4, Gen. Grigori Tiulin, helped Korolev push the proposal through a resistant bureaucracy by writing yet another letter to Grigori Pashkov, the official in Gosplan who had responsibility for the missile program.[65] Tiulin compared Korolev, to Tsiolkovskii, that "enthusiastic fantisizer, town lunatic," and encouraged Pashkov to support his plans. They arranged a meeting with Vasilii Riabikov at the

---

[62] Interview with Piskaraev. See alsoGolovanov, *Korolev...* pp. 519-520.

[63] A former participant in Politpuro decision-making noted that there were three basic speeds which proposals could mover through the Soviet administrative system. The highest priority issues, such as crises of foreign affairs go directly to the General Secretary (or Primier) for immediate resolution regardless of time of day. Other high priority decisions, are routed through the bureaucracy within a matter of days to a couple of weeks. These would include the decisions which were made on the ICBM. Other decisions fall into the normal channels. Here, each proposal must go through a painstaking process of approval of all Central Committee Departments which might have some cognizance over it. This process usually takes several months before te proposal can even get in the cueue for consideration by the Presidium. See Iuri Ra'anan and Igor Lukes, *Inside the Arraprat: Perspectives on the Soviet Unon from Former Functionaries,* (Lexington MA: Lexington Books, 1990).

[64] A former staff member of the Central Committee who did not begin working there until after Sputnik felt that, given the structure, it was unlikely that the first propsal ever reaeched the Presidium. Interview with Stroganov.

[65] Pashkov moved to Gosplan for a short time in the mid 1950s. His involvement in the missile program was informal stemming from his earlier work at the Ministry of Armaments and later at the Council of Ministers. Interview with Piskareev.

Council of Ministers. Korolev modified his tactics, stressing the political, rather than scientific, aspects of the first satellite flight, and the limited amount of additional resources he would require to conduct this mission. Riabikov was indifferent, but Gen. Mrykin, deputy chief of the Directorate of the Artillery Command for Special Technology (UZKA), objected to Korolev's proposal interjecting, "Why are we even talking about this?! When we launch the R-7, then we can think about satellites." Korolev had a list of participants in front of him and wrote "later" next to Mrykin's name.[66] Mrykin was not alone. There were others within the Soviet government, and even within the Council of Chief Designers, who felt Korolev's proposal was premature.[67] They did not share Korolev's sense of urgency over beating the Americans into space.

Undeterred, Korolev continued funding Tikhonravov's work. Another version of the "Document on Artificial Earth Satellites" was produced in July 1955, going into greater technical detail, with a discussion of the basic missions to be performed by satellites as well as organizational issues. Tikhonravov proposed expanding his group to 70-80 staff members, but Korolev pared this down to 30-35. Both were in agreement that the satellite design group should remain within NII-4 for the time being.[68] Korolev waited for the right time to submit this revised version the administrative agencies.

Korolev'sdid not have to wait long. On July 29, President Eisenhower announced that the United States would launch an Earth satellite during the IGY. Both Korolev and

---

[66] See Golovanov, *Korolev...* p. 520.

[67] Interviews with Chertok, Mozhorrin, and Mishin.

[68] See "M.K. Tikhonravov," in Ishlinskii, *Korolev....*

Keldysh had been keeping close track of the American space efforts, and their participation in the IGY did not come as a surprise. Nevertheless, the announcement created an international sensation in the popular press.[69] Within the Soviet Academy of Sciences, Keldysh held a series of conferences on space research the summer of 1955 which built a broad base of support not only among the leading members, but among the rank and file.[70]

The American announcement gave Korolev the pretext he was looking for. Korolev transmitted Tikhonravov's revised document to Pashkov on September 3. In the cover letter, he called attention to the political significance of the program, ***underlining this phrase three times,*** the economic uses of satellites, and finally the military uses, underlining the latter phrase a single time.[71] In the ensuing meetings, Korolev reiterated at the political significance of the space program. To make it appear scientifically legitimate, Korolev proposed that Keldysh, the new Vice President of the Academy, serve as the Chief Scientist and Chairman of an Academy commission coordinating the satellite effort. Korolev wanted t give the impression that he was only the project coordinator for Keldysh.[72] This alsoreassured Ustinov and the leadership that Korolev's first priority remained his missile work.

---

[69] See McDougall, *The Heavens and the Earth...*

[70] Interview with Eneev, see also Golovanov, *Korolev...* p. 527.

[71] These comments came from Tikhonravov's original unpublished, article.

[72] Interview with Eneev, Golovanov, *Korolev...* p. 519, 528.

This superficial division of duties between Korolev and Keldysh also made political sense for the Academy. The Academy President, Nesmeianov, was under attack at the time for isolating the Academy from the industrial ministries.[73] The satellite program gave him a chance to demonstrate that the Academy could work together with industrial design bureaus to produce scientific experiments which could advance Soviet industry. Putting the project under Keldysh's direction also provided a demonstration of Nesmeianov's assertion that the Academy "can fulfill its role in the country's scientific orchestra if it is the conductor, not merely a single performer."[74]

Korolev's strategy was finally successful. On January 30, 1956, the Council of Ministers issued a decree approving the use of one R-7 booster for launching an unstabilized 1,000-1,400 kg. satellite with unspecified scientific equipment comprising between 200-300 kg. of the overall weight. The satellite would be known as "Object D," and had a preliminary target launch deadline of the end of 1957. The technical proposal was exactly as Korolev had submitted to the leadership over 18 months earlier. It was Korolev's added emphasis on politics and the U.S. announcement that made the project more palatable to the Soviet leadership.

The Window of Opportunity

For more than a year and a half, Korolev and Keldysh pushed their proposal on the political leadership. Why did it stagnate for so long only to be summarily approved? The

---

[73] See Parrott, *Politics and Technology...* pp. 159-167.

[74] *Ibid.* p. 160.

answer lies in timing. Kingdon developed the concept of a policy window, a limited time at which political streams, policy streams, and agendas converge, providing an opportunity for major policy changes to take place.[75] Korolev built political force behind his proposal, steadily raising it higher on the leadership agenda by building a coalition within the Academy. This was not enough, to ope the window. The final push came from the American announcement of their intention to launch a satellite, and the strong public reaction supporting scientific space exploration. This opened the policy window. It was Korolev's bureaucratic acumen that enabled him to jump through it, by stressing the political aspect of beating the Americans into space.

ORGANIZATIONAL EMERGENCE AND INSTITUTIONALIZATION OF THE SOVIET SPACE PROGRAM

The decision to launch a satellite was only the first step. Korolev had to convince his new constituencies that his program could provide useful results. But could the existing organizational arrangement be modified to produce scientific satellites? Korolev's proposal relied heavily upon institutes of the Academy of Sciences to provide satellite harware and experiments. This was a risky proposition given their limited experience with actual production. Moreover, the Academy would have to produce this harware in time to

---

[75] See Kingdon, *Agendas, Alternatives and Public Policies...* esp. pp. 174-180.

beat the American's into space. This was the single most important factor in Korolev's mind.

At the same time, the embrionic space program would have to find some administrative home withn the Soviet bureaucracy. Would new agencies be created to oversee it? The military was again reluctant to accept a new technology, and were unintersted in assuming te role of customer. That left the Academy, which held a great deal of enthusiasm for space exploration, but little money to back it up. Korolev would need to more reliable means of support.

Beating the Americans into space

Though the technical issues involved in desiging and building a satellite were challenging enough, it was the organizational issues which would prove the most difficult for Korolev. He was relying upon institutes of the Academy of Sciences to produce many of the instruments and experiments being used in this new device, involving coordination of many institutes which were neither accustomed to producing hardware nor cooperating with other organizations. Korolev was already overburdened with design and production of the R-5, the R-11, and the R-7 and therefore, could no manage the satellite progra himself. Rather, he put the overall coordination under the direction of Tikhonravov, who was still in NII-4.

In April, 1956, owing in large part to the success of "Operation Baikal," Korolev's design bureau was separated from the rest of NII-88. Korolev finally gained complete control over his design bureau -- Order of Lenin OKB-1.[76] Shortly thereafter, Korolev formally brought Tikhonravov's group into his design bureau.[77] Most of his staff came with him.[78] Though a talented and creative engineer and theoretician, Tikhonravov was not a strong manager. This project was his first experience with administration, and it was not long before warning signs appeared that the project was in trouble. Korolev returned from Tiuratam after the successful nuclear test only to find the academics unable to come to a clear understanding of their basic scientific objectives. They had less than two years to complete the design and construction of the satellite, and they already wasted more than a month. At a conference in April, Korolev admonished the scientists

> "You have been working with geophysical rockets for more than six years and you really have nothing to say?!...[79] Today we are waiting for our comrades from the Geophysical Institute to provide proposals. But nothing has been said about this. We measured, we worked, we received results with whatever levels of accuracy, but we have not calculated that the container will rotate head over heels, we have not calculated the aerodynamic factors. Is this good science to leave open such questions?!"[80]

There were other problems with subcontractors for the satellite. Instruments being proposed by the Academy were at the levels of 1930s technology.[81]

---

[76] The order of Lenin was an honorific addition given to Korolev's group shortly after Operation Baikal. It became a formal part of the design bureau's title, but was not normally used.

[77] See "M.K. Tikhonravov," in Ishlinskii...

[78] The majority of scientists and engineers went to Korolev's design bureau, but Bazhinov chose to go to NII-88, where he served as a technical advisor on space issues. Interviews with Maksimov, Bazhenov, and Feoktistov.

[79] Korolev conducted 22 scientific launches using the R-1 and R-2 since 1949.

[80] See Golovanov, *Korolev...* p. 529.

[81] *Ibid.*

Changes were also needed in the R-7. Within Korolev's established network, these were moving at a far more rapid pace than work on the satellite. Calculations were made regarding engine cut-off; the telemetry system was modified; the nose cone was modified to handle the increased thermal loads of launch; and a system for separating the satellite from the booster was developed. All these changes were developed and approved by June 14, 1956.[82] The agility of the Council of Chief Designers only reinforced Korolev's concerns over the lethargy of the academy.

As rough as it was, Korolev approved the draft design of the satellite in July.[83] But he remained concerned. Keldysh tried to reassure him:

> We have had several delays in our work in Academy and we are still having delays. We should have provided the basic dimension of apparatus and attachment point to the rocket in August...We have a very tense situation in the creation of models for instruments, which we should provide in October for mounting into the satellite mockup in October...We hope that the majority of instruments will be given to you in October, the remaining ones in November...We want our satellite to fly sooner than the American [satellite]...[84]

Keldysh understood that the most important thing for Korolev was beating the Americans.[85] But November came and went without the instrument mock-ups appearing, and no one knew when they would arrive.[86] The situation had reached the critical stage. Korolev believed that at the rate they were progressing, the Americans would get into space first, and he would lose the most important justification for his program.

---

[82] See "M.K. Tikhonravov," in Ishlinskii...; and *Ibid.*

[83] Golovanov, *Korolev...* p. 530.

[84] *Ibid.*

[85] Interviews with Akim, Eneev.

[86] See Golovanov, *Korolev...* p. 529.

Korolev did not appreciate having his future dependent upon the whims of independent minded academics over whom he held little control But once again, a solution came from Tikhonravov. In November, Tikhonravov suggested a smaller, very simple satellite, weighing perhaps no more than thirty kilograms.[87] This solved Korolev's problem with the unwieldy Academy and provided Korolev greater assurance that he could beat the Americans into space. They dubbed the new satellite the PS.[88] Keldysh was naturally opposed to the project, as it all but eliminated the Academy, and there were others within the Council of Chief Designers who were also opposed to the idea.[89] Within his own design bureau, Ilia Lazrov called the PS "nonsense" and a "disgrace to the KB [design bureau]."[90]

Nevertheless, Korolev believed that the Americans were poised to launch a satellite at the beginning of the IGY, in July 1957, and he was single-mindedly focused on beating them. On January 5, he presented a document to Pashkov and Ustinov requesting "preparation of two rockets, the first for launch of an artificial earth satellite [ISZ] weighing 40-50 kg., -- the PS -- and another launch of an ISZ weighing 1200 kg., object "D." He proposed that these launches take place between April and June 1957 immediately following the successful launch of the R-7.[91] By this time it was clear to

---

[87] *Ibid.* p. 534.

[88] PS stood for simplest satellite. The Soviets always referred to this system simply as PS. The term "simplst satellite" was of course the same named they used for Object D, but it was obviously simpler still. In reality Object D was far more complicated than even the American satellites which would not be launched until well into 1958.

[89] Vetrov noted that Riazanskii was particularly opposed to the PS. Interview with Vetrov.

[90] Golovanov, *Korolev...* p. 533.

[91] Tikhonravov, "Notes on the History..."

Ustinov and Pashkov that the leadership was supportive of at least the political aspects of Korolev's space exploration program, and his proposal was put on the fast track for approval on January 20.[92] The preliminary decision authorizing the project was handed down only twenty days later, and the final decision on February 15, 1957.[93]

A State Committee was formulated at Korolev's request to oversee the first satellite launch. The Committee was headed by Riabikov, from the Council of Ministers. Korolev was the Technical Director. Other members included Keldysh, the five other members of the Council of Chief Designers (Glushko, Riazanskii, Piliugin, Barmin, and Kuznetsov), Nedelin, (Deputy Minister of Defense for Special Weapons and Rocket Technology), Pashkov from Gosplan, and Konstantin Rudnev, Riabikov's Deputy, and three other military officers.[94] Once again the Commission was stacked with members sympathetic to Korolev. Seven of the 15 members were directly tied to Korolev, and Rudnev and Nedelin both learned rocket technology from Korolev.[95]

Korolev scheduled the launch of the first satellite before the beginning of the IGY in July 1957 to ensure that he would beat the Americans into space. At the same time, he offered his assurances to the Academy scientists that their satellite would be launched later in the IGY. This schedule assumed the R-7 would fly on its first test launch scheduled for March. As it turned out, the missiles were ready in March but the launch site was not.

---

[92] Interview with Piskaraev.

[93] Tikhonravov, "Notes on the History..."

[94] Iu. A. Skopinskii, "Gospriemka kosmicheskoi programy" (State Acceptance of the space program,) *Zemlia i Vselennaia* No. 5 (September-October) 1988, pp. 73-79.

[95] For a deeper discussion of the relationship between Korolev and Rudnev see Chapter 4. On Nedelin, see chapter 5.

Moreover, the first launch was not a success, nor the second or third. The first successful launch was conducted on August 21st. A second successful test was donducted in September.[96] The next R-7 launch was reserved for the PS.

One of the arguments made by Korolev in defense of launching only two R-7s, was that the warhead re-entry problem had not been solved and any further test would only result in more warheads burning-up on re-entry.[97] He argued that since they were only testing the rocket, without an effective warhead, it made no difference whether it was configured as a space launch vehicle or as a missile.[98] While it cannot be proven that Korolev manufactured this problem, it was clear that he used it to his advantage by maintaining control over information regarding the true capabilities of the design bureau in solving re-entry problems. Korolev had a group working on this issue since 1952, but they were working on the more difficult issue of protecting humans during re-entry. If they could solve that problem, they could solve the problem of warhead re-entry. Korolev kept the work of this group isolated from the rest of the design bureau. Leadership and administrators did not know of the problem, until shortly before the test series.[99]

One group which did understand the problem was located within Keldysh's institute. Not only did Timur Eneev understand the problem, he developed a solution to it as early as 1953 by using materials which dissipated heat by burning-off, rather than

---

[96] A more detailed description of the development of the R-7 as well as the launch program appears in Chapter 5.

[97] For more discussion of this point see Chapter 5.

[98] See interview with Mishin.

[99] See Golovanov, *Korolev...* p. 536; and, interview with Mishin.

resisting the heat. However, Keldysh and Tikhonravov remained skeptical that ablative materials could solve the problem. In 1956, Eneev's calculations were replicated by Tikhonravov, and he became convinced that it was a viable alternative. In 1958, Eneev's solution was adopted for both the manned program and, initially at least, for warheads.[100] Did Korolev intentionally conceal Eneev's approach? Eneev believes that Korolev was certainly capable of such an action, but that his research was more likely stifled because it contradicted the conventional wisdom that materials needed to be devised which resisted heat rather than materials which burned off, thus transferring the heat away from the object.[101] Whatever the case, Korolev capitalized on the inability of the warhead to survive in order to push for a rapid launch of a satellite, going against critics such as Gen. Mrykin, who wanted to complete more tests with the R-7 before even talking about satellites.

The satellite itself a very simple device, consisting of little more that a polished sphere 560 mm. across, two antennae, a battery and a radio transmitter. The design and construction took a little over a month. The chief engineer, Viktor Kliucharev, commented: "For us, from the standpoint of manufacturing, it was something truly simple."[102] Korolev's only technical concern was that the satellite must be polished to a

---

[100] T.M. Eneev, "Spusk s iscusstvennogo sputnika zemli s tormozheniem v atmosfere" (Re-entry of an artificial Earth satellite with deceleration in the atmosphere) Museum in Keldysh Institute of Applied Mathematics; also, interview with Eneev.

[101] Interview with Eneev.

[102] See *Pravda,* October 4, 1987, p. 3.

mirror finish so that it would withstand possible thermal loads in space which were completely unknown.[103]

Korolev grew increasingly nervous in the weeks before the launch. Hearing of an American scientist who was planning to present a paper at an international conference titled "Satellite Above the Planet," Korolev called the KGB to verify that the Americans were not going to upstage him at the last minute. On October 2, the State Committee approved the launch and Korolev sent a declaration to Moscow for approval. Unwilling to wait, he rolled the R-7 out to the pad and prepared for launch. The declaration was signed well after Korolev initiated the launch sequence. He wasn't about to be thwarted by the leadership at this late stage.[104] At 10:28 PM Moscow time, the R-7 lifted off the launch pad carrying atop it an 80 kg. sphere which would change the world's perception of the balance of power.

After the second orbit Riabikov phoned Khrushchev to report the successful launch. The Soviet Premier was indifferent, if not a little disturbed at being awakened reporting: ""When the satellite was launched, they phoned me that the rocket had taken the right course and that the satellite was already revolving around the Earth. I congratulated the entire group of engineers and technicians on this outstanding achievement and calmly went to bed."[105]

---

[103]*Ibid*; and, Golovanov, *Korolev...*

[104] Golovanov, *Korolev...* p. 538.

[105] *New York Times*, October 9, 1957.

The rest of the world was not so unmoved. Dubbing the new satellite of the Earth "Sputnik" a cacaphony of praise and alarm burst immediately from the world's press corps. In an examination of the propaganda and space, Schaeür observed:

> Remarks included one unidentified Western ambassador who thought that "on October 4 the balance of political power shifted from Washington to Moscow". In France the Sputnik was viewed as a "Rude awakening," and in Italy as a warning to the West. A correspondent fro the British Sunday Express thought that it had thrown the US into "frantic and angry confusion." One French general, formerly with NATO, thought that "if the US did not pool its brains and its resources, it would be "condemned in advance." Japan's leading rocket expert saw the Sputnik as the "most significant scientific success since Newton discovered the law of gravity."[106]

It did not take Khrushchev long to grasp the political significance of this tiny orb floating around the Earth, for reasons he did not entirely understand. He quickly unleashed the opening rounds of what would be almost five years of incessant rocket rattling rhetoric. In response to comments by the Eisenhower administration that this was only a "neat scientific trick" and that it did not demonstrate any real military capability, Khrushchev provided one of his more entertaining comments:

> They now try to take comfort in telling the public that we do not have all types of modern weapons. But if there are any doubts, let us hold contests on a common proving ground and see who really has ballistic missiles and who does not. After all, it is now known for sure that neither the United States nor Britain nor France has the intercontinental ballistic missiles which the Soviet Union has.[107]

---

[106] William H.Schauer, *The Politics of Space: a Comparison of the Soviet and American Space Programs,* (New York: Holmes and Meier, 1976)

[107] *Current Digenst of the Soviet Press,* Vol. IX No. 43 p-18

Khrushchev had a new policy tool in his ideological competition with the West. In addition to demonstrating the military capacity of the Soviet state, the space program also advertised the scientific superiority of the socialist system:

> The favorite idea of the imperialists, of which they tried to convince themselves and others, was that the socialist system was not conducive to the development of science and culture, that it stifled man's efforts. They spread other fantastic fabrications as well and became so proficient in this that they came to believe those fabrications themselves...`
>
> But this bourgeoisie fabrication, too, came to a sorry end. The Soviet Union launched an intercontinental ballistic missile, the testing of which yielded positive results. We can now send a missile to any point on the globe, carrying, if necessary, a hydrogen warhead. Our announcement to this effect was greeted with disbelief and regarded as an attempt by the Soviet leaders to instill confidence in their own people and intimidate the Western governments. But then the Soviet Union, using the intercontinental ballistic missile, launched an artificial earth satellite, and when it stated circling the globe and when everyone--unless he was blind--could see by looking up into the sky, our opponents became silent, They thought at first they would get off with a slight shock. One American general even said that the launching of a satellite did nor require much brain and that anyone could take a piece of metal and throw it into the sky. Well, why don't you do it if you are so clever and strong?[108]

Organizational Flexibility

Korolev built a coalition of scientists and designers and capitalized on the emergence of a policy window to get approval to launch a satellite. But he knew that if there was going to be a second satellite, he would have to get the first into space before the Americans did. The new organizational arrangement between the Academy of Sciences and the Council of Chief designers was not up to this task. The Academy

[108] Dodd L. Harvey, and Linda C.Ciccoritti, , *U.S.-Soviet Cooperation in Space.* (Miami: University of Miami, 1974) p. 47

scientists quickly fell behind schedule and Keldysh could not get them up to speed soon enough for Korolev. Korolev, determined to take matters into his own hands, brought the project back into his own organizational fold, completely changing the design in the process. Pushing a new agenda through the leadership. This flexibility was absolutely essential to beating the Americans into space. As it was, Korolev beat them by 8 months, but the original "Object D" was not launched until after the first American satellite.

Building a program out of a project

With the launch of Sputnik, Korolev brought the nascent Soviet space program to a point where it could provide useful policy tools for the political leadership. In the decision authorizing the launch of the PS, Korolev also received approval to launch the original "Object D" satellite. Beyond this, however, he had no space program, just two individual projects. The original proposal for a satellite launch in 1954 was a long-term program including discussions of manned space flights, lunar flights, photoreconnaissance missions, and other economic support missions.[109] But this proposal was apparently buried by the Soviet administrative structure. As had Stalin with the missile program, the Khrushchevian leadership maintained an incremental approval strategy. For the year following the launch of Sputnik, Korolev's primary objective was to establish an autonomous space program. He wanted one time approval for a series of space projects.

[109] See Korolev and Tikhonravov, "Dokladnaia zapiska..."

This process may have moved faster than Korolev preferred. Immediately following the launch of Sputnik, Korolev, Mishin, and several other of his deputies vacationed at the Black Sea Dacha of Presidium member Nikolai Bulganin. After spending the entire summer in the brutal heat of the Kazaki desert, the vacation was richly deserved. It did not last for long, however. Shortly after arrival, Korolev was summoned to Moscow for a meeting with Khrushchev. The Soviet leader remarked to Korolev:

> When you wrote us about the satellite, we did not believe you. We thought this was a boastful fantasy of Korolev's... But now it is another thing... Soon we will have the anniversary of October [The Soviet revolution] Sergei Pavlovich [Korolev] 40 years of Soviet power. Some sort of celebration is desired.
>
> Anastas Mikoian, another Presidium member interjected, "For example a satellite which transmitted the 'International [the theme song for the Communist Party].'"
>
> "What is with you and your 'International'?" chided Khrushchev, "It is your organ grinder!"
>
> "Perhaps launching a satellite with a live animal, a dog?" Korolev proposed with an expression on his face as if he just thought of the idea.
>
> "A dog?" Khrushchev excitedly responded. "Well, splendid! What do you think Anastas, a dog in space? This is good enough! Let's do the dog! But before the celebration! Agreed, Sergei Pavlovich? Ask whatever you want, but before the celebration, agreed?
>
> "We will do our best Nikita Sergeevich [Khrushchev]" smiled Korolev.[110]

Korolev was playing for high stakes. There was less than one month until the November 7 anniversary.[111] A new, far more complex satellite would have to be designed

[110] See Golovanov, *Korolev...* p. 544.

[111] Before the revolution, Russia went by the Grigorian calendar, by which the Revolution took place in late October. When they shifted to the Roman calendar, the date of the revolution move to November 7, but it was still called the Great October Socialist Revolution.

and constructed. But Korolev had been launching dogs on ballistic flights for several years, and a considerable amount of work was already completed on a satellite with a dog on board as part of the "Object D" project. Korolev wanted to put dogs into orbit as a means of testing the ability of humans to survive the thermal regimes and solar rays of outer space. Not only would this launch serve Khrushchev's propaganda, but it would also serve Korolev's dreams of space flight.

Notwithstanding the fact that Korolev himself proposed the launch, Khrushchev adopted this as his personal program. He insisted on maintaining a close watch. The following day his second in command, Frol Kozlov, notified Riabikov that there would be daily reports on the progress of the satellite construction. Riabikov, in turn would communicate with Korolev. This set up a chain of blame, rather than a chain of command. If Korolev failed, Kozlov could blame Riabikov, who in turn could blame Korolev.[112] In the typical Soviet top down program, the more administrators implicated, the better the chances for at least avoiding personal blame in the event of failure.

Returning to OKB-1 with his new task, Korolev again used his leadership qualities and organizational consensus established over the past 15 years to bring forth a heroic effort from his staff. Boris Chertok recalled:

> The equipment we had was, by today's standards, comparatively simple. But our enthusiasm was colossal. We all worked without being urged on. We wanted to be sure of launching the second satellite before the 40th anniversary of the October revolution. This was difficult. Here is a typical detail from that time. Korolev went to the leading satellite designer M.S. Khomiakov, and said "Are you going home?"

---

[112] See Golovanov, *Korolev...* pp.. 548-549.

"Yes"

"Let's do this. Take my car and go tell your wife that they are sending you on assignment, and then come back and work at the shop."[113]

For his own part, Korolev rarely left the factory floor during the month of October, functioning as much as a shop engineer as Chief Designer. The entire design team worked on the shop floor along with the technicians assembling the spacecraft. Where drawings did not exist, the engineers would get together with machinists and build parts without designs. Incredibly, the complete satellite was designed and built in less three weeks.

Sputnik 2 was launched on November 3, 1957, four days before the 40th Anniversary of the Great October Socialist Revolution. Khrushchev had his celebration. Korolev was well on the way to establishing his space program. Laika, the unfortunate dog on board the satellite, survived eight days before the thermal regulation system broke down and the cabin overheated.[114]

After a short vacation, Korolev's design bureau returned to the original "Object D" project in January. But this time Korolev decided to take matters into his own hands, assuming personal responsibility for the satellite. The Academy institutes would still provide some experiments, but he would serve as Chief Designer of the satellite. Tikhonravov was designated as Chief Consultant. For design and construction of

---

[113] See *Izvestiia,* October 1, 1987, p. 3

[114]*Ibid*; and, Golovanov, *Korolev...* pp. 544-551.

scientific instruments, Korolev substituted design bureaus from the Council of Chief designers in place of Academy institutes to the extent possible.

From the beginning, "Object D" was plagued with inter-departmental barriers which Korolev had been unable to break down. To combat this, he united all the relevant designers from various bureaus, scientists from the Academy, and technicians from his own facility, under a single roof, proclaiming:

> Let's break with tradition. We will work this way: no one will wait for anybody else. No one will wait on any design or drafts. The project designers, the other designers, the industrial workers, the engineer, the developers of the scientific gear will be moved to the shops, and everyone will work together. Let the project designers lay out their ideas in the presence of the shop foremen and the workers; let the other designers make their sketches here, too; and let the engineers and workers make their corrections immediately--and we are in business.[115]

This informal arrangement accomplished in two months what the previous structure was unable to do in two years. They built not only one, but two satellites, featuring impressive arrays of scientific equipment. The first spun out of control at launch and was destroyed on April 28th. The second was successfully orbited on May 15, 1958.

Sputnik III, as it was dubbed in the international press, weighed 1,347 kg. Instruments on board recorded solar and cosmic radiation, electric field, geomagnetic field, ion density and composition, and structural properties. Telemetry far more sophisticated that that on board the first two satellites was used to transmit data back to Earth. The satellite also used solar batteries for the first time. Thus, they were able to maintain radio contact for almost two years until its orbit decayed into the upper layers of

---

[115] See *Izvestiia,* October 1, 1987, p. 3

the atmosphere.[116] Keldysh, Nesmeianov and the rest of the Academy had what they wanted, a real research satellite; Korolev had what he wanted, a real space program; and Khrushchev had what he wanted, a propaganda tool to bludgeon the West.

With the launch of the third satellite, Khrushchev began to utilize Korolev's success with more focus than simply demonstrating the superiority of the socialists system. It was no accident that Khrushchev held a reception for Egyptian leader Gamel Nassar on the same day as Sputnik 3 was launched. He took advantage of this opportunity to court the Soviet Union's most important third world client state.

> The economy, science, and technology of our country are steadily advancing. Recently the whole world hailed the launching of two Soviet artificial earth satellites, and today a third Soviet sputnik has been launched into space and has entered its orbit. The weight of this sputnik is 1,327 kg., including scientific equipment weighing 968 kg.... If we take the weight of our third Sputnik and, as is done in arithmetic, divide it by the weight of an American satellite, one would need a very large basket to accommodate a sufficient number of orange-sized American artificial satellites to equal the weight of the third Sputnik.[117]

Khrushchev also used the space program as a means of pressuring for American concessions on security issues. In particular, he attempted to use it as a lever to pry American military bases off Western Europe. On March 15, 1958 the Soviet Union submitted a proposal to the UN which made the connection between the non-militarization of space with the dismantling of forward based systems, entitled appropriately, "Question of Banning the Use of Cosmic Space for Military Purposes, the Elimination of Foreign

---

[116] See George E. Wukelic (ed.) *Handbook of Soviet Space-Science Research*, (New York: Gordon and Breach Science Publishers, 1968) p. 30. See also Golovanov, *Korolev...* p. 552.

[117] See Nikita Khrushchev, *For Victory in Peaceful Competition with Capitialism*, (New York, Dutton & Co. 1960) pp. 381-2

Military Bases on the Territories of Other Countries, and International Cooperation in the Study of Cosmic Space." In an open letter, Khrushchev rationalized the connection,

> We agree to discuss the control of cosmic space, which is in fact the question of intercontinental ballistic rockets. But it must be examined as part of the general disarmament problem, including the question of prohibiting nuclear weapons and the US military bases surrounding the Soviet Union. We are told that here the Soviet Union is again "presenting conditions," is again tying one disarmament question to another. Yes, we are tying them together in the same way that they are tied together in real life; for if we did otherwise, instead of an end to the arms drive, this drive could develop speeds such as the world has never known. There could be only one result: the moment would come, when, at the behest of imperialist circles, a holocaust would burst upon the world--and then it would be too late to discuss whether or not one disarmament problem is related to another.[118]

By the middle of 1958, Khrushchev was totally dependent upon Korolev for a major plank in his foreign policy platform. Khrushchev's son remarked that his father was enamored with Korolev, "he was ready to ceaselessly talk about him."[119] Korolev was irreplaceable.[120] He now had the power base to take his long term program for space development directly to the political leadership for a one time commitment to the complete program.

While he was building a coalition on the political and scientific fronts, his constituencies on the military and industrial fronts were falling apart at the top. Ustinov grew increasingly frustrated with Korolev's preoccupation with space.[121] He would only support Korolev's cosmic ambitions as long as they did not interfere with the more

---

[118] See Harvey, and Ciccoritti, , *U.S.-Soviet Cooperation in Space...* pp. 21-22.

[119] See Sergei Khrushchev, *Khrushchev: Raketi i Krizicy,* (Moscow: Novosti, 1994) p. 112.

[120] For a description and a discussion of irreplaceabiity see Pfeffer, *Power in Organizations...*

[121] See Interview with Mishin; see also Golovanov, *Korolev...* p.557.

important business of building missiles.[122] More to the point, Korolev had developed the habit of going directly to Khrushchev for project approval, and this infuriated Ustinov.[123] Ustinov turned to the more reliable designer Mikhail Iangel whenever possible.[124] For all his outward indifference toward space, Ustinov believed that it was a worthwhile venture. In early 1957, he ordered Iangel to begin preparations for a competing space launch using the R-12 intermediate range missile as a booster. The project was not completed until 1962.[125] There was also dissatisfaction with Korolev's program at the top layers of the military. Few Marshals saw any utility in space. They had only recently come grudgingly around to the utility of long range missiles.[126]

On the other hand, Korolev had made considerable progress building a military constituency from the bottom-up. There were increasing numbers of Generals, Colonels, and lower ranking officers who were strong adherents to Korolev's space program. Many of these officers worked with Korolev in Germany.[127] They went on to work either at the test range at Tiuratam or at the military research institute NII-4. Among the key figures tracing their ties to Korolev back to Germany were Generals Kerimov, Tiulin, Karas, and Smirnitskii. Kerimov remarked that

---

[122] Interview with Piskaraev.

[123] Interview with Mishin.

[124] For a discussion of the relationship between Korolev and Iangel, see chapter 5.

[125] Interviews with Mishin, and Budnik; see also V. Pappo-Korystin (et. al.) *Dneprovskii Raketno-kosmicheskii Tsentr,* (Dnepropetrovsk, Ukraine: POIu.Z., KBIuZ, 1994) p. 60.

[126] For a discussion of the military acceptance of missiles see Chapters 3, 4, and 5.

[127] See Chapter 3 for a discussion of the junior officers who went on to become key members of the space team.

> the ideology of the space forces was quite different from that of the missile men. We were concerned with far reaching research and development. The missile men were primarily concerned with fielding today's missiles. There was some hostility and a separation developed between us, leading to the creation of a separate military group... We were all strong supporters of Korolev.[128]

As he had done with the rocket troops, Korolev was building his military constituency from the ground up, fighting against resistance at the top.

In April 1957, even before the launch of Sputnik, Tikhonravov developed preliminary plans for lunar exploration concluding that an additional stage would have to be added to the R-7 to complete the mission as well as a host of other missions. Korolev initiated design of the new third stage in summer 1957. Glushko was designated as the primary designer for the engine, but technical differences between he and Korolev were growing intense, and Korolev had his own team design a competing engine. Glushko balked at Korolev's insistence on using liquid oxygen (LOX) and kerosene, preferring to use new fuel components including hydrazine. Ultimately, Glushko backed out of the project and, in late 1957, Korolev went to S.A. Kosberg's OKB-154 in Voronezh to finish the design and produce prototypes.

By late 1957, the United States was hinting that it would surpass the Soviet Sputniks by launching a flight to the Moon. On March 27, Defense Secretary McElroy made the official announcement that a U.S. lunar program would be initiated out of the DoD Advanced Research Projects Agency (ARPA).[129] As soon as he learned of the

---

[128] Interview with Kerimov.

[129] Robert Reeves, *The Superpower Space Race: An Explosive Rivalry Through the Solar System,* (New York: Plenum Press, 1994) p. 21.

American plans in December 1957, Korolev went to Khrushchev for approval of a series of lunar flights including an initial crash landing on the Moon in August or September, followed by a spacecraft which would execute an orbit around the Moon, taking photographs of the far side in October or November.[130]

By September, Korolev was ready to launch, but the new booster was not. The first three attempts never reached Earth orbit. The failed launches were, of course, never announced. On January 2, a Soviet probe appropriately named "Mechta" or "dream" was successfully launched toward the Moon, but missed and went into orbit around the Sun. On September 12 of the following year, Korolev launched Luna 2 which did reach the Moon, crash landing on the 15th and leaving several communist inspired plaques on the Moon as the first interplanetary demonstration of the superiority of socialist technology. Less than a month later, Luna 3 was launched into an orbit around the Earth and Moon. Incredibly, this craft contained video equipment capable of photographing the far side of the Moon, which is not visible from the Earth, and transmitting man's first glimpses of this side of the Moon back to Earth. While the quality of the pictures was poor, the impression which they made on world opinion was profound.[131]

In mid 1958, Korolev and Tikhonravov developed a ***program*** for space exploration over the next seven years (1958-1965). The document, titled "Preliminary Conceptions for Future Work on the Conquest Of Outer Space," was remarkable for both

---

[130] See Timothy Varfolomeyev, "Soviet Rockets that Conquered Space: Part 2 Space Rockets for Lunar Probes, *Space flight,* Vol 38, (February 1996) pp. 49-52.

[131] See Reeves, *The Superpower Space Race...* pp. 21-49.

its comprehensives and concision. Conforming to the official Kremlin format for proposals (five pages or less), Korolev's program included an impressive range of individual projects. There was something in his program for virtually every constituency in the Soviet government. At the top of the list was his most problematic customer -- the military. The first proposed category of systems addressed their interests specifically:

> 1. Creation of artificial satellites for research of outer space in the region of the Earth:
>
> a) creation of a stabilized Earth satellite... This satellite will be equipped with a specialized cassette, in which information or photographic film could be returned to the Earth (1958--1960);
>
> b) creation of an Earth satellite with an unlimited duration of operation (1961--1965);
>
> c) creation of an Earth satellite in high elliptical orbits, launched by rockets with third stages into a transfer orbit[132](1961--1965).

The military oriented satellites were only the first items in a far reaching comprehensive plan for the further development of space. The second section of his program provided fodder for his political and scientific constituents:

> 2. a lunar research program including a lunar orbiter and a satellite cycling between the Earth and moon (1958-1964);
>
> 3. a manned spacecraft launched on a ballistic trajectory (1958-1960);
>
> 4. a manned satellite orbiting the Earth and returning on a gliding trajectory (1959-1965);

---

[132] This was the Molniia orbit used for the vast majority of early Soviet communications and early warning satellites.

5. research on sending photographic spacecraft to Mars and Venus (1959--1960);

6. and, systems for rendezvous and docking of two spacecraft in orbit (1962--1966)

Korolev also proposed development of a new launch vehicle capable of putting 15-20 tons into low Earth orbit, and manned lunar flights to be completed in the 1963-1964 time frame. This was the only part of the program which was non-incremental, requireing substantial new outlays of resources. His longer term proposals attached to the use of this booster included:

1. a 2-3 man spacecraft for long term flights (1961-1965);

2. development of spacecraft with ion propulsion systems for manned lunar flights (1961-1965);

3. and, development of unmanned spacecraft which could be sent to orbit Mars or Venus and then returned to Earth (1963-1966).[133]

For the next year, Korolev informally circulated this document among the Council of Chief Designers, the Academy of Sciences, the State Committee for Defense Technology (GKOT),[134] the Military Industrial Commission (VPK), and the Central Committee, gaining strong support from the scientific community and meeting with little opposition from the administrative agencies.[135] On December 10, 1959 the program was

---

[133] See S.P. Korolev and M.K. Tikhonravov, "predvaritel'nye soobrazheniia o perspektivnykh rabotakh po osvoeniiu kosmicheskogo prostranstva" (Preliminatry conceptions of promising work regarding the exploration of outer space) in *Materialy po Istorii...*, p. 16.

[134] In 1957 GKOT replaced the Ministry of Armaments as part of the Sovnarkhoz reforms.

[135] Interviews with Stroganov, and Vetrov.

approved in full by the Presidium.[136] After a long, difficult, bureaucratic journey, ***Korolev finally had his space program.***

Developing and Strengthening A Broad Base of Constituencies Through Irreplaceability

With the success of Sputnik, Korolev developed a constituency in the Soviet political leadership. Khrushchev found that space launches served as a perfect club for politically bludgeoning the West.[137] Korolev knew that by feeding the Soviet leader a steady stream of "space firsts" he could maintain support for his program at the highest levels. Moreover, this could be done at a low marginal cost. Korolev used the same booster he was preparing for manned flights to launch a small orb filled with various Communist memorabilia to crash land on the Moon in 1958. He tested the orientation system and cameras to be used on photoreconnaissance satellites on Luna 3, which was the first spacecraft to take pictures of the far side of the Moon. But Korolev understood that Khrushchev would ultimately tire of trumpeting the latest Soviet space firsts. He also knew that reliance upon any single political figure was precarious in the post-Stalin Soviet Union. He needed to develop a broader base of constituents.

Korolev looked first to the military. Beyond the CPSU leadership, it was the most powerful institution in Soviet politics. While he had built a strong core of officers dedicated to space, many of whom were becoming Generals, he had little support for his

---

[136] See *Materialy po Istorii...*, p. 210.

[137] For a more in depth discussion of Khrushchev and space propaganda see Schauer, *The Politics of Space...*

space program at the upper levels of the military. By offering them the prospect of satellites capable of photographing the enemy with impunity, and satellites capable of transmitting radio communications around the globe in an instant, Korolev hoped to build a base of support within the military leadership. As was the case with missiles, the military leadership was slow to grasp the significance of these developments. so Korolev built his constituency from the ground up

The Soviet Academy of Sciences was Korolev's most reliable but least powerful constituency. Keldysh had long since overcome the insult of the postponement of Object-D, and Korolev's program offered a broad range of scientific missions ranging from exploration of other planets to research on living organisms in space. Beginning in the early 1960s, institutes in the Academy dedicated their research agendas to space research.[138] This put them solidly behind Korolev. However, the Academy of Sciences jealously guarded its independence, often sacrificing larger budgets in the process.[139] As the space age dawned, it was involved in yet another dispute with the government over the relevance of its research. The Academy needed Korolev's program for political as well as scientific support.

Korolev had something to offer all these constituents. Moreover, OKB-1 was the ***only*** organization capable of offering these policy options. It was ***irreplaceable***.[140] Korolev experienced first hand the importance of irreplaceability during the course of the

---

[138] Among these were the Institute for Space Research, the Institute for Biomedical Problems; and the Vernadskii Institute of Geochemistry.

[139] See Parrott, *Politics and Technology...*

[140] On irreplacability see Pfeffer, *Power in Organizations...*

missile program. His relationship with Ustinov and Nedelin changed considerably after Iangel began developing competing missile systems. By shifting the emphasis of his firm to space travel, Korolev was once again becoming the sole provider of a policy option.

Circumvention of Administration

While Korolev strenghtened his power base by building strong constituencies within the administrative agencies, he did not need to curry their faovr in order to get programmatic approval. After Sputnik, he could could go directly to the leadership. He could offer his constituents something for nothing. Since he was not seeking funding from these agencies, Korolev could protect his program from their intrusion. All he asked for was their political support. This enabled Korolev to develop powerful base of constituencies.

Comrades or Cameras in space?

In addition to producing a comprehensive long range plan for space exploration, Korolev and Tikhonravov initiated a more detailed study of projects for manned space flight and photo-reconnaissance satellites beginning in 1956. The basic issue to be decided was whether the next project for the design bureau would be a photo-reconnaissance satellite or a manned space flight. Korolev had to decide whether the basic purpose of his program was to be practical or political. As was the case with the PS project, Korolev chose politics over practicality. In so doing, he revealed a great deal about the institutionalization of the space program.

In 1954, the United States began exploratory research on satellite reconnaissance, and issued a formal contract to Lockheed in October 1956.[141] Aware of the American program, in 1956, Korolev initiated a study of photoreconnaissance satellites under the direction of Iuri Frumkin. The study was completed by 1958, yielding a satellite configuration which featured several conical film return canister housed in a satellite containing the cameras, signals interception equipment, guidance equipment and thrusters. It was to be a satellite dedicated to intelligence missions.[142] In 1958, Korolev closed the project and combined it with ongoing research on manned space flight.

At the beginning of 1958, Konstantin Feoktistov, who transferred from NII-4 a year earlier, began detailed design work on a project identified as Object-D2 (OD-2). This project explored three basic systems: 1) an unmanned photoreconnaissance satellite; 2) a manned spacecraft launched in a ballistic trajectory; and, 3) a manned orbiting spacecraft.[143] Feoktistov's research supported Korolev's contention that all three missions could use the same vehicle, replacing cosmonauts with cameras for reconnaissance missions. Feoktistov's recommendations were to begin with a ballistic manned flight and

---

[141] For a discussion of the American photoreconniassance program see Paul Stares, *The Militarization of Space: U.S. Policy, 1945-1984,* (Ithaca: Cornell University Press, 1985).

[142] Interviews with Feoktistov and Kerimov. See also *Aviatsiia i Kosmonavtika,* No. 3 (March 1993) pp. 41-42.

[143] The majority of this report is published as "Otchet OKB-1: Materialy predvaritel'noi prorabotki voprosa o sozdanii sputnika Zemli s chelovekom na bortu," (Report of OKB-1: Materials on preliminary development of issues regarding creation of an Earth satellite with a man on board,) in *Materialy po Istorii..* pp. 20-118.

then move to either photo-reconnaissance satellites or manned orbital missions. The decision on priorities was left to Korolev.[144]

Feoktistov finished the draft report in July 1958, and Korolev distributed it among other department heads for comment in August and September. The report passed through "practically without changing a line."[145] In late September, Korolev distributed the report on to the other members of the Council of Chief Designers, which met in November to discuss it. At this meeting Korolev argued that they should forego manned ballistic flights and move directly to orbital missions. Photo-reconnaissance satellites should be put off until a later date. With the exception of Riazanskii, who argued for photo-reconnaissance satellites, the members went along with Korolev's proposal.[146] Korolev's motivations were clear; he wanted to be first in space. He knew the Americans were preparing for a manned ballistic launch, but he wanted to go a step further. By completing an orbital flight, he would beat the Americans by years rathér than days or months. This would be a real victory!

Armed with the approval of the Council of Chief Designers, Korolev and Keldysh took their proposal for a manned orbiting spacecraft to the leadership in late 1958. Ustinov, who had been promoted to Deputy Chairman of the Council of Ministers, and Chairman of the Military Industrial Commission supported the proposal, and it quickly passed through the Central Committee for approval.[147] Having already informally

---

[144] Interview with Feoktistov.

[145] *Ibid.*

[146] Interviews with Feoktistov and Vetrov. See also Golovanov, *Korolev...* p. 599.

[147] Interview with Piskaraev.

approved Korolev's long-term program, the leadership did not give his proposal more than a perfunctory examination, and it was approved without dissent.[148] Final approval for the launch of Vostok-1 carrying the first man into space was put before the Soviet leadership on September 10, 1960 and approval was issued on October 11.[149]

In May 1959, Korolev proposed that all space related projects be managed out of a series of new international institutes which would be created within the Academy of Sciences. The central institute would be the Institute of Interplanetary Research under Korolev's direction. There would be four additional institutes for: inertial guidance; long-distance radio communications; radio telemetry; and, electrical power. A single prototype production facility would be developed for all these institutes.[150] The proposal was formally rejected, but important changes did occur. The Academy of Sciences was assigned as the official customer for manned space and all other non-military missions.[151] This installed Keldysh, one of Korolev's closest associates, as both the ádministrator and customer for his programs. The two were dependent upon one another for their power bases. But it was not an equal dependence. Korolev had other potential customers while Keldysh had no other designer who could provide him with a space program.

Korolev was also working to bring the military into the manned space program. He needed cosmonauts to fly in his spacecraft, and jet fighter pilots were the obvious

---

148 Interview with Stroganov.

149 See *Izvestiia KPSS* Vol. 1. No. 5 (May 1991).

150 See Golovanov, *Korolev...* p. 585.

151 Interviews with Vetrov, Akim.

choice because of their familiarity with high gravitational forces and other conditions likely to occur during the course of a space flight. At the same time, the Soviet Air Forces were suffering dramatic cutbacks as a result of Khrushchev's "revolution in Military Affairs" which stressed the development of missiles and a de-emphasis on all other forms of combat. The Commander in Chief of the Air Forces General Vershinin was anxious to participate in Korolev's program, and together they created a cosmonaut training center under the direction of Air Force General Kamanin. A symbiotic relationship quickly developed between the Air Force leadership and Korolev.[152] Ironically, the service which had been the strongest critic of the missile program was now among the strongest supporters of the space program.

There were no clearly established customers for space hardware within the rest of the military, however. Consequently, Korolev did not meet a great deal of resistance when he delayed the development of the reconnaissance satellite in favor of manned space. Military intelligence in the General Staff (the GRU) was primarily interested in tactical intelligence. In 1958 it was only beginning to understand the importance of intelligence information on U.S. strategic deployments. The vast majority of intelligence gathering on the United States was performed by the KGB, which relied upon a well established network of spies and informants. Neither intelligence agency possessed a culture which was compatible with photoreconnaissance technology.

---

[152] See Golovanov, *Korolev...* pp. 601-602.

Nevertheless, there "was some interest from the lower levels of the military in the possibility of photoreconnaissance satellites."[153] There was a group of officers working in NII-4 on issues related to space under the direction of Col. Kerim Kerimov. Korolev was satisfied to maintain, but not promote, their interest, since it might divert resources away from his manned space effort. He informed the military "that problems with guidance and orientation prevented them from developing a photoreconnaissance satellite. But these problems would be worked out in the course of the manned space effort."[154] Korolev was being disingenuous. While the high pointing accuracy required for reconnaissance satellites was difficult, they had already solved the problem in principle with Frumkin's earlier research and demonstrated this with Luna 3 which was launched in 1959. When asked why they did not push for a reconnaissance satellite, Kerimov responded simply "Korolev said that it was better to attempt manned flights first. We could not question his word."[155]

Ultimately, Korolev did build a photo-reconnaissance satellite based on the Vostok. It took less than a year to launch the first test of this vehicle once development began in earnest following the first manned space flight. But the vehicle which emerged was far less effective than that originally designed by Frumkin. After exposing a role of film (1500) exposures, the entire craft had to be returned to Earth only a week after launch. Frumkin's original version ejected several film capsules during the course of a

---

[153] Interview with Kerimov.

[154] *Ibid.*

[155] *Ibid.* The general tone of the early relationship between the military and Korolev was confirmed by his deputy, Vasiliy Mishin. Interview with Mishin.

mission which could last several weeks if not months.[156] The Soviets did not return to Frumkin's basic design using film return canisters for fifteen years.

Design and construction work on the first manned space craft --Vostok -- proceeded through 1959. In 1960, a series of spacecraft were orbited under the moniker of *Korabl' Sputnik* (or Satellite Ship). The second of these safely returned two dogs, Belka and Strelka, to Earth. The third came in at too sharp an angle and burned-up in the atmosphere. Two more test flights failed in February 1960, followed by two successes in March. In his report to the leadership, Korolev asserted that only the final two spacecraft represented the "construction intended for manned flight."[157] The leadership accepted Korolev's claim, and approved the launch on April 3. On April 12, 1961 Iuri Gagarin was launched on a single orbit mission around the Earth. The gap between the Soviet Union and the United States had widened considerably since the launch of Sputnik two and a half years earlier. It would take a substantial share of the technical strength of the United States over the next eight years to bridge this gap.

Konstantin Tsiolkovskii liked to tell his students: "The Earth is the cradle of reason, but man cannot stay in the cradle forever..." Man had left the cradle, propelled not by communist power, but by Korolev's vision.

---

[156] See *Aviatsiia i Kosmonavtika,* No3. (March 1993), pp. 41-42.

[157] See *Izvestiia KPSS,* Vol. I. No. 5 (May 1991) p. 104.

Information Control and Agenda Manipulation

Korolev put Gagarin into space by manipulating his research agenda, much as he did in launching the first satellite. As before, he chose politics over practicality. But in this case, his manipulations of information were even more egregious. He had completed preliminary designs for a reconnaissance satellite, but he chose to abandon those plans and go ahead with a manned space flight. The reconnaissance satellite he eventually built was far less effective than the one originally designed. He was able to do this because his expertise in space technology was unquestioned. Korolev beat the Americans into space by almost two years.

CONCLUSIONS

During the six years from 1954 to 1960, Sergei Korolev built a space empire. His early success changed the perceived global balance of power. Yet what may be most remarkable about this program is not so much that he did it without the active support of the leadership, but that he did it without large additional capital expenditures. He used the existing booster, adding only a small upper stage and whatever satellite or spacecraft was needed for a particular mission. He created a space program while still designing and producing ICBMs. From the leadership's perspective, there was very little opportunity cost associated with the program. This, of course, was no accident. Years before, Korolev carefully manipulated the ICBM program in order to build a missile which would be capable of launching a man into space with little modification. It was his intention all along to use the missile program as a bureaucratic foundation for a space program. In this respect alone, it was one of the great bureaucratic success stories of the 20th century.

Figure 6.2 depicts the progress of the Soviet space program from the mid fifties. What is immediately apparent is the absence of participation at the level of administrative agencies. With the exception of passing the first proposals through to the leadership, they played no role. The figure also provides a representation of the research done by Tikhonravov and Korolev in advance of any decision to initiate the space program. Both factors were decisive in the successful development of the Soviet space program.

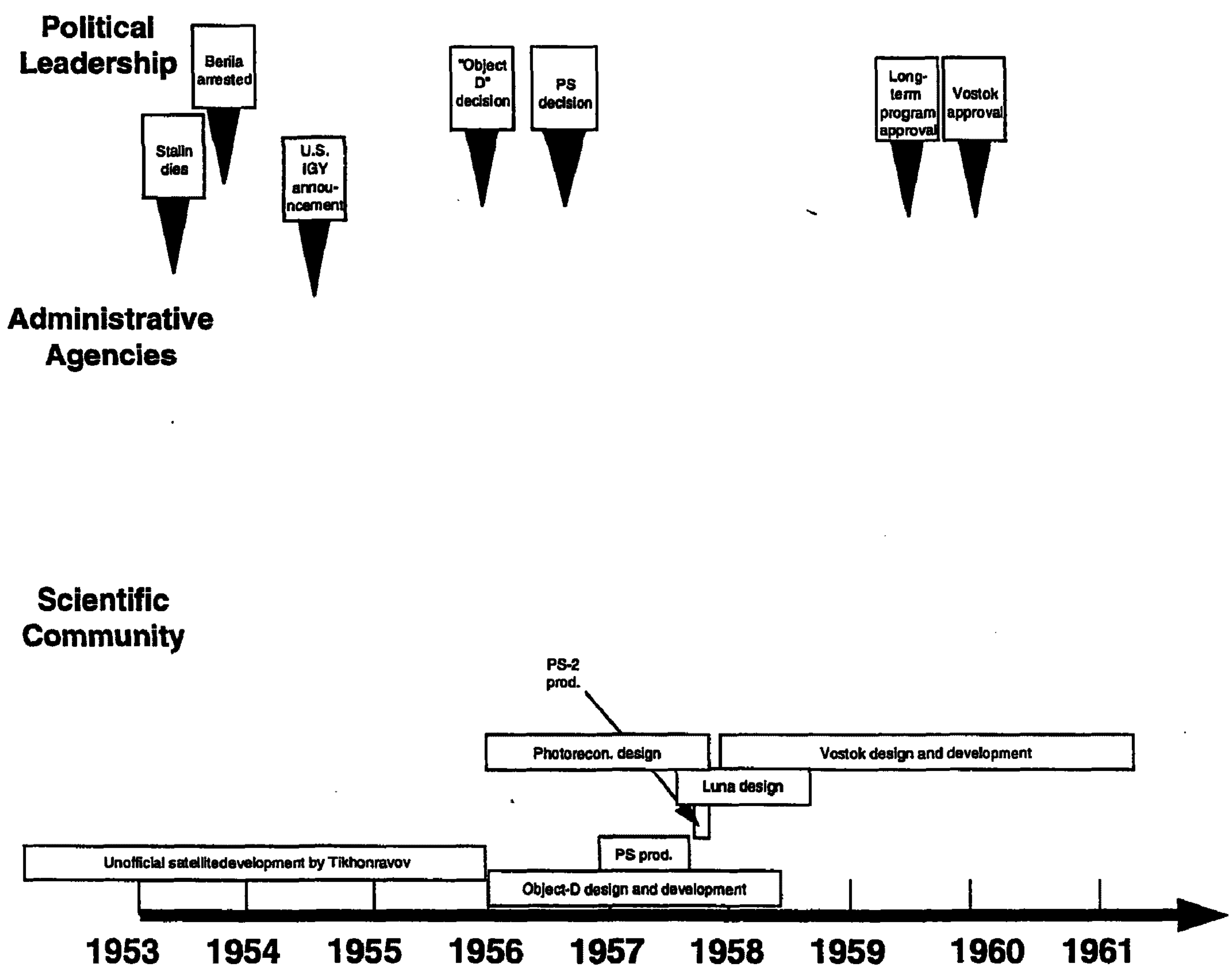

Figure 6.2 -- Major Events in theCreation of the Soviet Space Program

Observation of scientific autonomy

This chapter covered the creation of the Soviet space program, including all three phases of programmatic innovation: 1) conceptualization and program initiation; 2) organizational emergence; and, 3) institutionalization of the program. At each of the stages, scientific autonomy can be observed to a far greater extent than was the case with the missile program. Prior to initiation, and even with initiation, there are few indications that either the leadership or the administrators had any cognizance of the value and basic mission of a space program, let alone the technology. As the program emerged, it developed a very different organizational structure than the missile program. Administrative agencies were circumvented; Korolev dealt directly with the Soviet leadership to gain approval for individual projects, and ultimately a long-term program. The early years of the program, through 1961, were characterized by other technological deviations, providing the clearest observation of scientific autonomy. In the institutional phase, the program itself turned out to be a technological deviation from the original ICBM.

Conceptualization and program initiation

The original idea for a satellite was generated by Korolev and Tikhonravov within the scientific community. There was a lengthy process of convincing the leadership and administrative agencies of the political value of beating the Americans into space before the leadership finally agreed to allow the launch. Thus, we observed that it was ***technological possibilities*** rather than ***mission*** which led to the initial conception.

Korolev gained autonomy from the low ***leadership decision-making capacity*** of the Khrushchev leadership. The time during which he pushed for approval of the initial satellites was characterized by high level of internal conflict between Khrushchev and Malenkov. Garbage can theory suggests that under these conditions, relatively small to medium scale decisions are most likely to be addressed. Since Korolev's early missions required little additional expenditures, once they reached the leadership level, they easily passed through.

The ***review and funding schedule*** for the initial projects -- the Sputniks and the Lunas was moderately incremental. Korolev received approval for two to three projects at a time. This was a significant improvement from the missile program, where he had to go to the leadership for approval of each new modification and test series. After his initial success, Korolev won long-term programmatic approval. This was a clear indicator of scientific autonomy.

Organizational emergence

At the scientific level, the ***organizational structure*** that emerged for the space program was centered upon the Council of Chief Designers, which hadexisted for the preceding decade. The only significant change was the increased role played by institutes of the Academy of Sciences. For a short time in 1955, these institutes assumed a leading role in design and production of satellites. The most important difference between the two programs was that there were virtually no administrative agencies governing the space program. Korolev and Keldysh managed the program without interference from ministries, planning agencies, or party organizations, dealing directly with the leadership when they needed approval for the next stage of the program.

From the beginning, the ***scientists -- end user*** relationship between Korolev and the Academy of Sciences was mutually supportive. Ultimately, the Academy became the official customer for Korolev's most important program -- the manned space effort. For the Academy, Korolev was an irreplaceable source of political power. Korolev, on the other hand, found the Academy to be the most accommodating constituency, but he had other political and military constituents to turn to in the event of strained relations with the Academy.

Through the early years of the Soviet space program (at least through 1961), Korolev had a monopoly over space technology. There were no ***competing scientific organizations*** which could question the validity of his proposals or implementation. Korolev was able to use this monopoly to manipulate the research agenda toward manned spacecraft rather than photo-reconnaissance satellites.

Institutionalization of the program

The early years of the Soviet space program were characterized by ***technological deviations.*** The space program itself was a deviation from the missile program. No sooner would Korolev get leadership approval for an individual project than he would change the project. The original Object-D became the PS. The photoreconnaissance satellite became the manned Vostok. For the latter case it appears as if Korolev made the decision without consulting the leadership. He simply ignored the first project on his approved agenda and went to the second. These were the clearest observations of scientific autonomy and by themselves demonstrate that the scientific community, not the leadership or the administrative agencies, ran the Soviet space program.

Analyses

The creation of the Soviet space program provides one of the great observations of how the scientific community can use its informational advantages to advance a program through a resistant government. There were two essential elements to Korolev's strategy which he learned during the course of the missile program. The first was incrementalism. Korolev built the space program on his prior work. The necessary calculations for the satellite program were performed well in advance of any leadership decision. Korolev did not need to ask it for the time and money to perform the necessary fundamental research. The rocket was already built and tested, and with the *mysterious* failure of the re-entry vehicle, there was nothing else to do with the remaining launch vehicles but to put satellites atop them. It cost nothing to potentially gain some political mileage. Thus Korolev removed scale from the initial leadership calculation. Similarly, Korolev redirected the photo-reconnaissance program in order to build both the manned and photoreconnaissance satellites out of the same basic design. His argument to the leadership (in the event that the had to persuade them), was that there was very little incremental cost to the manned space effort.

Incrementalism can be a dangerous game. Because they must be relied upon for a larger number of smaller decisions, it requires constant maintenance of relationships with constituents. While Korolev was successful, there were many others who have not been able to maintain an incremental program. The American space station program is a good example. For the first several years, the station grew bigger and bigger with each annual planning cycle. Aware of the real costs, the designers were attempting to soft pedal them by increasing the projected cost with each planning iteration. Ultimately, administrative agencies (Congress) understood this, and more recently the budgets have decreased each year incrementally to the point where the existence of the program remains in question.[158] In most cases, scientists have pushed early and hard for a single decision authorizing an entire program. The U.S. atomic bomb program is the best example of this strategy as successfully implemented. But the Strategic Defense Initiative and the original US ICBM programs demonstrate that such a strategy can just as easily yield unsatisfactory results. The Strategic Defense Initiative Organization pushed for early funding of a large-scale space-based system, only to be attacked for advancing impractical goals.

The second basic lesson Korolev learned was the importance of maintaining a monopoly over critical information. He was successful at creating this monopoly in the first years of the missile program, but saw it evaporate with the creation of a competing

---

[158] See McCurdy, *The Space Station Decision...*

design bureau. By going into space, he was again creating a new program in which he held a monopoly over expertise. The only other competing source of expertise lay in the Academy of Sciences which was co-opted by Korolev early in the program. Internal control over information was maintained through the strong sense of organizational consensus established in the preceding ten years of the Council of Chief Designers. While organizational cohesion was damaged by the defection of the engine builder, Valentin Glushko, the focus of the future space program was on development of spacecraft, not boosters. Glushko's participation was unnecessary for satellites.[159]

Informational monopolies have characterized many programmatic innovations. Oppenheimer's control over critical information was enforced by secrecy rather than his sense of control, nevertheless he used it to his advantage in dealing with the leadership and his administrator -- General Leslie Groves.[160] Kelly Johnson used secrecy to protect the autonomy of the Lockheed Skunk Works.[161] Admiral Raborn went to elaborate extents to project positive information of the Polaris missile development while concealing areas where the program was falling behind.[162] The Strategic Defense Initiative, on the other hand, was plagued from the beginning with adverse information from a well-informed scientific community opposed to the program.

---

[159] In the coming years, Korolev would embark on development of a new booster, the N-1 in which Glushko refused to participate. His absense would be sorely missed, as engine failures would plague the program.

[160] See Rhodes, *The Making of the Atomic Bomb...*

[161] See Ben Rich and Leo Janos, *Skunk Works*, (Boston: Little Brown, 1994).

[162] See Sapolsky, *Polaris System Development...*

Finally, Korolev's sense of timing was important. Though he had the necessary proposals in hand, Korolev waited a year before pushing his proposals through a policy window created by a convergence of political streams. This was a sense he developed over the course of the missile project. Such a sense of timing was critical to a variety of military technical innovations in the United States as noted by Evangelista.[163]

---

[163] See Evangelista, *Innovation and the Arms Race...*

CHAPTER 7

The central fault with the current set-up for planning and directing research and development is simply this: the uncertainties of the future cannot be resolved by pretending that they are certainties. Research and development is not a business that can be carefully planned and directed, not if you expect to make progress rapidly and economically.

Burton Klein (1958)

CONCLUSIONS

In the late 1920's, a group of young engineers working in the cramped quarters of a basement workshop on Sadovo Spasskii near the center of Moscow, and driven by the seemingly mad ramblings of a deaf school teacher, embarked on a journey to the stars. What ensued was one of the more remarkable bureaucratic expeditions of the 20th century. Collectivizing themselves under a single organizational roof in the early 1930s, the scientists took the first steps in Konstantin Tsiolkovskii's plan for the colonization of space by developing small liquid fueled rockets and rocket powered gliders. Their path took an abrupt detour in the later 1930s, when a large portion of the emerging rocket team was arrested and sentenced to menial engineering work in the *sharagi*.[1] After the defeat of Nazi Germany, small groups of Soviet rocket scientists made their way into Germany as part of a massive technology collection effort. Gravitating to the remaining shards of the German V-2 program assembled by Boris Chertok; the scientists once again collectivized, forming an organizational structure which operated quite autonomously from the central government in Moscow. In Germany, they assembled enough remnants of the German missiles to reconstruct detailed plans, and proceeded to improve upon the German design. More importantly, they developed the foundation of an organizational structure under the technical direction and personal vision of Sergei Korolev. Korolev quickly emerged as a courageous, charismatic and dedicated leader, whose actions would be crucial to the emergence of the Soviet missile and space programs.

While such autonomy gave the scientists independence to create, it proved a mixed blessing when Korolev went back to Moscow to seek support for his program. None of the administrative agencies were willing to accept responsibility for development of a missile program. They understood neither the technology nor the mission of Korolev's proposed program and feared the uncertainty and the possibility of failure. One by one the Peoples' Commissars rejected Korolev's proposal. Only one, Dmitry Ustinov, the Peoples' Commissar for Armaments, was willing to at least send a representative, Vasiliy

[1] *Sharagi* is a term used by Russians to describe the prison design bureaus created by Stalin to intern engineers who were considered politically unreliable but talented enough to be forced into slave labor designing aircraft, tanks etc.

Riabikov, to Germany to evaluate the captured technology. Ustinov's concession was Korolev's coup. After Riabikov returned, Ustinov reluctantly agreed to manage the program. On May 13, 1946, the Soviet leadership promulgated a decree assigning the new program to Ustinov's ministry, but making no provision for designing, producing or launching any ballistic missiles. The decree was actually directed at developing anti-aircraft missiles. The structure which emerged was therefore organized for development of anti-aircraft missiles -- not ballistic missiles. Korolev's colleagues who built everything from guidance systems to rocket engines were strewn across five different industrial Narkoms, bureaucratically isolated from each other in the highly columnized Soviet industrial structure.

The following year, Korolev gained approval to test the captured V-2s, but was turned down in his request to develop an indigenous version. After launching 18 V-2s, Korolev was granted approval to produce an indigenous version, the R-1, but denied a follow-on. Over the next five years, Korolev would be forced to return to the leadership for incremental approval of each new stage in the development of missiles. It was a tedious process requiring constant maintenance of his base of constituents.

Korolev was keenly aware that missiles were made of more than metal. They were made by people in organizations. During the early years of the program, his attention was directed toward organizational issues to a greater extent than technology. It was a matter of necessity. His colleagues, who designed and produced the subsystems for missiles, were located in five different ministries. To overcome interministerial barriers, Korolev devised the Council of Chief Designers. Though it was an informal organizational arrangement, the Council possessed two important features. First, it permitted the six leading designers to coordinate their activities and freely exchange information. Second, it obtained authority over all technical decisions, effectively preventing ministers from intervening in the design process.

The Council solved many of Korolev's internal problems of autonomy, but he also had to maintain and develop his relationship with his primary constituents in the industrial and military structures. Ustinov, the Minister of Armaments, initially supported Korolev's program because it gave him a foothold in development of a new class of systems, but anti-aircraft missiles were his first priority. Ultimately, Korolev used his success on the test range to convince Ustinov that ballistic missile rather than anti-aircraft systems should be the focus of his ministry. Ustinov transferred the anti-aircraft program to the Ministry of the Radio Industry. Now, he was completely dependent upon Korolev for his own political success, becoming a facilitator rather than an administrator.

Korolev's relations with the military were far more problematic. Marshal Iakovlev, the Commander of the Main Artillery Directorate, was designated as the customer for the new missiles. From his perspective, rockets were little more than a noisy waste of alcohol. He fought introduction of every one of Korolev's missiles. He could not be won over, and Korolev's program progressed largely through the fortuitous intervention of Stalin's secret police who arrested him on unrelated charges.

Ultimately, Korolev needed to produce effective hardware. His first missiles were too short-range to be of utility to the military, but Korolev was fearful that the leadership would not fund the basic research he needed to progress to multi-stage intercontinental missiles (ICBMs). To clear this hurdle, he devised the R-3. The R-3 project was a sham, intended to serve as a cover for the necessary basic research. Korolev claimed to be designing a single-stage missile with a 3,000 km. range. He never intended to produce the missile, but since he maintained absolute control over information, neither Ustinov nor the leadership were cognizant of his deception. Korolev was able to use the R-3 project to develop a solid research base on the intricacies of long-range missiles, allowing his to embark on ICBMs.

Encouraged that the ploy worked, Korolev initiated an even greater deception with the first proposed ICBM. His real intention was space flight; but again, he faced the problem of basic research. This time Korolev sponsored the research in another institute, NII-4, thereby hiding it from the probing eye of Ustinov, who was growing concerned over Korolev's increasing autonomy. When Korolev proposed the first ICBM, he deliberately increased the payload capacity in order to use the same rocket for launching a satellite into space. Stalin's death and the ensuing leadership confusion provided the window of opportunity Korolev needed to get this proposal approved. Neither Ustinov, nor the leadership became aware of this shell game until well after the R-7 project was under way. Nevertheless, the leadership balked at Korolev's first proposals to launch a satellite. It finally agreed after Korolev's repeated entreaties stressing the political significance of beating the Americans into space and the low marginal cost of using an existing booster. Only after the successful launch of Sputnik, did Khrushchev become an active supporter of Korolev's space program, ultimately granting approval of a long-term space development plan. Korolev pursued this plan over the next three years virtually without oversight. He had arrived at his bureaucratic destination -- absolute control over a completely autonomous space program.

EXTENDING THE OBSERVATIONS

This study goes beyond a single case. It is an attempt to develop a broader theory of state sponsored technological innovation. I have argued that the Soviet missile and space programs offered a crucial test of the proposition that scientific autonomy is necessary for programmatic innovation, but a certain amount of work remains if this single case is to be placed within the context of a more general theory. The remainder of this chapter begins this process of empirically based theory building.

The first step is return to the systematic points of observation developed in Chapter 2, to consider the levels of scientific autonomy in this case in terms that are comparable across cases. In the ensuing section the causal connection between scientific autonomy will be considered in two senses. First was scientific autonomy an important contributor to programmatic innovation? Second, the counterfactual question will be considered of whether programmatic innovation could have occurred in this case given an absence of scientific autonomy. Through these two questions, we can gain a better appreciation of the connection between scientific autonomy and programmatic innovation.

For all the rigor with which I have defined the Soviet missile and space programs as crucial case studies, it is still conceivable that they are deviant cases. Therefore, the next section examines three additional cases. The U.S. atomic bomb program is explored as another clear-cut case of scientific autonomy. Yet we will see that autonomy was accomplished with considerably less effort than was exerted by Korolev. The creation of the U.S. ICBM program serves to illustrate what happens to a program which begins under leadership control, but which suddenly obtains scientific autonomy. The contrast was remarkable. A few bureaucratic changes shifted a program which was moribund to one which made rapid scientific progress. Finally, I will examine the creation of the Soviet atomic bomb program as an example of the difference between programmatic innovation and emulation. Through knowledge of the technological details of the U.S. program, the Soviet leadership was able to sharply limit the autonomy of Soviet nuclear scientists, and build the bomb in an extremely short period of time and with less duplication than the United States had earlier. However, once the Soviets surpassed the United States and moved on to thermonuclear weapons, the leadership lost its source of external expertise, and the scientists gained a significant degree of autonomy. Thus, the latter two cases illustrate the mechanism of scientific autonomy at work.

Evangelista's explanation of the relationship between state structure will be considered in the penultimate section as a competing hypothesis. Evangelista considered emulation and innovation to be the same phenomenon, and that the differences between the innovative processes of the United States and the Soviet Union were a result of differing state structures. I argue that Evangelista has fallen prey to the trap of considering too broad a range of innovation as the same phenomenon. His generally accurate portrayal of research and development processes in the two countries are better described in terms of innovation and emulation, rather than state structure.

Finally, the conclusions of this study will be considered in terms of their generalizability and application to public policy. Can the basic conclusion that programmatic innovation requires scientific autonomy be extended to lower level technological innovations? Can it be extended to policy innovations? Can the general conclusion that the leadership ought not try to control large scale innovation be applied to real world policy making situations? These questions will be addressed in the concluding section.

OBSERVATION OF SCIENTIFIC AUTONOMY

Chapter 2 defined scientific autonomy as the ability of the scientific community to exercise control over its own research agenda, and further specified several observation points which pitted the interests of the scientists against those of the leadership. Such observations provided the clearest indicators of scientific autonomy. The preceding chapters considered these indicators individually, and in the overwhelming majority of instances, revealed a high degree of scientific autonomy. These observations were compartmentalized within individual stages of programmatic innovation. This section will consider the relationship of the leadership and the scientific community in more general terms, as it developed over the entire course of the creation of the Soviet missile and space programs.

The battle for autonomy in the Soviet missile and space programs were not fought unilaterally. The leadership took measures to protect its interests. The most effective tool at the its disposal was its ability to control funding and approval schedules. From the beginning, the leadership was willing to grant only the most limited range of approval. Every test launch series, every new prototype missile development, every production run was given formal scrutiny. However, these formal reviews were conducted by non-experts. Consequently, Korolev was able to use his control over information to put the matter before the leadership in the most positive light. Test failures were concealed, expected performance exaggerated, and some proposals were complete fiction. Without expertise, the leadership was unable to use its power over agenda to control the scientists.

The leadership never gave many of their appointed administrators a chance to acquire expertise. Time and again, a new director, commander, or deputy minister, would be appointed, only to be removed and replaced with a less technically qualified administrator for purely political reasons. Such administrators became easy targets for an opportunistic scientist like Korolev. Much of the progress of the program can be traced to administrative turnover. In particular, the dismissals of Gonar as Director of NII-88 in 1950, and Iakovlev as Commander of the Main Artillery Directorate in 1952 provided Korolev with necessary openings.

It was only toward the latter stages of the institutionalization of the missile program that the leadership realized the power of competition. By creating a competing scientific center, the leadership was able to redress its informational disadvantage and shift the direction of the missile program toward a technology with far superior military characteristics. However, this was a lesson which it did not absorb. Korolev was just as easily able to create an informational monopoly during the formative stages of the space program as during the missile program.

In contrast, the scientists used every opportunity to maximize their autonomy. From the beginning, they drove a research agenda which was often at odds with leadership interests. To the extent that it was interested at all, the leadership wanted effective military weapons. The scientists wanted to go into space. Missile construction merely laid the foundation for their cosmic aspirations. However, the rockets required for space launches were significantly different from those required for ICBMs. Korolev needed the additional thrust of liquid oxygen/kerosene engines, but he was aware that these components were not as well suited as storable propellants (RFNA/UDMH) for use in military weapons. Through manipulation of information, the scientists were able to prevent the administrators and leadership from learning about the storable propellants until the R-7 was well under construction. The R-7 was never deployed in significant numbers as a military missile, but remains today as the basic booster used to send Russian cosmonauts into space.

Korolev began with minor technological deviations from stated objectives, steadily increasing these deviations as necessary. Early in the program, when he experienced difficulties with Marshal Iakovlev's refusal to accept the R-1, Korolev initiated a new project without his approval. He circumvented the formal approval process by asserting that the new rocket was only a minor modification of the original, as necessary to accommodate scientific payloads. In reality, the R-1A was vastly different from the R-1, but Iakovlev was apparently unaware. The R-3 project was a far greater deception, but it was still in the general direction of developing effective missiles. The R-7 was a clear deviation from leadership interests, as was the abandonment of photoreconnaissance satellites in favor of manned launches.

The Council of Chief Designers, developed by Korolev out of necessity, provides another observation of scientific autonomy achieved at the expense of leadership control. The basic procedure of the Council was to coordinate decisionmaking among institutes from five different ministries, depriving their respective ministries of any control over these activities. Over the course of the Soviet missile and space programs, the level of decision which the Council was able to make without reference to leadership increased dramatically. In the initial years, the Council limited itself to technical and engineering decisions in their quest to build a rocket. By the late 1950s, the Council was making programmatic decisions, such as whether to proceed with a photoreconnaissance satellite or manned launches.

There was an ebb and flow to the scientific autonomy of Korolev's rocket team. During their time in Germany, the rocket scientists enjoyed a great deal of autonomy. They were able to pursue German rocket technology in contraventión of orders from Moscow to pursue aviation technology. However, they found their autonomy severely constrained once they returned to Moscow. The next five years were characterized by the struggle to achieve autonomy. Having achieved a considerable level of autonomy in the early 1950s, Korolev enjoyed a brief period of genuine control over his research agenda. It would be short-lived, however, as the creation of the competing Iangel design bureau in 1954 threatened Korolev's pre-eminent position atop the missile program. Though there is no indication that this was his sole motivation, Korolev achieved even higher levels of autonomy by shifting his focus from military missiles to development of a space program.

He reached the apogee of autonomy in 1959 when Khrushchev approved a long-term space exploration program.

SCIENTIFIC AUTONOMY AND PROGRAMMATIC SUCCESS

The observation of scientific autonomy in the Soviet missile and space programs is clear enough. What remains is to consider the causal connection between this autonomy and programmatic achievement. Was autonomy necessary? There are two approaches to be taken to answering this question. The first is to trace the causal connection between scientific autonomy and the progress of the program. The second is to consider the counterfactual supposition: could programmatic success have been achieved without scientific autonomy?

Several observations indicate that scientific autonomy was necessary for the successful development of the Soviet missile program. Throughout this program scientists repeatedly used their autonomy to make decisive contributions at critical junctures. Immediately after the war, technology collection teams were sent to Germany to gather aviation technology. There were no orders to pursue any technologies related to the V-2 program. In fact, the Red Army deliberately passed by the missile test facilities at Peenemunde, allowing Werner Von Braun and his rocket team to escape and surrender themselves to the Americans. The Narkom for Aviation Production, which sponsored the technology teams, expressly rejected rocketry. However, Boris Chertok violated his instructions and went in search of the German rocket scientists and their technology. His initial collection efforts provided the nucleus around which the other rocket scientists gathered over the course of the next year. Without Chertok's independent efforts, it is doubtful that the Soviets would have been able to recruit the few quality specialists they did manage to bring back to the Soviet Union. While the contributions of the German rocket scientists was not decisive, they did provide an important spark to get the program going.

The creation of the Council of Chief Designers was another manifestation of scientific autonomy which proved crucial for the success of the missile program. All participants interviewed for this study believed that the program would have failed without the Council. The Council permitted Korolev to rapidly arrive at decisions and coordinate implementation without requiring cumbersome approval from all relevant ministers. Interministerial approval would have significantly increased the amount of time required to build missiles by several fold, if not killed the program altogether.

Korolev's ability to redirect the fundamental technical orientation of the program without full disclosure to the leadership and administrators was a third aspect of autonomy which was crucial to the success of the program. It is doubtful that either Stalin or Ustinov would have supported the fundamental research Korolev performed under the guise of the R-3 project if Korolev had been forthright regarding the project. Similarly, Korolev's deception regarding his true intentions with the R-7 was the decisive factor in the early Soviet victories in the space race. The leadership was completely unaware of the possibility of space flight, much less capable of directing a program. The only way it could have occurred was with Korolev's deceptive actions.

Counterfactual propositions pride a particularly useful means of testing for causal connections in this study. The proposed relationship is clear, and the observation of causal connection noted above is straightforward. One need simply consider a proposition of essentially the reverse relationship between the scientists and the leadership observed above. That is, leadership control was necessary for the success of the Soviet missile and space programs.

Was it possible for the Soviet Union to have beaten the United States into space or built the first ICBMs with leadership control? The answer to this question depends on the degree of control. It is obvious that the Soviet program would not have occurred before the United States' program if the leadership had been in absolute control. There was no indication that Stalin, or anyone else in the leadership, had anything more than a passing interest in ballistic missiles. Unprompted, it is unlikely that the Soviet Union would have initiated any program until it was clear that the United States was embarking on such a program. Emulation was the standard operating procedure for the Soviet leadership.[2]

---

[2] See Matthew Evangelista, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies,* (Ithaca NY: Cornell, 1988).

But what if we relax the degree of leadership control and consider the hypothetical in which the leadership seizes control of the missile program sometime in the early stages of development? The opportunity presented itself in the early 1950s, when there was a debate over the most appropriate fuel. It is entirely possible that if Ustinov had forced Korolev to pursue storable propellants instead of LOX/kerosene, the Soviet Union could have fielded a more effective military missile sooner, but probably not by more than a couple of years. Similarly, it is also possible that the leadership could have obviated the need for the Council of Chief Designers by placing the entire missile program within a single ministry. We must wonder, however, whether these organizations could have functioned in a rigid bureaucracy as well as they did by utilizing their informal means of coordination.[3]

Under any circumstances, it is difficult to imagine the Soviet leadership directing the initiation of a space program. Overall, we must conclude, therefore, that counterfactual supposition lend further support to the hypothesis that scientific autonomy was necessary for the creation of the Soviet missile and space program prior to that of the United States.

---

[3] Chisholm argues that informal coordination under such circumstances is often a more efficient system than hierarchy. see Donald Chisholm, *Coordination Without Hierarchy: Informal Structures in Multiorganizational Systems*, (Berkeley: University of California Press, 1989).

SCIENTIFIC AUTONOMY IN OTHER CASES OF PROGRAMMATIC INNOVATION

In the preceding pages we have seen clearly that scientific autonomy was a critical causal factor in the development of the Soviet missile and space programs. What does this tell us about other cases of programmatic innovation? This issue was dealt with theoretically by choosing a case of programmatic innovation in which the state leadership appeared strongest, thereby conducting a ***crucial case study***.[4] Nevertheless, as an empirical check, it is useful to briefly consider additional instances of programmatic innovation in order to observe the levels of scientific autonomy. As an additional exploration, a case of programmatic emulation will be examined to determine how the relationship between the scientists and the leadership changes when the leadership has access to technical information on an adversary's program.

The method for conducting these tests will be focused, structured comparative case studies. Scientific autonomy will be observed using the basic observation points outlined in Chapter 2 and referred to throughout this study. Each case will also be

---

[4] On case studies in general and crucial case studies in particular see Harry Eckstein, "Case Study in Political Science," pp. 79-137 in Fred I. Greenstein and Nelson W. Polsby (eds.) *Handbook of Political Science, Volume 7,* (Reading MA: Addison-Wesley, 1975).

considered for the causal connection between scientific autonomy and programmatic innovation.[5]

<u>The U.S. Atomic Bomb Program</u>

The stereotypical case of programmatic innovation was the creation of the world's first atomic bomb. Research related to nuclear explosions began decades before the war within the loosely coupled, emerging scientific community of physicists, mathematicians and chemists studying the possibility of fissile reactions. In the 1930s, when they realized that such reactions were potentially explosive, the scientists, led by Leo Szilard, Edward Teller and Enrico Fermi, resolved to bring the matter to the attention of world leaders in the hope that some democratic state would develop the technology before the Nazis. After presenting a basic proposal to expand nuclear research through a friend of Roosevelt's, a committee was formed to investigate the future of atomic energy. At the first meeting of the Uranium Committee in October 1939, the scientists' proposal for consideration of an atomic bomb was met with contempt from the military. The Army Scientist on the committee, Lt. Col. Admonson, interjected: "In Aberdeen, we have a goat tethered to a stick with a ten-foot rope, and we have promised a big prize to anyone who can kill the goat with a death ray. Nobody has claimed the prize yet." He went on to

---

[5] Alexander George, "Case Studies and Theory Development," paper presented to the Second Annual Symposium on Information Processing in Organizations, Carnegie-Mellon University, October 15-18, 1982.

assert "that it was naive to believe that we could make a significant contribution to defense by creating a new weapon. He said that if a new weapon is created, it usually takes two wars before one can know whether the weapon is any good or not."[6] In the end, however, the Army relented and provided $6,000 dollars for the first year research. It was hardly a crash program at this point.

Five months later, Szilard remarked: "We heard nothing from Washington at all... I had assumed that once we had demonstrated that in the fission of uranium neutrons are emitted, there would be no difficulty in getting people interested; but I was wrong."[7] Teller, Fermi, and Szilard continued to pressure the administration, gaining funding in the hundreds of thousands of dollars when the National Defense Research Council (NDRC) was with a team of scientists led by Vannevar Bush and James Conant. Still, the program was small by standards of weapons research. The program languished. A member of the NDRC, Frank Jewett expressed continued administrative skepticism in June 1941 exclaiming: "Even if the physicists get all they expect, I believe that there is a very long period of engineering work of the most difficult nature before anything practical can come out of the matter..."[8] A decision to accelerate the bomb development program did not occur until October or November 1941. Even so, the decision was one merely to

---

[6] See Richard Rhodes, *Making the Atomic Bomb,* (New York: Simon and Schuster, 1986) p. 315.

[7] *Ibid.* p 331.

[8] *Ibid.* p 366.

accelerate research, promising additional resources as required. The decision apparently went into few specifics.

The conceptualization and decision making phase was clearly driven by the scientists. It was the scientists' technological possibilities which drove the decision, not any clear notion of military requirement. In fact, the military utility of such weapons remained virtually unconsidered at the time. The initial decision and the negotiation process, on the other hand, offered mixed observations of autonomy. From 1939 through 1941, decision making was highly incremental. Money was doled out in relatively small amounts. However, there were few constraints as to how the scientists might spend the money. After late 1941 and the US entrance into WW II, the financial floodgates were opened. The scientists could get whatever funding for whatever research they wanted. Therefore, we observed a mid level of autonomy through 1941 with much greater autonomy after the October/November decision.

The organizational structure devised to undertake development of the bomb was driven by concerns over secrecy. In 1942, the program was dispersed among universities in New York, Chicago, and Berkeley. Initial attempts made to unite the program at Chicago failed, and it was put under the direction of General Leslie Groves in September 1942. One month later, Groves selected Oppenheimer as chief scientist, delegating control over all technical issues to him. The Manhattan Project, as the program was dubbed, would focus its efforts on creating a single laboratory for designing and building the bomb. Only facilities for producing uranium and plutonium materials would be located outside this remote facility in Los Alamos New Mexico. Groves and Oppenheimer both wanted to concentrate all efforts in a single facility, but for different reasons: Groves believed this was the only way to maintain absolute secrecy -- not the least of all from the prying eyes of Congress; Oppenheimer believed this was the only way to maintain a critical scientific mass.

Scientists began arriving at the laboratory at Los Alamos in March 1943. Up to that point most of them were unaware of the full scope and scale of the work that had been performed. Open scientific communications across previously compartmentalized scientific disciplines proved critical in the rapid development of the bomb. For a time, Groves attempted to retain some scheme of compartmentalization of information, isolating individual research groups, but was soundly defeated by the scientists. From that time forward the scientists maintained almost complete control over technical activities. Groves duty was to facilitate the scientists activities, not to question the validity of their technical approach. This led to rapid scientific progress, albeit with a great deal of duplication and other inefficiencies.

Externally, the administrative structure for the program was almost non-existent. Groves was in charge of coordination of supplies, most importantly uranium and plutonium production, and served as the liaison with the political leadership. James Conant, Bush's deputy on the NDRC, maintained overall supervision. Only a handful of others outside the NDRC were even aware of the project. Secrecy precluded anyone whose participation was not absolutely essential from even knowing of the program's existence. This included Congress and the Vice President.

High levels soft scientific autonomy can be observed for this time period. Programmatic oversight was highly constrained and compartmentalized within a an independent bureaucracy. This strengthened the scientists' autonomy. The fact that there were no other scientific organizations attempting anything similar, or even having knowledge of the bomb program further strengthened their position. The only point of weakness in the scientists autonomy was that the same isolation which gave them scientific freedom also prevented them from personally building constituencies outside of Groves and Conant.

As the program progressed, fundamental choices had to be made. A bomb using purified uranium 235 appeared to be a more certain alternative from a design standpoint, but it was uncertain whether sufficient amounts of enriched uranium could be produced before the end of the war. Exactly the opposite conditions prevailed with a plutonium bomb. It appeared that the plutonium could be produced, but the bomb design involved many technical uncertainties. The scientists, with the support of the NDRC, undertook both alternatives. It was a hugely expensive duplication, but one which they felt was necessary in order to build at least one bomb before the end of the war. As events turned, both approaches worked, and two different bombs were developed and detonated over Japan.

With the explosion of the atomic bombs over Hiroshima and Nagasaki, the atomic bomb program began to provide useful policy alternatives to the U.S. government. In this sense, programmatic innovation had occurred. But it would be several years before the new weapons were coordinated with U.S. military doctrine, as the strategy for "massive retaliation" was developed under the Eisenhower administration. In the intervening period, the scientists who had developed the atomic bomb evolved into an informal defense intellectual community advising the government on the use of atomic weapons. In August 1949, the Soviet Union detonated their first atomic bomb, setting off a debate in the U.S. policymaking community over development of a thermonuclear bomb. The so-called "super." To settle this issue a meeting was called of the, the General Advisory Commission (GAC), a scientific council consisting primarily of scientists from Los Alamos. Despite military requests that the weapon be developed with the greatest possible speed, the scientific community concluded that the "super", was not likely to have any clear military utility and, therefore, should not be pursued. Tactical nuclear weapons should be pursued instead.[9] Thus, the influence of the scientists was extended beyond technical questions to issues of military policy.

In the period of institutionalization, the scientists controlled the research agenda. They decided that two distinctly different approaches should be taken, and that one -- the super -- should not. While the first did not constitute a clear technological deviation, it

---

[9] See Herbert F. York, *The Advisors: Oppenheimer, Teller, and the Superbomb,* (San Francisco: W.H. Freeman and Company, 1976)

did represent agenda control. The super seems to be a clearer case of technological deviation since the scientists derailed a program which the military supported.

While it is clear that Oppenheimer and the U.S. atomic scientists had a great deal of autonomy, it was considerably less than that which Korolev and his rocket scientists achieved. It cannot be argued that the U.S. atomic scientists foisted an undesired program upon the leadership. It can simply be said that the leadership gave the scientists the autonomy to undertake the project in whatever fashion they thought best, and that this autonomy was decisive to the rapid success of the program. Korolev, on the other hand, had to fight hard to convince his leadership of the efficacy of both the missile and space program. U.S. scientists were assisted by the crisis precipitated by the entrance of the United States into WW II. The crisis effectively removed any concerns over absolute sums of money spent on the program. The only concern was in terms of opportunity costs. Furthermore, wartime conditions made it easy for Roosevelt to justify the intense secrecy of the program. Both these conditions contributed to scientific autonomy and suggest that such exceptional measures as creating a separate, secrete administrative channel for a program may only occur under conditions of crisis.

The U.S. ICBM Program[10]

The dynamic nature of the relationship between the leadership and the scientific community in the US ICBM program presents a particularly interesting case study. Programmatic development was stifled in the early years due to the opposition of well educated administrative agencies. When the organizational structure was changed, the program underwent dramatic growth and delivered a new system which revolutionized the way war-fighting was considered by the US military.

The United States beat the Russians to the German rocket hardware. (More precisely, the Germans found the Americans before the Russians even began looking for them.) As a result, more than 200 fully constructed V-2s were transferred to White Sands testing grounds, and a substantial community of German rocket scientists led by Werner Von Braun, was established in Huntsville Alabama under the administration of General Medaris. For the next six years the facility did little more than produce improved copies of the V-2 Von Braun which had produced by the thousands in Germany.

In January 1946, the Convair Corporation proposed a 5,000 mile missile, developing designs for both a cruise missile and a ballistic missile. The project was designated as MX-774. A year later however, the project was canceled by the Air Force

---

[10] This case study was based on material from: Edmund Beard, *Developing the ICBM: a Study in Bureaucratic Politics*, (New York: Columbia Press, 1976); John B. Medaris, *Countdown to Decision;* (New York: G.P. Putnam's and Sons, 1960); and Ernest G. Schwiebert, "USAF Ballistic Missiles -- 1954-1964" in *Air and Space Digest*, (May 1964).

because the proposed fuel was not regarded as sufficiently energetic, and the service believed that the warhead would burn up on return into the atmosphere. The program remained a low level research effort considered by few beyond the rank of Colonel. Most damning perhaps, the program was condemned by Presidential Advisor Vannevar Bush who asserted

> In my opinion such a thing is impossible and will be impossible for many years. The people who have been writing these things that annoy me have been talking about a 3,000-mile high-angle rocket shot from one continent to another carrying an atomic bomb... I say technically I don't think anybody in the world knows how to do such a thing, and I feel confident it will not be done for a very long period of time to come.[11]

Reinstituted in 1951, MX-774 became the Atlas program, but it continued to stagnate, strangled by too little money and too high operational requirements for accuracy.

In 1954 the Strategic Missile Evaluation Committee recommended

> that a radical reorganization of the ICBMs project considerably, transcending the Convair framework is required if a military useful vehicle is to be had within a reasonable space of time...the nature of the task for this new agency requires that overall technical direction be in the hands of an unusually competent group of scientists and engineers capable of making systems analyses, supervising the research phases, and completely controlling the experimental and hardware phases of the program.[12]

This evaluation, combined with developments in the Soviet Union, would lead to a radical reorganization of the missile program.

---

[11] Beard, *Developing the ICBM* ... as quoted on p. 70

[12] *Ibid.* p. 168.

Leadership control characterized the initial phase of conceptualization. Although the initial proposals for ICBM development came from scientific organizations, they were renegotiated, canceled, restarted, and diverted so many times by administrative agencies that the initial proposals had little bearing on the final program direction. The leadership supported the development of competing centers of expertise, openly using one against the other in order to scrutinize the work of all participants. This created well-educated administrators, but stifled the development of the program.

As result of the SMEC evaluation the ICBM program underwent a significant reorganization in 1954 with the creation of the Western Development Division (WDD) under General Bernard Shriever, and the installation of the Ramo-Woolridge Corp. as systems integrating contractor for the entire program. Shriever separated the WDD from the rest of the Air Force administration and instituted streamlined planning procedures which virtually eliminated the rest of the Air Force R&D bureaucracy. He then succeeded in getting the requirements for accuracy loosened from 400 yards to five miles.

The key organizational change was the partnership between the WDD and Ramo-Woolridge. Putting together some of the best scientific minds in the country, Simon Ramo and Dean Woolridge managed the technical design and oversaw the production of the Atlas missile, being produced by Convair. Shriever managed the external environment -- an arrangement similar to that between Groves and Oppenheimer noted above. Shriever came to be completely reliant upon Ramo-Woolridge for technical judgments.

In 1954, the Deputy Secretary of Defense for Research and Development, Trevor Gardner requested electronic surveillance of potential Soviet missile tests. When an electronic listening post was erected in Iran in mid 1955, Gardner was shocked to find the Soviets in the final testing stages of an IRBM (the R-5).[13] At Gardner's prompting, in September, Eisenhower ordered that ballistic missile development be given the highest priority. Gardner and Shriever used the Presidential priority to further distance the WDD from the rest of the Air Force.

The President also ordered that several additional projects be initiated. The Army Redstone arsenal began developing an Intermediate Range Ballistic Missile (IRBMs), the Jupiter, under General Medaris and Von Braun. A competing IRBM, the Thor, was proposed by the North American Aviation Corp. and there was an additional ICBM under development by the Douglass Aircraft Corp. There were no apparent concerns over dilution of scientific expertise. Competition was viewed as essential for scientific development.

The organizational structure which emerged for this program featured scientific autonomy of WDD from the higher levels of the Air Force Bureaucracy, and reliance upon civilian scientists for technical judgments. Before 1954, the ballistic missile program was in direct competition with the manned bomber program for scarce R&D resources. The

---

[13] See Jeffrey Richelson, *American Espionage and the Soviet Target*, (New York: Quill, Willian Morris, 1987)

bomber program enjoyed higher profile and broader support within the Air Force. It was the core technology of the service.[14] The WDD separated the ICBM from the bomber program and gave it a separate budgetary path which circumvented the supporters of the manned bomber program.

Development of the Atlas proceeded rapidly, and by 1957, sub-system testing began. In the same year, Ramo-Woolridge became TRW through the infusion of cash from Thompson aviation. The new company created a separate division for ballistic missiles called Space Technology Laboratories (STL). STL continued technical management of the WDD ballistic missile program, assuming responsibility for the next generation Titan missile as well. The Atlas proceeded to full-scale testing in late 1958 and, after a long series of failures, finally achieved required objectives in February 1961. Much like Korolev's R-7, however, the missile was never deployed in large numbers.

In the late 1950's, the Air Force strategy of duplication began to pay off. In 1959, the first Titan missiles began testing, but did not enter deployment for another three years. The most significant new development by WDD/STL was solid fueled rockets. In 1958, STL delivered a report indicating that the development of solid fuels had reached the point at which ICBMs were possible. Full-scale development began that year and the Minuteman missiles entered testing in early 1961, becoming operational the following year.

---

[14] See James D. Thompson, *Organizations in Action*, (New York: McGraw Hill, 1967).

STL was contractually prohibited from building hardware. Since this was the most profitable activity for an aerospace firm, by the late 1950s pressure grew to alter their arrangement requiring them to serve as the design-only organization. In 1960, the majority of STL became a Federally Funded Research and Development Center (FFRDC) known as the Aerospace Corp. and continued its role as the chief design and technical management organization for the WDD. By this time, ICBMs were entrenched as a key leg of the U.S. strategic triad.

The United States began to reap the benefits of an unique and controversial organization structure during the institutionalization phase of the ICBM program. The partnership between the scientists of STL producing the design and Gen. Shriever managing the government relations and contracting produced a variety of new systems which probably would not have occurred without the level of flexibility inherent in this organizational design. Unburdened by the necessity of producing the systems they designed, STL was free to consider without prejudice many options which covered the range of ballistic missile options including: cryogenic propellants (Atlas), storable propellants (Titan), and solid fuel. It also enabled them to manage these separate projects with equanimity.

Was this arrangement necessary for the success of the ICBM program? To answer this question we need only look at the differences between the pre-WDD/STL era and the WDD/STL era. Before 1954, the program was considered to be a poor substitute for bombers by its many detractors within the Air Force. The ideological bias towards manned aircraft within the service would not permit this program to develop. Even the supporters of the program considered it to be technologically moribund. When the WDD was created, the program was immediately freed from the resistant Air Force bureaucracy. The infusion of scientific talent from STL overcame the technological stagnation, and the program rapidly developed new technological approaches.

The U.S. ICBM program provides an excellent study of the effect of scientific autonomy. For the early years the program was characterized by low scientific autonomy. Both the Air Force and the political leadership maintained tight reigns on its progress. But when the organizational structure was changed, providing scientific autonomy, the program grew by leaps and bounds. Perry concluded that it was management techniques, which made the difference between the ballistic missile program and the parallel cruise missile program, which were both programs of high national urgency. It was not simply a matter of increased funding.[15]

---

[15] See Robert L. Perry, *System Development Strategies: A Comparative Study of Doctrine, Technology, and Organization in the USAF Ballistic and Cruise Missile Programs, 1950-1960* (Santa Monica: RAND, 1966) RM-4853-PR

The Soviet Atomic Bomb Program[16]

The Soviet atomic bomb program was fundamentally different from other programs considered here in that it was a case of emulation rather than innovation. This distinction altered the basic nature of the relationship between the leadership and the scientists. Because they possessed strong intelligence information on the US atomic bomb program, the Soviet leadership was able to closely monitor the progress of their own program through reference to the experience of the United States. From the beginning, the leadership was in control of this program.

Nuclear research in the Soviet Union began well in advance of Stalin's decision to initiate a crash atomic bomb program. However, the Soviet nuclear science community was not large, and the leading member, Petr Kapitsa, did his most productive research in England before the war. Moreover, the few scientists who were engaged in nuclear physics were divided between Moscow and Leningrad. During the war, nuclear scientists discarded their former research projects to concentrate on more practical science in support of the war effort.

In 1942, Georgii Flerov, a young scientist serving as a Lieutenant in the Red Army, noticed a sharp decline in publications by American atomic scientists. He deduced

---

[16] This section is based primarily on David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy 1939-1956,* (New Haven: Yale University Press, 1994); E.A. Negin, *Sovetskii Atomni Proekt: Konets Atomnoi Monopoli. Kak eto Bylo...; (The Soviet Atomic Project: the End of the Atomic Monopoly. How it Happened...)* (Nizhnyi Novgorod: Nizhnyi Novgorod Press, 1995); and Steven Zaloga, *Target America: the Soviet Union and the Strategic Arms Race, 1945-1964,* (Novato: Presidio Press, 1993).

that atomic research in the United States had been declared secret, and that a nuclear bomb program was under development. He appealed to Stalin to undertake a corresponding Soviet effort. His appeals met with no response.[17] Instead, the initiative for a low level Soviet effort came from the head of the secret police (NKVD), Lavrentii Beriia. Beriia's agents had obtained a copy of the British Maud Report, which concluded that an atomic bomb was feasible using far less uranium than was previously believed. The report argued that only 10 kg. of purified uranium-235 were required to generate an explosive yield of 1,600 tons of TNT. Based on this information, Stalin ordered a low-level nuclear research effort before the end of 1942.

The Soviet Union was not at a loss for candidates to lead the effort. World renowned scientists Petr Kapitsa , Abram Ioffe, and N.I. Vavilov were all involved in atomic research. However, all had demonstrated an independence which concerned Stalin. The relatively unknown physicist, Igor Kurchatov was appointed to head the program because, "he produced on us a very pleasant impression" according to one of the administrators charge with initiating the effort.[18] Leadership interest remained lukewarm, however, and the program continued at a low level for the next two and a half years.

---

[17] The general mythology was that the wise and just Stalin read this letter, recognized its insight, dressed-down those who trivialized it, and immediately set up a corresponding Soviet program. Holloway demonstrates that this could not have been the case. See Holloway, *Stalin and the Bomb...*

[18] Holloway, *Stalin and the Bomb...* p. 87.

Stalin's interest changed dramatically with Truman's whisperings at Potsdam that the United States had tested a new weapon of unusually destructive potential. Beriia had kept Stalin aware of US progress on the atomic bomb, and had agents well-placed within the program constantly feeding him data on detailed design specifications. Nevertheless, Stalin seemed to be taken by surprise by the US test at Alamogordo. Immediately upon return from Potsdam he ordered a massive acceleration of Kurchatov's program.

The relationship between the leadership and the scientists during the conceptualization and initiation phase of the atomic bomb program was almost exactly opposite that of the missile program. The scientific community was small and dispersed, lacking leadership of the scientific community. The political leadership developed the concept of the atomic bomb from its own intelligence sources, and while it did not understand the physics, it did have a road map of how the Americans made the bomb. Therefore, the leadership could make a single point decision to initiate a crash program with the confidence that the bomb would work, if they copied the American version. Clearly then, the level of scientific autonomy at this stage was low.

The invigorated project was based closely upon the US Manhattan project. In June 1945, Klaus Fuchs, who was working as an agent of the NKVD, provided detailed descriptions of the American plutonium bomb. According to Iuri Khariton, the designer of the Soviet bomb, the description "was detailed enough to enable a competent engineer to produce a blueprint for the bomb."[19] The most difficult task facing the leadership was construction of an entirely new industry to extract and process sufficient uranium to make a reactor, as well as the facilities for processing uranium into weapons-grade plutonium.

The organizational structure which emerged, separated the atomic industry from the remainder of the Soviet economy under the Ministry of Munitions, directed by Boris Vannikov. Vannikov had several deputies supervising various aspects of uranium extraction and processing, but they were still dependent upon Kurchatov and the scientists for much of the technical direction. Not surprisingly, the structure at the scientific level was very similar to that of the Manhattan project. However, it was very different at the leadership level. Beriia was directly in charge of the program, and he had three important resources at his disposal: detailed intelligence on the US program, a deep reservoir of slave labor to perform the extraction and construction work, and the ear of Stalin. Combined, these factors gave him complete control.

Kurchatov's contact outside the Ministry of Munitions was limited. There was almost no contact between the scientists and any military service. The military was ignorant of the existence of an atomic bomb program. Stalin's officially promulgated military doctrine trivialized the significance of such weapons. His ability to develop a broad based constituency was therefore limited. He was dependent upon Beriia. Beriia,

[19] *Ibid.* p. 138

on the other hand believed that any number of Soviet scientists could accomplish Kurchatov's task. All they had to do was follow the pilfered directions of the Americans.

Through the organizational emergence phase, the leadership continued to exercise a high degree of control over the Soviet atomic bomb program. Beriia had a steady flow of intelligence information and continued to use it to monitor progress. The scientists had no choice but to confine themselves to the American path. Petr Kapitsa was rudely criticized by Beriia when he proposed an innovative new direction which would produce a bomb more rapidly and at less cost than the approach they were currently taking.

As Kurchatov's program proceeded to testing of reactors, and ultimately, the first Soviet atomic bomb, Beriia was quick to compare the results of every test with known results of similar American activities. He reserved judgment until he was able to provide this independent verification. His caution led to some personal embarrassment when, after the first atomic test, he refused to telephone Stalin until he could compare the results with those of the Americans. When he finally did phone the Soviet leader some hours later, he was distraught to discover that Stalin had been informed some hours earlier, and was not pleased with Beriia's delay.

Following the atomic bomb, Beriia's reservoir of intelligence evaporated. The Americans had elected not to go ahead with development of a thermonuclear weapon. Soviet scientists, on the other hand, were quick to propose several ideas. Having established a constituency in Stalin, a much tighter organizational structure, and an organizational mission based on a distaste for Beriia, Kurchatov and his team of scientists were in a better position to exercise autonomy in pushing for the thermonuclear bomb. Using this autonomy, Kurchatov simultaneously pursued three different methods of creating the new device. Thus, in the end, Kurchatov was able to achieve a certain level of autonomy.

The Soviet atomic bomb program was clearly driven by the leadership agenda. Drawing on the military and political success of the American bomb, Stalin understood that such weapons had political as well as military significance. The mission for the program was understood. Beriia was able to control the technological development of the bomb through his intelligence sources. The leadership redressed the imbalance of expertise with the scientists through infusion of information from the American program. In essence, the Americans functioned as a competing scientific organization, providing a benchmark by which the Soviet scientists were judged.

Comparisons and Contrasts

From the preceding discussion it is clear that scientific autonomy played a significant role in the success of the two American programs as it had in the Soviet missile and space programs. Consequently these cases lend further support to the hypothesis that was the ability of the scientific community to drive the research agenda was decisive in cases of programmatic innovation. Scientific autonomy was not apparent in the case of programmatic emulation suggesting that given adequate information the leadership can retain control over a program.

At the same time, there were differences among these cases which point toward useful directions for further investigation. The U.S. ICBM and the U.S. atomic bomb cases suggest that the scientists don't always have to act alone. They may establish close partnerships with lower level military constituents at an early stage of the program, and together develop autonomy from the rest of the administrative agencies and the leadership. This sort of partnership appears to be a common phenomenon is US R&D.[20] These partnerships created mutual dependence between the scientists and the military program office. In both cases the military officers performed administrative functions while the scientists were left considerable freedom over technical issues. The net effect for both the scientists and the military was that of building a constituency for their program.

Korolev built a local military constituency within NII-4, but the military institute possessed little authority in comparison with WDD or the Manhattan District. This was a product of a very different Soviet bureaucracy which separated the Ministry of defense from industrial ministries. The two ministries came together at the ministerial level to agree upon weapons systems. There was not the same level of cooperation between the military customers and the industrial producers as in the American system. This factor may go a long way in explaining the relatively low innovation rates for the Soviet Union as

---

[20] See for example Evangelista, *Innovation and the Arms Race...*

compared with the United States. It was more difficult for Soviet scientists to establish military constituencies. Instead, they built their constituencies on the industrial side, and the Soviet industrial system provided very low incentives for innovation.[21]

Another difference between systems was the relatively higher level of technological competence of American leaders. The U.S. leadership was quick to draw upon the scientific community for technical advice in the post war years. This had the curious effect of stifling program initiation in both the A-bomb and ICBM programs. By the same token, the lack of technical competence which the Soviet leadership provided Korolev with important opportunities. But his deceptions were a risky game which very few other Soviet scientists were willing to undertake.

To a far greater extent than the other programs examined here, Korolev had to contend with a leadership which was only willing to grant incremental approval. He had to return to the leadership for critical decisions at least once a year. Therefore, Korolev had to devote a great deal of energy to maintaining relations with administrative agencies through which decisions had to pass. Constant contact led to closer relations and over time Korolev built a constituency throughout the Soviet administrative bureaucracy.

The differences between the government structures ultimately suggest that the requirements for autonomy are higher in order for programmatic innovation to occur in the Soviet system. In the United States, where scientists easily establish military

---

[21] See Joseph Berliner, *The Innovation Decision in Soviet Industry*, (Cambridge: MIT, 1976).

constituencies and informal connections to the leadership through high level scientific advisors, scientists may need a lower degree of autonomy in order to successfully undertake programmatic innovations.

Finally, the Soviet atomic bomb programs provides an indication that the relationship between the leadership and the scientific community may be dramatically different for cases of emulation. In cases of emulation, the leadership may be able to redress its informational disadvantage, and closely monitor the progress through comparison with a foreign program. Scientific autonomy is not necessary for emulation, and the Soviet leadership which placed a high value on control was far more comfortable with emulation than innovation.

THE PROCESS OF PROGRAMMATIC INNOVATION COMPARED

Given the observation of these case studies, it will be useful to briefly retrace the process of innovation, combining the theoretical observations from chapter one with empirical information from real world instances of programmatic innovation. This section will consider the phases of: 1) conceptualization and initiation; 2) organizational emergence; and, 3) institutionalization primarily, from the perspective of the Soviet program, but also introducing insights form other instances of programmatic innovation.

Conceptualization and Initiation

The initial phase of programmatic innovation involves generating a proposal and gaining approval from the leadership to begin a new program. Two aspects of this phase emerged from the case studies as critical: early scientific coordination, and the incremental process of decision-making.

The Soviet missile program was characterized by a long period of informal interaction within the scientific community. Informal ties among Soviet scientists were bound decades before any decision was made to initiate a program. The Soviet rocket scientists were further aided by the independence they enjoyed during the years spent in Germany where they developed an informal structure based on the leadership and vision of Sergei Korolev. When the time came to present a proposal, the scientists were well organized, had clear leadership and were able to defend their mission with a single voice.

There were similarities between Korolev's team and the group of nuclear scientists advancing the U.S. atomic bomb program. Szilard, Teller, and Fermi were a tightly organized nucleus of a more loosely coupled community than the Soviet rocket scientists under Korolev. In the years prior to initiation, the U.S. atomic community suffered from the fact that there was no single leader. Nevertheless, they were able to present a unified vision to the American leadership.

The U.S. ICBM program had an even weaker scientific community behind it prior to programmatic initiation. Several aerospace companies were competing for the next strategic delivery system, advocating radically different approaches. Scientific dispersion compromised the initial progress of the program. It was not until the scientific community spoke through the single voice of STL that the program made substantial progress.

A lack of scientific cohesion and leadership seemed to characterize other programs as well. The clear leader of the Soviet nuclear community, Petr Kapitsa, refused to participate in the Soviet atomic bomb program.[22] The early U.S. space program suffered from a similar lack of scientific cohesion, with three entirely different organizational hierarchies competing to put the first American satellite into space. The fact that the Soviets beat them into space by more than six months was in large part due to this lack of focus.[23] The American scientific community was shocked by President Reagan's announcement of the Strategic Defense Initiative, and the program has been plagued by scientific fragmentation from the beginning.[24] The U.S. space station has suffered from a similar lack of scientific support.[25]

In the cases of the U.S. ICBM program, the U.S. space program, and the Soviet atomic bomb, scientific cohesiveness was achieved during the phase of organizational

---

[22] See David Holloway, *Stalin and the Bomb...*

[23] See Walter A. McDougall, *The Heavens and the Earth: a Political History of the Space Age*, (New York: Basic Books, 1985)

[24] See Paul Stares, *The Militarization of Space: U.S. Policy, 1945-1984*, (Washington D.C.: Brookings, 1985)

[25] See Howard McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice*, (Baltimore: Johns Hopkins, 1990).

emergence, yielding and programmatic innovation. In the cases of SDI and the space station, lack of scientific cohesion has continued to plague the programs. Therefore, we can only observe that early scientific cohesion was an enabling factor, but not that it was necessary.

One notion dispelled by the Soviet missile and space programs is the assertion that single point commitments are necessary for large scale programmatic innovation.[26] Both the Soviet missile and space programs were initiated on an incremental decision-making basis. Naturally, this made Korolev's management task more difficult, but it forced him to build a strong and resilient constituency. Most U.S. programs were also characterized by incremental decision-making. Contrary to conventional mythology, the U.S. atomic bomb program was approved over an incremental series of steps from 1939 to late 1942.[27] The U.S. ICBM also underwent several stops and starts from 1947 to 1954.[28]

Curiously, the programs characterized by leadership initiation ---SDI and the Soviet atomic bomb -- are among the few which involved a single large-scale decision to fully develop a new program. This suggests that scientists are deceiving themselves when they push for single-point decisions. They may be better served by developing an

---

[26] This point is made most forcefully in Paul R. Schulman, *Large-scale Policymaking,* (New York, Elsevier, 1980)

[27] See Rhodes, *Making the Atomic Bomb...*

[28] See Beard, *Developing the ICBM...*

incremental strategy from the outset. While political leaders may be technically ignorant, they are politically astute and do not cede control readily.

<u>Organizational Emergence</u>

A decision to create a new program is only the beginning of a long process. Not only must a program perform technologically, but it must perform organizationally. Two basic tasks face an emerging program. First, it must find an administrative home in a government and establish a constituency. Second, it must develop mechanisms for coordinating the work of scientists from disciplines which may not have worked together in the past. The experience of the Soviet missile and space programs indicates that these organizational tasks are at least as important as technological achievements.

A new technology program must be fit within the organizational structure of a government. There are three general possibilities. The new program may be separated from the rest of the administrative bureaucracy and given a complete independence, as was the case with the U.S. atomic bomb program. This arrangement is unusual and may only occur during times of crisis. Creating a completely independent structure required a great deal of administrative work by the leadership, and other administrative agencies will fight to gain control over a new program if it appears promising.

A second possibility is to assign a new program to an existing administrative structure that is familiar with the technology and mission, and would thus be able to manage programmatic uncertainties. This is a more common arrangement, but risks placing a new program in an established hierarchy, where is must compete with other programs for scarce resources. Such an arrangement nearly killed the U.S. ICBM program.[29] The Polaris program was similarly threatened, though it was isolated from the rest of the Navy at an earlier stage.[30]

The third possibility is that a program may be misplaced within an administrative structure having little familiarity with either the mission or technology. The Soviet missile program experienced exactly such a problem. Korolev's first Deputy, Vasiliy Mishin, regarded the placement of the missile program in the Ministry of Armaments as "the single greatest mistake in the Soviet rocket program."[31] As it turned out, placement of the missile program in an administrative structure which did not understand the technology or mission permitted Korolev to engage in his many deceptions. It is unlikely he could have accomplished this in the Ministry of Aviation Production. Paradoxically, the failure of the Soviet leadership was an important component of the success of the missile and space programs.

These cases therefore lead us to the conclusion that a new program must find some means of relief from close monitoring by administrative agencies. The problem grows

---

[29] Beard makes this point explicitly. See Beard, *The Development of the ICBM...*

[30] See Harvey Sapolsky, *The Polaris System Development: Bureaucratic and Programmatic success in Government* (Cambridge: Harvard University Press, 1972)

[31] Interview with Mishin.

acute when administrators understand the technologies, and there are entrenched interests in competing programs.

While scientists sought independence from administrative agencies, they needed to develop and maintain constituencies. No activity is more important.[32] No balance is more difficult to strike. Each program considered here faced a different set of possible constituents. For the US ICBM, program the constituencies were the low levels of the US Air Force, that were dedicated to the program, and the higher levels of the Department of Defense. Ultimately, the program built its own constituency from the ground up within the lower levels of the Air Force. The U.S. and Soviet atomic programs, as well as the space programs of both nations, found their constituencies primarily in the political leadership. Korolev found his constituency for the missile program in the industrial administration.

One factor remained constant in all these cases: there was only a limited degree of progress until the program found a constituency. Technology alone was never enough. In most cases, it was scientists who sought supporters, though in the case of the U.S. ICBM, the constituency (i.e. the military) sought the scientists. Thus, the pathway linking scientists and constituencies can be a two-way street.

Programmatic innovation necessarily involves new technologies, or new combinations of existing technologies. New scientific organizations must be created. A

---

[32] See Wilson, *Bureaucracy...*

balance must be struck between coordination and flexibility. Different scientists and disciplines must be able to communicate with each other rapidly and coordinate detailed activities. However, rigid lines of communication may seize a program in an inappropriate organizational structure.[33]

Each program seems to find its own way of solving this dilemma. Korolev created the Council of Chief Designers by necessity, but it further enabled a level of flexibility and autonomy which he could not have achieved in a single hierarchical structure. Each individual member of the Council had the freedom to develop his own lines of communication within his industry and control over the activities within that industry. The program was centrally coordinated among the six Chief Designers by Korolev. It was an unique organizational arrangement in the Soviet system which was never replicated.

The U.S. atomic bomb program took a brute force approach to scientific organization. As many scientists as possible, who were thought to be able to offer support to the program were gathered in a single facility and permitted to communicate freely amongst themselves. Scientists were free to go from one aspect of the program to another. Physicists worked with chemists, chemists with explosives experts. Whatever the requirements, the organization changed to suit them. Such an organizational structure can only be held together by force, however. Once the bomb was built, and the war won,

---

[33] See Chisholm, *Coordination Without Hierarchy...*

the organization quickly disintegrated. For the vast majority of programs, this is not a realistic organizational approach.

The U.S. ICBM program adopted yet another organizational form. The STL/WDD marriage took the approach that the best scientific minds could be concentrated in an organization which would perform only design and oversight activities. STL was free to develop relationships with which ever aerospace firms it felt were necessary to produce the current project. Given the luxury of the expansive American aerospace industry and the abundant funding created by the post-Sputnik fever, it had the luxury of contracting with several different firms at the same time to take different technological approaches to the same problem.[34] This was a solution to the dilemma of centralization vs. flexibility, that appears to be applicable to a wider variety of situations, but it relied on abundant funding to work well. The Special Projects office of the Polaris Program bore some resemblance to this model and was very successful.[35] On the other hand, NASA has used a derivation of this model, essentially combining WDD and STL in a single government agency with only mixed success.[36]

One aspect clearly observed in the organizational emergence phase of the Soviet missile program was that Korolev consciously dedicated his energy to organizational

---

[34] See Beard, *Developing the ICBM...*

[35] See Sapolsky, *The Polaris Program...*

[36] See Howard McCurdy, *Inside NASA: High Technology and Organizational Change in the U.S. Space Program,* (Baltimore: John's Hopkins, 1993)

issues, putting the development of his organizational foundation above that of his technological foundation. He understood that without a strong organization capable of operating autonomously, his technology would never get past the first test flights. The military was trying to eliminate his program, and without the support of Ustinov and a strong organization behind him, it is doubtful that Korolev would have made it past the R-1. This was a lesson which applied generally to all programs. Organizational success must precede technological success.

Institutionalization

Even with a strong organizational foundation, the success of a program is far from assured. It must provide the leadership with some demonstration of technical success. Once again, this creates a dilemma. In order to make dramatic technological achievements, a great deal of expensive fundamental research must be performed. How does the program leadership convince the political leadership without providing some demonstration of technological success?

Different programs found different ways to solve this problem. Korolev resorted to outright deception, claiming to undertake the design and production of a missile he never intended to build. The R-3 project enabled him to perform the critical research necessary for developing intercontinental range missiles. To accomplish this absolute control over information was necessary. He did this by developing a strong organizational consensus within the Council of Chief Designers through enunciation of a clear organizational mission and an understanding that information leaks would jeopardize that mission.

Korolev also inserted his technical experts in the lines of communication with the leadership. Reports of launch tests were written by his team, providing the most optimistic assessments of apparent launch failures. Technical reports on the validity of competing concepts, such as the use of storable propellants, were authored by his associates. Using this technique he was able to eliminate, or at least delay, his competitors. However, Korolev's situation was unusual.

In the United States there was typically higher levels of available expertise. Outside of the WDD/STL, the Army had its own center for long-range missile development -- the Redstone Arsenal. In the years prior to the 1954 decision to accelerate the ICBM program, General Medaris, Commander of the arsenal, served as a constant source of adverse information on the Convair ICBM. However, once both the ICBM and IRBM were a high priority, and Medaris' program was fully funded, his efforts were concentrated on competition rather than criticism. The need for information control was essentially buried beneath a sea of money.

This is not to say that U.S. program managers have not been above a little deception. The Polaris program managers regularly marched up to Capitol Hill to demonstrate the progress of their program using elaborate and colorful PERT charts. These invariably impressed Senators and Congressmen, who happily continued funding the program generously. However, the PERT charts bore very little resemblance to the actual progress of the program. They were a bureaucratic smokescreen.[37]

As a program enters the testing phase, the cost rises sharply, attracting the attention of the political leadership. The program leaders must find means of demonstrating that the program will provide useful policy alternatives in the near future. Korolev solidified his constituency by proposing that an atomic bomb be mated with an IRBM (the R-5) in order to conduct a live atomic test launch. Not coincidentally, this test was concurrent with a major political event -- the 20th Congress of the Communist Party of the Soviet Union. Following the successful test, Korolev was finally given his own design bureau, awarded the order of Lenin, and given greater political support for his space program. It was a lesson Korolev would not forget. Time and again he made considerable efforts to demonstrate the utility of his program to the political leadership: launching the first satellite, launching a dog a month later in honor of the 40th anniversary of the October Revolution and finally, launching the first man into space guaranteed the autonomy of his program for the rest of his life. In this respect Korolev had no equal. With a few exceptions, such as Admiral Rickover and the nuclear submarine program, American scientific organizations devoted little attention to the political leadership as their most important constituency.

---

[37] See Sapolsky, *The Polaris Program...*

INNOVATION/EMULATION VERSUS STATE STRUCTURE

Evangelista argued that it was the differences in state structure between the United States and the Soviet Union that led to different patterns of innovation. The United States was a weak state with a strong society; while the Soviet Union was strong state with a weak society.[38] In the United States, innovation began with the scientists, who developed new technologies; developed a consensus among lower level military officers; promoted the program at higher levels of the executive or legislative branches; and ultimately won high level endorsement. Conversely, in the Soviet Union, innovations were characterized by stifled initiative in the early years; followed by low level efforts at developing basic research; reaction to foreign stimuli; leadership initiation of a high priority program; and ultimately, mass production of a new technology.[39]

One cannot quarrel with Evangelista's characterization of the state structures of the Soviet Union and the United States. The Soviet Union was clearly more centralized and hierarchical than the United States. Nor should we question the relative innovativeness of the two countries. The record shows a clear pattern of the United States leading the Soviet Union in the development of almost every new technological program. The United States has been the innovator; the Soviet Union the emulator. In

---

[38] See Evangelista, *Innovation and the Arms Race...*; see also Stephen D. Krasner, *Defending the National Interest: Raw Materials Investments and U.S. Foreign Policy,* (Cambridge: Harvard University Press, 1978)

[39] See Evangelista, *Innovation and the Arms Race...*

fact, the Soviet development of the missile and space program offer us one of the very few instances of Soviet innovation.

Similarly, Evangelista's pattern of innovation fits well with the cases of American programmatic innovation covered in this chapter. It also fits well with the pattern of innovation for the Soviet missile and space programs. This, however, raises a question regarding Evangelista's overall theory. If the processes of innovation in both the United States and the Soviet Union appear to be remarkably similar. Is he observing the effect of state structure, or the difference between innovation and emulation?

We should return to one of the organizing principles of this study for further illumination of Evangelista's thesis. In Chapter 1, I discussed the general failure of work on innovation as a result of overly broad generalization of the dependent variable. This is where the major fault with Evangelista's work lies. He is considering the different processes of innovation and emulation to be a part of the same phenomenon. Given a more precise definition of innovation, Evangelista's argument would be restated as: state structure leads one state to innovate while the other is more comfortable with emulation. It is not merely a matter of semantics. This study has shown that both innovation and emulation are similar processes in very different state structures, but that state structure may affect the propensity of a state to innovate.

There is support for this notion in the case studies covered here. The U.S. ICBM program initially followed a pattern which was quite similar to the emulative (Soviet) pattern outlined by Evangelista: stifled initiative; initially slow scientific basic research; rapid mobilization after the discovery of Soviet missile activities. Without the necessary intelligence information regarding the technical approach of the Soviets, the US leadership had little choice but to permit its scientists a great deal of autonomy in order to pursue several different approaches to developing an ICBM.[40] A similar pattern occurred in the years the United States was attempting to catch up to the Soviet Union in the space race.[41] On the Soviet side, we observed that once the leadership's intelligence sources dissipated, Kurchatov and the Soviet nuclear scientists achieved a significant degree of autonomy from the leadership and were able to develop three versions of thermonuclear weapons.[42]

Theoretical support to this argument is found in the issue-area literature which contended that certain policy processes were similar across different types of states.[43] Zimmerman asserted that:

> the ultimate conclusion may even be that differences in policy process across issue areas within a given state, the United States of the Soviet Union as cases in point, may be as great as differences in foreign policy processes within a particular arena of power for each.[44]

---

[40] See Beard, *Developing the ICBM...*

[41] See MacDougall, *The Heavens and the Earth...*

[42] See Holloway, *Stalin and the Bomb...*

[43] See for example James N. Rosneau, "Pre-Theories of Foreign Policy," in Barry Farrel ed. *Approaches to Comparative and International Politics,* (Evanston Ill.: Northwestern University Press, 1966; William Zimmerman, "Issue Area and Foreign-Policy Processes: A Research Note in Search of a General Theory," *American Political Science Review,* Vol. 67 (December 1973) pp. 1204-1212; and William Potter, "Issue Area and Foreign Policy Analysis," *International Organization,* (Summer 1980).

[44] See Zimmerman, "Issue Area..."

It is beyond the scope of this study to prove or disprove the issue-area approach in general. However, it raises the question that if the process of innovation which is so widely accepted as a difference between the two nations, proves to be similar, what other similarities will be revealed upon closer examination?

GENERALIZABILITY AND POLICY IMPLICATIONS

The basic conclusion of this study is that programmatic innovation requires scientific autonomy. The operative mechanism behind this is that when the leadership does not understand the basic mission or the technology, it is in a poor position to manage innovation. Therefore, it must rely upon the scientific community to define the basic mission and technology. Given high uncertainty, the leadership's first instinct will be to avoid difficult decisions. Consequently, it will reject large-scale, expensive technical proposals from the scientific community when such proposals are presented on an all-or-nothing basis. In rare cases, usually characterized by crisis, the leadership will grant autonomy to the scientists. More often, however, autonomy is achieved by establishing the support of a strong constituent.

This is a disquieting assertion for governmental leaders. Leadership wants to be in control of innovative programs to ensure that money is not spent unwisely, and that credit will be gained in the event of success. Recent examples of leadership management of programmatic innovations indicate that it has become increasingly difficult for leaders to deny their urge to manage new programs into the ground. Both the space station and SDI have been subjected to an endless stream of Congressional hearings and high level administrative oversight reviews. Both programs have been stymied by the inability of the scientists to define to the leadership exactly what their mission is and how they intended to accomplish it. Does increased leadership intervention and inspection mean an end to innovation?

To consider this question, we should return to a figure provided in Chapter 1 illustrating the relationship between originality and scale.

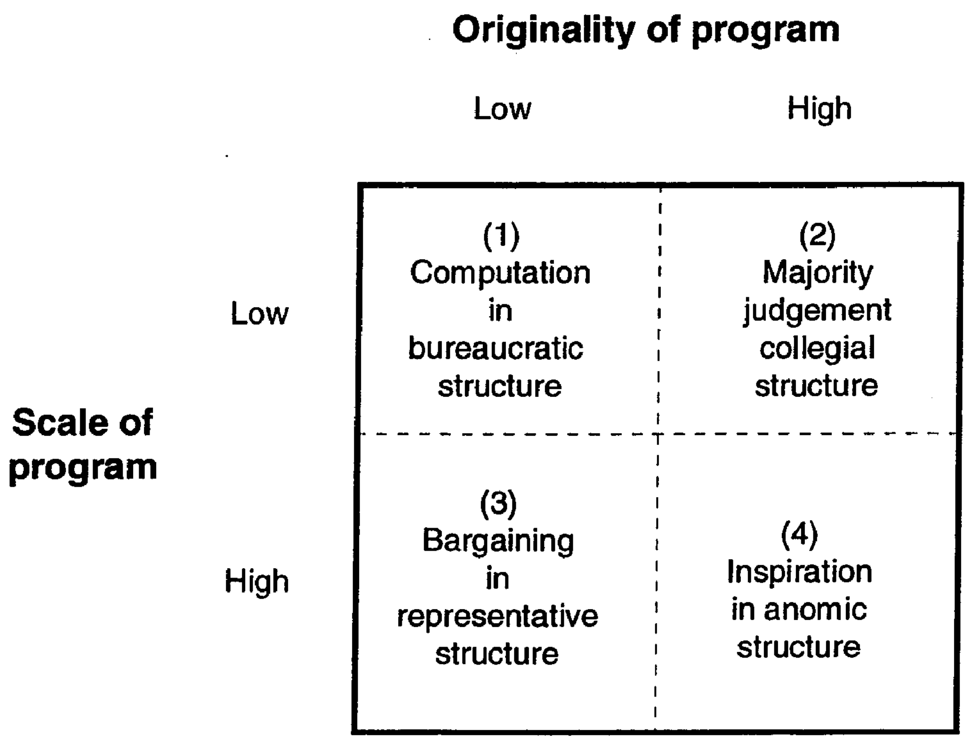

Figure 7.1 Originality and Scale of New Technology Programs

Governments are most uncomfortable in cell 4. There is a strong inclination to shift the decision-making process to cell 3 when they do not understand the new technology or mission in large scale programs. Often however, their bargaining is be based upon a misinterpretation of goals. Thus, early space station decisions were based on geographic distribution of government contracts rather than potential scientific benefits.[45] New programs become matters of intense political bargaining in a zero-sum game rather than a matter of scientific analyses to remove the uncertainty. For example, he space station was approved at the expense of the super-colliding superconductor. While many policy programs can be successfully decided through political bargaining, this process is not well suited to decision-making for programmatic innovations. Inappropriate programs may be initiated, while others with strong merits may languish.

The solution may lie in reducing the scale, thereby bringing the program into cell 2 where better informed decisions ma be made by subjecting the program to review by a scientific collegium. Scale can be lowered by reducing a program into incremental decisions. The obvious way to accomplish this is to separate research from development, and development from production. Since the greatest funds are expended for production and the least for research, the leadership should allow relatively unfettered research. Development could be funded to the extent that it is needed to define mission and technological choices. Production could then be funded, but only when both mission and technology become clear.

This is not a novel idea. Klein argued in 1958:

> The central fault with the current set-up for planning and directing research and development is simply this: the uncertainties of the future cannot be resolved by pretending that they are certainties. Research and development is not a business that

---

[45] See McCurdy, *The Space Station Decision...*

> can be carefully planned and directed, not if you expect to make progress rapidly and economically.
>
> To make better progress in military R and D, one thing we must do is put more emphasis on exploring many avenues of technology without insisting that a precise goal wait at the end of each avenue. This means both more basic research and more exploratory development.[46]

Others have argued along similar lines. Rosen contends that decisions on procurement should be delayed until there is a clear military requirement for a new system. Putting his argument in the terms used here, one should eliminate the technological uncertainty through low cost research, and wait for intelligence information to reduce mission uncertainty.[47] Where mission is clear, Brown argued that technological uncertainty should be resolved through development before procurement is initiated.[48] Such a strategy places the leadership close to cell 1, where it is most comfortable.

However, giving decision-makers more opportunities to make decisions, as Rosen and Brown argue, addresses only half of the equation. In exchange for increased incrementalism, the leadership must be willing to grant the scientists complete autonomy, up to a full-scale development decision, allowing scientists to develop their prototype system with minimal oversight. This, is of course, a much more difficult policy

---

[46] Burton Klein, "A Radical Proposal for R&D," *Fortune*, May 1958.

[47] See Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military*, (Ithaca: Cornell University Press, 1991).

[48] See Michael Brown, *Flying Blind: the Politics of the U.S. Strategic Bomber Program*, (Ithaca: Cornell University Press, 1992).

prescription. How do you force policy-makers to allow scientists autonomy without interference?

The answer offered by this study suggests that the scientists will have to achieve their autonomy. The leadership will not give it to them willingly under normal circumstances. First of all, they will have to concentrate efforts on organizational issues. Technological success is seldom enough to ensure programmatic success. Three organizational issues emerged as critical for the scientists. First, they need to establish and maintain a constituency within some established government agency. Second, a flexible organizational structure must be developed. Third, the scientists must protect their informational monopoly. The onus for performance will always be on the scientists. They will have to take the initiative.

Ultimately, we must return to Wilson's dictum that innovation so often "depends upon the chance appearance of an individual, so as to confound social science theory."[49] But while we must recognize that the appearance of Sergei Korolev was the most important factor in the creation of the Soviet missile and space programs, this does not confound theory. It illuminates it. It was not the man himself, but his actions which led to innovation. It was not so much the exceptional individual, but an individual who was willing and able to take exceptional actions which led to innovation.

---

[49] See Wilson, *Bureaucracy...* esp. p. 227.

Extending applications

This study considers a narrowly defined range of innovations -- programmatic innovations. These innovations were specifically considered because they demonstrated the highest levels of originality and scale. They require that national level decision-makers operate in highly uncertain environments. What insight does this study offer on other, lower levels of technological innovation? Does it tell us anything about policy innovations?

In some cases, the transfer can be fairly straightforward. In a private corporation, large scale technological innovations are likely to be considered along very much the same dynamic. The corporate leadership will be faced with the dilemma of whether to pursue a fundamentally new and expensive research direction without assurance that the new product will perform in the market place. Investigations into cases studies of large-scale corporate innovations may prove to be a fruitful direction for further research either confirming or infirming the general theory presented here. This might provide particularly fertile ground for comparing innovations with emulations. The major caution with such studies is that it may be difficult to find cases in which the innovations involve high levels of both mission and technical uncertainty.

Within the government, there may be instances where innovations at lower levels, for example, project innovations, might remain compartmentalized within an agency, or subsystem modifications might remain compartmentalized in an office. However, it will be difficult to locate cases which feature high levels of mission and technological uncertainty (cell 4 above). My expectation is that even in such cases, the agency, or office, will attempt to differ the decision either up to higher levels of authority outside the agency, or create an external scientific review board.[50] Therefore, the application of this study to those levels may be difficult.

Application of this model to policy innovations is likely to be even more problematic. Policy innovations present different concepts of uncertainty and scale. In policy innovations while there can be uncertainty surrounding the basic objectives and the ability of suggested programs to achieve those objectives, political leaders tend to have a better understanding of even the highest levels of policy uncertainty than they do moderate levels of technical uncertainty. Leadership may have to turn to policy experts for advice on these issues.[51] In this sense, there may be a similar need to allow experts the freedom to develop their concepts.

Regarding the concept of scale, I believe the differences are likely to be significant. Policy experts do not need large sums of money to develop ideas. Even after a decision is made to enact a policy, a political leader can reverse the decision without loosing large sums of money. There are other important differences from the experts' position. Experts do not need to form into organizations capable of producing hardware. Once a decision is

---

[50] The first assertion draws form Wilson, *Bureaucracy...*; the second from Thompson and Tuden,...

[51] See Polsby, *Political Innovation In America...*

made, it is not the experts who typically implement the innovation. Existing agencies are saddled with this responsibility. For these reasons alone, though there are likely to be others, the theory advanced here is likely to have limited application to policy innovations.

The most fruitful extension of the theory may be toward other nations. Does the relationship outlined here between the scientists and the state leadership apply to innovations (or emulations) in Japan, China, or Brazil? Are these nations locked into a pattern of emulation from which it will take the equivalent of a Sergei Korolev to break through to innovation? Will they follow a similar pattern? Discussions of state sponsored technological innovations in other countries outside of the defense and space arena will be particularly interesting investigations in these other countries. Through these investigations, the theory advanced here can be further refined and adapted.

BIBLIOGRAPHY

Achen, Christopher H. and Snidal, Duncan, "Rational Deterrence Theory and Comparative Case Studies," *World Politics,* vol. 41 (1989).

Allison, Graham T., "Questions About the Arms Race: Who's Racing Whom? A Bureaucratic Perspective" in Robert L. Pfaltzgraff Jr. *Contrasting Approaches to Strategic Arms Control,* Lexington MA: D.C. Heath, 1974.

Anisimov, N.L., and Oppokov, V.G., "Proisshesvie v NII-3," *Voenno-Istoricheskii Zhurnal,* 11:89.

Avduevskii, V.S. and Grishin, S.P., "Razvitie raketnoi tekhniki v SSSR v period 1946--1957 gg." in D'ianenko, S.M., *Issledovaniia Po Istorii i Teorii Razvitiia Aviatsionnoi i Raketno-Kosmicheskoi Nauki i Tekhniki, Vol. III,* Moscow: Nauka, 1984.

________, (ed.) *M.V. Keldysh: Raketnaia Tekhnika i Kosmonavtika,* Moscow: Nauka, 1991.

Baier, Vicki Eaton, March, James G., and Saetren, Harald, "Implementation and Ambiguity," in James G. March, *Decisions and Organizations,* Cambridge: Basil Blackwell, 1988.

Bailes, Kendall E., *Technology and Society Under Lenin and Stalin: Origins of the Soviet Technical Intellgentsia, 1917-1941,* Princeton: Princeton University Press, 1978.

Bazhinov, I.K., "O teoreticheskikh isslecovaniiakh problem sozdaniia iskusstvennykh sputnikov zemli v SSSR v 1947-1956 gg." Separate publication Academy of Scientists Institute of the Natural Sciences and Technology, Moscow: Nauka, 1981.

Beard, Edmund, *Developing the ICBM: a Study in Bureaucratic Politics,* New York: Columbia University Press, 1976.

Bendor, Jonathan, Taylor, Serge, and Van Gaalen, Roland, "Stacking the Deck: Bureaucratic Missions and Policy Design," *American Political Science Review,* Vol. 81, pp. 873-896.

Berliner, Joseph, *The Innovation Decision in Soviet Industry,* Cambridge: MIT, 1976.

_______, "The Informal Organization of the Soviet Firm," in Joseph Berliner, *Soviet Industry: From Stalin to Gorbachev,* Ithaca: Cornell, 1988.

Brooks, Harvey, "The Military Innovation System and the Qualitative Arms Race," *Daedalus,* Vol. 104 (Summer 1975).

Brown, Michael, *Flying Blind: the Politics of the U.S. Strategic Bomber Program,* Ithaca: Cornell University Press, 1992.

Brzezinski, Zbigniew, *The Soviet Bloc: Unity and Conflict,* Cambridge MA: Harvard University Press, 1960.

_______, and Huntington, Samuel P., *Political Power: USA/USSR,* New York, 1972.

Burns, T. and Stalker, G.M., *The Management of Innovation,* London: Tavistock, 1961.

Bush, Vannevar, *Modern Arms and Free Men,* New York: Simon and Schuster, 1949.

Central intelligence Agency, *The Soviet Weapons Industry,* Washington D.C.: GPO, 1986.

Chertok, Boris, *Raketi i Liudi,* Moscow: Mashinostroenie, 1994.

Chisholm, Donald, *Coordination Without Hierarchy: Informal Structures in Multiorganizational Systems,* Berkely, University of California Press, 1989.

Cohen, Michael D., March, James G. and Olsen, Johan P., "A Garbage Can Model of Organizational Choice," *Administrative Sciences Quarterly,* Vol. 17 (1972) pp. 1-25.

Conquest, Robert, *Stalin: Breaker of Nations,* New York: Viking Books, 1991.

Coulam, Robert F., *Illusions of Choice: The F-111 and the Problem of Weapons Acquisition Reform,* Princeton: Princeton University Press, 1977.

Daniloff, Nicholas, *The Kremlin and the Kosmos,* New York: Alfred A. Knopff, 1972.

Deagle, Edwin A., Jr., "Organization and Process in Military R&D," in Franklin A. Long and Judith Reppy, *The Genesis of New Weapons: Decision Making for Military R&D,* New York: Pergammon Press, 1980.

Devons, Ely, "The Problem of Co-ordination in Aircraft Production," *Papers on Planning and Economic Management,* Manchester: Manchester University Press, 1970.

Djilas, Milavan, *Conversations with Stalin,* New York: Harcort, 1962.

Doig, Jameson W. and Hargrove, Erwin C., *Leadership and Innovation: a Biographical Perspective on Entrepreneurs in Government,* Baltimore: Johns Hopkins University Press, 1987.

Downs, Anthony, *Inside Bureaucracy,* Boston: Little Brown, 1967.

Downs, George W. and Mohr, Lawrence B., "Conceptual Issues in the Study of Innovation," *Administrative Sciences Quarterly,* Vol. 21 (December 1976) pp. 700-714.

Dunmore, Timothy, *Soviet Politics 1945-53,* London: Macmillan, 1984.

Eckstein, Harry, "Case Study in Political Science," pp. 79-137 in Fred I. Greenstein and Nelson W. Polsby (eds.) *Handbook of Political Science, Volume 7,* Reading MA: Addison-Wesley, 1975.

Eneev, T.M., "Spusk s iscusstvennogo sputnika zemli s tormozheniem v atmosfere" collection of Keldysh Institute of Applied Mathematics Muséum.

Erikson, John, *The Road to Berlin: Continuing the History of Stalin's War with Germany,* Bolder Col.: Westview, 1983.

Evangelista, Matthew, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies,* Ithaca NY: Cornell, 1988.

________, "The Paradox of State Strength: Transnational Relations, Domestic Structures, and Security Policy in Russia and the Soviet Union," *International Organization,* Vol. 49:1 (Winter 1995) pp. 1-38.

Fama, Eugene, "Agency Problems and the Theory of the Firm," *Journal of Political Economy,* Vol. 88 (April, 1980) pp. 288-307.

________,and Michael C. Jensen, "Separation of Ownership and Control," *Journal of Law and Economics,* Vol. 26 (June, 1983) pp. 301-325.

Frolov, K.V., *Anatolii Arkad'evich Blagonravov,* Moscow: Nauka, 1982.

George, Alexander, "Case Studies and Theory Development," paper presented to the Second Annual Symposium on Information Processing in Organizations, Carnegie-Mellon University, October 15-18, 1982.

Gershenkhron, Alexander, *Economic Backwardness in Historical Perspective,* Cambridge: Harvard University Press, 1962.

Glushko, Valentin, *Rocket Engines: GDL-OKB*, Moscow: USSR Academy of Sciences Press.

________, *Perviy v Mire,* Moscow: Nauka, 1981.

________, *Razvitie Raketostronniia i Kosmonavtiki v SSSR*, Moscow: Mashinostroenie, 1987.

Golovanov, Iaroslav, "Start kosmicheskii ery," *Pravda,* October 4, 1987.

________, *Korolev: Fakty i Myfy,* Moscow: Nauka, 1994.

Gruber, William H. and Marquis, Donald G. eds., *Factors in the Transfer of Technology,* Cambridge: MIT Press, 1969.

Hahn, Werner, *Post-War Soviet Politics: The Fall of Zhdanov and the Defeat of Moderation 1946-53,* Ithaca: Cornell University Press, 1982.

Halpern, Morton H., *Bureaucratic Politics and Foreign Policy,* Washington D.C.: Brookings, 1974.

Holloway, David, "Innovation in the Defense Sector: Battle Tanks and ICBMs," in Ronald Amann and Julian Cooper, *Industrial Innovation in the Soviet Union,* New Haven: Yale University Press, 1982.

________, *Stalin and the Bomb: The Soviet Union and Atomic Energy 1939-1956,* New Haven: Yale University Press, 1994.

Hone, Thomas C. and Mandeles, Mark D., "Interwar Innovation in Three Navies: U.S. Navy, Royal Navy, Imperial Japanese Navy." *Naval War College Review,* Vol. 40, No. 2 (Spring 1987) pp. 63-83.

Hough, Jerry and Fainsod, Merle, *How the Soviet Union is Governed,*Cambridge: Harvard University press, 1979.

Humble, Ronald D., *The Soviet Space Programme,* London: Routledge, 1988.

Iakovlev, Aleksandr, *Raskazy Aviakostuktyra,* Moscow, 1964.

Ishlinskii, Iu.A., *Akademik S.P. Korolev: Uchenyi, Inzhener, Chelovek,* Moscow: Nauka, 1986.

Jensen, Michael C., and Meckling, Willian, "Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure," *Journal of Financial Economics,* Vol. 3 (October, 1976) pp. 305-360.

Jervis, Robert, *Perception and Misperception in International Politics,* Princeton NJ: Princeton University Press, 1976.

Kandalov, A.I. (et. al), *Andrei Nikolaevich Tupolev: Zhizn i Deatel'nost,* Moscow: TsAGI, 1991.

Kassof, Allen, "The Administered Society," *World Politics,* (July, 1964); and Maria Herszowicz, *The Bureaucratic Leviathan,* Oxford: St. Martin's, 1980.

Keldysh, M.V., *Tvorcheskoe Nasledie Akademika Koroleva,* Moscow: Nauka, 1980.

Khrushchev, Nikita, *For Victory in Peaceful Competition with Capitialism,* New York, Dutton & Co. 1960.

Khrushchev, Sergei, *Khrushchev: Raketi i Krizicy,* Moscow: Novosti, 1994.

Kimberly, John R., Miles, Robert H., and Associaes, *The Organizational Lifecycle: Issues in the Creation, Transformation, and Decline of Organizations,* San Francisco: Jossey Bass, 1980.

Kingdon, John W., *Agendas, Alternatives, and Public Policies,* Boston: Little Brown, 1984.

Klein, Burton, "A Radical Proposal for R&D," *Fortune,* May 1958.

Konovalov, Boris, "U Sovetskikh raketnykh triumfov bylo nemetskoe nachalo" *Izvestiia,* March 4, 1992 pp. 1,3

Kornai, Janos, *The Socialist System: The Political Economy of Communism,* Princeton: Princeton University Press, 1992.

Korolev, Sergei Pavlovich, "Regarding work of the bureau on aircraft rockets at OKB-RD attached to Factory No. 16" (1944) archives of the Cosmonautics memorial museum, Korolev's home museum, f.1 ed. Xp. KP 135, ll. 16-21.

_______, "Zametki po raketnoi tekhnike," 1947, NPO Energiia Archives.

_______, "Tezisy doklad po resul'tatam issledovanii perspectiv razvitiia ballisticheskikh raket dal'nego deistviia," (1949), reproduced in M.V. Keldysh (ed.) *Tvorcheskoe Nasledie Akademika, sergeia pavlovicha Koroleva,* Moscow Nauka, 1980.

_______, "O vozmoshnosti razrabotki isksstvennogo sputnika Zemli" (1954) reproduced in M.V. Keldysh (ed.) *Tvorcheskoe Nasledie Akademika, sergeia pavlovicha Koroleva,* Moscow Nauka, 1980.

_______, and M.K. Tikhonravov, "predvaritel'nye soobrazheniia o perspektivnykh rabotakh po osvoeniiu kosmicheskogo prostranstva" reproduced in *Materialy po Istorii Kosmicheskogo Koroblia "Vostok,"* Moscow: Nauka, 1991.

Kosmodemianskiy, A.A., *Konstantin Tsiolkovskii -- His Life and Work,* Moscow, Nauka, 1960.

Krasner, Stephen, *Defense and the National Interests: Raw Materials Investments and U.S. Foreign Policy,* Princeton NJ: Princeton University Press, 1978.

Kuhn, Thomas, *The Structure of Scientific Revolutions,* Chicago: University of Chicago Press, 1969.

Lapp, Ralph E., *The Weapons Culture,* New York: Norton, 1968.

Latour, Bruno, *Science in Action,* Cambridge: Harvard, 1987.

Lawless, Michael W. and Price, Linda L., "An Agency Perspective on New Technology Champions," *Organizational Science,* (1992) 3:3 pp. 342-355.

Lel'chuk, V. S., *Nauchno-Tekhnicheskaia Revolutsiia i Promyshlennoe Razvitie SSSR,* Moscow: Nauka, 1987.

Lewis, Kevin, "Balance and Counterbalance: Technology and the Arms Race," *Orbis,* Vol. 14, (Summer, 1985) pp. 259-269.

Lewis, Tracy, "Defense Procurement and the Theory of Agency," in Jim Leitzel (ed.) *Economics and National Security,* Boulder CO: Westview Press, 1993.

Lindblom, Charles, "The Science of Muddling Through" *Public Administration Review,* (1958).

MacKenzie, Donald, *Inventing Accuracy: a Historical Sociology of Nuclear Missile Guidance,* Cambridge MA: MIT Press, 1990.

Maksimov, Iu. p., *Raketnye Voiska Strategicheskogo Naznacheniia: Voenno-istoricheskii Trud,* Moscow: RVSN, 1992.

Malinovskii, Rodion Ia., "The Revolution in Military Affairs and the Task of the Military Press," as translated in William R. Kinter, and Harriet Fast Scott, *The Nuclear Revolution in Soviet Military Affairs,* Norman, OK: University of Oklahoma Press, 1967.

March, James G. and Johan P. Olsen (eds.), *Ambiguity and Choice in Organizations,* Bergen Norway: Universitetsforlaget, 1976.

_______, and Weissinger-Baylon, Roger, *Ambiguity and Command: Organizational Perspectives on Military Decision Making,* Marshfield MA: Pitman Publishing, 1986.

McCubbins, Mathew D. and Schwartz, Thomas, "Congressional Oversight Overlooked: Police Patrols versus Fire Alarms, *Political Sciences Quarterly,* Vol. 28:1 (1984) pp. 165-179.

McCurdy, Howard, *The Space Station Decision: Incremental Politics and Technological Choice,* Baltimore: Johns Hopkins, 1990.

McDougall, Walter A., *The Heavens and the Earth: a Political History of the Space Age,* New York: Basic Books, 1985.

Medaris, John B., *Countdown to Decision;* New York: G.P. Putnam's and Sons, 1960.

Medvedev, Roy, *All Stalin's Men,* New York: Doubleday, 1985.

Meyer, Alfred, "USSR Incorporated," *Slavic Review,* October 1961.

Moe, Terry, "The New Economics of Organization," *American Journal of Political Science,* Vol. 28 (November, 1984) pp. 739-777.

_______, "Politics and the Theory of Organization," *Journal of Law, Economics and Organization,* Vol. 7 (1991 special edition) pp. 106-129.

Morrison, Elting, *Men, Machines and Modern Times,* Cambridge: MIT Press, 1966.

Mowery, David C. and Rosenberg, Nathan, "The U.S. National Innovation System," in Richard R. Nelson (ed.) *National Innovation Systems: A Comparative Analysis,* Oxford: Oxford University Press, 1993.

Mozhorrin, Iuri A. *Dorogi v Kosmos Vol. 1,* Moscow: Moscow Aviation Institute, 1992.

_______, *Dorogi v Kosmos Vol. II,* Moscow: Moscow Aviation Institute, 1992.

_______, "Istoriia sozdaniia i razvitiia Tsentral'nye nauchno-issledovatel'skii institute mashinostroeniia," *Kosmonavtika i Raketostroenie,* Vol. 1, No. 1 (1993) pp. 28-38.

Nederhof, A.J., "Between Accommodation and Orchestration: The Implementation the Science Policy Priority for Biotechnology in the Netherlands," *Research Policy,* Vol. 19(1990) pp. 379-386.

Negin, E.A., *Sovetskii Atomni Proekt: Konets Atomnoi Monopoli. Kak eto Bylo...;* Nizhnyi Novgorod: Nizhnyi Novgorod Press, 1995.

Nove, Alec, *An Economic History of the USSR: 1917-1991,* Middlesex UK: Penguin Books, 1993.

Ordway, Frederick, *The Rocket Team,* Cambridge, MA: MIT Press, 1972.

Pappo-Korystin, V.(et. al.) *Dneprovskii Raketno-kosmicheskii Tsentr,* Dnepropetrovsk, Ukraine: POIu.Z., KBiuZ, 1994.

Parrot, Bruce, *Politics and Technology in the Soviet Union,* Cambridge: MIT, 1983.

Pastukhova, Mariia, "Iarche liuboi legende" *Ogonek,* #49, (December 1987).

Perry, Robert L., *System Development Strategies: A Comparative Study of Doctrine, Technlogy, and Organization in the USAF Ballistic and Cruise Missile Programs, 1950-1960* (Santa Monica: RAND, 1966) RM-4853-PR.

Petrakov, V.M., "O vklade OKB-23 V.M. Miasishcheva v prakticheskoe osyshchestvlenie idei K.E. Tsiolkovskogo" paper presented at the 25th annual Tsiolkovskii Lectures, Kaluga, Russia September 1991.

Pfeffer, Jeffrey, *Power in Organizations,* Cambridge: Ballinger, 1981.

Poliarin, A.N., "K 50-letiiu organizatsii konstruktorskogo biuro #7 po raketam na zhidkom toplive," in *Iz istorii aviatsii i kosmonavtikii,* Moscow: AN SSSR, 1986.

Polsby, Nelson W., *Political Innovation in America: the Politics of Policy Initiation,* New Haven: Yale University Press, 1984.

Posen, Barry, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars,* Ithaca: Cornell, 1984.

Potter, William, "Issue Area and Foreign Policy Analysis," *International Organization,* (Summer 1980).

Powers, Thomas, *Heisenberg's War: the Secret History of the German Bomb,* Boston: Little Brown, 1993.

Ra'anan, Uri and Lukes, Igor, *Inside the Apparat: Perspectives on the Soviet Union from Former Functionaries,* Lexington MA: D.C. Heath, 1990.

Rathjens, George, "the Dynamics of the Arms Race," *Scientific American,* April, 1969.

Raushenbakh, B.V., *Iz Isororii Sovetskoi Kosmonavtiki,* Moscow: Nauka, 1986.

Reeves, Robert, *The Superpower Space Race: An Explosive Rivalry Through the Solar System,* New York: Plenum Press, 1994.

Rhodes, Richard, *The Making of the Atomic Bomb*, New York: Simon and Schuster, 1986.

Richelson, Jeffrey, *American Espionage and the Soviet Target,* New York: Quill, Willian Morris, 1987.

Rigby, T.H., "Stalinism and the Mono-organizational Society," in Robert C. Tucker, *Stalinism: Essays in Historical Interpretation,* New York: W.W. Norton, 1977.

________, *The Changing Soviet System,* Brookfield VT.: Edward Elgar, 1990.

Rip, Are and Nederhof, Anton J., "Between Dirigism and Laissez-Faire: Effects of Implementing the Science Policy Priority for Biotechnology in the Netherlands," *Research Policy,* Vol. 15 (1986) pp. 253-268.

Rogers, E. and Schoemaker, F., *Communications of Innovations,* New York: Free Press, 1971.

Romanov, A.P. and Gubarev, V.S., *Konstruktori*, Moscow: Politizdat, 1989.

Rosen, Stephen Peter, *Winning the Next War: Innovation in the Modern Military,* Ithaca: Cornell University Press, 1991.

Rosneau, James N., "Pre-Theories of Foreign Policy," in Barry Farrel ed. *Approaches to Comparative and International Politics,* Evanston Ill.: Northwestern University Press, 1966.

Rush, Myron, *Political Succession in the USSR,* New York: Columbia University Press, 1965.

Progress: gazeta tsentral'nogo nauchno-issledovatel'skogo instituta mashinostroeniia, May 23, 1991.

Rudenko, M., "Uskol'znyvshaia luna," *Ekonomika i Zhizn,* No. 40 (October 1991)

Sapolsky, Harvey, *The Polaris System Development: Bureaucratic and Programmatic success in Government* Cambridge: Harvard University Press, 1972.

Sappington, David E. M., "Incentives in Principal-Agent Relationships," *Journal of Economic Perspectives,* Vol. 5, No. 2, (Spring 1991) pp. 45-66.

Schaeur, William, *The Politics of Space: A Comparison of the Soviet and American Space Programs,* New York: Holmes and Meier, 1976.

Schroeer, Deitrich, *Science, Technology and the Arms Race,* New York: Wiley, 1984.

Schulman, Paul R., *Large-scale Policymaking,* New York, Elsevier, 1980.

Schwiebert, Ernest G., "USAF Ballistic Missiles -- 1954-1964" in *Air and Space Digest,* (May 1964).

Scott, Harriet Fast, and Scott, William F., *The Armed Forces of the USSR,* Boulder: Westview Press, 1979.

Serebrenikov, V.A., Serov, G.P, Tarasenko, M.L., "O deatel'nosti KB Lavochkina v oblasti raketnoi tekhniki," paper presented at the 9th Moscow Symposium On the History of Aviation and Cosmonautics, June 1993, Moscow.

Shapely, Deborah, Roy, Rustrum, *Lost at the Frontier: U.S. Science and Technology Policy Adrift,* Philadelphia: ISI Press, 1985.

Simon, Herbert A., "Organizations and Markets," *Journal of Economic Perspectives,* Vol. 5:2 (Spring 1991).

Skopinskii, Iu. A., "Gospriemka kosmicheskoi programy" *Zemlia i Vselennaia* No. 5 (September-October) 1988, pp. 73-79.

Spielmann, Karl F., *Analyzing Soviet Strategic Arms Decisions,* Boulder: Westview Press, 1978.

Stares, Paul B., *The Militarization of Space: U.S. Policy, 1945, 1984,* Ithaca, Cornell University Press, 1985.

Stein, Jonathan B., *From H-Bomb to Star Wars: The Politics of Strategic Decision Making,* Lexington MA: Lexington Books, 1984.

Stinchcombe, Arthur L., *Information and Organizations,* Berkeley CA: University of California Press, 1990.

Sutton, Antony C., *Western Technology and Soviet Economic Development, 1945-1965,* Palo Alto: Stanford University Press, 1973.

Talbott, Strobe, and Khrushchev, N.S., *Khrushchev Remembers: the Last Testament,* New York: Little Brown, 1971.

Teece, David J., "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy," *Research Policy,* Vol. 15 (1986).

Thompson, James D., *Organizations in Action*, New York: McGraw-Hill, 1966.

_______and Tuden, Arthur, "Strategies, Structures, and Process of Organizational Decision," in James D. Thompson et. al. *Comparative Studies in Administration,* Pittsburgh: University of Pittsburgh Press, 1959.

Thompson, Victor, *Bureaucracy and Innovation,* University Alabama: University of Alabama Press, 1969.

Tikhonravov, M.K., "Puti ocushchestvleniia bolshikh dal'nostei strel'by raketami, Doklad v Akademii Artilerichekikh nauk, July 14, 1948)" *Raketnaia Tekhnika,* January 1980.

M.K. Tikhonravov, S.P. Korolev, "Dokladnaia zapiska ob iskusstbennom sputnike zemli," (1954) reproduced in *Materialy po Istorii Kosmicheskogo Koroblia "Vostok,"* Moscow: Nauka, 1991.

Tiulin, G., "Godi, sversheniia, liudi," in G. Miranovich, *Otvaga Iskani,* Moscow: Krasnaia Zvezda, 1989.

Tokaty, G.A., "Soviet Space Technology" *Space flight,* Vol. 5, No. 2 (March 1963), pp. 58-64.

Tolubko, V., *Nedelin: Pervyi Glavkovm Strategicheskikh,* Moscow: Molodaia Gvardiia, 1979.

Ulam, Adam, *Expansion and Coexistence: Soviet Foreign Policy 1917-1973,* New York: Holt, Reinhart and Winston, 1974.

van Crevald, Martin, *Technology and War: From 2000 B.C. to the Present,* New York: Free Press, 1989.

Varfolomeyev, Timothy, "Soviet Rocketry that Conquered Space," *Space Flight,* Vol. 38, January, 1996.

Vetrov, Georgi S., "Mikhail Kladevich Tikhonravov, k 80 letniu dnia rozhdeniia" *Zemlia i Vselennaia,* May 1980, p. 40.

______, *S.P. Korolev i Kosmonavtika: Pervie Shagi,* Moscow: Nauka, 1991.

_______, *Sekrety Ostrova Gorodomliia* (mimeo) 1991.

_______, *S.P. Korolev i Kosmonavtiki: Pervye Shagi,* Moscow: Nauka, 1993.

Voslensky, Michael, *Nomenklatura: the Soviet Ruling Class,* New York: Doubleday, 1984.

Waltz, Kenneth, *Theory of International Politics,* Reading MA: Addison-Wesley, 1979.

Webb, James E., *Space Age Management: The Large-scale Approach,* New York: McGraw-Hill, 1969.

Weingast, Barry, "The Congressional-Bureaucratic System: A Principal-Agent Perspective," *Public Choice* Vol. 44 (1984) pp. 147-192.

Wildavsky, Aaron, "The Self-Evaluating Organization," *Public Administration Review,* Vol. 32 (1972).

Williamson, Oliver, *Markets and Hierarchies: Analysis and Antitrust Implication,* New York: Free Press, 1975.

Wilson, James Q., "Innovation in Organizations: Notes Toward a Theory," in James D. Thompson, *Approaches to Organizational Design,* Pittsburgh: University of Pittsburgh Press, 1966.

_______, *Bureaucracy: What Government Agencies Do and Why They Do It,* New York: Basic Books, 1989.

Wohlstetter, Albert, "Legends of the Strategic Arms Race, *Strategic Review,* Fall 1974, pp. 5-48.

Wukelic, George E. (ed.) *Handbook of Soviet Space-Science Research,* New York: Gordon and Breach Science Publishers, 1968.

York, Herbert, *Race to Oblivion: A Participants View of the Arms Race,* New York: Simon and Schuster, 1974.

_______, *The Advisors: Oppenheimer, Teller, and the Superbomb,* San Francisco: W.H. Freeman and Company, 1976.

_______, *Making Weapons, Talking Peace,* New York: Basic Books, 1987.

Zaloga, Steven J., *Target America: The Soviet Union and the Strategic Arms Race 1945-1964,* Novato: Presidio, 1993.

Zaltman Gerald, Duncan, Robert, and Holbeck, Jonny, *Innovations and Organizations,* New York: John Wiley and Sons, 1973.

Zimmerman, William, "Issue Area and Foreign-Policy Processes: A Research Note in Search of a General Theory," *American Political Science Review,* Vol. 67 (December 1973) pp. 1204-1212.

Zuckerman, Solly, *Nuclear Illusion and Reality,* New York: Viking, 1982.