TRANSFORMING FEDERAL INFORMATION

TECHNOLOGY ACCOUNTABILITY

by

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ABSTRACT

Changes in federal information technology accountability were studied in this dissertation. The topic is at the intersection of two great trends that are altering the course of federal government in the United States, namely, the ever-expanding role of information technology and accountability reform. At any point in time in the mid-1990s over 700 federal information technology projects valued at more than $100 billion total are underway. Their accountability mechanisms were subjected to considerable reform in the mid-1990s which culminated in the Information Technology Management Reform Act, enacted in February 1996.

This study assessed those changes. The hypothesis was that reform of information technology accountability practices in the mid-1990s will cause improved economy and efficiency in federal agencies' largest and most important information technology programs. The overall research employed a two-stage design. The first stage surveyed the federal information technology community. The second stage studied two major federal information technology programs, namely, the Federal Aviation Administration's Advanced Automation System and the National Oceanographic and Atmospheric Administration's Advanced Weather Information System. Together, the results of the two stages were used to forecast the success of the new accountability methods.

The research results showed that the overall federal-level focus on information technology will not diminish. Instead the new reform direction will centralize and strengthen statutory authority for information technology oversight in the Office of Management and Budget (OMB) at the government-wide level. Those changes, as implemented, will be facilitative rather than oversight oriented, and OMB will seek to manage through collaborative responsibility rather than control by means of

management oversight. Nonetheless, without oversight and an "M" in OMB, success may be elusive when addressing endemic problems such as the multi-billion dollar cost overruns of some major systems development programs. With those important exceptions, the 1996 legislative changes have a good probability of improving the success of many other programs which encounter only easily correctable problems, including enhancing their timely and cost-effective delivery of mission-level results.

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INTRODUCTION AND STATEMENT OF THE PROBLEM

A. Introduction

Changes in federal information technology accountability are studied in this dissertation. The topic is at the intersection of two great trends that are altering the course of federal government in the United States, namely, the ever-expanding role of information technology and accountability reform. At any point in time in the mid-1990s, over 700 federal information technology projects valued at more than $100 billion total are underway. Their accountability mechanisms seem to be constantly scrutinized and subjected to considerable reform.

"[W]e will re-engineer government activities, making full use of computer systems and telecommunications to revolutionize how we deliver services . . ." promised the Clinton Administration in the National Performance Review (NPR, 1993). This commitment at the federal level apparently arose in large part from the hue and cry being raised throughout the mid-1990s about the costs, types and quality of services provided by all levels of government throughout the United States. Information technology has also been at the forefront of even higher-level debates about government's size, scope and types of services because it has been perceived by many as being closely intertwined with government's ability to change and "reinvent" its methods and purposes. Moreover, information technology has continued to be regarded throughout the mid-1990s as the engine-of-choice for "re-engineering" and "business process improvement."

On the accountability front, many people throughout the mid-1990s have said that it is time to strip away oversight controls and layers of accountability which have stifled innovation and prevented people in agencies from effectively doing their jobs. Such critics have demanded either elimination of oversight or radically streamlined control mechanisms; that is, "[W]e must untangle the knots of red tape that prevent government from serving the American people well" (NPR, 1993, p.13). Politically, both Republicans and Democrats have been philosophically alike because they have spoken almost daily about "cutting out the layers." Some preliminary steps had already been taken to reform information technology accountability early in the Clinton Administration. However, even more significant changes were passed by Congress under the Information Technology Management Reform Act and were signed into law by President Clinton in February 1996. This reform is likely to have wide reaching effects that will permeate throughout the entire federal government for many years to come.

Numerous information technology programs have been rapidly propagated in this dynamic environment. Federal information technology budgets have continued to grow at a time when massive cuts have loomed across all agencies. "Cutting red tape" has become a mid-1990s reality in the oversight of many of these programs. Yet, these reforms may affect the federal government's future ability to hold individual agencies accountable for the outcomes of their information technology programs. The potential long-term consequences are enormous because major information technology programs are very costly and stretch in impact across years or even decades, thereby, ultimately affecting each agency's ability to perform its mission.

This study assesses whether mid-1990s Clinton Administration and 104th Congressional reform of information technology accountability practices will cause improved economy and efficiency in federal agencies' largest and most important information technology programs. To date, research has been sparse in this cutting-edge area. This study is intended to fill some of those gaps in knowledge about these issues. Also, it identifies related topics for follow-on research opportunities. Only those documents, books and records which are available to the general public were used in researching this paper.

B. Statement of the Problem

A formal statement of the study problem is provided in this section. The research question is presented along with additional information about the scope of this study. The section concludes with an outline of this dissertation.

Research Question

Accountability for federal information technology in the mid-1990s is a topical and turbulent area of public administration theory and practice. The old, hierarchical oversight structures built over the last 30 years are being forcibly torn down while, at the same time, scholars and practitioners continue to develop new theories and methods. Words and deeds have already caused major redirection of the central management agencies' roles. The enormity of these changes may affect the success of federal agencies' information technology programs, thereby suggesting the following research question which is addressed in the dissertation:

> *Will mid-1990s Administration and Congressional reform of information technology accountability practices cause improved economy and efficiency in federal agencies' largest and most important information technology programs?*

Additional information about this area of research and its background is provided in the following sections of this chapter.

The Phenomenon of Information Technology

Information technology is a relatively recent phenomenon, but it has already had an almost inestimable impact on civilization and governance. Probably everyone in the United States has already been impacted by the computer revolution; the history of the human race is even now being radically transformed by information technology's advent.

Imagine calculating all United States social and economic statistics, air traffic information and construction of the atomic bomb using pencils, paper and only a few mechanical adding machines. Yet, that is how public business was conducted until the 1950 Census which was the first significant federal application of computer technology to a major information problem. More opportunities came with improving technology and better pricing in the 1950s and 60s. However, serious federal information technology procurement problems ultimately caused passage of Public Law 89-306, the Brooks Act, in 1965. This was the first serious foray into federal information technology accountability and oversight.

Over the intervening years, additional accountability initiatives have built a complex hierarchy to oversee federal agencies as they devise information technology programs to develop and implement new information systems, or to modify existing systems in order to meet their governmental responsibilities. Three central management agencies, namely the General Services Administration, the General Accounting Office and the Office of Management and Budget emerged to dominate information technology oversight into the mid-1990s. Each has had a different but somewhat complementary role in the existing structure. However, roles of the Office of Management and Budget and the General Services Administration were radically transformed with legislation that was enacted in February 1996. The probable impacts on information technology accountability caused by transformation of their roles is a touchstone of this study.

Three observations characterize the state of federal information technology in the mid-1990s: (1) The magnitude is enormous; information technology funding exceeds $25 billion each year; (2) information technology leverages even larger dollars because it directly affects every federal agency's ability to perform its mission; and (3) large and costly federal information technology failures have drawn persistent public and congressional criticism. Clearly, an often-controversial procurement motif is woven throughout information technology and its oversight.

For these reasons, accountability for federal information technology programs engendered spirited debate, especially throughout 1995 and the first few months of 1996. Commingled within those debates were intrinsic issues and underpinnings of economy and efficiency. Several proposals had previously emerged to remedy perceived information ills by transforming federal accountability practices into new precepts, attributes and mechanisms. With the enactment of the Information Technology Management Reform

Act in February 1996, significant information technology reform occurred, and the possibility of its success is an important focus of study in this dissertation.

Information Technology Oversight Periods

Even prior to the February 1996 law, Administration changes and prior National Performance Review (NPR) induced reforms were already underway which had the intention of refocusing central management agencies on information technology economy and efficiency. The totality of those changes provide one venue for comparison in this study because they suggest that information technology accountability and oversight can be arrayed into three periods (Figure I-C-1).

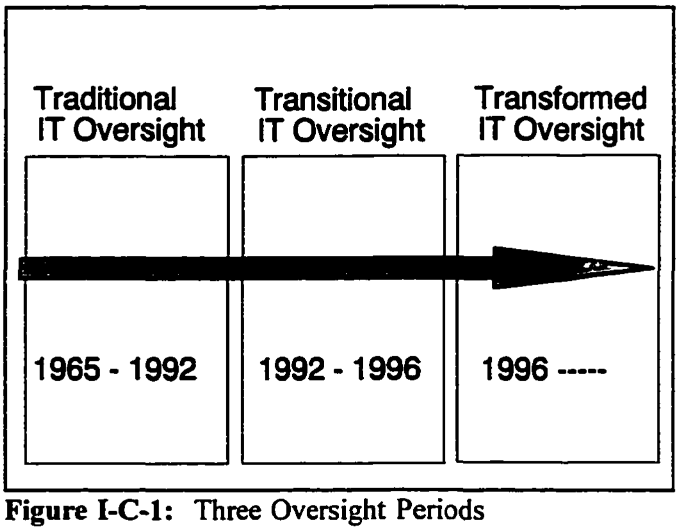

Figure I-C-1: Three Oversight Periods

Within this taxonomy, a *Traditional* period of hierarchical oversight existed from the Brooks Act's inception until 1992. Then, the NPR induced a *Transitional* mode and revised oversight practices from 1992 through February 1996. As of that date, the Information Technology Management Reform legislation included as Division E in the 1996 Defense Authorizations Act had been enacted. Information technology was on the cusp of a new or *Transformed* mode which would embody still another set of accountability precepts and mechanisms.

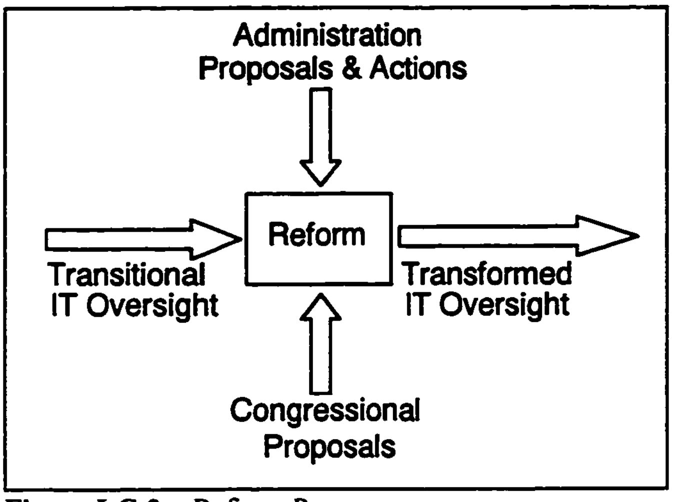

Figure I-C-2: Reform Process

Both the Administration and Congress had previously devised proposals which led to this transformation of oversight roles and methods (Figure I-C-2). Clearly, both had their own perceptions of the causes and nature of information technology's ills; each had its individual and specific reform goals.

A few years earlier an intermix of congressional and administration perceptions and actions had converted the *Traditional* approach into the *Transitional* period under the broad umbrella of the National Performance Review reforms during the first two years of the Clinton Administration. In fact, those years embraced a ground swell of reform efforts that foresaw information technology having a key role in the new order. Those changes laid a malleable foundation and helped line up the targets for the next set of changes. By 1995 both the Republican-led 104th Congress and the Administration had outlined their plans for information technology reform based upon their respective perceptions of both the problems and the cures.

However, actual *Transformed* era reform outcomes may differ from Administration intentions or Congressional expectations due to the very nature of their values and individual perceptions about information technology problems; reality and beliefs often differ (figure I-C-3). This difference is a crucial one, because it is the ultimate rationale for this study; reform may paint the sky chartreuse rather than blue, in spite of the best intentions.

The three oversight periods can be characterized by their principal documents. The Brooks Act guided the Traditional period (PL 89-306). The National Performance Review was the philosophical underpinning of the Transitional era (NPR, 1993). Finally, Senator Cohen's Computer Chaos report undergirded the birth of the Transformed era (Cohen, 1994). Each of those documents brought major changes as information technology entered another era. The changes from each period to the next were tested in this study to identify the probable success of future outcomes in the third, the *Transformed* era.

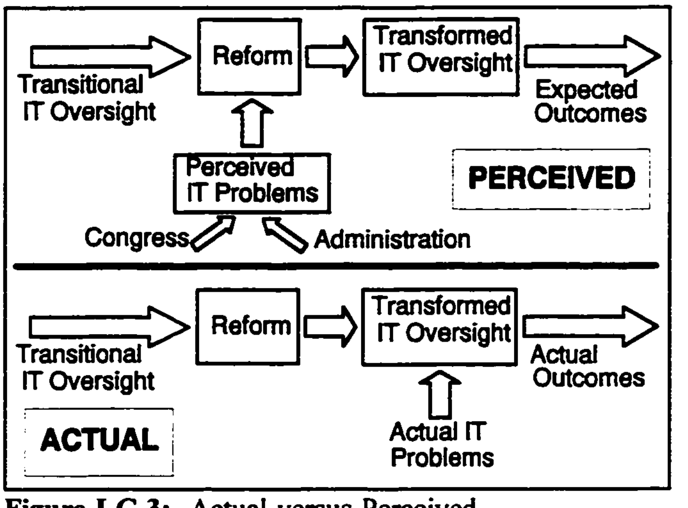

Figure I-C-3: Actual versus Perceived

Research Question Basis

Two important and overarching themes seem to have emerged from mid-1990s administration and congressional beliefs, namely, information technology as a key component in "reinvention" and, secondly, transformation of central management agencies through reform to focus specifically on economy and efficiency. Together they form a fundamental basis for studying the impact of transformations of information technology accountability.

Clearly, economy and efficiency is important in its own right; the federal government is managing over $100 billion in mission-critical information technology procurements at any given time. Also, information technology oversight reform can serve as a generalized model since it is, in effect, a microcosm of overall federal oversight, accountability and control activities, albeit for a highly specialized area. Finally, any changes will have significant long-term consequences because information technology programs often take years and can drive agencies for decades, hence completing the basis for the research question. Some additional background information about information technology and accountability is provided in the next two chapters after which the research question is addressed in chapters V and VI and synthesized in chapter VII.

Related Research

Some remarks about related research efforts are appropriate before concluding this chapter. In general, scholarly research specifically focused on federal-level information technology accountability reform has been sparse. Moreover, research about the specific topic of this paper had not been reported in the literature as of mid-1996. One important reason was that reform of federal information technology accountability had just been consummated in February 1996. Therefore, the findings in this study are new, and there is no comparative basis for the results.

However, there has been research at the broader and higher-level areas of information technology and accountability; some of that has been at the federal level. Federal information technology accountability is a point of nexus which conjoins those two important areas of public administration research. Procurement is a theme which is woven throughout both of those areas. Therefore, some of the research and findings reported in the literature about related parts of those areas are described, as appropriate, in subsequent chapters.

This dissertation is organized, as follows. Information technology and its associated federal accountability processes are the topics of chapters II and III, respectively. Chapter IV formulates the study methodology, and chapters V and VI give results from a survey of information professionals and two case studies, respectively. Those results are synthesized in Chapter VII which also provides concluding remarks and suggests additional topics for research.

CHAPTER II

INFORMATION TECHNOLOGY BACKGROUND

Individuals today have rapid access to an enormous span of knowledge through information technology's wide availability, declining costs and increasing functionality. Information technology empowers people to perform an ever-expanding range of tasks which could only be performed, previously, by large organizations such as industry giants or big governments due to their cost-driven and immense economies of scale. However, over the last three decades, information technology has transformed, forever, the face of human existence. Personal computers provide word processing capabilities in myriad settings; computers and modems are a familiar fixture in most schools and many homes. In organizational life typing pools have become dim memories while new jobs have emerged like "senior software engineer" or "Chief Information Officer."

Indeed, information technology in the mid-1990s is like Prometheus firing such crucibles as the electronic fax machines of the "Right-to-Life" movement as well as the process re-engineering methods of the "streamliners," "right-sizers," "down-sizers" and "re-inventors." Information technology is truly a bringer-of-change in the mid-1990s. With its catalytic propensity for fomenting change, information technology has now become a significant part of the ongoing United States' public administration debate.

Four important information technology themes are discussed in this chapter. The first is a short depiction of its nature and scope. Secondly, information technology's role in the federal government is described, and some current issues are subsequently illustrated in the third section. Finally, this chapter concludes with a characterization of information technology's future role in the federal government.

A. The Nature and Scope of Information Technology

One of the most important events of this century is the Information Age. Although it has no universally accepted date of birth, its principal roots (Hayes, 1988) can easily be traced back into the 1950s and 60s when digital computer (Dorf, 1977) technology became available to government and industry, and the 1960s and 70s when telephone companies (Martin, 1976) began to implement digital communications systems. In combination, these technologies have facilitated today's large-scale system designs, with applications that span people, time and organizations. The Internet, which transcends governments and other artificial boundaries, is a familiar example of the power and variety of modern information technologies. Appendix A contains a short primer about information technology and its evolution.

At a conceptual level, information technology in the mid-1990s has become both an integrator and a transcendent force over modern civilization. In scope, information technology integrates knowledge across almost all disciplines and fields. It is transcendent by nature in the sense that people can use the power of information technology to rise above their current limitations of knowledge and circumstance and, thereby, move to a new plateau which has an even broader range of possibilities.

At a more material level, people in the mid-1990s generally speak of information technology in terms of "hardware" and "software." Yet, such a description is deficient because information technology is usually not an "out-of-the-box" solution; rather, it is the process of devising information-based solutions to problems. In such a process a need or a requirement must first be specified, and then its essence must be abstracted in order to devise a "hardware" and "software" solution.

Definition of Information Technology

Therefore, a broader definition than "hardware" and "software" would be more appropriate for any realistic examination of "information technology." Apparently, a federal definition--preferably one grounded in law or regulation--is desirable since federal information technology is the subject of this paper. For those reasons, information technology is defined throughout the remainder of this paper using the following government-wide definition contained in the Information Technology Management Reform Act which is Division E of the National Defense Authorization Act for fiscal year 1996 (section 5002):

> [A]ny equipment or interconnected system or subsystems of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception, of data or information by the executive agency . . . [and] includes . . . computers, ancillary equipment, software, firmware and similar procedures, services (including support services), and related services.

Previously the Federal Information Resources Management Regulations issued by the General Services Administration under authority of the Brooks and Paperwork Reduction and Reauthorization Acts provided the only government-wide definition of federal information technology. Yet, that definition was almost identical to the one, above. The definition contained in the reform legislation is a very appropriate one because it makes clear the fact that the federal government continues to regard information technology as a very broad field with porous boundaries. Furthermore, from a regulatory viewpoint the definition accurately portrays "openness" as the true nature of federal information technology as well as its explicit and broad focus on information processing as its scope.

Information Technology In Practice

From a practical perspective, change is really the nature of information technology, and its scope is pervasive. Information technology has fomented considerable change on both the individual and societal levels. As an example, today, once on the Internet, anyone can use a personal computer (PC) and modem with appropriate software to reach the Louvre or read in Chinese characters about the sage, Sun Tzu. "For the Fiscally Interactive, California Offers Budgeting Via Internet," according to a June 17, 1995, Washington Post article which described how California taxpayers could play a game designed by the state's finance department to allow players to make budget-balancing decisions about California's $2 billion deficit.

Although not interactive, each major federal agency and many political movements have had "Home Pages" on the Internet. "Right to lifers" and other politically-oriented groups use electronic facsimile machines, automated telephone dialers, and electronic mail (email) to bombard Congress, industry, organizations, businesses and even individual citizens with their messages; the John Birch Society has had a "Home Page" on the Internet. Also, using a PC, a self-employed antique dealer can prepare a detailed inventory, or a retired person can easily use complex formulae to double check the amount of a social security check. Information technology enlightens and empowers all who are technology-savvy, and it provides almost unlimited participatory opportunities ranging from taxidermy to politics.

Simply, mid-1990s information technology has increasingly given people power and stature in proportion to their technical prowess and their available information technology resources. Individuals, governments and other types of organizations have continued to gain considerable leverage whenever their access to information resources has been maximized.

B. Information Technology's Role in the United States Government

Imagine calculating all of the United States government's social and economic statistics, air traffic information and computations for construction of the atomic bomb using just pencils, paper and only a few mechanical adding machines. Yet, that is how the United States government conducted practically all public business until the 1950s. Although a few special purpose devices were employed during World War II, the 1951 sale of a UNIVAC electronic computer to the Census Bureau really started the Information Age in the federal government (Forsythe, 1969). This first significant application of general purpose electronic computing to a major information problem demonstrated the technology's potential to a federal community that had many complex problems to solve. As a result, several other federal agencies began using the then-new electronic computers of the 1950s for computational-intensive applications like weather forecasting (Hayes, 1988).

Agency-Level Perspective

Automated computational power appealed to many agencies because of their large, intensive record keeping and data processing tasks. However, the scarce computer resources of the 1950s and early 1960s were limited in capability and very expensive (Dorf, 1976). Only large-scale and highly critical governmental applications like the census, weather forecasting, income tax processing, air traffic control and certain defense systems were considered in those times for computer automation. Communications also assumed a new level of government-wide importance because of the 1962 Cuban Missile Crisis incident and led to implementation of the Federal Telecommunications System (FTS). The FTS was specially designed to link federal agencies and guarantee continuing communications, especially in times of war or other crises.

Nonetheless, by the late 1960s and throughout the 1970s almost every major federal agency was exploring the new technology as a way to increase economy and efficiency through automation of work processes. Also, agencies like the Internal Revenue Service that were early pioneers in the first and second computing generations began mounting modernization programs (e.g. Martin, 1976) to replace and upgrade old equipment. However, modernization was not the same as a "new start," and agencies were confronted with new issues and challenges.

Moreover, an important point was the breadth of such automation efforts. Take the example of one agency, the Social Security Administration. In the 1970s, SSA was issuing over 40 million checks each month and tracking social security taxes for almost the entire working population of the United States (SSA, 1995). Enormous data processing capabilities were required for those tasks.

During that era, SSA experimented with and implemented a variety of computing and communications technologies to automate portions of its work processes (SSA, 1995). SSA at that time successfully established a single computer record for each beneficiary called the Master Beneficiary Record for maintaining all payment information. In fact, any SSA office in the United States could electronically access and update that record. (This was quite a feat considering that, as of 1996, the Department of Veterans Affairs has been unable to replicate this achievement or even establish a single electronic record for each veteran in spite of repeated proddings by Congress--see GAO reports and congressional hearings about VA.)

SSA also used specialized telecommunications equipment to establish its TeleService Centers in 20 or so of the largest cities to provide centralized telephone services like answering general social security questions and some performing claims-related processing (SSA, 1995). SSA also began installing several types of computer terminal devices in its 1300+ field offices to enable its staff to directly access and make changes to the centralized master beneficiary records. The idea was to speed claims processing, reduce staff requirements, and provide a better level of service to the public using computer and telecommunications technology.

Finally, SSA in the 1970s began an outreach program to have the largest employers report wage information about employees on magnetic tape for direct input into SSA's computers. Previously, all employers fulfilled their legal obligation by submitting paper documents which had to be manually re-keyed into SSA's computers (SSA, 1995). SSA was only one of many federal agencies which embraced the new computer and telecommunications technologies as ways to gain economies and improve overall operational efficiency.

During the 1980s two significant technical innovations had a substantial effect on federal agencies' information technology focus. Those innovations were digital telecommunications and personal computers. Consider the Department of Defense as an example.

By the mid-1980s DOD was heavily in the throes of plans to replace and upgrade all of its old telecommunications systems from analog to digital technology. The new technology had the potential for enormous cost and performance benefits because it would greatly reduce staff requirements as well as provide greater reliability along with increased functionality. Work also began on replacing and upgrading the old and well-known military AUTOVON telephone network with its five levels of precedence and preemption with a new Defense Switched Network (DSN). The new DSN was planned to provide greatly increased capacity at reduced cost because it would use the latest digital switching and carrier facilities (DSN-PMO, 1985). The remaining military networks and base-level switches were also planned for digital upgrades or replacement to achieve the same types of cost and performance benefits. DOD foresaw digital information technologies as an opportunity for better performance, new capabilities and lower costs.

That decade also saw the first of many joint services and DOD-wide efforts to rapidly introduce the then-new personal computers throughout the commands. Ordered under contracts with names like Desktop or Lapheld, the new PCs were used in support of major defense programs and for routine tasks such as inventorying rations and munitions or preparation of briefings (GCN, 1994a). Not unique to the military, purchases of PCs were a major thrust for all agencies in their quest to become information proficient. Civilian agencies readily embraced the new technology, and set about deploying them throughout their headquarters, regional and field organizational structures. In fact, over two million PCs were procured between 1980 and 1995 by federal agencies (IRMCO, 1995). At that rate they had become commonplace throughout the federal agencies, and were on the desks of numerous federal military and civilian workers.

As of the February 1996 baseline, which started the Transformed oversight era, federal agencies were telling the world about their plans for numerous, and often ingenious, applications of information technology to meet their mission needs. In fact, the technology seems to have become ubiquitous in the federal arena. Some examples are described, below.

<u>Coast Guard</u>

> The Coast Guard turned on its nationwide Differential Global Positioning System network last week, launching what Secretary of Transportation Federico Peña called a 'new era in navigation.' The 47 sites in the Coast Guard DGPS network provide complete coverage of all U.S. coastal waters [and] will provide accuracies at 10 meters or better to some of the 275,000 commercial and recreational vessels already equipped with GPS receivers . . . the Federal Railroad Administration

> plans to use DGPS stations in the Pacific Northwest to help control trains (FCW, Feb. 5, 1996, p. 20).

<u>Social Security</u>

> The Social Security Administration issued last month a request for proposals to upgrade [computer] mainframes the agency uses to process everything from Social Security benefits to administrative programs . . . . We're going to save $4 million a year (just off licensing fees) right off the bat and about $20 million over five years (FCW, Feb. 6, 1996, p. 20).

<u>General Services Administration</u>

> The General Services Administration ended the year...giving contracts to all eight finalists on its $840 million Multiple Award Indefinite Quantity support services program . . . . The procurement will replace existing contracts that offer such services as . . . [computer] systems integration, satellite communications and business process re-engineering (FCW, Jan. 8, 1996, p. 3).

<u>Department of Defense</u>

> The Air Force and Navy plan to award personal computer and workstation contracts over the next three months with a combined value of $2 billion (FCW, Jan. 8, 1996, p. 58).

<u>Justice</u>

> GTE topped five other vendors to win the seven-year Justice Consolidated Office Network (JCON) pact, which includes an array of services, such as [computer systems] planning, installation, integration and support for almost all of DOJ's office networks (FCW, Jan.8, 1996, p. 3).

Information technology during the mid-1990s has become intertwined with almost all programs and pervades all federal agencies. Over $25 billion has continued to be budgeted each year for federal information technology according to the Office of Management and Budget (OMB, 1995).

The General Services Administration indicated that, as of 1995, over 700 federal information technology contracts valued in excess of $100 billion were in various stages of the procurement process at any point in time (IRMCO, 1995). The General Accounting Office selected information technology as a principal area of focus in its 1995 "High Risk" series of

Table II-B-I: Fiscal Year 1995 Information Technology Budget

PRESIDENT'S FISCAL YEAR 1995 BUDGET--ESTIMATED OBLIGATIONS IN THOUSANDS OF DOLLARS

	CAPITAL INVESTMENT			PERSONL	EQUIP RENTAL SPACE OTHER				COMMERCIAL SERVICES							TRANSFER PAYMENTS			TOTALS	
Agency	1A. Equip	1B Software	1C Site	2A Compensation	3A Equip Lease	3B Software Lease	3C. Space	3D Supplies	4A ADP Time	4B Voice Comm	4C Data Comm	4D Operations	4E System Eng.	4F Studies	4G Significant Use	5 Inter-Agency	6 Intra-Agency	7 Other	Total	FTE
OA	2,661	1,031	35	3,171	84	580	1,229	702	355	0	0	8,141	1,275	40	0	25	0	0	19,327	47
USDA	168,031	29,427	16278	357,238	18,181	10,443	14,278	35,246	7,019	34,953	3,153	113,109	85,600	34,556	6,792	36,278	-3,686	207,078	1,173,974	7,240
Commerce	148,382	24,915	7,271	177,359	14,646	3,023	12,401	23,325	3,766	17,483	32,351	107,117	148,291	13,415	3,708	-19,402	390	-897	717,544	3,259
Air Force	194,134	16,273	3,345	484,989	10,186	1,475	0	22,113	3,986	0	107,559	442,813	87,091	29,570	0	388,701	0	0	1,792,235	10,765
Army	271,815	73,838	378	604,704	2,724	10,332	8,550	66,050	16,702	0	155,574	513,562	211,531	29,292	0	178,053	0	4,214	2,147,499	12,984
Navy	344,686	52,267	619	791,792	7,984	10,170	6,264	179,889	3,778	175,500	41,132	380,809	26,547	36,852	0	281,294	-3,362	-30,301	2,305,940	16,355
Defense	628,486	147,355	26,874	813,397	1,643	5,086	81,031	137,281	12,512	744,202	548,190	649,575	569,439	274,670	3,588	-1,067,517	-38,420	-796	3,536,576	15,849
Education	9,934	0	0	21,274	0	106	1,377	2,749	5,297	2,870	0	190,506	56,558	4,424	4,013	11,932	0	0	311,040	270
Energy	464,023	147,820	31,701	110,433	70,856	18,242	23,767	103,946	4,219	80,010	28,864	416,975	396,835	138,719	0	-12,572	0	6,952	1,987,790	640
HHS	169,835	38,750	48,713	442,140	5,044	10,925	25,675	29,366	12,746	51,141	27,287	114,407	116,242	14,217	418,001	111,017	48,883	1,227,653	2,910,042	8,551
HUD	10,600	3,300	0	22,700	9,000	8,000	2,000	16,500	3,200	8,700	4,00	25,000	40,350	0	0	4,100	0	0	157,450	370
Interior	118,396	21,125	5,270	212,713	3,177	1,210	6,435	22,015	2,089	10,101	6,397	50,697	36,067	4,038	3,161	43,947	0	-6,696	540,162	3,881
Justice	258,165	24,872	14,216	138,812	26,157	8,255	14,836	11,312	5,401	33,526	26,013	131,498	86,292	51,865	17,864	61,871	44,695	2,278	957,727	2,404
Labor	29,586	4,779	155	31,674	241	634	6,516	4,558	5,445	2,772	280	43,340	26,901	1,595	70	24,362	0	75	182,983	553
State	55,110	4,956	1,316	190,424	2,829	20	4,180	10,900	240	4,517	27,982	283	43,391	2,456	45	5,786	0	375	382,871	2,145
DOT	918,588	83,363	143,037	78,348	4,655	2,751	7,907	41,772	10,059	235,016	108,701	155,372	259,917	40,409	8,038	81,900	0	18	2,179,851	1,414
Treasury	480,401	71,529	61,627	636,561	13,631	998	73,045	71,983	3,787	122,510	101,327	231,257	254,475	26,832	0	75,946	-87,610	-6,003	2,132,296	11,223
VA	178,245	5,818	595	247,400	10,505	7,260	2,664	42,053	11,124	32,980	27,157	44,715	12,863	17,375	0	43,421	0	53	684,229	5,412
EPA	30,126	6,391	458	51,589	4,199	5,392	114	6,483	1,972	24,208	5,024	114,236	54,179	5,470	3,817	4,213	0	0	318,161	834
GSA	26,309	5,061	1,990	159,658	1	72	13,135	34,498	5,477	598,904	161,465	100,109	356,701	81,748	0	-1,073,633	-9,621	-50,305	411,569	24
NASA	290,275	36,127	20,278	116,143	53,944	19,696	5,344	24,137	31,555	22,756	27,181	415,095	520,787	64,178	70,096	34,870	0	0	1,752,469	14,493
OPM	3,057	160	66	28,935	174	1,118	2,766	1,945	50	1,859	307	8,932	6,854	4,091	0	-536	0	0	59,778	535
SBA	3,180	989	116	5,951	0	187	1,333	328	4,974	52	565	727	4,038	124	0	8,882	0	0	31,446	96
AID	19,042	3,301	263	7,882,1,786	16	58	1,618	1,226	185	1,738	270	18,538	9,732	253	5	5,548	0	0	69,675	183
CFTC	885	50	15	889	0	450	449	90	175	174	158	267	622	16	0	567	0	0	5,706	28
CPSC	10	0	0	47,994	6	0	27	185	0	131	35	405	0	32	0	555	0	0	2,265	14
COE	42,746	8,126	3,231	3,101	700	303	4,747	8,134	1,486	4,219	6,619	25,481	8,048	9,460	960	0	-29,402	429	143,281	842
EEOC	363	300	0	2,647	0	0	633	92	0	312	379	493	83	0	0	4,622	0	400	10,778	48
EXAM Bk.	458	738	0	4,151	644	0	36	1,145	0	440	0	55	763	343	0	98	0	0	7,367	49
FCC	2,752	0	0	9,690	560	303	597	1,162	0	343	0	1,424	1,341	50	0	1,945	0	0	14,628	71
FEMA	400	6,700	0	1,962	520	95	1,085	650	950	13,269	1,235	4,247	4,697	49	0	7,000	0	0	50,587	208
FTC	997	497	0	663	0	0	225	52	0	275	0	1,349	299	336	0	701	0	0	6,693	27
ICC	95	0	0	4,151	2	0	162	89	534	4	5	112	0	0	0	3,892	0	0	5,578	11
NARA	1,200	0	0	5,034	0	0	162	1,272	0	956	10	2,441	777	200	0	1,414	0	0	15,466	117
NLRB	478	172	0	1,028	18	0	304	30	351	0	0	1,159	350	100	0	961	0	0	4,951	17
NSF	3,268	203	0	3,980	0	500	0	120	0	0	1,429	4,350	3,150	0	0	741	0	0	17,741	58
NRC	9,772	938	0	11,610	27	0	31	180	355	2,606	1,349	15,893	4,436	1,253	0	15,893	0	0	64,943	135
PCC	859	0	100	5,574	1,509	391	0	926	0	48	1	585	0	0	0	0	0	0	9,993	152
Peace Corp	486	0	0	1,438	0	87	536	150	17	731	393	84	0	0	0	1,084	0	0	5,006	25
RRB	445	0	0	15,033	0	350	896	326	392	0	40	1,172	65	110	0	2,983	0	0	21,712	252
SEC	8,740	4,225	0	10,238	200	975	1,741	335	0	656	219	7,500	5,300	3,300	0	2,793	0	0	46,222	166
SSS	27	36	0	4,309	111	0	340	170	53	87	97	209	0	0	0	1,031	0	0	6,470	100
Smith	0	3,977	66	7,307	0	629	895	1,531	309	0	4,964	2,486	446	476	0	948	0	0	24,034	152
USIA	6,515	3,249	51	16,454	117	189	2,345	1,751	827	3,512	19,766	6,625	2,392	3,146	1,693	3,085	0	0	71,719	370
USTC	204	0	0	1,368	0	79	204	152	297	0	0	269	0	22	0	931	0	0	3,526	23
ADCA	1,000	100	100	500	0	0	300	150	300	0	25	2,000	800	100	0	0	0	0	5,375	10
TOTALS	4,906,738	789,758	388,166	5,892,135	264,291	130,384	332,200	909,669	161,984	2,233,561	1,477,690	4,383,4800	3,445,545	895,082	541,871	-720,271	-80,133	1,354,527	27,306,675	122,403

reports (GAO, 1995a). The National Performance Review issued in 1993 cited information technology as a key to making government cost less and work better. Federal information technology is "big business."

Information technology in the mid-1990s certainly has been very important from an agency-level perspective. Indeed, it also has had a government-wide focus from the perspective of politicians, citizens, users, managers and overseers (see figure II-B-1; reprinted courtesy of *Government Computer News*, copyright 1994 and 1995 by Cahners Publishing Company, a division of Reed Elsevier Inc., 275 Washington Street, Newton MA 02158, all rights reserved).

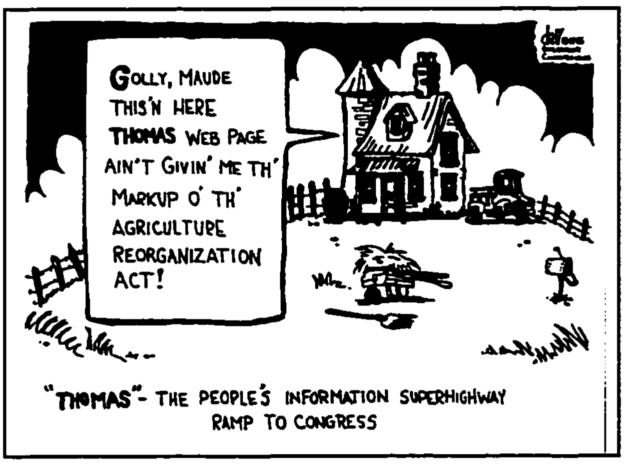

Figure II-B-1: Taxpayers and the Internet

In fact, information technology is requisite in the mid-1990s. Agencies and even individual representatives and senators have their own "Home Page" on the Internet. The mid-1990s role of information technology in the federal government is briefly described, below, from the perspective of the three central management agencies that had primary responsibilities for information technology at that time.

Office of Management and Budget Perspective

The Office of Management and Budget's cost-oriented perspective is indicated in the information technology component of the president's fiscal year 1995 budget request (OMB, 1995). The total request was $27.3 billion or 1.8% of the total federal budget. It should be observed, however, that this amount does not actually reflect the total amount of information technology obligations; it is only a lower boundary. Not included, for example, are military command, control and intelligence information technology costs which the General Accounting Office estimated at greater than $23 billion on an annual basis (GAO, 1994a).

Some observations follow. First, the budget document shows that each military department planned information technology capital investments which exceeded $200 million; the largest was Navy at $400 million. The remaining defense agencies, in the aggregate, budgeted over $750 million. However, a number of civilian agencies, like Transportation, Treasury and Energy, also had large-scale plans for capital investments during fiscal year 1995. In fact, each of these three planned to invest over $500 million in new hardware and software. Several civilian and defense agencies had very large-scale information technology requirements to fulfill.

Smaller agencies were also represented in the budget. In fact, examination showed that meeting new information technology needs was an ongoing task, year in and year out, for those agencies. Even an agency with a very tentative and tenuous future at that time, the Interstate Commerce Commission, still planned to make capital investments in information technology. Smaller agencies also made their mark on the information technology budget.

Additional highlights from OMB's Information Resources Management Plan of the Federal Government (1995) indicated that information technology rose from 1.4% of the president's budget in 1987 to 1.8% in 1995. In real dollars the increase was from $16.1 to $27.3 billion. Another observation is that, whereas, defense barely exceeded civilian spending in 1987, the reverse became true, and by a wider margin (approximately $10 billion for defense and $17 billion for civilian agencies in 1995). Clearly, federal information technology costs are significant, and growth has continued to occur, primarily on the civilian side.

All agencies planned to make new capital investments in information technology during 1995. Also, costs continued to grow at a rate exceeding that of the overall budget even during times of fiscal restraints. As a final note, the information technology portion of the fiscal year 1996 budget was expected to exceed $26 billion, thereby, continuing a pattern of growth.

General Services Administration Perspective

With its Brooks Act authority (PL 89-306), GSA had government-wide responsibility in the mid-1990s for monitoring almost all federal information technology procurements with the exception of those for certain command, control and intelligence systems. Each year between 1988 through 1995 GSA delegated to agencies the authority to conduct over 500 information technology procurements; 1994 and 1995 each exceeded 800 such delegations (IRMCO 1994, 1995). GSA's authority ended with enactment of the Information Technology Management Reform Act which was Division E of the 1996 Defense Authorizations Act that also repealed the 30 year old Brooks Act.

As background, until July 1995 federal agencies were required by regulation to obtain GSA's approval for most procurements exceeding $2.5 million (FIRMR, 1995). Afterwards, the threshold amount was raised to $100 million. Therefore, from the above it appears that at least 500 to 800 such information technology procurements, each valued above $2.5 million, were underway at any point in time. The largest information technology contracts exceeded $1 billion in some cases, as reported in the media. From 1993 through 1995 GSA annually granted authority for information technology contracts valued in excess of $20 billion (IRMCO, 1993, 1994, 1995). Furthermore, through its tracking mechanisms GSA determined that information technology contracts valued at over $100 billion were at various stages of the procurement process at any point in time (IRMCO 1994, 1995).

Thus, from GSA's vantage point information technology was woven throughout federal agencies and their programs through contracts valued in excess of $20 billion each year. Furthermore, over 500 contracts, each valued in excess of $2.5 million, were awarded each year, thereby, further emphasizing information technology's diversity and pervasiveness. Some exceeded $1 billion in value. Finally, from GSA's perspective information technology programs were not short term efforts but, rather, were conducted over long periods of time because of their complexity.

General Accounting Office Perspective

GAO confirmed the Office of Management and Budget's fiscal year 1995 estimate of $27.8 billion (GAO, 1994a), and also stated their perspective of information technology's overall role in an excerpt from their "High Risk" series of reports (GAO, 1995, preface):

> Today's information technology offers unprecedented opportunities to improve the delivery of government services and reduce program costs. Using technology well is central to enhancing the information available to federal managers and the public.

Thus, in GAO's view information technology became an integral part of each federal agency's programs and methods. GAO observed how budgets for information technology have continued to occupy a significant part of the federal budget in the mid-1990s as well as during each of the past 30 or more years. In recent years its share has grown as agencies attempted to take advantage of information technology's " unprecedented opportunities to improve the delivery of government services and reduce program costs." GAO, like OMB and GSA, perceived a significant and still-growing role for information technology in federal government.

However, GAO also repeatedly counseled that information technology's pervasiveness, complexity and enormous costs entail considerable risk. For example, in the Overview report from its 1995 High Risk series, GAO cautioned (p. 12-13):

> Today's information technology offers unprecedented opportunities . . . Unfortunately, the government has not been able to take advantage of these opportunities. The result is wasted resources, a frustrated public unable to get quality service, and a government ill-prepared to measure results and manage its affairs in a businesslike manner. Despite a $200 billion investment in the last 12 years, there is too little evidence of promised capabilities being delivered on time and within budget.

Clearly, GAO's perspective was one of enormous optimism about the potential of information technology, but serious concern remained about the government's ability to effectively, efficiently, economically use it.

Government Reform Perspective

Information technology's perceived universality has made it the instrument of choice for reformers' mid-1990s plans to improve methods and "reinvent" government. It is this difference that makes information technology unique. From the 1980s through the mid-1990s information technology was seen as an enabling mechanism to cost-effectively automate processes across all governmental entities, programs and functions.

> *"[W]e will re-engineer government activities, making full use of computer systems and telecommunications to revolutionize how we deliver services."* (NPR, 1993)

This theory of its ubiquitous nature has seemed to remain unchallenged and, in the mid-1990s, encouraged numerous government pronouncements like " . . . we will re-engineer government activities, making full use of computer systems and telecommunications to revolutionize how we deliver services . . ." (NPR, 1993). However, information technology has not been a complete "cure." Rather, some substantive issues remain, and these are described next.

D. Federal Information Technology Issues

At the forefront of many mid-1990s issues of government size, scope and services, information technology has become intertwined with government's ability to change and "reinvent." Unlike other problem areas which can remain buried and unknown to the public for decades, such as military waste or certain types of nuclear dumping, information technology problems stand out because many are at the interface of government services and the public. Newspapers, radio and the television media have given headline attention to major federal information technology debacles. Politicians have continued to make political hay about cost overruns and service delays. Some examples of major federal information technology problems reported in public media such as GAO reports or the news media follow.

Failed Information Technology Programs

These are often the most visible examples of federal-level waste, fraud and abuse. Examples of some mid-1990s failures are given below.

FAA's Advanced Automation System: The Federal Aviation Administration's $6 billion Advanced Automation System (AAS) was the centerpiece of a program to modernize the 20 year old air traffic control system. FAA in the mid-1990s still has vacuum tubes in some of its computers which no longer have the capacity to track all of today's airplane flights. By 1994, AAS experienced more than $2 billion in cost overruns and a six year schedule slippage (GAO, 1994d). Software development was a failure and only minor hardware results had been achieved by FAA's contractors. In 1995 FAA attempted to restructure AAS by down-scaling the requirements and breaking the program into several smaller projects. Claiming that it had been hamstrung by regulations, FAA through early 1996 also aggressively sought Congressional approval to privatize the operations and acquisition arms of the agency, free from oversight (e.g. 1995 FAA House Aviation Subcommittee hearings). By mid-1996, FAA still had not achieved tangible results for AAS; air traffic controllers were still using displays that more properly belonged in a World War II movie or a museum, and the media continued to report computer outages throughout 1995. AAS is one of the two case studies depicted in Chapter VI.

VBA Modernization: The $500 million Veterans Benefit Administration Modernization program was developed as a three-stage initiative in the late 1980's to modernize its benefits information systems. Because of a $100 million cost overrun and schedule delays, the Office of Management and Budget, General Accounting Office, General Services Administration and Congressional oversight committees in 1993 required the Department of Veterans Affairs, which oversees the Veterans Benefits Administration, to accept Modernization performance measures in return for continued funding (GAO, 1992e). Subsequently, some hardware and software development successes were achieved. However, the General Services Administration limited the Department of Veterans Affairs contracting authority in 1994 and mandated an independent assessment because the program was not meeting the performance measures, at that time (GSA, 1994b). In spite of considerable oversight attention and continued funding, veterans' benefit checks still were excessively delayed. At the start of 1996, the Department of Veterans Affairs was still reviewing the program for possible restructuring (*e.g.* CGN, 1994b). The old 1970s vintage payment systems had not been re-hosted on new mainframe computers; there was no replacement software for those payment systems, and it still took too long for veterans to start getting their checks. In mid-1996, Modernization was still not a success.

NOAA Weather Modernization: The $4 billion Weather Modernization program was planned to integrate four key weather information subsystems to achieve personnel savings, close redundant weather offices, and produce billions of dollars in annual savings to the economy by more accurately forecasting damaging hurricanes, tornadoes, and floods as well as more common thunderstorms and other weather phenomena. The National Oceanographic and Atmospheric Administration (NOAA) would accomplish that task by bringing on line new doppler radar, satellite and ground-based sensor systems and integrate them through a sophisticated computer and telecommunications system (GAO, 1994a). In 1994 serious software development delays kept over $2 billion worth of sophisticated ground-based sensors and newly launched weather satellites' information from being effectively used (GAO, 1994a). NOAA and Commerce initiated an independent assessment of the program, and GSA suspended contracting authority in 1994 for one of the subsystems until NOAA devised a restructuring plan. NOAA finally began deploying a few prototypes in mid-1995 (FCW, 1994d). However, at the end of 1995 the full deployment decision was pushed back as

NOAA, once again, attempted to get its integrating system, AWIPS, on track through a revised contract and restructured program. Weather forecasting was no more accurate at the end of 1995; no redundant weather offices had been closed. The promises of billions of dollars in savings and improved weather forecasting had still not come to fruition when NOAA approached the end of 1996. The AWIPS portion is one of two case studies that are examined in greater detail in Chapter VI.

IRS Tax System Modernization: The $8 billion Internal Revenue Service Tax System Modernization (TSM) program was planned to improve tax compliance monitoring, facilitate enforcement, and increase revenues (GAO, 1994). Parts of the program were over eight years behind schedule by 1996, and tax collection efforts were still using antiquated computer systems with limited capabilities (NRC, 1994). TSM was IRS' third attempt in as many decades to modernize the antiquated tax processing system (NRC, 1994). Over $2.5 billion had already been spent to date without meaningful results (*e.g.* NRC, 1994). IRS had still not been able to achieve any of TSM's goals such as improving the quality of customer service, resolving taxpayer problems upon first contact, reducing taxpayer burden, and increasing information systems security. The nation's taxpayers still had an enormously expensive, antiquated system that had not adequately reduced taxpayer burden or operating costs; IRS had still not delivered any results to taxpayers on its TSM promise as of mid-1996.

PTO Modernization: The Patent and Trademark Office (PTO) Modernization program was 10 years behind schedule as of 1996 and would eventually cost over three times the original estimate (GSA, 1995a). PTO is one of the larger components in the

Department of Commerce. Begun in 1984 to automate the patent examination, issuance, and dissemination process, Modernization would eventually cost over $1 billion after experiencing significant changes in direction and substantial delays. The same old contract was still in use as of 1996, and it had already been extended twice on a costly sole-source basis rather than having been subjected to a new competition (GSA, 1995d). GSA had previously limited PTO's contracting authority and required an independent assessment along with a restructuring plan (GSA, 1995a). PTO's modernization was still not completed at the start of 1996; it was scheduled to be delayed until 2003, a full decade late and over four times its original cost estimate. No personnel savings had yet been achieved, even though that was one major premise of the program. Patent-granting processes still took over 18 months, on the average, which was considerably longer than in Japan or Europe. The United States in mid-1996 was patently behind the times because of PTO's failures.

Unfortunately these are not the only examples of federal information technology program failures. Other agencies and other information technology programs have also experienced such problems.

However, just these five examples of troubled federal information technology programs, alone, had cost increases of over 50% because of major problems. Their 1996 totals exceeded the original estimates by almost $7 billion (table II-D-I). The new total in 1996 exceeded $20 billion. Observe that the real dollar impact of the problems with each of these programs was actually much greater because those investments were supposed to leverage technology to improve each agency's economy and efficiency. As an example, the AWIPS cost overruns were minimal but, importantly, the delays had prevented timely closing of numerous redundant weather offices and caused billions of dollars in unnecessary personnel and facility costs. Moreover, NOAA had previously said (GAO, 1994a) that weather modernization savings to the economy would annually amount to billions of dollars. It had not met that promise.

Therefore, the total for those programs of $7 billion in cost overruns, though quite large by any standard, is really only a shadow of the true waste or "lost opportunity" costs. These five programs and their investments were not meeting public needs because, as of 1996, there had only been a minimal return on the investments. It is no wonder that the public and Congress in the mid-1990s have continued to be outraged by those types of problems.

Four attributes of those problem systems are easily identifiable: (1) cost overruns, (2) schedule delays, (3) failure of the information system to meet agency mission objectives, and (4) management problems (table II-D-I). Those characteristics highlight the severity of the issues surrounding those troubled programs. However, root causes and cures are not as easily found. After all, some of the top people in government and industry have been grappling with those troubled programs for several years. Additional information about troubled information technology programs as discussed in subsequent chapters.

Information Technology Procurement

The whole federal procurement system has often come under attack, because it continues to be viewed as cumbersome and cost intensive; people when prodded recall hearing stories about "$600 toilet seats" and other nefarious excesses. Information technology has not been immune to those perceptions, and it remains part of overall procurement reform initiatives. However, information technology has also been especially unique in federal procurement because through mid-1996, it had special rules--the Federal Information Resources Regulations (FIRMR)--and its own court, namely, the General Services Administration Board of Contract Appeals (PL 99-500).

Table II-D-I: Five Problem Information Technology Programs

	Original Cost Estimate	Cost Overruns	Schedule Delays	Meeting Mission Objectives	Management Problems
FAA AAS	$4 billion	$2+ billion	6+ years	no significant operational results	entire senior management team replaced in 1995
VBA Modernization	$300 million	$100+ million	6+ years	veterans checks are still delayed for over six months	several senior manager changes in 1995
NOAA Weather Modernization	$2 billion	$2+ billion	5+ years	there is still no integration of sensor, satellite and radar data for weather forecasting	new management structure in 1995
PTO Modernization	$200 million	$700+ million	10+ years	goal of 18 months for patent processing is still not met	all senior managers quit in 1994; new team in 1995
IRS TSM	$6 billion	$2+ billion	4+ years	revenues have not increased, service has not improved and taxpayer burden has not been reduced	several senior manager changes in 1995
Total	$12.5 billion	$6.9 billion			

This added a singular flavor to debates about procurement's impact on the functions and methods of government. The desirability of special procurement rules and procedures has continued to be an issue for federal information technology.

From another viewpoint, procurement has increasingly been used to place information technology functions in the trust of non-government organizations. The Departments of Defense and Energy, the General Services Administration, and National Aeronautics and Space Administration have been quintessential examples because of their almost complete dependence on contractors to perform vast parts of their information technology missions (see GAO reports about these agencies). Proponents have argued that industry can perform tasks better and more cost effectively than government. However, a significant point was made by Thompson (1993, p. 314), who cautioned that there may be an excessive cost for such contracts when government fails to employ effective control mechanisms. Nonetheless, the most recent administrations and congresses seem to have operated under a theory that information technology is one of an increasing number of government functions that can be privatized or at least contracted out without much attention to controls. Certainly this debate has not ended.

Regarding the relationship of information technology procurement and government methods, issues have continued to arise because of ongoing conflicts between seemingly contrary themes of efficiency and countering waste, fraud and abuse. Briefly, included in the 1996 Information Technology Management Reform Act was a provision that eliminated the role of the General Services Administration Board of Contract Appeals in deciding vendor protests of contract awards. The political rhetoric that caused this legislative change was that the Board's rules encouraged frivolous protests which harmed the government, according to senior Administration officials (*e.g.* OFPP's Steve Kelman at Senator Cohen's S946 hearings, July 1995); efficiency was clearly the theoretical focus.

Yet, government must react when procurement scandals are in the public eye. Such exposés engender public criticism; people remember Defense procurement scandals and vacuum tubes in FAA computers. Moreover, vendors may be reluctant to bid if they surmise that contracts will not be awarded through a fair and reputable process (*e.g.* ITAA, 1995); closed-room deals cannot accommodate all vendors, just a few "fat cats." Democratic government has responded to those problems in the past by passing laws or instituting preventive regulations.

> *"Unfortunately, weak oversight and a lengthy acquisition process have lead to the American taxpayers not getting their money's worth on $200 billion in [information technology] expenditures over the last decade."* (Cohen, 1994)

Therefore, past policies to prevent future abuses tended to be process controls which ran counter to efficiency. This issue certainly moved on its fulcrum in the mid-1990s. Thus, any recurring or future debates in this area will really be about achieving a reasonable balance between efficiency and controlling for abuses.

Oversight Methodology and Mechanisms

A hue and cry continued to be raised throughout the first part of the 1990s about stripping away all of the oversight controls and layers of accountability which, they believed, prevented agencies and programs from doing their jobs. Still more demanded new, streamlined forms of accountability and oversight control mechanisms. Politically, both Republicans and Democrats in the mid-1990s have been philosophically correlated because they have spoken almost daily about "cutting out the layers."

Senator Cohen's (R-Maine) 1994 report entitled Computer Chaos was a comprehensive compendium of those issues (Cohen, 1994). The report spanned the content of a number of previous Republican and Democrat studies, General Accounting Office reports and numerous reform proposals. The key recommendations were:

- Emphasize early oversight and planning,
- Reduce bureaucratic barriers to purchases,
- Avoid reinventing existing technology,

- o Encourage innovation, and
- o Reevaluate existing procurements to determine if they provided the best value to the taxpayers, and halt new procurements pending improvements in the computer acquisition process.

Interestingly, the first and last recommendations were conservative and would have continued and possibly strengthened the mainstream tradition of up-front oversight. The others, at least on the surface, utilized the prevailing "reinvention" language to express a need to strip away controls. Computer Chaos drove the 1996 information technology reform efforts.

Thus, in the mid-1990s it was not removal of controls that was the real issue, but rather their form and where oversight would reside. Such debates have not yet been resolved for all times; the 1996 reform legislation will surely start a new round of acclaim and criticism. This issue area brings into focus all of the others because of the centrality of oversight and accountability to the achievement of information technology programs' results.

E. Information Technology's Future

Federal information technology's future seems to lie firmly along the path espoused by a General Accounting Office report entitled Improving Mission Performance Through Strategic Information Management and Technology (GAO, AIMD-94-115, 1994, p. 1), namely:

> Making government more effective and efficient is a national issue. But getting it to work better and cost less will be impossible if federal agencies cannot learn to manage with modern practices the information age demands. Today's information technology offers the government unprecedented opportunities to provide higher quality services tailored to the public's changing needs delivered more effectively, faster and at a lower cost. Moreover, they can enhance the quality and accessibility of important knowledge and information, both for the public and for federal managers.

Thus, in GAO's view, information technology is really a keystone in any plan to make government more efficient and effective. The Clinton Administration supported this theory of information technology's ubiquitous role; "[W]e will re-engineer government activities, making full use of computer systems and telecommunications to revolutionize how we deliver services " (NPR, 1993). Finally, the Republican's "Contract With America" exhibited considerable dependence on information technology to cut the size of the government work force; Republican Speaker of the House Newt Gingrich was renowned throughout 1995 for his enchantment with computers and technology. Clearly, information technology seems to have an assured and even growing role in federal government.

However, there could be a gap between this sparkling vision and the realities of actual information technology deployment. Computerizing the production of Social Security cards proved very successful and cost effective to the Social Security Administration; it allowed citizens to obtain the cards in days rather than the weeks that were needed before computerization. However, people only need look at the spectacle of the Internal Revenue Service's repeated and costly modernization failures (*e.g.* NRC, 1994) to see another type of reality. Accountability for information technology through predetermined oversight methods may be the touchstone of success for those programs.

Important questions about the role of accountability and the appropriateness of various oversight methods for information technology are embroiled within mid-1990s debates about government's role in society, in general. Their outcomes will certainly affect government-wide management of information technology in the future and, thus, change the likelihood of success for the largest and most important programs.

In the mid-1990s, federal information technology has been very complex, and requirements have dramatically expanded as the United States government has sought to "re-invent," devolve and embrace what Milward (in Ingraham, 1994) called the "Hollow State." Information technology has become so intertwined within agencies and business methods that its impact spans organizational, mission and even governmental boundaries. Rapid innovation is constantly changing and transmogrifying agencies' requirements because the commercial viability of new technologies' life-cycles is now measured in months, not years. Accountability and control processes must find a way to span these complexities.

CHAPTER III

FEDERAL INFORMATION TECHNOLOGY ACCOUNTABILITY

The establishment of specific structures to provide accountability and oversight of federal information technology has been a relatively recent phenomena in the history of the United States and its government. Dating from enactment of Public Law 89-306 in 1965, the so-called Brooks Act, those accountability structures and corresponding mechanisms have had a pronounced influence on information technology's federal role.

In the American experience government-wide accountability mechanisms have generally been reserved only for those processes which are cross-cutting in nature and have a significant and ongoing effect on government. Examples include procurement and federal personnel practices. Information technology's increasingly important but costly role earned it that type of distinction, and a number of accountability mechanisms were put in place over the years. Those started with the 1965 Brooks Act controls, continued with intervening legislation, and were transformed in 1996 as information technology accountability took a major redirection resulting from reform legislation contained in the Information Technology Management Reform Act.

Key events in the establishment of federal information technology accountability between 1965 and 1996 are reviewed in this chapter. The overarching concepts and themes are subsequently used to establish a framework for analysis which is used in the sequel. Key legislation is first described and then followed by an overview of some important regulations for completeness.

A. Key Federal Information Technology Authorities

The Brooks Act of 1965, Public Law 89-306

Improving information technology and better pricing in the 1960's brought new opportunities but also serious issues about federal information technology acquisition practices which ultimately led to passage in 1965 of Public Law 89-306, the so-called "Brooks Act." Congressional concerns had been raised about vendor favoritism, lack of accountability and ineffective controls, all of which often caused the government to pay excessive prices for ineffective products. The real issue was a lack of faith in federal management of information technology. Agency officials had abused their authority, or so it was perceived, and certain vendors had wrongfully used their power to dominate the federal market.

This Act, authored by powerful Texas Congressman Jack Brooks, gave the General Services Administration (GSA) authority over the acquisition and management of all federal information technology. For 30 years, through February 1996, the Act remained the principal legislation for federal information technology oversight (table III-A-I). Specifically:

> The [General Services Administration] Administrator is authorized and directed to . . . provide for the economic and efficient purchase, lease, and maintenance of automatic data processing equipment by Federal agencies . . . ,

according to section 111 of the Act which also amended GSA's fundamental legislation, namely, Title I of the Federal Property and Administrative Services Act of 1949.

> *"... to provide for the economic and efficient purchase...and utilization of automatic data processing equipment by Federal departments and agencies"* (Brooks Act of 1965).

Two important mechanisms were established which gave GSA the ability to enforce the Act, namely, delegations of procurement authority and a GSA-controlled centralized information technology fund. Specifically, the Act stated in Section 111 (b) 2:

> The Administrator may delegate to . . . Federal agencies authority to operate automatic data processing pools and data processing centers, and to lease, purchase, or maintain individual automatic data processing systems or specific units of equipment . . . .

and in Section 111 (c) and (d):

> (c) There is hereby authorized to be established on the books of the Treasury an automatic data processing fund which shall be available without fiscal year limitation for expenses, including personal services, other costs, and the procurement by lease, purchase, transfer, or otherwise of equipment, maintenance, and repair of such equipment . . . (d) There are authorized to be appropriated to said fund such sums as may be required which, together with the value, as determined by the Administrator of supplies and equipment from time to time transferred to the Administrator, shall constitute the capital of the fund . . . .

By centralizing oversight authority in this way, the Act gave GSA exclusive procurement authority for all federal information technology procurements. GSA could either conduct the procurement or re-delegate its authority. Procurement authority provides considerable leverage because it is quickly effectuated and it is global in its effect on a program. Rule-making requires months or even years to redirect a federal practice. However, procurement authority can be withdrawn, instantly bringing any program to a screeching halt, at least in theory, thereby making it a credible oversight tool.

To implement the 1965 Act, GSA subsequently constructed a process to delegate procurement authority to agencies on a case-by-case basis. This process is described more fully in the regulations portion of this chapter. Agencies could appeal adverse decisions about delegations to the Office of Management and Budget. Specifically:

> The [GSA] Administrator shall provide adequate notice to all agencies and other users concerned with respect to each proposed determination specifically affecting them . . . . In the absence of mutual agreement between the Administrator and the agency or user concerned, such proposed determinations shall be subject to review and decision by the Bureau of the Budget [later, the Office of Management and Budget] unless the President otherwise directs (Section 111, 2 (g)).

Therefore, a check-and-balance mechanism on GSA's delegations authority was envisioned by the Act which was to occur through an independent appeals process.

Also, GSA gained initial financial leverage through the centralized fund. However, Congress, over the years, became increasingly reluctant to capitalize the fund. It was less an instrument of oversight and became more of a hollow shell used to fund some GSA-managed, government-wide programs.

Thus, GSA's real authority rested on two pedestals. One was its delegations authority, and the other was its regulatory authority. Through writing regulations to implement its Brooks Act authority and controlling procurement delegations to agencies, GSA became an important central point of control over federal information technology.

Although the Brooks Act centralized accountability functions for information technology in GSA, it addressed technical responsibilities in a different way as recounted in Section 111 (f), namely:

> The Secretary of Commerce is authorized (1) to provide agencies, and the Administrator of General Services in the exercise of the authority in this section, with scientific and technological advisory services relating to automatic data

> processing and related systems, and (2) to make appropriate recommendations to the President relating to the establishment of uniform Federal automatic data processing standards . . . .

The Department of Commerce subsequently exercised this authority by issuing a number of federal information processing standards, over the years. Additional details are provided later in this chapter.

With passage of the Brooks Act, the General Services Administration and the Department of Commerce became the fourth and fifth government-wide information technology players. Congress always had a role because of its legislative authority, and its General Accounting Office arm had already become a major player, in its own right. The Bureau of the Budget (now the Office of Management and Budget) because of its budget role remained an important player.

The Federal Procurement Policy Act of 1978, Public Law 95-563

The Federal Procurement Policy Act created the well-known Federal Acquisition Regulation (FAR) which in the mid-1990s is still the most pervasive of current federal procurement regulations. The Act was designed to simplify procurement by creating a single, government-wide set of regulations. Thus was born the Federal Acquisition Regulations (FAR). However, in practice agencies added their own rules on top of the FAR, making the procurement process very complex. In fact, the General Services Administration added an entire set of special procurement-oriented regulations, just for information technology, on top of the FAR. Procurement-related issues have held a special role for information programs because frequent acquisitions are needed for agencies to remain current due to rapidly advancing and constantly changing computer software and hardware.

Briefly, the FAR applies to all executive federal agencies with some exceptions like the Central Intelligence Agency in the intelligence community; the General Accounting Office voluntarily follows the FAR. It was supposed to provide a uniform and consistent set of guidelines and practices for all procurements. The intention was to simplify the process, but the FAR has become subject to castigation and blame for procurement woes. In reality, these are only a part of the issue. In fact, agencies magnified the FAR's deficiencies by building numerous regulations on top of it; DOD, for example created the DFAR which incorporated another very large layer of regulations on top of the FAR.

The FAR contains subchapters, parts, and sections. As examples, contracting methods are found in Part 13. Part 14 prescribes Sealed Bidding methods, and Part 15 describes contracting by negotiation. The General Service Administration is responsible for establishing and operating the FAR Secretariat to print, publish, and distribute the FAR through the Code of Federal Regulations system. Compliance with the FAR is the responsibility of the Secretary of Defense for the military departments and defense agencies. The GSA Administrator is responsible for civilian agencies except the National Aeronautics and Space Administration which is responsible for its own implementation.

Therefore, this Act became important for information technology oversight for two major reasons. First, it created a uniform set of procurement rules which simplified accountability for virtually all information technology acquisitions. This was especially important for the General Services Administration because its leverage was through its "lock" on procurement authority under the Brooks Act. Secondly, it provided the basis for special regulations that applied only to information technology. Through such regulations, especially the Federal Information Resources Management Regulations, the oversight community was able to tailor the conduct of information technology programs as well as leverage government-wide participation through various regulation-focused councils and committees.

However, there is another perspective that demonstrates the "down side" of such visibility. Federal procurement has always been a very large target, one that seems constantly to be in the public eye. Congress has continued to use procurement for policy purposes, such as small business or minority set-aside programs, and has "reformed" it with regularity to advance policies or retreat through imposition of controls when excesses occur. Information technology is only one small body in the entire constellation of federal procurements; its interests can easily be subsumed by larger questions and political interests. Also, any high-level focus on information technology procurement can tend to be myopic because procurement is just one component in a very complex system for managing highly-technical information programs. Thus, information technology can be entangled, to its own detriment, in procurement reform. Clearly, oversight through regulation of procurement authority is a two-edged sword.

The Paperwork Reduction Act of 1980, Public Law 96-511

This Act has had a number of broad effects on a variety of federal functions ranging from the time to prepare income tax forms to information technology. For information technology its purpose stated in section 3502 (5) was:

> [To] ensure that automatic data processing and telecommunications technologies are acquired and used by the Federal Government in a manner which improves service delivery and program management, increases productivity, reduces waste and fraud, and wherever practicable and appropriate, reduces the information processing burden for the Federal Government and for persons who provide information to the Federal Government . . . .

The Act established an Office of Information and Regulatory Affairs within the Office of Management and Budget with responsibilities for information resources management. Specifically, the Office was to develop uniform information management policies, principles, standards and guidelines for the agencies. The Act also mandated a review function to ensure that agencies were complying with regulations. Five-year plans were mandated for each agency. Finally, each agency was required to designate a senior official reporting to the head of the agency, who would be responsible for agency-wide information resources management.

This sweeping Act gave government-wide policy-making authority to the Office of Management and Budget. It raised information technology responsibilities within the agencies to a senior-level function. The Act also required coordination between the Office of Management and Budget and the General Services Administration in developing five-year plans; the latter performed the reviews function through 1995 at OMB's request. The Act formalized OMB's management responsibilities and its government-wide policy authorities for information technology.

The Defense Authorization Act of 1982, Public Law 97-86

Originally, the Brooks Act applied to all federal information technology acquisitions. However, the Department of Defense successfully changed that Act through the so-called Warner Amendment to the Defense Authorization Act of 1982 that eliminated certain defense command and control (C^2) and intelligence (C^2I) systems from the General Services Administration's purview. Thus, the scope of centralized oversight was restructured to include only general purpose, administrative information technology systems.

The impact of this change is indicated by the ratio between the costs of administrative and C^2I systems. Annual information technology funding subject to oversight by the General Services Administration before the 1996 reform legislation was approximately $25 billion (IRMCO, 1995). This did not include the so-called "Warner-exempt" procurements of the C^2I variety which in the mid-1990s ranged in the neighborhood of $23 billion, annually (GAO, 1995e). Apparently, information technology overseen by GSA plus the "Warner-exempt" portion totaled approximately

$48 billion, annually. Thus, the Warner Amendment effectively removed $23 billion or about one-half of all federal information technology from the original Brooks Act oversight intentions.

The Competition in Contracting Act of 1984, Public Law 96-369

This broad Act revamped some fundamental premises underpinning federal procurement by requiring agencies to achieve maximum competition, wherever possible. As such, it affected information technology because of the developmental nature of many of its programs.

However, the Act also began a very important accountability experiment by establishing the General Services Administration Board of Contract Appeals as a three year pilot to hear and resolve contractors' information technology protests. Award of information technology contracts was the focus. The Act also amended the Budget and Accounting Act of 1921 to strengthen the General Accounting Office's overall bid protest process. Moreover, it specifically mandated that contractors could only protest to either the General Accounting Office or the Board, but not both.

Creation of the Board touched off a longstanding area of contention between the oversight and the agency-level federal information technology communities, in general. Specifically, General Accounting Office protest decisions were not binding on agencies, but the Board's decisions became mandatory and binding on all parties. At that time, and even now, agencies are not obligated to adopt an adverse GAO protest decision. In fact, it is unlikely that an agency would adopt such a decision when it is believed that the decision would cause exceptional and untoward harm to that agency. This set of circumstances occurred because GAO is a legislative agency; making its decisions binding on an executive branch agency would raise serious constitutional issues. However, at the time of its creation, there were no such obstacles for the Board because the General Services Administration was an executive branch agency. Therefore, agencies could not ignore one of the Board's protest decisions; even under the most egregious circumstances, there was no latitude. An agency's only recourse was appeal through the federal courts.

Furthermore, upon the filing of a protest, the Board, in most cases, would rescind the agency's procurement authority and cause all procurement activity to halt until the case was decided. Thus, any work would immediately cease until a decision was reached about the protest. Clearly, the protestor had everything to gain while the agency had everything to lose if a protest was filed. Thus began an ongoing agency refrain about unscrupulous contractors being able to stop multi-billion dollar programs for the price of a postage stamp. The slang term "fedmail" came into vogue in the late 1980s to describe financial arrangements made between agencies and contractors to avoid protests and their corresponding lengthy delays to agencies' programs.

The Paperwork Reduction Act Reauthorization of 1986, Public Law 99-500

For purposes of information technology oversight, this Act made permanent the General Services Administration Board of Contract Appeals. Moreover, the Act responded to contentions about the Board's authority by explicitly stating that the Board was authorized to determine its own jurisdiction and it was not bound by Office of Management and Budget determinations about the scope of delegations of procurement authority.

Further, the Act made a number of important expansions and clarifications about the General Services Administration's Brooks Act authority. Specifically, it redefined the Brooks Act interpretation of "automatic data processing" to include software, support services and telecommunications as well as computer equipment. Rather than limiting it, this Act firmly supported a broader interpretation of the Brooks Act. Moreover, it gave the General Services Administration authority to delegate general procurement authority (*i.e.* not just for individual procurements) to agencies. The increased flexibility extended GSA's delegation options because it could treat whole agencies differently and not just their individual procurements; GSA could reward or punish at the agency-wide level.

The Act was also important to solidifying the Office of Management and Budget's management and policy authorities. Specifically, it strengthened the Office of Information and Regulatory Affairs by mandating its funding. It also acknowledged the converging role of computers (i.e. automatic data processing) and telecommunications within the overall realm of information technology. Thus, the Act strengthened in-place oversight mechanisms and recognized the rapidly expanding pace of information technology's role in government.

The Department of Transportation Appropriations Act of 1996, Public Law 104-50

Over a 30 year period in the history of the Brooks Act, only the Department of Defense had been successful in extricating some of its information technology programs out from under the General Services Administration's Brooks Act authority. That record remained intact until 1995 when Congress passed the Transportation Appropriations Act. Then, the Federal Aviation Administration became the first civilian agency to successfully challenge the General Services Administration's 30-year-old monopoly on information technology procurement authority.

Though but one of the many FAA reforms enacted as a part of this legislation, removal of GSA's authority over FAA further emphasized Congressional intentions about the Brooks Act. In fact, this legislation offered FAA broader relief than Congress later granted to the Internal Revenue Service (see PL-104-52, below). Whereas the Secretary of the Treasury was delegated authority for the largest IRS information technology program, Tax System Modernization, FAA was given a free rein over all of its programs. This Act made FAA exempt from federal procurement regulations, in general, not just the General Services Administration's authority. *Congressional actions were interesting because they really rewarded failure.* Even though it had been grossly mismanaged, FAA's multi-billion dollar Advanced Automation System debacle, described earlier in Chapter II, was also included in the Act's exemption from any government-wide procurement controls.

The Treasury Appropriations Act of 1996, Public Law 104-52

The fiscal year 1996 Transportation and Treasury Appropriations Acts contained a special requirement that the General Services Administration delegate, without conditions, authority to the Secretary of the Treasury for the Tax System Modernization program of the Internal Revenue Service. That multi-billion dollar troubled program was described in the prior chapter. Furthermore, the Act specified that only the Director of the Office of Management and Budget could revoke that authority, and not the General Services Administrator. This action was a second sign that the 104th Congress was determined to reform or, more likely, end the 30 year old Brooks Act.

The Defense Authorization Act of 1996, Public Law 104-106

Under the umbrella of this Act several federal-level changes were made, and some were controversial. This Act included, for example, a provision which made mandatory the discharge of HIV-infected military personnel and stripped them of certain health benefits, a requirement that President Clinton called "mean spirited." Moreover, within the Act were also very significant and government-wide reforms of federal procurement practices in Division D, and those of information technology management in Division E. Included was the most significant reform ever made since information technology had been centrally managed, namely, repeal of the 30 year old Brooks Act. The information technology effects are described next.

Division D--The Federal Acquisition Reform Act: This was the second major reform of federal procurement practices and policies within less than two years. No specific reforms of information technology procurement were made in this Act. Instead, those consequences were realized through Division E, below.

Division E--The Information Technology Management Reform Act: The Act provided 180 days for transition to a new system of information technology oversight. At the end of that period, in effect, the General Services Administration would no longer have oversight authority for information technology. Also, the General Services Administration Board of Contract Appeals jurisdiction over information technology contract awards was rescinded.

The Act reassigned GSA's formerly exclusive procurement authority directly to the agencies. As importantly, the Office of Management and Budget was assigned increased authority over information technology. Major agencies were required to establish a Chief Information Officer position reporting to the agency head, and OMB was given authority to establish a number of committees to assist its management of information technology. Under such an aegis, a council of Chief Information Officers was created by OMB in February 1995. The Council was to be headed by the Office of Management and Budget and serve, in effect, as a government-wide board of directors advising OMB about federal-level information technology policy issues. Thus, the Act centralized all information technology management, policy, and oversight authority within the Office of Management and Budget. It was the most significant reform of information technology accountability since the 1965 Brooks Act.

Specifically, the Information Technology Management Reform Act contained in Division E of the National Defense Authorization Act for fiscal year 1996 made major redirections in government-side management of such programs. Accordingly, all of the reforms of information technology oversight are contained therein. Some additional details about the Act's requirements, follow.

Section 5002 defines information technology as:

> [A]ny equipment or interconnected system or subsystems of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception, of data or information by the executive agency . . . [and] includes . . . computers, ancillary equipment, software, firmware and similar procedures, services (including support services), and related services.

Section 5101 Repeals the Brooks Act which was section 111 of the Federal Property and Administration Act of 1949, as amended.

Section 5111 Makes the Director of the Office of Management and Budget accountable and responsible for information technology oversight.

Section 5112 Requires the Office of Management and Budget to be responsible for capital planning and investment control of information technology, which includes:

- Improving the acquisition, use and disposal of information technology by the federal government to improve the productivity, efficiency and effectiveness of federal programs,
- Analyzing, tracking and evaluating the risks and results of major capital information technology investments by federal agencies,
- Overseeing the development of standards by the Department of Commerce and the National Institute of Standards and Technology,
- Designating agencies to act as "executive agents" for procuring information technology for government-wide use, and
- Encouraging "best practices."

Section 5113 Authorizes the Office of Management and Budget to use performance based approaches to evaluate information resources management practices by federal agencies.

Section 5125 Requires federal agencies to establish a Chief Information Officer who is responsible for developing, maintaining and facilitating the implementation of a sound and integrated information technology architecture.

Section 5126 Requires agency heads, in consultation with their Chief Information and Chief Financial Officers, to establish policies and procedures to ensure that agency information systems are designed, developed, maintained, and used effectively to provide financial and program performance data.

Section 5132 Gives the "sense of Congress" that during the next five year period beginning in 1996, executive agencies should achieve a five percent decrease in overall information technology costs and, correspondingly, a five percent per annum increase in the efficiency of agency operations.

Section 5141 Excludes "National Security Systems" from the scope of coverage under the Act; those systems are ones that involve (1) intelligence activities, (2) cryptological activities related to national security, (3) command and control of military forces, (4) integral to a weapons system, or (5) those critical to the direct fulfillment of military or intelligence missions, but systems used for routine administrative applications are not excluded.

The Act also establishes several pilot projects in an attempt to simplify information technology procurements.

Not without controversy, a number of politicians, agency officials, and industry representatives complained that those procurement reform and information technology provisions had been included without public hearing and debate (*e.g.* Washington Post, February 8, 1996, p. A25). It was, in fact, a valid charge because those provisions were never aired in a full committee hearing. The closest activity to deliberation had been a single September 1995 subcommittee hearing on the old Cohen information technology reform bill, S946. Portions of that bill had become the information technology reform language incorporated into the Defense Authorizations Act. Even those hearings were inconclusive because they never led to hearings before the full committee. Regardless, the provisions were enacted and, became law under the Information Technology Management Reform Act.

The Acts listed in Table III-A-I are the most important ones enacted into law for information technology between 1965 and 1996. Exclusive of the 1996 Acts, they formed the foundation for information technology oversight as it was practiced from 1965 through 1995. That same legislation also formed the basis for reactions to oversight practices by Congress, agencies, industry and the general public which led to the 1996 reforms. Table III-A-I summarizes this key legislation and its effects on the authorities of the Office of Management and Budget, General Accounting Office, General Services Administration, and Department of Commerce.

Additionally, two other legislative Acts are important for information technology. Though not focused directly on information technology, they have important ramifications and are the following.

Table III-A-I: Key Legislation and Central Management Agencies Authorities

Legislation	**OMB**	**GAO**	**GSA**	**Commerce**
Brooks Act 1965			exclusive IT procurement authority	technical standards authority
Federal Procurement Policy Act 1978			created FAR, the basis for FIRMR	
Paperwork Reduction Act 1980	IT policy authority			
Warner Amendment 1981			rescinded C^2I procurement authority	
Competition In Contracting Act 1984			Board of Contract Appeals was created	
Paperwork Reduction Reauthorization Act 1986	funded OIRA		GSA Board of Contract Appeals made permanent	
Information Technology Management Reform Act 1996	centralized IT oversight in OMB		revoked Brooks Act and rescinded Board's bid protest authority	continued technical standards role

The Government Performance and Results Act (GPRA) of 1993, Public Law 103-62

This Act was designed to shift the federal focus to results-oriented government management; that is, from process to outcomes. Although not specifically directed at information technology programs, the Act has had two important effects. First, it made information technology programs subject to the same types of overall performance and results controls as any other type of program or supporting component of a program. Secondly, by requiring performance measures, it provided additional leverage for oversight agencies in their review of major information technology programs and projects.

Succinctly, agencies are expected to shift their focus from: (1) inputs to outcomes, (2) process to results, (3) compliance to performance, and (4) controls to improvements. Agencies must prepare five-year strategic plans which define their long-term general goals and set specific annual performance targets. The plans must be submitted to the Office of Management and Budget by September 30, 1997, and they must be updated at least once during each three years thereafter. An annual performance plan must be submitted based on the strategic plan. Reports are due annually.

Annual performance plans must include performance goals for programs, requests for resources consistent with the President's budget, performance indicators, and lists of proposed waivers. Agencies can request waivers from administrative procedures, but not from law or statute, in order to achieve the planned outcomes.

The Office of Management and Budget is responsible, under the Act, for consolidating the information and preparing a government-wide performance plan, each year, which then becomes part of the President's Budget. The concept is to devise a government-wide set of performance measures beginning with the fiscal year 1999 budget. Agencies will annually report actual performance to Congress with the first report due by March 31, 2000.

This Act has already played a role in information technology accountability because the General Services Administration had required agencies during 1994 and 1995 to develop performance measures as a condition to obtain delegations for their largest programs (NAPA, 1994). However, its main effect on information technology programs remains to be seen because of its delayed implementation schedule. Even so, incorporation of the Act into information technology mechanisms has been and will continue to be an issue; GSA's misadventures in applying the principles of the Act to information technology are instructive (NAPA, 1994). Simply, as chronicled by NAPA, GSA attempted to demand performance measures for agencies' information technology programs but failed to help those agencies place their measures in the larger context of their mission programs. Moreover, GSA was viewed by agencies as overstepping its legislative authority; it had not worked in concert with the Office of Management and Budget or the General Accounting Office and, as a result, demanded conformance to contradictory policies.

The Federal Acquisition Streamlining Act of 1994, Public Law 103-355

This Act implemented large-scale reforms throughout federal government contracting. Its importance for information technology accountability at one level was that it retained the concept of a uniform set of procurement rules. Even in the midst of "cutting red tape" it did not rescind or modify the General Services Administration's Brooks Act procurement authority for information technology.

Moreover, the Act specifically demanded an information technology solution to streamline procurements. Specifically, a Federal Acquisition Computer Network (FACNET) was established by the Act. Agencies are required to establish interim FACNET capability with review and certification by the Office of Management and Budget. Before FACNET certification a $50,000 simplified threshold would apply; afterwards, the full $100,000 would become available to the agency. The $100,000 threshold was especially established for small purchases called "simplified procurements;" a threshold of $2500 was established for "micro procurements." Thus, the Act provided a number of incentives in the form of increased authority for agencies to implement "electronic commerce" in procurement processes.

Key Regulations

Two key compendiums of regulations have been issued by the Office of Management and Budget and General Services Administration, respectively, under authority of the above laws. Both are briefly described below for completeness of the presentation.

OMB Circular A-130

The Office of Information and Regulatory Affairs within the Office of Management and Budget has had responsibility, under the Paperwork Reduction Act, for developing and implementing uniform and consistent information resources management policies. This Circular remains the main policy document for information resources management during the Brooks Act years. The policies in this Circular continued to apply to the information activities of all agencies of the executive branch of the Federal government throughout that period. It, along with associated circulars and guides, was also used by the Office of Management and Budget to evaluate agency information resources management practices and determine compliance with its policies, principles and standards. The Circular was OMB's principal policy vehicle at the time the Information Technology Management Reform Act was enacted in February 1996. OMB announced shortly thereafter that A-130 would remain the major policy document for information technology.

Federal Information Resources Management Regulation (FIRMR)

Developed by the General Services Administration under its exclusive Brooks Act procurement authority, this was until 1996 the principal government-wide regulation for information technology procurements. It was applicable to all federal agencies subject to the Brooks Act. This means that it only excluded the so-called Warner exempt procurements of the Department of Defense, namely, command and control, and intelligence (C^2I) acquisitions; civilian agencies had no exclusions--even for their intelligence requirements (government corporations were generally not considered to be "agencies" under the Brooks Act). The General Accounting Office voluntarily followed those regulations.

The FIRMR was issued by GSA with policy direction from the Office of Management and Budget. It was subject to rule-making procedures, and changes were published in the *Federal Register*. The major sections were: General, Management and Use of Information and Records, Management and Use of Federal Information Processing Resources, and Acquisition of Federal Information Processing Resources by Contracting. The FIRMR also implemented the Paperwork Reduction Act's requirement for each agency to have a Designated Senior Official who was responsible for that agency's information technology investments, and it provided implementing regulations for GSA to transfer its exclusive Brooks Act procurement authority to individual agencies through blanket, specific and agency-unique delegations of procurement authority.

The FIRMR, therefore, had two thrusts: management direction and procurement policies. GSA used the FIRMR to levy requirements for specific management structures and practices upon the agencies. For instance, agencies developed elaborate information resources management organizations in response to FIRMR requirements. In addition, the FIRMR drove those structures through detailed actions required to document and justify information technology procurements.

Under the Information Technology Management Reform Act the FIRMR remained in effect until August 7, 1996. However, prior to that date the Office of Management and

Budget utilized an inter-agency group to place some parts of the FIRMR into the Federal Acquisition Regulations (FAR). Of particular importance to agencies was the authority to award information technology contracts up to 10 years in length; without this action agency information technology contracts would have been restricted to a maximum of five years. The move of some FIRMR regulations to the FAR also retained certain General Services Administration mandatory for use and mandatory for consideration programs in telecommunications and financial systems software.

Importantly, through both sets of regulations the Office of Management and Budget was able to centralize overall policy direction while, until 1996, strengthening the General Services Administration's focus on its exclusive procurement authority. Thus, these regulations broadened the span of oversight beyond the procurement venue. Instead, the central management agencies used these regulations to control government-wide management of information resources.

Executive Order 13011

A number of Executive Orders have been issued, over the years, mentioning or affecting, in some way, federal information technology management. These included Executive Order 12845 dated April 21, 1993, which required federal agencies to purchase only energy efficient computers, and Executive Order 12999 dated April 17, 1996, that required federal agencies to donate surplus computers to educational institutions, whenever possible. Other Executive Orders have dealt with specific security issues and intelligence matters in the overall management of federal computer and telecommunications resources.

Of particular interest, however, is Executive Order 13011 issued on July 16, 1996. This Order established a framework for management of information technology to implement the Information Technology Management Reform Act of 1996 (ITMRA). The Office of Management and Budget's (OMB's) preeminent role under ITMRA was affirmed by the Order, and three committees were established to assist in government-wide management of information technology. Those committees and key elements of the Order are described in the following.

A Chief Information Officers (CIOs) Council was created, and would consist of the CIOs and Deputy CIOs from the largest agencies as well as those from the central management agencies. A total of 28 agencies were to be represented along with two representatives from the smaller ones. The Deputy Director for Management of OMB was designated to chair the council with a vice chair elected by the membership.

A Government Information Technology Services Board (GITSB) was established, and its initial membership was selected by OMB. Its function was to implement the information technology recommendations of the National Performance Review, and promote the development of innovative information technologies, standards, and practices among agencies and state and local governments. Thus, the Order made permanent, under the direction of OMB, the ad hoc Government Information Technology Services committee that had previously been created by the Administration under the auspices of the National Performance Review to assist with the National Information Infrastructure initiative.

The Order also established an Information Technology Resources Board (ITRB) to provide independent assessments of agencies' programs. OMB selected the initial membership. ITRB reviews were intended to provide assistance to an agency by making recommendations about the status of a system or identifying next steps. The ITRB was also mandated to publicize lessons learned and promising practices. In effect, the Order transferred to OMB and made permanent the ITRB originally created by the General Services Administration in 1993.

Interestingly, the Executive Order also designated specific roles for the General Services Administration (GSA). In addition to maintaining the well-known FTS2000 telecommunications program, GSA was slated to develop information technology strategies and acquisition methods for the agencies, and provide support for the CIO Council as well as the GITSB and ITRB. Additionally, GSA was designated to assist OMB in evaluating agencies performance-based management tracking systems and agencies achievement of cost, schedule and performance goals.

Thus, the Executive Order established a facilitative framework for implementing the Information Technology Management Reform Act of 1996, and for OMB's assumption of responsibility for government-wide management of federal information technology. Oversight was not the vision; rather, collaboration and facilitation were the Executive Order's themes.

OMB was to be supported in its responsibilities by the three committees. The CIO Council was designed to promote collaboration, and the GITSB was devised to facilitate information technology solutions to meet government-wide needs. Facilitative support for OMB by GSA was also required by the Order. Accordingly, the Executive Order envisioned a management-by-committee approach for federal information technology, wherein each committee would be held in thrall by OMB. One committee would address management and policy issues (CIO Council), another would deal with cross-governmental technology requirements (GITSB), and the third would respond to individual agency and system needs (ITRB).

The above mentioned laws, regulations, and the Executive Order created the mid-1990s federal information technology oversight environment. In effect, they made it a very special accountability area replete with a diversity of oversight structures and processes. However, such structures did not materialize from the mists. Key actors and organizations, which are discussed below, gave birth to such mechanisms and influenced oversight directions.

B. Key Organizations and Actors

From the above, it is clear that development of information technology accountability mechanisms has not been an altruistic lesson in civics; rather, it has demonstrated the complexity of political relationships in the oversight arena. Information technology's promises for improved governmental efficiency, effectiveness and economy have often been extolled. However, its management and oversight has been the target of deprecations about waste, fraud and abuse in federal information technology. Yet, often embedded within those adulations and outcries have been deep-seated political issues of power, authority, accountability and control.

Those complexities have woven a rich tapestry of accountability concepts and practices about information technology, its oversight and management. As indicated in the legislation section, above, five principal actors emerged over the years to dominate information technology oversight. With passage of the Brooks Act, the General Services Administration and the Department of Commerce had become the fourth and fifth government-wide information technology players. Congress always had its legislative authority. The General Accounting Office was certainly a major player. Finally, the Office of Management and Budget was clearly an important actor because of its budget role (table III-B-I).

Of the four, the General Accounting Office has had no authority to direct changes; it could only make recommendations. Congress could legislate, the Office of Management and Budget could withhold or change funding levels, and until mid-1996 the General Services Administration could grant or withhold contracting authority. The fifth agency, the Department of Commerce, was made responsible for setting the federal governments' information technology technical standards. Some perspectives about each of these key actors are offered below.

Table III-B-I: Information Technology Authorities of Five Key Actors

Organization	Budget	Policy	Regulations	Procurement	Standards
Congress	appropriations	legislation	legislation	legislation	legislation
OMB	yes	yes	yes		
GAO	audit only	audit only	audit only	audit only	audit only
GSA	no	procurement (through mid-1996)	procurement (through mid-1996)	exclusive (through mid-1996)	
Commerce					technical

Congressional Actors

Over the years from 1965 through 1996, the following committees and specific senators and representatives have had an important influence on federal information technology accountability.

The House Government Operations Committee

Modern federal information technology oversight began with Jack Brooks, a former House of Representatives Democrat from Texas. Brooks, dating back to the 83rd Congress, was a forbidding information technology presence until he lost his seat in the 1994 elections. As committee chairman, the well-known 1965 Brooks Act bore his name, and remained the principal piece of information technology legislation for 30 years.

However, the Brooks Act did far more than reform information technology accountability; it centralized a tremendous amount of power in the committee, particularly its chairman. As an example, there were many anecdotal accounts throughout the information technology community about how, in the early years, Brooks's staff would personally review many of the proposals for the largest information technology procurements before allowing the General Services Administration to delegate its authority. Agencies needed Jack Brooks's "stamp of approval."

Even after moving to the Judiciary Committee, he still emoted a powerful presence. As an example, when GSA's Administrator Johnson spoke in 1994 of giving up the General Services Administration's Brooks Act authority (see the figure), Brooks took the unusual step of scheduling himself as a witness at each future congressional hearing where Johnson was scheduled to speak. At one of the first ones, a Government Operations hearing, Brooks caustically stated "why doesn't he just go home" (GCN, 1994a). Afterwards, under Johnson's revised direction, the General Services Administration began, for a time, to strengthen rather than reduce its use of Brooks Act authority using both old and new mechanisms. Brooks was certainly colorful, and one of the most powerful actors who influenced information technology oversight.

The Government Operations Committee chairmanship was subsequently assumed by John Conyers (D-MI). Representative Conyers was first elected to the 89th Congress. Conyers took measures to strengthen the committee's information hand, and, under his leadership, GOV-OPS typically took the lead over the Senate in information technology matters.

He was instrumental in authorizing numerous General Accounting Office and staff investigations of troubled information programs. His 1989 interest in the "Gang of Six" allegations (GOV-OPS, 1990) was sufficient impetus for the committee to cause several General Accounting Office investigations. The allegations centered around widespread Department of Defense abuse caused by wrongfully directing contracts to IBM. He also held hearings about Administrator Johnson's 1994 attacks on the General Services

Administration's Brooks Act responsibilities (GOV-OPS, 1994). Conyers was a strong protector of the Brooks Act and the prerogatives which it had brought to the Committee.

Interestingly, one of Conyers' investigations prompted the adoption in 1992 of performance measure controls by the Department of Veterans Affairs, as a precursor to the Government Performance and Results Act of 1993 (GAO, 1992e). Conyers, working with the General Accounting Office, General Services Administration and the Office of Management and Budget, required the Department to commit to specific, measurable performance criteria as a condition of receiving continued funding and procurement authority for a large information technology modernization program.

The House Government Reform and Oversight Committee

With the sweep of the 1994 elections by the Republicans, the House Government Operations Committee became the House Government Reform and Oversight Committee. Chairmanship of the new committee passed to William Clinger (R-PA). Through 1995, the committee's interests did not focus on information technology. Specifically, no significant initiatives to reform federal information technology management emerged from the committee under Clinger's leadership.

However, the committee under Clinger's leadership had been extensively involved in procurement reform efforts which would possibly have had a significant effect on information technology oversight. The most probable impact on the Committee's deliberations centered on the General Services Administration Board of Contract Appeals.

A mid-1990s idea to reduce bid protest opportunities originated outside the Committee,, thereby limiting the right to redress for vendors or citizens who believed they had been unfairly restricted from government contracts. Senator Cohen, a leading proponent, advanced this idea in 1994 by introducing legislation (S946) to eliminate the General Services Administration Board of Contract Appeals, the preeminent information technology bid protest forum. Administrator Kelman (1995) of the Office of Federal Procurement Policy also supported neutering the Board by stating that industry protested contract awards too often, thereby, delaying the process at great harm to the government.

However, the opposite occurred in the House. Representative Clinger introduced a 1995 procurement reform bill (HR1388) that would have used the Board as a model for all procurement disputes by consolidating the dozen or more federal protest forums into one board. Later in 1995 his proposal was revised to consolidate protests into just two boards, one for defense and the other for civilian agencies' protests. Under either scenario the Board would have been the recipient of consolidated authority, with a sound affirmation of its practices. However, Clinger's bill faded when the 104th Congress adopted a variation of Cohen's proposal under the umbrella of the 1996 Defense Authorizations Act which was signed into law during February 1996.

The Senate Government Affairs Committee

Rather than leading and directing information technology, this committee tended to work with and support the House Government Operations Committee's leadership until the 1994 elections. John Glenn (D-OH), first elected to the Senate in 1974, remained the chairman until the 1994 elections. Glenn had frequently joined Conyers in information technology legislation and in targeting major programs for review.

However, leadership in federal information technology had already begun shifting from the House to the Senate when the Republicans took control of the 104th Congress. In fact, Government Affairs member William Cohen (R-ME) jumped out in front in late

August 1994, just before the elections, with release of his Computer Chaos report (Cohen, 1994). Numerous proposals subsequently emerged from his staff to change, relocate and eliminate much information technology oversight. Legislation introduced in early April 1995 by Cohen, S946, was not passed in 1995. However, as previously recounted, several key elements of his proposal were added to the fiscal year 1996 Defense Authorizations bill which was signed into law in February 1996 as the Information Technology Management Reform Act. That Act was the most significant reform of information technology oversight since the Brooks Act.

Until the 1994 elections, Brooks, Conyers and Glenn were the "big three" congressional actors in federal information technology legislation and oversight. They established a government-wide oversight structure which lasted over a thirty year period. With the 1994 onslaught, the new Republicans took the lead and information technology was caught up in the whirling Congressional winds of the reform movement.

Office of Management and Budget

Through its budget functions, the Office of Management and Budget always had a generalized responsibility for information technology. However, the Paperwork Reduction Act of 1980 gave specific management and oversight responsibilities to OMB. The Office of Information and Regulatory Affairs was established within OMB to fulfill these information resources management functions. OMB implemented these responsibilities, over the intervening years, through a number of policy issuances, principally Circular A-130, and other circulars.

It also exercised its government-wide policy-making responsibilities by working with the General Services Administration in implementing activities such as the previously mentioned

Federal Information Resources Management Regulations (FIRMR). Through participation, such as co-chairing the FIRMR Council with the General Services Administration, OMB continued to play an active role until the FIRMR was abolished as an outcome of the 1996 reform legislation. The Council had included senior-level agency representatives, and it recommended areas of information technology management actions and policy initiatives. OMB announced upon enactment of the reform legislation that it would continue in the future to use committees in implementing that legislation.

The Office of Management and Budget had also previously worked with the General Accounting Office to devise a 1994 audit guide entitled "Evaluating Agency Investments in Information Technology." This guide was developed to provide a common framework for OMB examiners and GAO evaluators to use in information technology audits. The guide focused on three major areas of control, namely, agency problems such as cost overruns or schedule delays, the agency's management capacity, and information technology portfolio analysis. The goal of this effort was to maximize risk-adjusted return on such investments. Those three areas also pointed towards the newly-charted direction and were reemphasized in a late 1995 update to the guide.

OMB was also previously assigned an audit function in the 1980 Paperwork Reduction Act, namely, one of reviewing agencies' information resources management programs. Through an agreement, the General Services Administration conducted the reviews on OMB's behalf through 1995.

Through the Bush administration, OMB leaders exhibited little interest in radically changing the format of information technology oversight. No sweeping legislation was suggested or supported by OMB. Rather, OMB continued in the path charted by the 1980 Paperwork Reduction Act with only occasional bumps in the road.

Through its first two years a similar observation could have been made about Clinton's OMB. However, in 1995 OMB officials began advocating some important information technology oversight changes. As an example, Steve Kelman (1995), the Administrator of OMB's Office of Federal Procurement Policy, began publicly advocating elimination or radical restructuring of the General Services Administration Board of Contract Appeals. OMB Deputy Director Koskenin and Administrator Johnson of the General Services Administration co-chaired a panel to create a plan for restructuring information technology oversight (FCW, 1995e). The results were submitted to Vice President Gore and Senator Cohen.

Table III-B-II: OMB Changes

Period	Changes
1965-88	issued IT policy
1989-92	issued IT policy
1992-95	issued IT policy joint OMB/GAO IT audit guide joint OMB/GSA oversight work group
1996	centralized IT oversight

A comparison with the 1996 reform legislation showed that OMB had exercised considerable influence and had become a more active player in mid-1990s information technology accountability and oversight. In fact, it is clear that OMB was a key player in pushing for enactment of the 1996 Information Technology Management Reform Act that revoked the Brooks Act and made OMB the single agency with centralized information technology authority. Table III-B-II depicts the changes and advances in OMB's role.

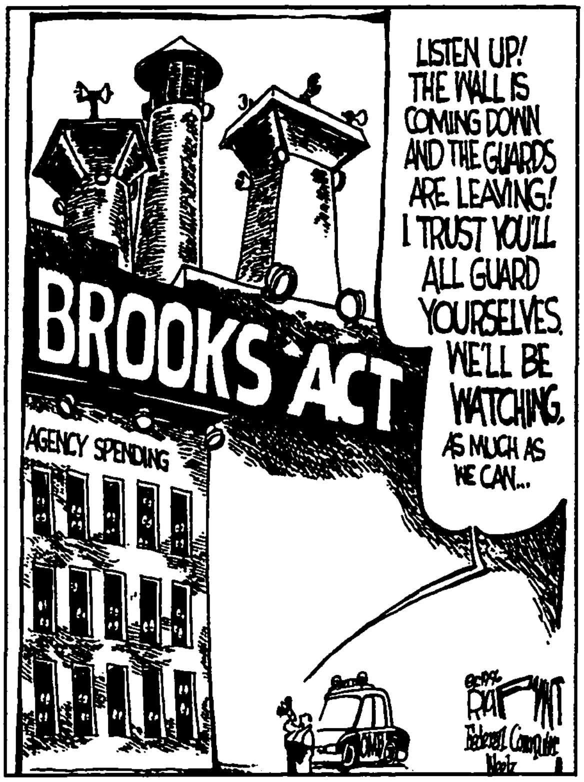

Figure III-B-1: End of the Brooks Act

Enactment of the Information Technology Management Reform Act indicated that both the Administration and Congress thought that OMB could effectively manage federal information technology. However, confidence was not universal in OMB's ability to hold agencies accountable for the cost-effectiveness of their information technology programs (see figure III-B-1; reprinted by permission of Rich Tennant, Rockport MA, email: the5wave@tiac.net). Regardless, OMB assumed its new role, and began implementing the reform legislation when it was enacted in February 1996,.

General Accounting Office

Oversight complexities drove GAO in 1983 to create its own information technology management (IMTEC) organization. Major federal agencies, and particularly the Department of Defense, had developed more information technology expertise than GAO. Audit quality had declined and GAO sponsored a major recruiting effort in 1984-1985 to attract highly skilled information technology professionals to IMTEC.

Under the old IMTEC organization, GAO was a powerful influence and frequently "locked horns" with agencies over their information technology programs (*e.g.* GAO, 1992e). A well-known example was the GAO investigations of the Social Security Administration in the mid-1980s. GAO concluded that poor planning and mismanagement had caused Social Security to reach the point where its computers were out of capacity; there was a real danger that the agency would be unable to issue social security checks. Earlier in the decade, GAO had investigated Social Security in the so-called "Paradyne Scandal" (SSA, 1995). In that affair, certain Social Security officials had accepted bribes in the award of computer equipment contracts. GAO's investigations were the key impetus in major oversight actions such as severe funding cut backs and constraints as well as withdrawal of all procurement authority from the Social Security Administration for almost a decade.

> *"[T]he issue before federal executives and policy makers, then, is not whether to change federal information management practices, but exactly what to change and how to do it."* (GAO, 1995)

Another important GAO action was its investigation of information technology procurement practices in several large agencies. The investigations were initiated because a "Gang of Six" IT vendors presented in 1989 what appeared to be incontrovertible proof that major agencies, primarily in the Departments of Defense and Health and Human Services, were illegally directing major contract awards to IBM. GAO's investigations led to the so-called Navy Bias Hearings by the House Government Operations Committee (GOV-OPS, 1990) which confirmed the assertions. Numerous actions were taken to strengthen oversight of large programs. Authority and funding were withdrawn or modified for large Navy, Army, Air Force and Defense information technology programs; a large National Institutes of Health computer procurement was suspended. GAO and IMTEC had been instrumental in those actions.

However, in 1993 that traditional role of power and influence was debilitated with the demise of IMTEC. Another blow occurred in the 1994 elections, bringing an end to Conyers' (D-MI) role as GOV-OPS Chairman, along with the considerable influence of his investigative staff. Some of the old IMTEC functionality and focus began to resurface when its functions were reconstituted in the new Accounting and Information Management Division in 1994. However, its sponsorship was still in the formative stages during 1995 through mid-1996. Moreover, GAO as a whole was undergoing a strong dose of NPR-like "reinvention" including the potential loss of up to one-third of its staff. Table III-B-III depicts changes in GAO's approach to its information technology role.

Table III-B-III: GAO Changes

Period	Changes
1965-88	1) IMTEC created in 1983 2) individual IT project audits
1989-92	1) individual IT project audits
1992-96	1) IMTEC dissolved in 1993 2) IT functions in new AIMD 3) joint OMB/GAO joint audit guide 4) focus on "best practices," "high risk" programs & IT reform

Beginning in 1994 GAO issued four reports that had considerable importance for information technology. In the first one, GAO (1994d) formally began recommending a "best practices" approach to information resources management. The report identified 11 practices from industry and government that were claimed to lead to overall performance improvements. In the second one, GAO's 1995 "High Risk" series (GAO, 1995a), information technology was identified as a cross-cutting area of risk. Specific information programs were declared high risk including the Internal Revenue Service's Tax System Modernization program. GAO continued a high risk focus in a third report and also addressed the broader issue of government-wide management of information technology investments (GAO, 1994e). GAO also linked best practices in the report as a way to ameliorate problems with non-performing programs. In the fourth report, GAO (1995e) attacked the effects of traditional delegation and audit oversight mechanisms on delays in acquisition times for major information systems. GAO suggested "best practices," performance measures and budget linkages as more effective mechanisms.

Apparently, GAO's traditional "junkyard dog" audit role came under revision. "Reinvention" of that role moved GAO in a new direction. Moreover, GAO began focusing on information technology in a different way. Best practices, performance measures and budget linkages became the new mid-1990s prescription. These observations clearly align with GAO's consistently favorable and supportive stances through 1996 on the National Performance Review, Government Performance and Results Act and Chief Financial Officers Act. GAO embraced considerable change and supported information technology reform in the mid-1990s.

General Services Administration

From 1965 through mid-1996 the Brooks Act had been the source of the General Services Administration involvement in and centralized authority over the acquisition of federal information technology. Though under considerable attack in the early 1990s, the Act remained in effect for over 30 years until it was revoked by the Defense Authorizations Act of 1996.

Briefly, the Brooks Act was the principal authority for GSA's role in information technology oversight. Shortly after passage of the Act, GSA created the Automatic Data Processing and Telecommunications Service to administer this responsibility. To implement the Act, GSA focused on regulations and delegations of authority for computers.

During the initial years, GSA designed a delegations program to manage information technology acquisitions by transferring GSA's authority to agencies so that they could directly contract for the resources; GSA granted delegations of procurement authority (DPAs) to Federal agencies. However, under the Government Operations Committee's guidance and direction, GSA at that time conducted extensive reviews of information technology acquisitions valued as low as $50,000. This procedure caused some significant delays in procuring and deploying new information systems.

Notable oversight changes occurred during the early and mid-1980s through 1988. In 1983, GSA responded to criticism about delays by raising the delegations threshold to $2.5 million for competitive and $250,000 for non-competitive procurements and abbreviating the review process. Below those levels agencies did not need advance GSA approval. By 1988, GSA was granting over 500 delegations of procurement authority each year. The value of these delegations exceeded $20 billion, annually. Individual delegations typically ranged in value from $2.5 million to over $1 billion; the 1987 delegation for the previously mentioned Federal Aviation Administration's Advanced Automation System exceeded $4 billion. When requests were submitted to GSA, delegations were routinely granted to agencies with very few rejections.

The Federal Information Resources Management Regulations (FIRMR) was devised by GSA early in the 1980s to supplement the Federal Acquisition Regulations (FAR). The 1978 Federal Procurement Policy Act had given birth to the FAR with a mandate to create a uniform, government-wide set of rules. Within this mandate, GSA accepted the opportunity to promulgate a uniform, government-wide set of information technology procurement rules. Both GSA and the Office of Management and Budget used the FIRMR as an opening to create interagency councils and working groups to further leverage policy and regulation across the federal community. Both agencies co-chaired a FIRMR Council that consisted of senior-level representation from the major agencies. The Council was chartered to assess information technology issues as well as to recommend areas of policy for study.

GSA also began to conduct reviews of agencies' information resources management programs under an agreement with the Office of Management and Budget. The 1980 Paperwork Reduction Act had levied a specific requirement on the Office of Management and Budget to review agencies' information management programs. GSA devised a program to review the largest 25 agencies' programs. The 1986 Paperwork Reduction Act Reauthorization gave GSA a specific incentive to offer agencies that underwent a successful review; the Act enabled GSA to grant agency-wide delegations thresholds. GSA could, in effect, grant a blanket level of authority for an agency above or below the $2.5 million threshold implemented in 1983. With this tool, GSA began raising individual agencies' authority levels when the information resources management review was successful. By 1988 GSA was conducting up to six reviews a year, and four agencies had raised levels of authority--up to $10 million in one case (IRMCO, 1990).

By 1988, GSA had also pursued some other approaches. For example, a training program for senior information technology managers started in 1988. The requirement to seek a delegation of procurement authority from GSA helped to fill the program's training classes to capacity. GSA was also publishing an "Information Resources Management Newsletter" and a series of non-mandatory Information Resources Acquisition Guides. GSA was also hosting annual "Information Resources Management Conferences" which were heavily attended by the agencies (IRMCO, 1995).

However, in 1989 the previously mentioned Navy Bias Hearings by the House Government Operations Committee (GOV-OPS, 1990) caused a significant redirection of GSA's oversight strategy. GSA was subjected to considerable criticism because of the affair; GSA had not prevented the identified problems of widespread misuse of the procurement process to illegally direct over $1 billion worth of contracts to IBM. The charges of the "Gang of Six" competitors of IBM had been proven correct.

GSA was forced to rescind delegations previously granted for some major Department of Defense and National Institute of Health computer systems. When the delegations were later reinstated, numerous oversight controls were placed on the offending procurements (GOV-OPS, 1990).

A more lasting effect resulted from major restructuring of GSA's delegations and reviews programs. Specifically, GSA put more "teeth" into the process by requiring comprehensive reviews of the largest information technology procurements (typically exceeding $100 million) before granting a delegation. Further, GSA inserted "stop and go" check points whereby agencies needed additional GSA approvals at specific pre-contract award events in the procurement process. Moreover, GSA would continue to oversee such programs throughout their life cycles through imposition of pre-timed requirements for specific reports and briefings.

GSA also intensified its information resources management reviews, and it raised the total to nine a year to shorten the interval between individual agency reviews to three years. Subsequently, GSA used the reviews to reduce several agencies like the Army Corps of Engineers below the $2.5 million level although others like the Department of Commerce remained at higher levels (GSA-Reviews, 1993).

Such actions continued through 1992 wherein GSA pursued a regulations-based strategy and strengthened its delegation and audit approach to oversight. GSA also broadened its Brooks Act mandate through the use of specialized training functions and interagency activities.

Moreover, the GSA Board of Contract Appeals had been strengthened by the 1986 Paperwork Reduction Act Reauthorization which made the Board permanent and broadened its authority. The Act also consolidated computers and telecommunications into the Brooks Act definition of "automatic data processing," thereby, affirming and strengthening GSA's oversight role. In that way GSA had consolidated its computer influence with its well-known consolidated local telephone services and inter-city federal telecommunications (FTS) systems. Before the 1992 presidential elections, there appeared to be no retreat in sight for information technology oversight; it had reached its zenith.

Figure III-B-2: The Hill and GSA's Johnson in 1994

Prior GSA Administrators consistently had little inclination towards reforming information technology oversight processes. However, GSA's Clinton Administration Administrator broke that mold and embraced a number of initiatives. Until the 1994 elections, there was one orthodox approach to federal information technology oversight; it was spelled out in the Brooks Act, interpreted in GAO reports and brokered in the Democratic 103rd Congress by the House Government Operations Committee working hand-in-glove with the Senate Government-Affairs Committee. The 1992 and 1994 elections opened the gates to a flood of "reinvention" possibilities. Table III-B-IV depicts changes in GSA's approach to its information technology oversight role.

Table III-B-IV: GSA Changes

Period	Changes
1965-88	1) exclusive Brooks Act procurement authority--1965 2) established a separate Service, ADTS, for government-wide IT oversight 3) audited agencies' IT management under OMB agreement 4) permanent GSA Board of Contract Appeals - 1986
1989-92	1) comprehensive review of largest delegations 2) strengthened IT management audits
1992-95	1) "Time Out" for high-risk programs - 1994 2) required agency performance measures -1994 3) $25 million agency authority levels - 4/95 4) $100 million agency authority levels - 7/95 5) IT Service dissolved - 1995
1996	Brooks Act revoked; IT oversight authority rescinded

After the 1992 elections, opponents were quick to label the Brooks Act as culpable for agencies' costly information technology failures, and GSA's new Administrator, Roger Johnson, spoke openly of giving up GSA's authority. However, the Democratically-controlled 103rd Congress was still in session, and supportive Democratic senators and congressmen led by powerful Brooks, Glenn and Conyers castigated Johnson, and blocked his plan (see figure III-B-2; reprinted courtesy of *Government Computer News*, copyright 1994 and 1995 by Cahners Publishing Company, a division of Reed Elsevier Inc., 275 Washington Street, Newton MA 02158, all rights reserved). In fact, the House Government Operations Committee held hearings to forestall such changes (GOV-OPS, 1994).

Subsequently, GSA began changing its oversight methods. First, it began moving towards the performance measures concept promulgated by the 1993 Government Performance and Results Act. In January 1994, GSA announced that all future delegations of procurement authority for major information systems would require agencies to commit to specific mission-level performance measures. GSA's commitment to performance measures was solidified in March 1994, when the Federal Aviation Administration announced huge cost overruns (e.g. *USA Today*, 1994) in its multi-billion dollar Advanced Airspace System computer modernization program. The mismanaged program lacked performance measures and was being conducted under GSA's Brooks Act authority. A commitment was given to Congress by GSA that future procurements would have performance measures to prevent those types of problems (IRMCO, 1994).

GSA also overlaid a new program for troubled systems on top of its delegations process. GSA's "Time Out" program (IRMCO, 1994) began suspending delegations in May 1994. The Federal Aviation Administration's $6 billion Advance Airspace System, the Veterans Benefits Administration's $500 million Modernization and the National Oceanic and Atmospheric Administration's $500 million Advanced Weather Information and Processing System were all suspended between May and August 1994. The concept was to cancel any program or portion of a program that could not readily be fixed. First, the agency was required to institute a "time out" and obtain an independent review of the information program. If curable, authority would be reinstated only after GSA approval of a recovery plan. By the end of 1995, Administrator Johnson touted "time out" as having saved the taxpayers $7.4 billion (GSA, 1995e).

The 1994 elections removed Jack Brooks from office. By 1995 Republicans Clinger and Stevens had replaced Conyers and Glenn, respectively, in their chairmanship positions. Opponents lost no time in decrying the perceived ill effects of "red tape" driven by Brooks Act processes; the General Services Administration Board of Contract Appeals was attacked from within the Administration as well as by the new Congress for not protecting the government from vendors' protests. It was made eminently clear during that period that changes were imminent because information technology oversight's "big three" were certainly out of power.

Responding to those pressures, GSA first created a three-tiered scheme in April 1995 to raise agencies' authority levels from the decade-old $2.5 million amount; the largest agencies received a blanket authority of $25 million. Selected agencies received up to $50 million (FCW, 1995c). In July 1995, GSA went further and raised all agencies, regardless of size, to $100 million (GCN, 1995d). Until that time, GSA was granting about 800 delegations with a total value of $25 billion, annually, and overseeing approximately 2000 procurements worth over $100 billion at any point in time (IRMCO, 1994). Comprehensive review of large-scale procurements was discontinued along with any reporting requirements. Reviews of agencies' information resources management were also permanently suspended; the last one was conducted in 1993. In effect, GSA gave up its previously powerful delegations and reviews programs. Some believed that GSA was giving up its authority in fear of Senator Cohen's reform legislation (see figure III-B-3; reprinted courtesy of *Government Computer News*, copyright 1994 and 1995 by Cahners Publishing Company, a division of Reed Elsevier Inc., 275 Washington Street, Newton MA 02158, all rights reserved). Regardless of the reasons, the Brooks Act strategy of oversight through delegation and audit was effectively neutered by the end of 1995 even though legislation had still not been enacted.

The GSA Board of Contract Appeals also came under attack from within the Administration and by members of Congress. First, in 1993 GSA's Administrator had commissioned an Interagency Acquisition Review Board to study information technology procurement and to make recommendations. The Information Technology Review Board consisted of senior-level career information technology managers. Its report entitled To Improve

The Federal IT Acquisition Process (GSA, 1993) made a number of recommendations, many of a "best practices" nature. Moreover, there were two important proposals regarding the Board, namely:

- o Change the Board's process to penalize vendors' frivolous protests, and
- o Not allow the Board to delay work when a protest is filed until litigation is completed.

Those attacks on the Board were joined by Senator Cohen in his 1994 Computer Chaos report, and by Administrator Kelman from the Office of Federal Procurement Policy (Kelman, 1995). Both cited harm to the government caused by delays in the procurement process when vendors filed inappropriate or "frivolous" protests. Both demanded elimination of the Board or, at least, substantial changes in its rules and processes.

Figure III-B-3: GSA Abandons Brooks Authority

It is important to observe that rescinding the Board's "stop work" authority would have been a significant change. Under the rules at that time agencies had considerable incentive to work with bidders in order to prevent a protest. Any protest, if filed timely, would almost with certainty have delayed the largest information programs. Except under the most unusual circumstances, the Board routinely issued "stop work" instructions when a protest was filed, even if a contract had already been awarded.

Thus, the agency was forced into a situation where it could not obtain the information resources to meet its mission until the protest was resolved.

Rescinding the Board's "stop work" authority would have taken leverage from vendors and placed it with the agencies; the "balance of power" would have shifted by 180 degrees. Agencies would have had no incentive to settle protests. Instead, it would have been to an agency's advantage to award and continue using a contract even under threat of protest because that protest could have been kept in the courts for years. Mounting costs would have forced all but the most hardy and cash-rich vendors to withdraw their protests. Agencies would have had a considerable advantage.

Moreover, the fact that agencies wanted to "punish" some industry challenges to contract awards also caused fundamental public administration concerns to some because of Constitutional issues in that proposal. The right-to-redress issue is obvious, and it would always have been difficult to separate a "frivolous" protest from one grounded in reasonable concerns.

However, a broader issue was predicated upon a fundamental American political thought that each citizen should have the opportunity to participate in government. As an example, it has been held since Jacksonian days (circa 1826) that each citizen is capable of seeking and performing government jobs. Likewise, by extension, it could be argued that each citizen should be able to participate in the government's business by seeking and competing for government contracts. Federal procurement legislation through the Federal Acquisition and Streamlining Act of 1994 consistently advanced that view by supporting the Competition In Contracting Act imperative to maximize competition opportunities, whenever possible. The proposal to "punish" was certainly troublesome, in that context.

One more significant GSA change took place in 1995. Finally, GSA began dissolving the Information Technology Service which had been responsible for Brooks Act oversight. By the end of 1995 any remaining Brooks Act functions had been incorporated into a newly-created Policy, Planning and Evaluation organization that became responsible for administering all GSA policy functions, not just information technology. It had already been publicly announced that any vestiges of the old Service would become a small Chief Information Officer function responsible only for internal GSA information technology. Even without enacted legislation, no longer was there a special place for Brooks Act functions at GSA by the end of 1995.

In February 1996, as reported earlier in this chapter, the 1996 Information Technology Management Reform Act was enacted, and with it came revocation of the 30 year old Brooks Act. GSA's oversight role ended at that time. The GSA Board of Contract Appeals lost its bid protest jurisdiction. With the Office of Management and Budget as the sole oversight agency for information technology GSA's role became just like that of any other agency; it was relegated from being the government's exclusive information technology procurement manager to a position of being managed just like any other agency. Any future government-wide role to be played by GSA would be one of support and facilitation, and then, only at the wish and request of OMB.

Department of Commerce

In 1965 the Brooks Act centralized technical responsibilities for information technology in the Department of Commerce as recounted in Section 111 (f), namely:

> The Secretary of Commerce is authorized (1) to provide agencies, and the Administrator of General Services in the exercise of the authority in this section, with scientific and technological advisory services relating to automatic data processing and related systems, and (2) to make appropriate recommendations to the President relating to the establishment of uniform Federal automatic data processing standards . . . ."

The old National Bureau of Standards, now the National Institute of Standards and Technology (NIST), became the focal point of Commerce's responsibility.

Over the years, NIST exercised this authority by issuing a number of federal information processing standards. However, although playing a major government-wide role in information technology, neither NIST nor Commerce have had the same type of an accountability and oversight role for large information systems as the other central management agencies. Furthermore, through February 1996 there have been no significant proposals to alter, reform or abolish NIST's information technology standards role. Therefore, any further delineation of their role in this paper will be limited to the effects of their standards setting activities.

The mix and relative power of key information technology oversight actors came to a watershed in February 1996 with enactment of reform legislation. Nonetheless, the above discussion of key information technology actors and legislation both suggests and affirms the three-part classification of oversight periods described in Chapter I. A characterization of each period is refined in the following, and the results are subsequently used to develop a framework for analysis.

C. Traditional Period

Information technology's most important *Traditional*-era legislation occurred over a 21-year period stretching from 1965 through 1986. It began with the Brooks Act which was enacted because of congressional concerns about vendor favoritism, lack of accountability and ineffective controls, all of which often had caused the government to pay excessive prices for ineffective products. Key actors had devised the implementation of this Act and subsequent legislation into a rigid pattern of hierarchical processes between 1965 through 1988: they then strengthened the oversight hand through hearings and guidance between 1989 and 1992.

In those early years, information technology accountability developed a very rich tradition of seeking hierarchical control through regulation and systems of delegation and audit. An enumeration of the most important such mechanisms, taken from the prior sections, is listed in table III-C-I.

Table III-C-I: Hierarchical Control Authorities of Central Management Agencies

Agency	Hierarchical	Regulate	Delegate	Audit
OMB	yes: central IT policy authority	yes: A130 & other Circulars	yes: to senior agency official	yes: actually conducted by GSA
GSA	yes: exclusive IT procurement authority	yes: FIRMR and policy letters	yes: IT procurement authority	yes: 1) agency management reviews, & 2) comprehensive review of delegations
Commerce	yes: central IT technical standards	yes: mandatory technical standards	yes: authority to waive standards by agency head	

Apparently, such centralized mechanisms were well-rooted in the scientific management and management movement schools of public administration. It is not surprising, then, that such controls were predicated upon paramount precepts of economy and efficiency. Contrast the 1965 Brooks Act mandate:

> The [General Services] Administrator is authorized and directed to coordinate and provide for the economic and efficient purchase, lease, and maintenance of automatic data processing equipment by Federal agencies . . . .

with one of Henri Fayol's famous principles (Mosher, 1981, pp.110-111):

> Unity of Direction: This principle is expressed as: one head and one plan for a group of activities having the same objective . . . .

Clearly, centralization of authority was a concept common to both.

The Brooks Act requirement also had an implicit technocratic thought, namely, one that integrating computers into government processes required a highly-technical and specialized organizational approach which centralized the function within one structure, specifically, GSA. Compare this concept with another of Fayol's principles (Mosher, 1981, pp.110-111):

> Division of Work: Specialization belongs to the natural order . . . . The object of division of work is to produce more and better work with the same effort.

or Luther Gulick's (Mosher, 1981, pp. 154-155) dictum:

> [T]he efficiency of a group working together is directly related to the homogeneity of the work they are performing . . . . [I]t follows from this (1) that any organizational structure which brings together in a single unit work divisions which are non-homogeneous in work, technology or purpose will encounter the danger of friction and inefficiency, and (2) that a unit based on a given specialization cannot be given technical direction by a layman . . . .

The General Services Administration was expected by the Brooks Act to be "one head" and provide unity of direction for a technical specialty, namely, automatic data processing which is called, today, information technology. GSA implemented these responsibilities through regulations like the FIRMR and before-the-fact delegation and audit systems.

The Office of Management and Budget was expected to centralize information policy-making and provide unity of direction through a then-new organization, the Office of Information and Regulatory Affairs . Specifically, under the 1980 Paperwork Reduction Act pronouncement:

> [Its] purpose . . . is . . . (4) to coordinate, integrate and, to the extent practicable and appropriate, make uniform Federal information policies and practices . . . .

OMB worked to fulfill its mandate to implement uniform (*i.e.* "one best way") practices through regulations like Circular A130, and by having GSA conduct information resources management audits on its behalf.

Therefore, singling out information technology for a special and unique oversight role was consistent with so-called pre and post-World War II Management Movement concepts of technical specialization (division of work) and central management (unity of direction). The chosen methods, namely hierarchical control through regulation and systems of delegations and audits, were also consistent with those ideas. Apparently, both the structural and functional thinking of the 1900s through 1950s greatly affected both the design and implementation of information technology oversight mechanisms; the imperatives and injunctions of early authors such as Max Weber, Frederick Taylor, Henri Fayol, and later ones, such as James Mooney and Alan Reiley, Lyndall Urwick, and Luther Gulick, were certainly some important antecedents.

During the mid-1960s the ideas of hierarchical control and bureaucracy were not always denigrated as they often are in the mid-1990s. In addition to the teachings of Weber, Fayol and others, the authors and implementers of the Brooks Act had seen with their own eyes the spectacular results that could be achieved through centralization, specialization and systems of before-the-fact hierarchical controls that were exercised through regulations, delegations and audits.

The Allied successes in World War II were brought to fruition, in part, by hierarchical control of a veritable plethora of specialized combat-related organizations. Those of the corresponding German and Japanese technocratic terrors were still in living memory at that time. The Manhattan Project clearly demonstrated the highly successful use of hierarchical methods for efficient goal achievement over a very large-scale project superimposed over numerous and diverse technical specialties. The time from its inception to Hiroshima was only a few short years.

Nearer to the time of Brooks and his Act were the successes achieved by centralized controls instituted over 1950s and 1960s technical bureaucracies which had culminated in orbiting satellites and new fleets of sophisticated aircraft and ships. It was obvious at that time that hierarchical control had been a key contributor to the United States' rise in the world, its defense against communism, and its resplendent superpower status.

Furthermore, *Traditional*-era federal information technology oversight was not the child of any one school of thought, discipline or experience. Just as information oversight methods were molded by hierarchical precepts, so they were also shaped by American traditions, and specifically the desire for separate and competing governmental elements, none of which could achieve hegemony.

Specifically, even under the 1965 Brooks Act, not all accountability and oversight authority was vested in any one body. Instead, power was divided between the four previously described central management agencies with Congress retaining considerable influence and an active role through its committees. However, even the act of fractionating power bore the stamp of Management Movement principles; the division of information technology labor was deliberately specialized in functional ways. The Office of Management and Budget became responsible for overall policy, the General Services Administration oversaw procurement, and the Department of Commerce's bailiwick was technical standards. Though without separate legislative authorities for information technology, the General Accounting Office was clearly responsible for overall "watch dog'" functions under the 1921 Budget and Accounting Act which was the basis for GAO's audit authority over those same technology programs.

Therefore, in the *Traditional* period, information technology oversight was not a "pure" system in the sense that there was only "one head." Rather, it was established as a multiplicity of systems, each of which operated as a system of before-the-fact hierarchical controls exercised through regulations, delegations and/or audits. Nonetheless, each system of controls centralized specific authority in individual central management agencies. That is, individual central management agencies held sway over specific government-wide authorities for the procurement, management and use of information technology. Thus, the Management Movement principle of centralization held true in this period.

This leads to identification of three overarching *Traditional*-era concepts which frame and characterize information technology accountability and oversight during this period. They are government-wide accountability, centralized authority, and hierarchical systems of controls over information technology programs. Each is further specified, below.

Government-wide accountability for information technology

This concept affirmatively answered the question: Should there be separate and distinct government-wide methods to ensure accountability for federal information technology programs? The Brooks Act answer was "yes" in 1965, and subsequent legislation went beyond mere concurrence. The Paperwork Reduction Act of 1980 created a specific information policy function at the Office of Management and Budget, the Competition In Contracting Act of 1984 piloted the GSA Board of Contract Appeals, and the 1986 Paperwork Reduction Reauthorization Act emphatically sought permanence for both actions. Importantly, the answer remained affirmative from 1965 through 1992. Though there were significant opportunities, no information technology, procurement nor accountability legislation overturned this approach.

Centralized authority for information technology

The Brooks Act centralized information technology procurement authority at the General Services Administration, and it gave authority for federal information technology technical standards to the Department of Commerce. The 1980 Paperwork Reduction Act ensured that information policy was the sole bailiwick of the Office of Management and Budget. The Competition In Contracting Act of 1984 centralized resolution of information technology legal appeals within the GSA Board of Contract Appeals. Building upon the Brooks Act, successive legislation extended the concept and by the end of 1986 fiscal, procurement, technical and judicial authorities were fully centralized at their respective central management agencies.

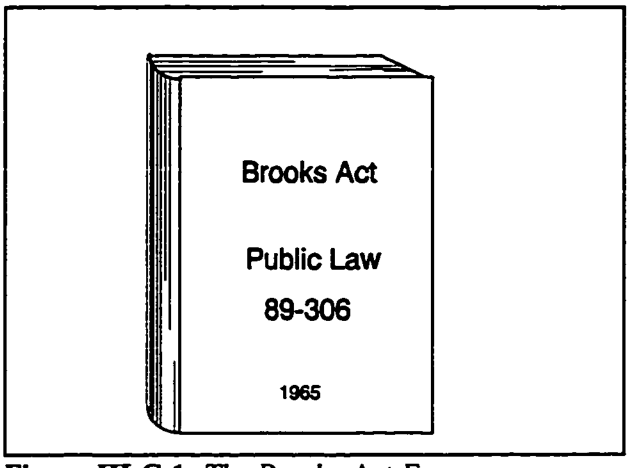

Figure III-C-1: The Brooks Act Era

No fragmentation of authorities took place during this era with the exception of the 1981 Warner amendment which removed command, control and intelligence (C^2I) Department of Defense systems from Brooks Act reviews. Yet, even that legislation did not obviate the centralizing precept because it retained authority at a central, albeit Department of Defense, level. That is, it established a hierarchical requirement within Defense for obtaining a "Warner waiver." It also retained centralized authority at GSA for non-combat computer systems. Moreover, the centralizing concept was emphasized and enhanced through legislation as well as the previously described direction and intercession of key actors like Representatives Brooks and Conyers and Senator Glenn under the auspices of their respective committees. By 1992, information technology authority was firmly entrenched and securely centered at the respective central management agencies.

Hierarchical systems of controls over information technology

Three major systems of controls were created. In the first, a delegations system, the Brooks Act required agencies to obtain General Services Administration approval of their information technology procurements, a two-stage hierarchy of before-the-fact controls. However, considerable embellishment occurred, over the years, as departments emulated the concept and required their subordinate agencies and bureau-level components also to implement delegation processes. By 1992, larger departments could document five or more hierarchical levels of delegation and approval needed to begin an information technology procurement--three at the agency-level, namely, program, region and headquarters, the department, and finally, the General Services Administration. Delays occurred. Some were in excess of one year; frequent delays in obtaining the necessary approvals were common and anecdotal.

Audits constituted a second system of controls. The 1980 Paperwork Reduction Act levied on the Office of Management and Budget a responsibility to review agencies' information resources management programs. As previously described, OMB arranged for the General Services Administration to conduct these audits. GSA did so and reviewed major agencies as often as once each three years. Though after-the-fact in concept, these reviews became, in actuality, before-the-fact controls because their outcomes were used to fix dollar thresholds which determined whether or not the agency needed GSA's advance approval to conduct an information technology procurement. Thus, each audit determined, in advance, the level of control or oversight that GSA would exercise over that agency and its individual information programs.

Regulations were the third form of hierarchical controls. By their very nature, regulations tend to have a "one best way" orientation. Further, they are typically aligned towards mandatory injunctions and inveigh against innovation and creativity. Finally, they are before-the-fact controls because they proscribe specific actions. The three major regulatory bodies in this era were OMB's issued Circulars under its general policy authority, GSA's procurement regulations, and the Department of Commerce's federal information processing technical standards. GSA's Federal Information Resources Management Regulations (FIRMR) grew into an extensive compendium of rules. By the early 1990s GSA began to supplement the FIRMR with its Acquisition Guides series. OMB's Circular A130 became the principal regulation for information resources management. The National Institute of Standards and Technology, Commerce's technical arm, issued a plethora of standards. Regulations were in the forefront of information technology oversight during much of this period.

Thus, these three overarching concepts underpinned and characterized information technology accountability and oversight during this period. Above all, the Brooks Act (figure III-C-1) typified the era. Its philosophy created a multiplicity of before-the-fact hierarchical controls, replete with elaborate systems of regulations, delegations, and audits. A 1992 General Accounting Office audit, described below, is an excellent example of these concepts and *Traditional*-era information technology oversight-in-practice.

The report entitled Veterans Benefits: Acquisition of Information Resources for Modernization is Premature (GAO, 1992e) assessed the Department of Veterans Affairs' $500 million Veterans Benefit Administration (VBA) Modernization program. The program was conceived in the early 1980s to modernize aging computerized benefit payment systems used to issue, record and track payments issued to veterans under a variety of programs. GAO reported

Table III-C-II: Summary of Traditional Oversight Concepts and Controls

Concept				
Government-wide IT Accountability	**Laws**			
	1965 Brooks Act			
	1980 Paperwork Reduction Act			
	1984 *Competition* In Contracting Act			

Central IT Management	**Agencies**	**Type of Authority**	**Statutory Authority**	**Source of Direction**
	OMB	program	1980 Paperwork Reduction Act	
		fiscal	1921 Budget & Accounting Act	
	GSA	procurement	1965 Brooks Act	GOV-OPS
	Commerce	technical standards	1965 Brooks Act	GOV-OPS

Hierarchical Controls	**Control System**	**Type of Control**		**Review Basis**		**Control Aspects**				
		before-the-fact	after-the-fact	all	exception	program	fiscal	procurement	technical	legal
	OMB Policy Regulations	x		x		x	x			
	GSA Procurement *Regulations*	x		x				x		
	GSA delegations	x		x				x		
	NIST technical standards	x		x					x	
	GSA agency audits		x	x		x				
	GSBCA		x		x					x

seven findings:

- o VBA lacked a comprehensive strategy to improve service,
- o VBA had not sufficiently analyzed its current business processes,
- o VBA had not identified specific goals for improved service,
- o VBA's hardware procurements were not supported by a information architecture,
- o VBA's effort lacked effective communication and leadership,
- o VBA lacked effective communication and working relationships, and
- o The Chief Information Officer lacked authority to resolve problems in the Modernization effort.

Generalizing these findings leads to several wide-ranging principles:

- o A public agency must develop an overall service improvement strategy.
  - Planning and budgeting must be conducted up front.
  - An overall information architecture is needed.
  - Existing business processes must be targeted for re-engineering.
- o A public agency must identify specific service goals to be achieved.
- o To implement the strategy, a public agency must centralize authority.
  - A responsible Chief Information Officer should provide leadership and direction.
  - An information program's plans, budgets and goals should be centrally tracked.

Centralized planning, budgeting and implementation, and strong accountability and control systems were clear GAO themes. As a corollary GAO suggested that a before-the-fact methodology was the way to hold individuals accountable for information technology programs. To meet GAO's desire for hierarchy and centralization, the agency must have retained centralized and direct control of personnel, budgets and program decisions through up-front reviews. This was clearly a before-the-fact system of hierarchical controls; systematic delegations, audits and inspections were to be used for enforcement and redirection purposes in this model. Such admonitions are certainly consistent with the three overarching *Traditional* concepts previously identified, above, namely:

- o Government-wide accountability for information technology,
- o Centralized authority for information technology programs, and
- o Hierarchical systems of controls over information technology programs.

GAO's suggested approach to information technology oversight was, therefore, consistent with congressional, OMB and GSA practices at that time; hierarchical controls epitomized the *Traditional* period.

In summary, the specific oversight practices described in this section correspond to and characterize certain *Traditional* period accountability concepts. Table III-C-II summarizes their relationships. Later in this chapter these concepts and practices are incorporated into an analytic framework for information technology accountability.

D. Transitional Period

Like a rising ground swell, ideas of "reinvention" clashed with hierarchical traditionalism and, after the 1992 elections, drove substantial oversight changes throughout the government. Ideas from authors such as Osborne and Gaebler (1992) urged politicians and managers to change "how" organizations do their work. The new Administration began a National Performance Review, and its findings (NPR, 1993) supported the new leadership's beliefs that they had been placed in office to "reinvent" government. Regarding hierarchies and bureaucracies:

> From the 1930s through the 1960s, we built large, top-down, centralized bureaucracies to do the public's business. They were patterned after the corporate

> structures of the age: hierarchical bureaucracies in which tasks were broken into simple parts, each the responsibility of a different layer of employees, each defined by specific rules and regulations. With their rigid preoccupation with standard operating procedure, their vertical chains of command, and their standardized services, these bureaucracies were steady--but slow and cumbersome. And in today's world of rapid change, lightning-quick information technologies, tough global competition, and demanding customers, large, top-down bureaucracies--public or private--don't work very well (NPR 1993, p. ii).

Those thoughts meant that information technology was not a "problem" requiring specific oversight mechanisms and accountability structures. Rather, information technology had an affirmative role:

> As everyone knows, the computer revolution allows us to do things faster and more cheaply than we ever have before. Savings [after the NPR recommendations are implemented] due to consolidation and modernization of the information infrastructure [will] amount to $5.4 billion over 5 years (NPR, 1993, p. iii).

Regarding oversight and control, in general, the NPR (1993, p.12) further exhorted:

> The layers begin with 'staff' agencies, such as the General Services Administration (GSA) and the Office of Personnel Management (OPM). These staff agencies were designed originally to provide specialized support for 'line' agencies, such as the Interior and Commerce departments, that do government's real work. But as rules and regulations began to proliferate, support turned into control. The Office of Management and Budget (OMB) which serves the President in the budget process, runs more than 50 compliance, clearance, and review processes. Some of this review is necessary to ensure budget control and consistency of agency actions--with each other and with the President's program--but much of it is overkill.

This clear message meant that "control" needed to be re-transformed into "support" by empowering agencies and workers through elimination of hierarchies in order for information technology to deliver on its promise of enabling "lightning quick" government

"Those layers begin with . . . the General Services Administration . . . as rules and regulations began to proliferate, support turned into control." (NPR, 1993).

performance and results. Obstacles to be dealt with included GSA, in particular, and OMB, both of which had too many "compliance processes" of which many were "overkill."

Such directions seemed to be in complete conflict with the Brooks Act paradigm of the Traditional era. The anti-hierarchical injunctions of the NPR seemed emphatically to answer "no" to the question: Would separate information technology accountability mechanisms still be necessary? Yet, the NPR (1993, p.29) did not venture quite that far:

> Action: The GSA will significantly increase its delegated authority to federal agencies for the purchase of information technology, including hardware, software, and services.

Therefore, before-the-fact, hierarchical controls were to be retained along with their accompanying systems of regulations, delegations, and audits. The NPR rationale (1993, p. 29) for this recommended action is instructive:

> In 1965, when "automated data processing" meant large, mainframe computers --often developed specifically for one customer--Congress passed the Brooks Act. It directed GSA to purchase, lease, and maintain such equipment for the entire federal government. The Act also gave GSA authority to delegate to agencies these same authorities. In 1986, Congress extended the requirement to software and support services.
>
> Today, with most computer equipment commercially available in highly competitive markets, the advantages of centralized purchasing have faded and the disadvantages grown. The federal government takes, on average, more than four years to buy major information technology systems; the private sector takes 13 months. Due to rapidly changing technology, the government often buys computers that are state-of-the-art when the purchase process begins and when prices are negotiated, but which are almost obsolete when computers are delivered. The phenomenon is what one observer calls 'getting a 286 at a 486 price.'
>
> Currently, the GSA authorizes agencies to make individual purchases up to $2.5 million in equipment and services on their own. The GSA Administrator will raise authorization levels to $50 million, $20 million and $5 million. These levels will be calculated according to each agency's size, the size of its information technology budget, and its management record. In some cases, GSA may grant an agency greater or unlimited delegation.

> GSA will also waive requirements that agencies justify their decisions to buy information technology items under $500,000 that are mass-produced and offered on the open market.

Rather than entirely eliminating information technology controls, the NPR recommended that they be streamlined. Apparently, control over the largest information technology procurements by the Clinton Administration was still desirable. Moreover, the NPR also explicitly recognized the complex interplay of rapidly-changing information technology and the highly-structured federal procurement processes.

Excessive procurement time became the NPR's issue since delays caused the government to pay premium prices for old or obsolete information technology. Interestingly, the NPR suggested retention of GSA's exclusive information technology procurement authority, but it mandated an increase in delegation levels using a three-tiered processes dependent on agency size. Implementation was delayed for reasons previously described in this chapter.

> *"Fortunately, solutions to seemingly intractable, complex information technology problems do exist . . . agencies can . . . [use] 11 fundamental practices"* (GAO, 1994).

A May 1994 General Accounting Office report entitled Improving Mission Performance Through Strategic Information Management and Technology is also instructive because it demonstrated commitment to the NPR-sought redirection from "control" to "support" while retaining the concept of specific government-wide information technology accountability. Briefly, specific "best practices" were recommended for use by federal agencies to modernize their information technology management practices. Federal agencies had not developed effective management practices to make government more effective and efficient, according to GAO. The results had been wasted resources and frustration by the public because of poor results, even through over

$200 billion had been expended on information technology modernization during the previous 12 years.

GAO grouped the eleven suggested "best practices" according to three key functions. The first was "deciding to work differently." The second was "directing resources toward high-value uses," and the third was "supporting improvement with appropriate skills, roles and responsibilities." According to GAO these functions and their associated "best practices" were:

> Deciding to change included: (1) recognizing and communicating the urgency to change, (2) getting line management involved, and (3) taking action and maintaining momentum,
>
> Directing change included: (4) anchoring strategic IT planning in customer needs, (5) measuring key mission processes, (6) focusing on IT architecture, (7) managing IT projects as investments, and (8) integrating IT planning, budgeting and evaluation, and
>
> Supporting change included: (9) establishing internal customer and IT supplier relationships, (10) making the Chief Information Officer a senior partner, and (11) upgrading management's information technology skills.

GAO said that increased productivity, improved customer service, and higher returns on information systems investments would be achieved, allowing agencies to reduce the government's burden on the public and improve public access to valuable governmental information and records.

Moreover, GAO grouped "best practices" along with the National Performance Review, the Chief Financial Officers Act, and the Government Performance and Results Act, as important government-wide steps to facilitate information technology management change. Thus, centralized information technology authority should be retained, according to GAO, but the Paperwork Reduction authority of the Office of Management and Budget was to be its fulcrum, not the

Brooks Act. Moreover, GAO stated that additional legislative and regulatory changes would be necessary to complete a framework for information management change.

Another force was starting to have an increasingly significant influence during this period, namely re-engineering. Complementing the "reinvention" literature, re-engineering dealt with organizational management and restructuring teachings of numerous authors like Warren Bennis, Peter Block, Edward Deming, and Tom Peters. Yet, process re-engineering, often called business process re-engineering--BPR, provided a new twist because it was heavily focused on the organizational use of computers and telecommunications as technology-driven change-mechanisms.

Interweaving those themes of organizational change and technology, James Champy, Michael Hammer, James Martin and their acolytes charted a new course which gained rapid acceptance throughout the business and government arenas. In particular, the General Accounting Office quickly became a BPR standard bearer (*e.g.* GAO, 1992e). For federal agencies in the 1992 through 1996 period the fiscal and downsizing pressures of "doing more with less" provided even more of an incentive than GAO's invectives or counsel to use information technology for re-engineering work processes.

Specifically, with process re-engineering mere automation became *passe*; "re-inventors" were required to start anew and create a fresh design for each process. Information technology needed to be intrinsic to the redesign process since it was the apparent engine of economy and efficiency. Furthermore, in the limit BPR went even further. Its logic demanded that, before re-engineering, re-inventors must reassess the organization's rationale for being in each of its lines of business.

None of these ideas existed just because of rapidly-changing information technology developments, yet all were imbued with its promises of improved economy and efficiency.

Furthermore, the perceived universality of information technology's applications throughout all corners of government made it the instrument of choice for reformers' plans to "reinvent" government. It was this difference that made information technology oversight unique among all governmental accountability structures. Federal information management was not only to be "reinvented;" it was also expected to be the enabling mechanism for "reinvention" of processes across all governmental entities, programs and functions.

In this way, process re-engineering at the federal level was consistent with NPR dictums about information technology management. Both were conjoined by the tenet of information technology's promise. Rather than eliminating controls, the magnitude and overarching effects of such government-wide process re-engineering efforts argued for strengthened oversight. GAO reported: "The Congress is focusing increased attention on accountability for achieving results from [information technology] projects, reflecting a growing consensus on the need for better investment decisions" (GAO, 1995a, p.1).

From the investment perspective, it is intuitive that the outcomes of information re-engineering processes must be measured in order to determine the return on investment and to determine the degree to which mission objectives were being achieved. GAO argued similarly in (1994e, preface) and suggested that:

> Solutions to this problem are not simple. However, several critical elements necessary to bring about management change are already in place or are being considered--from the Chief Financial Officers Act . . . to the Government Performance and Results Act . . . to the National Performance Review . . . to the Paperwork Reduction Act (to improve federal information management) . . . .

Notably, the Brooks Act was omitted and not identified as one of GAO's "critical elements." However, an ongoing requirement for specific information technology accountability was recognized by identification of the Paperwork Reduction Act. Accountability through performance measurement was also recognized. Complementing those Acts was GAO's identification (1995a, p.1) of the 1994 Federal Acquisition Streamlining Act as a legislative initiative that was particularly important for ". . . focusing attention on accountability for achieving results from [information technology] projects . . . ."

Therefore, the narrowness of this *Transitional* period in time, 1992 through 1995, belies the breadth and depth of its supporting theoretical basis. In addition to the "reinvention" and process re-engineering there were a number of governmental contributions towards changing the overall federal management and oversight direction, particularly in the form of legislation originating from Congress and redirection of the central management agencies from "control" to "support."

Thus, the three overarching concepts from the Traditional era underwent radical change in the *Transitional* era. The forces of "reinvention" that drove both Congress and the Administration were the same ones that caused massive changes in perspectives about those concepts. Recall that those were government-wide accountability, centralized authority, and hierarchical systems of controls over information technology programs. Though retaining some remnants of the old, these concepts became new ones, as described, below.

Government-wide accountability for information technology

This concept remained in place; the General Accounting Office, in particular, continued to assert a need for separate and distinct government-wide methods to ensure accountability for federal information technology programs, particularly through the Paperwork Reduction Act (GAO, 1995a, preface).

The orthodoxy of the Brooks Act, however, underwent restructuring during this era. In early 1992 the Democratic-controlled 103rd Congress still supported the Act. In fact, that

Congress forbade any changes to the General Services Administration's oversight role or methods during its term; the NPR mandate for GSA to "significantly increase its delegated authority to federal agencies for the purchase of information technology, including hardware, software, and services" was not fulfilled during that entire period of Democrat dominance. Congressmen Brooks and Conyers along with Senator Glenn blocked any such changes.

However, the Republicans in the 104th Congress had no such loyalty to the Brooks Act. Moreover, Jack Brooks lost the election and both Conyers and Glenn lost their chairmanships in the new Republican-controlled Congress. The climate was right for change. By July 1995, GSA, with Congressional support and Administration direction, significantly increased its delegated authority to federal agencies even beyond the levels suggested by the National Performance Review (FCW, 1995). However, the concept of separate, government-wide information technology accountability was still not obviated by such actions. The principle of government-wide accountability through the Paperwork Reduction Act was reaffirmed through its re-authorization in 1994.

In summary, the Paperwork Reduction Act of 1980, which had previously created a specific information policy function at the Office of Management and Budget, was reaffirmed in events that occurred in 1995 and early 1996. Though it took a number of "jabs," the National Performance Review did not, however, call for eradication of separate information technology accountability. Finally, the General Accounting Office increased its already strong support for separate information technology accountability through its kudos for reauthorization of the Paperwork Reduction Act. Thus, any question about separate federal information accountability was answered affirmatively from 1992 through 1995. Though there were significant opportunities, no legislation overturned or modified this concept.

Decentralized authority for information technology

The old Brooks Act idea of centralized authority underwent radical reform in this era. The NPR exhorted cutting "layers," particularly from those "staff" agencies, such as the General Services Administration. The problem, according to the NPR, was that specialized support for "line" agencies had turned into control. Regarding information technology procurement authority and systems, the NPR stated that "[E]ffective governments . . . streamline their procurement systems . . . liberating organizations to pursue their missions" (NPR, 1993).

Yet, the changed concept was neither fully nor even consistently implemented in this era. For example, in May 1994 the General Services Administration announced its new "Time Out" program for troubled information technology programs. "Time Out" overlaid GSA's delegations process and during 1994 suspended authority for five major information technology programs valued at over $16 billion. The idea was to cancel any program or portion of a program that could not readily be fixed. If curable, authority would be reinstated only after GSA approval of a recovery plan. Though not consistent with the new "decentralizing" maxim, "Time Out" was well received (*e.g.* GAO, 1995c), and by the end of 1995 "Time Out" was touted as having saved the taxpayers $7.4 billion (GSA, 1995e).

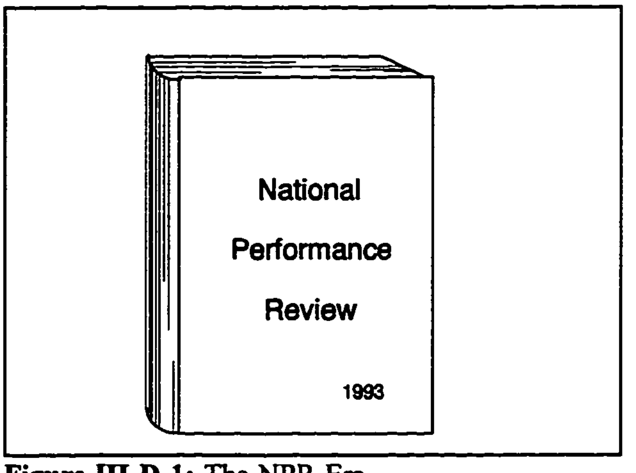

Figure III-D-1: The NPR Era

Along those NPR-charted lines, at the end of 1995 information technology procurement authority had been decentralized to a level of $100 million per project by the General Services

Administration. The GSA Board of Contract Appeals was under attack from the Administration (*e.g.* Kelman, 1995) and Congress (*e.g.* Cohen, 1994). Importantly, all support for retaining the old Brooks Act had vanished with the inception of the Republican controlled 104th Congress. By the end of 1995, the concept of centralized information technology authority was gone. "Cutting the layers" was the vision; decentralization remained the goal.

Government-wide systems of controls over information technology

Three major systems of hierarchical controls remained in place and were carryovers from the Traditional era. In the first, a delegations system, the Brooks Act still required agencies to obtain General Services Administration approval of their information technology procurements. However, the levels were raised to $100 million by the end of 1995.

Audits, the second system of controls, were still required by the 1980 Paperwork Reduction Act. However, neither the Office of Management and Budget nor GSA had conducted any such agency level reviews since 1993. Finally, government-wide regulations, the third form of hierarchical controls were still issued by OMB under its general policy authority and GSA's Federal Information Resources Management Regulations (FIRMR) system was still in effect. The National Institute of Standards and Technology, Commerce's technical arm, remained in the standards business. Regulations were still an integral part of information technology oversight during this period. Separately, the GSA Board of Contract Appeals, though under attack, retained its full authority.

Nonetheless, a different form of information technology control developed in this period, namely, oversight by management committees. Three important ones were the following. The Government Information Technology and Services (GITS) working group was established in 1993 under the auspices of the NPR to promote agencies performance improvements through

Table III-D-I: Summary of Transitional Oversight Concepts and Controls

Concept				
Government-wide IT Accountability	**Statutes**			
	1993 Government Performance & Results Act			
	1994 Federal Acquisition Streamlining Act			
Decentralized IT Management	**Agencies**	**Activities Authorized**	**Statutory Authority**	**Source of Direction**
	OMB	program performance	1980 Paperwork Reduction Act	NPR
	GSA	procurement	1965 Brooks Act	GOV-OPS
	GAO	"best practices"	1921 Budget & Accounting Act	NPR

Government-wide Controls	Control System	Type of Control		Review Basis		Control Aspect				
Hierarchical		before-the-fact	after-the-fact	all	exception	program	fiscal	procurement	technical	legal
	OMB Policy Regulations	x		x		x	x			
	GSA Procurement Regulations	x		x				x		
	GSA delegations	x		x				x		
	GSBCA	x			x		x	x	x	
Management Committees	GITS		x		x	x				
	GSA ITRB		x		x		x	x	x	
	GSA IMC	x			x		x	x		

information technology, and to accelerate the deployment of advanced networking technologies (OMB, 1995). To accomplish these goals GITS, was also made responsible for assisting OMB and GSA in information technology policy development. The Inter-agency Management Committee (IMC) was established by GSA to oversee the government-wide FTS2000 telecommunications system, including policy development and finances (GSA, 1995). The third group was the GSA-established Information Technology Review Board (ITRB) which became responsible for reviewing GSA-designated high-risk information technology programs. Both GSA and OMB agreed to use the ITRB's recommendations in their delegation of procurement authority or funding decisions, respectively.

Thus, three changed but still overarching concepts underpinned and characterized information technology accountability and oversight during this period. Above all, the National Performance Review (figure III-D-1) typified the era. Its philosophy created a drive to decentralize and reduce the numbers and types of hierarchical controls along with their elaborate systems of regulations, delegations, and audits. Interestingly, the combined power of a Democrat Administration and a Democratic 103rd Congress was not sufficient to implement the Administration's NPR mandates; rather, for information technology it was ultimately the Republican-controlled 104th Congress which made those major changes possible that Representative Jack Brooks and his confederates had previously blocked. Such was the power of Representatives Brooks and Conyers along with Senator Glenn in that era.

In summary, the specific oversight practices described in this section correspond to and characterize certain *Transitional* period accountability concepts. Table III-D-I summarizes their relationships. The table is in the same format as was used to characterize the Traditional and

Transitional period concepts. Later in this chapter these concepts and practices are incorporated with the *Traditional* ones into an analytic framework for information technology accountability.

E. Transformed Period

Mid-1990s concerns about the size, scope and services provided by government seem to have been globally embraced by United States citizens regardless of political party or persuasion. Federal information technology is intricately intertwined with many of those issues because on the one hand it has been seen as having a major role as an enabling technology to facilitate change. On the other hand, however, others have portrayed information mismanagement as sharing in the culpability for government's failure to change.

"What is the government's business?" became the implicit cry when the Republicans unleashed their Contract With America plan just before the 1994 elections. The Republicans scored many points with voters and took over both houses of Congress. Nonetheless, the then-old National Performance Review was headed in that direction anyway, according to the Democratic Administration. For information technology, the "what" question became very portentous. For example, huge and often multiple computer data centers could be found in all of the larger agencies; was it the government's business to operate such centers? The government had failed in many important and expensive information technology programs; should they have been privatized, instead? Questions like those led to broad generalizations of information technology accountability issues. Many were fundamental in their nature. One question, for example, was whether separate and distinct mechanisms were still needed for federal information technology. Another concerned their form; should there be an information technology "tsar" at the federal level? At the start of 1996 those types of debates were still underway. By February 1996 decisions had been made and information accountability was embarked on a new direction.

Yet, often embedded within all of those earlier debates were even deeper-seated issues of power and control. Many still recalled the broad power that Jack Brooks had wielded; John Conyers had held a strong Democratic sway over the agencies in the 103rd Congress.

For those and other reasons, many relevant actors at the start of 1996 were still formulating positions although almost all public pronouncements were about stripping away oversight controls and layers of accountability. In fact, "cutting out the layers" was just a continuation of a big theme from the earlier part of the 1990s.

Briefly, with the sweep of the 1994 elections by the Republicans, GOV-OPS' chairmanship had passed to William Clinger (R-PA). It was seen earlier in this chapter that until those elections, Democrats Conyers, Glenn and Brooks were the "big three" congressional actors in federal information technology legislation and oversight. However, Clinger, the natural heir as Chairman of the new Government Reform and Oversight Committee, did not focus on information technology.

Instead, power and leadership in federal information technology appeared to shift from the House to the Senate in the early days of the Republican-controlled 104th Congress. Prior to the elections, a relatively unknown senator, GOV-Affairs member William Cohen (R-ME) issued in late August 1994 a report entitled Computer Chaos (Cohen, 1994). It contained numerous proposals to fundamentally change and eliminate much information oversight.

However, proposals do not always mirror enacted legislation. Sometimes a credible threat can be sufficient to cause great change. "The people who can destroy a thing, they control it" (Herbert, 1965, p. 422), in fact, portrayed the true nature of information power-in-politics at that time. In a dark, dire sense, this was a classical but accurate portrayal of Lasswellian-like power relationships in the legislative arena with a strong emphasis on severe deprivation as a powerful motivator (Lasswell, 1979). It was dark in the sense that the strongest threat of "severe deprivation" for any of the oversight actors was destruction. Initially, Cohen pointedly pronounced that his legislation would eliminate either the Office of Management and Budget or the General Services Administration from an information technology oversight role (GCN, 1994d). This very threat was sufficient to cause both agencies to drastically change their methods and allegiances. Importantly, those outcomes pointed directly to GOV-Affairs as a major broker of power, influence and information technology authority. Congressional information technology leadership and power had clearly moved to the Senate by early 1995 with GOV-Affairs as its broker.

A brief review of Senator Cohen's (R-Maine) Computer Chaos (1994) is instructive because it captured much of the thinking which differentiates the *Transformed* period from the two earlier eras. Its basis spanned the content of a number of pre-1994 Republican and Democrat studies, reports and proposals. The report's key recommendations were:

- Emphasize early oversight and planning,
- Reduce bureaucratic barriers to purchases,
- Avoid reinventing existing technology,
- Encourage innovation, and
- Reevaluate existing procurements to determine if they provide the best value to the taxpayers, and halt new procurements until the computer acquisition process is improved.

Interestingly, the first and last recommendations were conservative and would have both continued and strengthened the mainstream tradition of up-front oversight and before-the-fact controls. The others, on the surface, utilized the then-prevailing "re-invention" language and expressed a need to strip away controls. However, beneath the surface there were substantively different ramifications. In fact, the first and last suggested before-the-fact oversight of decisions, while the others were really after-the-fact methods, and still centralized sets of controls.

Thus, it was not removal of controls that was the real issue, but rather their form and where oversight would reside. The first and last recommendations, which were traditional, clearly suggested increased centralization of oversight. The others seemed to cry for decentralization; however, they really demanded not only centralization, but increased centralization in a traditional way!

The reason lies within the last recommendation with its explicit requirement that information technology procurements must be halted until certain criteria are met. In the 1994 system of oversight, accountability and controls, halting an information technology procurement would have been a work of art. It was then and remains even now an almost an impossible task, as witnessed by GAO's unsuccessful efforts to halt the massive VBA Modernization program (GAO, 1992e). Theoretically, GSA could have stopped such a procurement with its Brooks Act authority, OMB could have withheld or rescinded funding, or Congress could have passed legislation. However, the fact was that "Killing a major [information technology] procurement is impossible" according to senior acquisition officials (see Chapter V).

Yet, Cohen's plan was to halt them all until certain criteria were met. This would certainly not have been a one-time event; the other recommendations would have needed to be met, henceforth. This would have required enormous political power; in effect, the then-disjointed authority of OMB and GSA would have needed to be combined, under the added coercive power of key congressional committees, for such a task to succeed. Oversight = centralization + augmentation, in this scenario.

The efficacy of this argument is easily demonstrated by subsequent events. The Senator's legislation which was introduced in the summer of 1995, namely S946, would have eliminated the General Services Administration's authority and reconstituted it along with additional authorities into OMB's Office of Information and Regulatory Affairs in order to oversee federal information technology. Under the bill, a government-wide chief information officer (CIO) would have had full authority over all federal information technology, a concept that goes beyond mere oversight. In that way, a new and greatly strengthened, highly centralized, hierarchical structure would have been established with tremendous power. Rather than reducing or eliminating oversight mechanisms, the S946 legislation would have, in fact, fortified information oversight with new authority, influence--and a "tsar."

Cohen's legislation was still not enacted by the end of 1995. The previously-obscure Senator placed his legislation "on hold" after a less-than-luke-warm reception by industry during his August 1995 hearings. However, many of its major concepts received new life when they were incorporated into the fiscal year 1996 Defense Authorizations Bill. Though not passed during the time of two budget-breaking federal shutdowns, portions of Cohen's S946 were part of the final version of the 1996 Defense Authorizations Act that became law in February 1996 within the guise of Division E which was the Information Technology Management Reform Act; the *Transformed* era had begun.

Thus, the three overarching concepts from the *Transitional* era underwent considerable change upon entry into the *Transformed* era. Recall that those concepts were government-wide accountability, decentralized authority, and government-wide systems of controls over information technology programs. Each was reassessed, reviewed, revised and restructured in the new era. The transformation is described below.

Government-wide accountability for information technology

This concept seems destined to remain in place for the foreseeable future. Neither Senator Cohen's S946 nor the enacted 1996 reform legislation detracted from this concept. Rather, both enhanced the concept by introducing the Chief Information Officer concept. Though not included in the final reform legislation, the CIO as a government-wide "tsar" would have been a unique test in accountable as well as a challenge for the efficacy of the bill's focus on integrating federal information technology systems.

A supporting action was the Office of Management and Budget and General Services Administration agreement to reform information technology oversight, which was widely-reported throughout the federal community (FCW, 1995e). In essence, this July 1995 agreement documented a plan that required GSA to delegate, without conditions, all of its information technology procurement authority directly to the federal agencies. Furthermore, GSA was called upon to transfer management of its "Time Out" program as well as the inter-agency Information Technology Review Board (ITRB) to OMB for administration. Apparently, government-wide information technology accountability was still the Administration's intention, but its form and shape were targeted for change; GSA under the agreement would no longer "control" information technology procurements, OMB would have that job. GSA's new role was targeted to be one of support to OMB.

In summary, the reform legislation contained in the 1996 Defense Authorization Act became the principal information technology accountability legislation, thereby strengthening the information policy function at the Office of Management and Budget. In the first part of 1996 both the Administration and Congress were firm in their support for continued government-wide federal information accountability, though in a newly restructured form.

Centralized authority for information technology

The old Brooks Act concept of centralized authority was dead, even without legislation, by the end of 1995 The National Performance Review exhortation to cut "layers" from "staff" agencies had come to fruition by the end of 1995 for the General Services Administration. Although it still retained its delegations program until mid-1996, few agencies' programs required GSA's approval with the new $100 million level of authority. Even for those projects, GSA's reviews were superficial without any follow-through or reporting requirements; "control" had vanished from GSA's repertoire. All that remained was for the Office of Management and Budget, under the reform legislation, to begin managing information technology as a replacement for and upgrade from GSA's revoked Brooks Act authority.

Although the Brooks Act form of control was finished, centralization of information technology oversight was not. In fact the 1992 through 1995 Transitional-era push for decentralization was being transformed back to one of centralization by early 1996. GSA's transfer of its "Time Out" program and the inter-agency Information Technology Review Board (ITRB) was accomplished early in 1996. New legislation coupled with OMB's existing Paperwork Reduction Act policy-making authority gave it considerable, and in fact exclusive, "clout" over agencies and their information technology programs. "Cutting the layers" in the Transformed era came into sharp focus. It meant centralization of information technology authority within OMB rather than the decentralizing and decontrolling of oversight processes envisioned by the National Performance Review.

Government-wide systems of controls over information technology

Regarding hierarchical controls, the General Services Administration's delegations system had clearly been rendered ineffectual by the end of 1995. Audits of agency information resources management practices, though still required by the Paperwork Reduction Act had not been conducted since 1993. Finally, government-wide regulations were still being issued by OMB under its general policy authority; GSA's Federal Information Resources Management Regulations (FIRMR) was destined for the scrap pile during mid-1996. Separately, the GSA Board of Contract Appeals succumbed under attack, and it lost its authority under the 1996 reform legislation.

Recall that OMB retained overall policy authority under the Paperwork Reduction Act. In fact, OMB used its Circulars, extensively, as a mechanism to promulgate its regulations. Finally, the National Institute of Standards and Technology, Commerce's technical arm, remained in the standards business. Clearly, regulations were still an integral part of information technology oversight during this period. However, with the Brooks Act in full retreat OMB was in firm control of all information technology under its Paperwork Reduction Act authority. By mid-1996 it was clear that there would no longer be a multiplicity of centralized hierarchical control systems. There would be just one, OMB. Power would no longer be fragmented among the central management agencies.

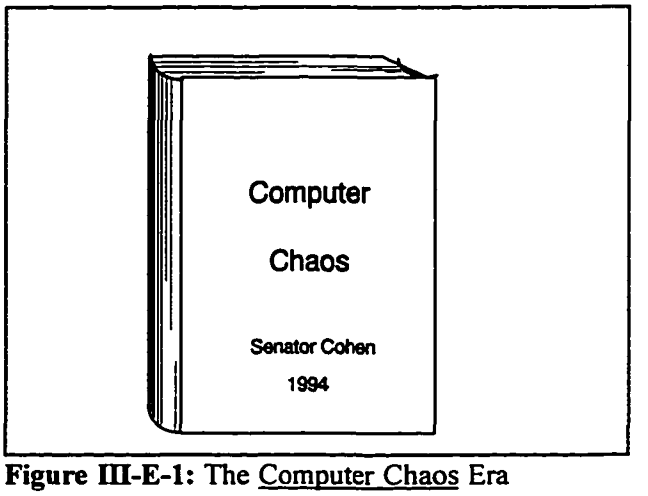

Figure III-E-1: The Computer Chaos Era

Table III-E-I: Summary of Transformed Oversight Concepts and Controls

Concept										
Government-wide IT accountability	**Statutes**									
	1980 Paperwork Reduction Act									
	1984 Competition In Contracting Act									
Central IT Management	**Agencies**	**Activities Authorized**	**Statutory Authority**							
	OMB	program	1996 Defense Authorizations Act 1980 Paperwork Reduction Act							
		fiscal	1921 Budget & Accounting Act							
	Commerce	technical standards	1996 Defense Authorizations Act							
Hierarchical Controls	**Control System**	**Type of Control**		**Review Basis**		**Control Aspects**				
		before-the-fact	after-the-fact	all	exception	program	fiscal	procurement	technical	legal
	OMB Policy Regulations	x		x		x	x			
	NIST technical standards	x		x					x	

Regarding the management committees of the Transitional era, their roles remained almost unchanged by early 1996. Importantly, the ITRB, now under OMB's control, was targeted for an increased number of reviews. Under GSA's leadership the ITRB had audited just two major programs, namely the Federal Aviation Administration's Advanced Automation System and GSA's Public Building Service modernization programs. It was publicly announced that OMB planned to have the ITRB review 10 such programs a year. The plan was to use the results for program funding decisions. Centralization of information technology oversight control systems, indeed, seemed to be the direction by early 1996.

Thus, three changed but still overarching concepts underpinned and characterized information technology accountability and oversight changes during this period. Above all, Cohen's Computer Chaos report characterizes (figure III-E-1) this era. It was the impetus for the 1996 reform legislation. Moreover, its philosophy created a drive to centralize hierarchical controls along with management committees under the purview of OMB. Fragmented oversight was anathema in that setting. In this way, centralizing accountability emerged as an overarching theme for the new *Transformed* era.

Under these circumstances, however, management committee structures seemed to be positioned for an evolution from the "support" role envisioned by the National Performance Review into the "control" mode dreaded by the authors of that report. Information technology in the later part of the 1990s will test that possibility.

Thus, the political bases for information technology oversight transformation became well established in 1996. Both the Administration and Congress fomented considerable reforms which included the rapid decline of any possible future General Services Administration role in information technology oversight. The Office of Management and Budget rose in its ascendancy during the first part of 1996. Under this scenario, "reform" seemed to mean that the Office of Management and Budget was given an early 1996 opportunity to consolidate information technology accountability and control mechanisms within its own dominion. This ran counter to long-held traditions of fragmenting power over the federal establishment; the 104th Congress had overturned that tradition.

In summary, centralizing before-the-fact accountability emerged as an overarching theme during the first part of the new Transformed era. Moreover, the use of management committee structures seem to be intrinsic to this evolution. It is those specific oversight practices which were described in this section that apparently correspond to and characterize *Transformed* period accountability concepts. Table III-E-I summarizes their relationships.

In the next chapter these concepts and practices as well as those from the other two eras are incorporated into an analytic framework and study methodology for information technology accountability. The method is used in subsequent chapters in a survey of senior federal officials views about oversight changes on major information programs, and for case studies of two large-scale programs in a later chapter in this paper.

CHAPTER IV

RESEARCH METHODOLOGY

Intentions of this research were to examine information technology and its role in federal government and to review federal accountability practices and processes. Recall that the study question is the following:

Will mid-1990s Administration and Congressional reform of information technology accountability practices cause improved economy and efficiency in federal agencies' largest and most important information technology programs?

The research methodology to address this question is explicitly described in the remainder of this chapter.

A. Hypothesis

The study hypothesis is that Administration and Congressional reform of information technology accountability practices in the mid-1990s will cause improved economy and efficiency. Several propositions follow. First, it was already shown that accountability can be classified into three time periods, namely *Traditional*, *Transitional*, and *Transformed*, because of overarching changes in beliefs about administration. Secondly, transformations of the central oversight agencies' information technology roles and methods will substantively cause specific and identifiable changes in program outcomes. A final proposition is that *Transformed* accountability changes will focus central management agencies on holding individual federal agencies accountable for the outcomes of their IT programs.

B. Model

Figure IV-B-1 shows a model which was used to test the hypothesis. It has an output or dependent variable which equates to variations in any major information technology program's efficiency and economy. Each of the independent inputs or variables corresponds to an oversight attribute which characterizes a specific time period.

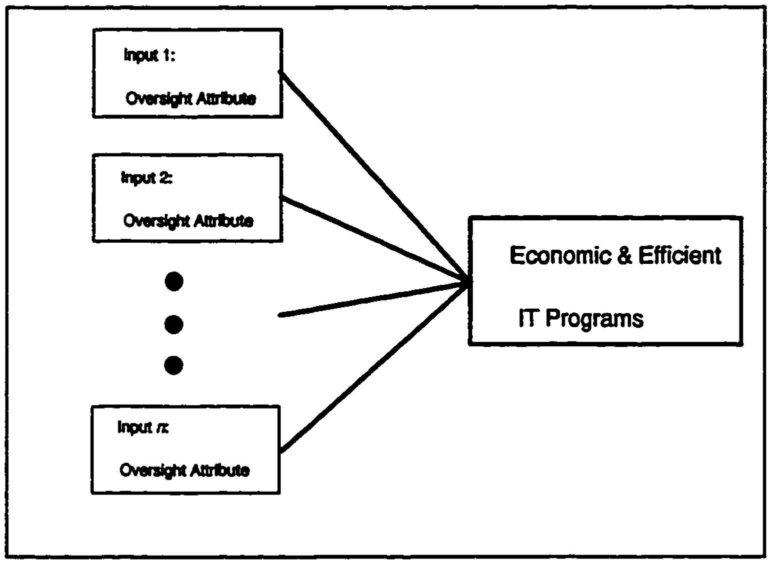

Figure IV-B-1: A Model

In the model accountability is underpinned by certain *precepts* at the conceptual level. As an example, centralized accountability of information technology would be a *precept*. In turn, all precepts have one or more associated *attributes* which are their qualities. Finally, each *attribute* is implemented by a *mechanism* or practice. For example, as previously described the Traditional era has a *precept* about hierarchical administration which is characterized by *attributes* of delegation and audit. Implementing practices or *mechanisms* could be creation of an oversight bureau or the institution of reporting procedures. That is, the inclusive set of all such inputs characterizes and represents information technology oversight practices during the Traditional, Transitional and Transformed time periods.

Moreover, Chapter III presaged those oversight practices that are anticipated to emerge or be rejected in the Transformed period. Conceptually, the model was designed to identify those central management agency precepts, attributes or mechanisms which have affected (positively or negatively) the outcomes of federal agencies' major information technology programs.

C. Method:

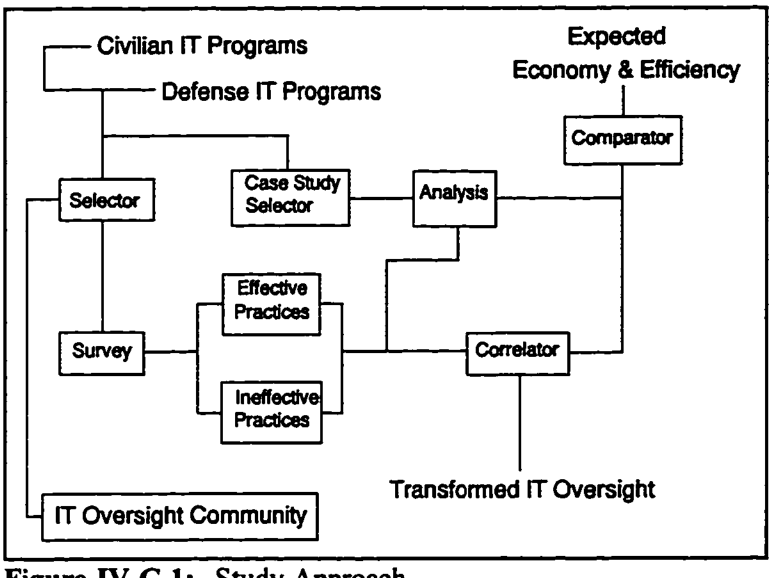

Figure IV-C-1: Study Approach

Formally, the overall research employed a two-stage design. In the first stage a directed sample of the federal information technology communities was asked to complete a survey instrument. The concepts identified in Chapter III were used to devise the survey questionnaire.

The results of the survey were subsequently used to accomplish three tasks: (1) identify the model's inputs (see figure IV-B-1) as well as, (2) associate each of the three possible types of inputs, namely, precept, attribute or mechanism, with its respective Traditional, Transitional, or Transformed period, and (3) forecast the success of new oversight methods in the Transformed period. That is, through the stage one method the concepts and practices identified in Chapter III were tested using a survey of the information technology community to identify the precepts, attributes or mechanisms for each of the three oversight periods. The stage one method is described in more detail and the survey results are presented in Chapter V.

In the first stage, the responses from the information technology community approached the problem from different directions. The sample was constructed to obtain responses from two broad segments of the community. Specifically, the sample queried those very people who had been directly involved in program decisions; this segment garnered an "inside" perspective for analysis. Another part of the sample was directed towards members of the oversight community who were responsible for monitoring those programs; this segment ensured that this "outside" perspective was included in the analysis.

In the second stage the model was applied to two major federal information technology programs using a case study approach. Inputs identified from the first stage were assessed as either successful or unsuccessful oversight practices using the model. In turn, those results were used to predict the expected results of accountability precepts and mechanisms that are anticipated in the Transformed era. Major programs that were selected met three criteria: (1) at least $100 million in value or 25% of an agency's information technology budget, (2) critical to the agency's mission, and (3) have had high visibility within the agency. The model was applied to two major information technology programs which spanned the Traditional, Transitional, and Transformed periods. In turn, the Traditional period provided a baseline while the effects of changes in the Transitional mode were instrumental in helping to predict any correlation between program outcomes and new central management agencies' practices and roles in the Transformed era.

Chapter VI contains the case studies and results. Figure IV-C-5 depicts the overall research method.

The second stage was designed to provide an objective, "independent" observer perspective through case study analysis of the two programs. Thus, the "inside" and "outside" perspectives from the first stage, and the "independent" perspective from the second stage were combined to provide a complete picture and to ensure validity since they complemented one another.

D. Research Design

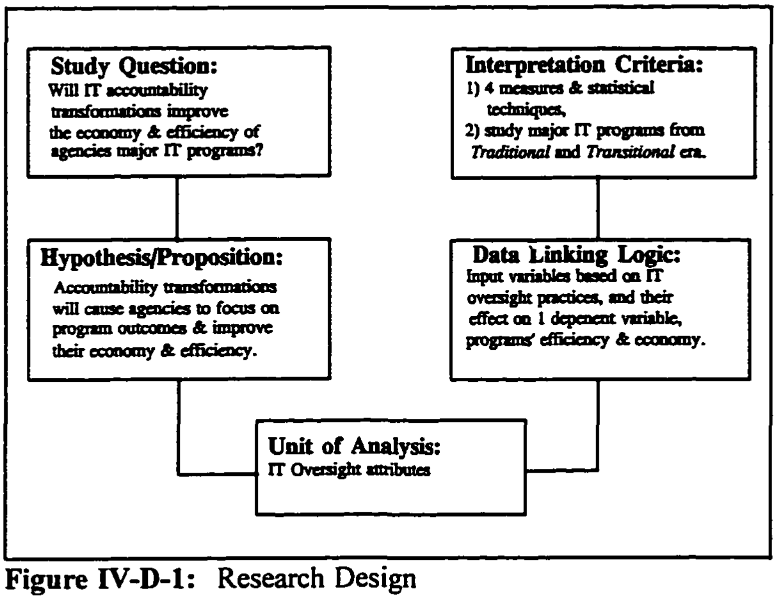

Figure IV-D-1: Research Design

The design was built upon the two stage concept and had five components: (1) the study question, (2) propositions, (3) unit of analysis, (4) data linking logic, and (5) interpretation criteria. The approach taken in developing the research design relied heavily upon Yin (1989) and Poister (1978). The reason for reliance upon Yin was due to the Stage II case study approach which is a significant part of this research. Yin's classical treatment of case study methods was used to formalize the approach. Utilization of Poister's results followed from the statistical design and analysis of the survey in Stage I. The approaches suggested in that book were also useful in providing general guidance for structuring the overall research approach.

The two methods were not contradictory in any sense. Rather, they complemented one another as tools for developing the research design. Accordingly, both analytical rigor and case study methods were embraced by utilization of both their results. Together, they were useful in developing a viable research strategy.

Figure IV-D-1 depicts the overall design. The first two design components have already been presented but are repeated, below, for completeness. A description of the remainder follows.

Research Question

Will mid-1990s Administration and Congressional reform of information technology accountability practices cause improved economy and efficiency in federal agencies' largest and most important information technology programs?

Propositions

Three propositions were derived from the research question. These were used to frame the research. Together, they outline the ramifications of the research question, and are as follows:

Proposition One: Information technology accountability can be classified in three time periods, namely Traditional, Transitional, and Transformed, because of overarching changes in beliefs about administration,

Proposition Two: Transformations of the central oversight agencies' information technology roles and methods will substantively cause specific and identifiable changes in information technology outcomes, and

Proposition Three: Transformed accountability changes will focus central management agencies on holding individual federal agencies accountable for the outcomes of their information technology programs.

Unit of Analysis

The unit of analysis was an individual information technology accountability precept. Each was reified in action through one or more attributes and implemented through one or more specific oversight mechanisms which, in turn, were applied to information technology programs. That is, the unit of analysis was a theoretic concept which arose because of certain values; thus it was a precept. Such precepts, in turn, characterized the overall expectations set by the developers of central management structures used for overseeing information technology programs. The distinction and relationship between precepts, attributes and mechanisms is described in more detail in Chapter V.

Data Linking Logic

This was the means of linking the data to the propositions. The logic was that the data collected would correspond directly to the propositions, thereby allowing them to be tested. The Survey Questionnaire was an important mechanism for linking data collected in Stage I to the propositions. Stage II directly links the data with propositions through the analysis. Statistical inference and pattern matching were employed to link data to propositions, as appropriate. In both stages the logic was driven by the propositions, depicted in the data collection process, and demonstrated by analytically linking the data with conclusions and findings.

Interpretation Criteria

This was the integrating portion of the study wherein analytic means were used to transmute the gathered data into knowledge. It relied on a system of measures, each of which could be directly associated with any of the input variables (accountability precepts). In turn, each of the input variables could also be associated with an oversight action by one or more of the dominant central management agencies, namely the General Service Administration, General Accounting Office and the Office of Management and Budget or Congress and any other intervening agency or organization.

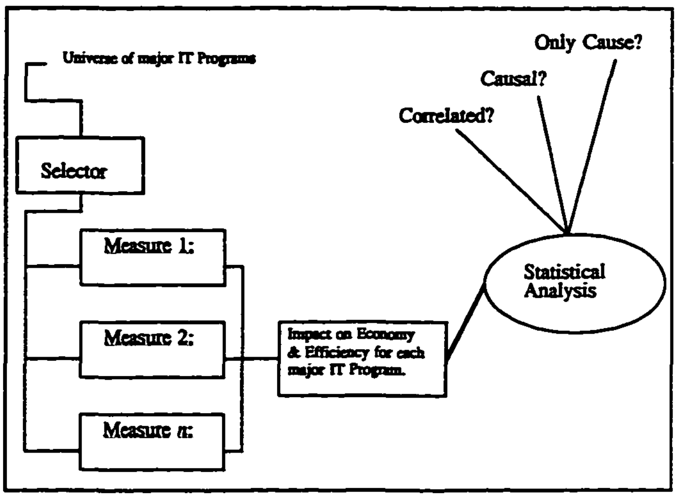

Figure IV-D-2: Empirical Method

Identification of the responsible central management agency was sometimes possible, but it was a measure of correlation with specific practices (input variables) which was desired. Thus, the measures were specifically focused on information technology programs' economy and efficiency; that is:

Measure 1: Did the oversight practice help the program meet mission requirements?

Measure 2: Did the oversight practice help the agency acquire information technology in a timely manner?

Measure 3: Did the oversight practice help the agency acquire current technology?

Measure 4: Did the oversight practice help the agency reduce prices?

Each measure was able to assume one of five values: (1) no impact, (2) some impact, (3) moderate impact, (4) significant impact, (5) substantial impact. As an example, Agency Y's Program X may have had a Measure 1 value of "some impact" caused by an audit (*e.g.* a GAO report), and a level of "significant impact" caused by specific guidance (*e.g.* OMB's guidance under Circular A-109). Observe that a rating of greater than 1 or "no impact" only means that some change was caused by the oversight practice. It does not mean that all problems were cured. Figure IV-D-2 shows the mechanism and the relationship of input variables with measures.

E. Data Collection

Stages I and II required different methods of data collection because they were intended to obtain the views of complimentary portions of the information technology community. Accordingly, both required separate data collection techniques. Their respective data sources are described, below.

Stage I: Directed Sample

A Survey Questionnaire was used to solicit perspectives from the information technology community about oversight in the Transitional, Traditional and Transformed periods. The intention was to solicit responses from senior-level federal and private sector officials who had significant responsibilities for the largest and most important federal information programs. It was preferred in selecting those officials that they had experience with major programs that involved an oversight action from at least one of the central management agencies during at least one of the three previously described oversight time periods. For private sector representatives it was also preferred that they had held, in the recent past, a senior-level federal position with significant responsibility for large-scale federal information technology systems and programs.

Therefore, an important part of Stage I was to obtain an "insider" perspective from those very officials who were making important decisions about major federal information technology programs. Such an approach was selected to help assure validity and to obtain the views of those who were making day-to-day, line decisions about the federal government's largest and most important information technology programs.

As part of the overall survey, an effort was made to solicit input from a few, selected representatives of the oversight community, including some from the central management agencies as well as some former and current congressional staffers. In this way, the "outsider" perspective of the oversight community was brought to bear in the study. To the extent possible, oversight respondents were selected from those who were known to have had direct involvement in developing and recommending courses of oversight actions for large-scale information technology programs including the two studied in the Stage II Multiple Case Study.

Therefore, the Stage I survey instrument was used to solicit information from a cross section of the information technology community that included senior-level program, technical, contracting, marketing, media and oversight officials. That is, the "insider" and "outsider" perspectives were brought to bear in this stage of the study. The survey instrument, therefore, was used to capture those perspectives, and to provide sufficient detail for analysis and identification of trends. Appendix C contains the survey instrument. Moreover, follow up interviews were conducted, as appropriate. Chapter V provides specific details about survey participants and their responses to the survey.

Stage II: Multiple Case Study

Two major information technology programs were selected for analysis. This approach was selected because it provided the opportunity to explore, in depth and breadth, substantive examples of theory-in-practice.

Major information technology investments are not undertaken lightly by federal agencies. The considerable risk inherent in these projects is well known to all; tales of misdeeds are frequently used by politicians and the media to regale the public. Each program has its own tale to tell. Even the most successful programs and their managers do not complete their tasks unscathed. For these reasons, specific case study of any large program would have yielded meaningful conceptual and theoretical knowledge.

However, accountability and oversight precepts are the focus of this study, and for this reason it was those programs which had experienced oversight actions that were thought more likely to yield the sought-after knowledge. A logical extension was to seek the most significantly troubled programs for study because of their innate susceptibility for more oversight involvement. It is this path that was chosen.

The task was made easier because the central management agencies had already identified several of the largest and most important information technology initiatives as "High Risk" programs. The Office of Management and Budget and the General Accounting Office had previously selected "High Risk" information technology programs that they track (GAO, 1995j). Also, in 1994 GSA had developed a "Time Out" mechanism for major, troubled information technology programs (GAO, 1995j). Two cases, namely, the Federal Aviation Administration's Advanced Automation System and the National Oceanographic and Atmospheric Administration's Advanced Weather Information Processing System were selected from those lists based upon specific criteria. First, each selected program spanned (or will span) all three information technology oversight time periods. An implication was that the program would be very old, and undoubtedly had encountered significant problems at one or more points in time. Thus, at least one, and potentially almost all members of the oversight community would have had the opportunity to become involved at one time or another with each of the two programs.

Furthermore, the problems and issues surrounding the selected high-risk programs had caused creation of multiple sources of data. A broad literature search was made of journals, trade press, publicly available studies, agency documents, as well as publicly-available Office of Management and Budget and General Services Administration sources and General Accounting Office reports. Data sources included interviews, publicly-available documentation, and existing studies as well as related reports.

The overall research for both stages was conducted using the above design. The use of multiple data sources from the "insider," "outsider" and "independent" perspectives strengthened the study through identification of redundant findings. The multiple sources also helped determine the sensitivity of the variations.

F. Data Analysis

After completing collection efforts, Stage I data was analyzed to identify a Traditional, Transitional, and Transformed baseline of correlations between program outcomes and inputs (*i.e.* accountability precepts, attributes and mechanisms). Finally, accumulated data for the two selected information technology programs was analyzed in Stage II, Multiple Case Study. The results were used to indicate the likelihood of efficiency-economy improvements in future information technology programs caused by similar inputs (new accountability precepts, attributes and oversight practices) in the Transformed era. Comparison and synthesis of the findings from the two stages was also used to provide a broader basis to determine whether changes in the multiple case studies were actually caused by the input variables, providing an opportunity to assess possible mediating or extraneous variables. Moreover, the "insider," "outsider," and "independent" data was compared in the analysis to ensure validity through identification of any redundancy and to contrast any divergence in their results.

The Stage I and II findings are reported in Chapters V and VI, respectively. Those chapters identify the precepts, attributes and mechanisms that characterize each of the three oversight periods. Also, their results are generalized, to the extent possible, in Chapter VII which answers the study question and evaluates the prospects for improvements in the efficiency and economy of federal agencies' major information technology programs.

CHAPTER V

FEDERAL INFORMATION TECHNOLOGY SURVEY

Fundamental precepts of federal information technology accountability from the Traditional, Transitional and Transformed eras are identified and characterized in this chapter. Those results are subsequently applied to assessing the likelihood of improvements in major information technology programs in the Transformed era. An empirical method was used to identify the precepts along with their corresponding attributes and mechanisms. The method employed a survey of information technology professionals who were serving in higher-level positions with responsibilities for federal information technology programs as of December 1995. The results of the survey are reported, the likelihood for improvement is assessed, and the precepts are incorporated into a baseline for use with the case studies in the next chapter.

A. Purpose of the Survey

The survey had a three-fold purpose. First, it was intended to identify overarching and fundamental accountability precepts, attributes and mechanisms. As a second purpose it would categorize those precepts and their attendant attributes and mechanisms into each of the three information technology accountability eras. Finally, the survey was devised to identify the likelihood that changed information accountability methods would help federal agencies achieve success in the Transformed era, especially, for their largest and most important, federal information technology programs. The study was conducted during January and February 1996.

Regarding the first purpose, implementation of accountability in any federal setting can be generalized and viewed as a three-tiered architectural process. Accountability precepts comprise the highest-level tier, and refer to those overarching principles which form the basis for associated standards and rules.

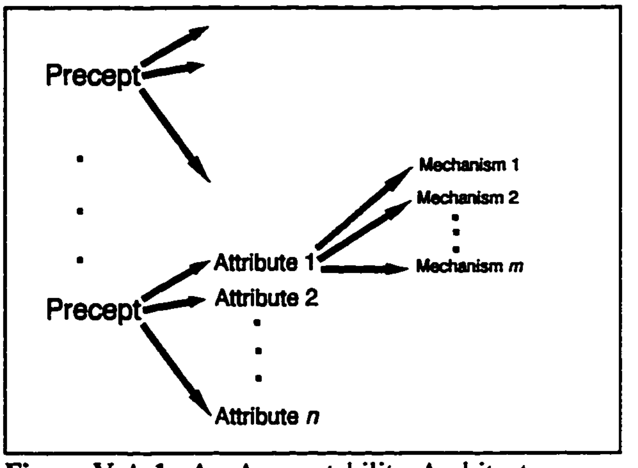

Figure V-A-1: An Accountability Architecture

Therefore, this first tier is value-based and defines accountability principles at a conceptual level. The second tier, attributes, is one in which the associated precept is characterized by specific qualities and distinctive features. Thus, the second tier highlights and selects as points of focus only some of the qualities from the overarching principle defined in the first tier. The third and final one is the mechanisms tier wherein the attributes are refined into implementable practices.

As an example, an accountability precept of central control might have delegation and audit as its associated attributes and creation of a specialized bureau in a central management agency as an implementing mechanism. That is, a high-level accountability *precept* (principle) is characterized by *attributes* (qualities or features) as points of focus or emphasis which, in turn, are implemented through one or more *mechanisms* (specific practices). The first two tiers are at the concept level (an attribute may or may not completely characterize a precept--usually it does not) while the third is tangible.

A more specific example comes from the years of Lyndon Johnson's presidency. "Eliminate Poverty" was such a precept from that time. It had several attendant attributes including one that "every child's daily food intake should meet or exceed a standard nutritional level." In turn, that attribute had subsidized school lunches as one of its implementing mechanisms. Figure V-A-1 illustrates the three-tiered architectural process.

The efficacy of using this three-tiered accountability architecture can be demonstrated from examination of the close relationship between accountability and decision-making. Three decision-making models have come to dominate public administration, according to Smith (1993-4). Two of those models are, indeed, well-known and recognized throughout the social sciences. The correspondence of those two models (as described in Smith, 1993-4) with the three-tiered accountability architecture depicted, above, is given in the following:

> "Satisficing": As posited by James March and Herbert Simon (1958), alternatives are sequentially evaluated in this approach and the first viable (not necessarily optimal) alternative is accepted. March and Simon's selected alternative corresponds to an attribute in the three-tiered architecture; a precept in the three-tiered architecture corresponds to the scope of the decision-making problem in March and Simon's scheme.
>
> "Incrementalism": This model suggested by Charles Lindblom (1959) employs incremental use of change to redirect a program in the desired direction. A precept in the accountability architecture corresponds to desired direction in the Lindblom model; selection of those increments for change in the Lindblom model corresponds to attributes in the three-tiered architecture.

Therefore, the three-tiered accountability architecture is closely akin to decision-making processes. Appendix B takes this argument one additional step and, using an approach from (Wolfe, 1995), demonstrates the relationship of the three-tiered architecture to certain concepts of mathematical and statistical decision-making. Figure V-A-2 depicts the interrelationship of decision-making and the three-tiered architecture. In that context the old debate about rational versus political decision-making is worth mentioning from two perspectives and with respect to accountability issues.

Regarding the first perspective, an important issue in rational decision-making is one of tractability. Value-base precepts, because of their high-level breadth, can typically be implemented through any of a very large number of instrumentalities. Choosing the optimal alternative would require an examination of each of those instrumentalities. Such a decision-making problem may be said to be intractable, in a rational sense, when the set of possible alternatives is too large. This is because the rational decision-maker would have lost the opportunity to render a decision; because he or she would still have been examining alternatives. The "right" time would have passed. Thus, insertion of an attribute "screen" in between a precept and possible mechanisms can make the decision process tractable by filtering out, at a higher level, whole sub-classes of alternatives. The rational decision-maker selects that attribute or "screen" on the basis of the following question: "What minimal set of qualities is the essence of that precept?" Thus, the decision-maker need only examine a smaller and tractable subset from the set of all possible alternatives. Such a process also bears a close resemblance to Herbert Simon's concept of bounded rationality (Simon, 1946).

The second perspective is one of politics. In that model the decision-maker has already identified a value-base accountability precept. Regarding its implementation, through a political process the decision-maker selects certain qualities of that precept for emphasis. Other players submit considerations and exert influence; the decision-maker integrates all of this in selecting the attributes which best achieve the desired political ends. Those qualities or attributes then become the decision-makers' focus and guide the selection of specific implementing mechanisms. By not selecting other qualities the decision-maker has, in effect, constrained the set of all possible alternatives. The decision-maker has really determined through a political process that only a particular subset of all possible alternatives needs to be examined, namely, the subset of alternatives which is associated with the chosen attributes. Thus, the size of the problem has been greatly reduced. In that way, the decision-maker has rendered the precept implementation problem tractable, albeit through a political process. Observe the similarity of this perspective with that of Graham Allison's Governmental Politics model (Allison, 1971).

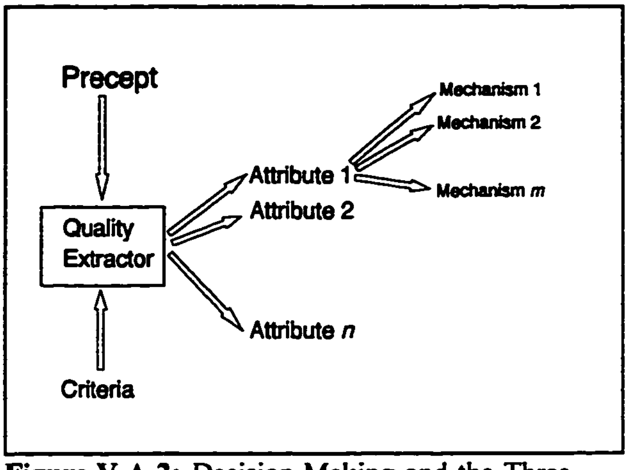

Figure V-A-2: Decision-Making and the Three-Tiered Architecture

Clearly, this generalized three-tiered architecture is applicable to information technology accountability. Regarding the first and second purposes of the survey, in fact, the information technology community was uniquely positioned by both time and circumstance to opine about such precepts, attributes and mechanisms at the time of the study. Because the history of the Traditional era was fresh in their minds, they were immersed in the mechanisms of the Transitional era and they were also on the cusp of the Transformed period. Thus, they could both readily identify and classify those precepts, attributes and mechanisms.

Regarding the third purpose, the federal program-level and oversight-level information technology communities were well-positioned by virtue of their respective "insider" and "outsider" knowledge to serve as an accurate gauge of the likelihood that changed information accountability methods would help individual federal agencies achieve success in the Transformed era, especially for their largest and most important federal information technology programs. The point is important because of the exceptional changes experienced by the information technology community throughout the Transitional period in terms of increased expectations and rapidly fragmenting and shifting foundations of the field.

That is, changes were being wrought wherein the information technology community would provide technological solutions as the "engine of change," thereby giving politicians the practical wherewithal to pursue the "three Ds" of the mid-1990s, namely, downsizing, devolution and declining budgets for individual federal agencies. At the time of the study, focusing on this enormous leveraging quality of information technology emphasized the importance of achieving success in the oversight mechanisms of the Transformed era. Clearly, with this exceptional impetus, the information technology community was uniquely positioned at the time of the survey to respond sagely to the question of success in the new era.

B. Survey Instrument

The survey instrument was constructed in three stages: the draft, pre-test and final instrument stages. The intention was to utilize the concepts and practices identified in Chapter III as a foundation for developing a draft survey instrument. Subsequently, that draft was refined through a review by the peer committee and dissertation advisor, and finally, through a pre-test experience.

The literature of the three accountability eras was researched in the first stage in order to develop a baseline that would be subsequently used to prepare a draft survey instrument. Recall from Chapter III that the Brooks Act characterized the Traditional era, the National Performance Review represented the Transitional era, and Senator Cohen's Computer Chaos was identified as pointing the way towards the Transformed era. Therefore, the essence of the draft survey instrument was primarily drawn from those three documents. Careful attention was given to inclusion of questions about both tangible and abstract depictions of oversight. This was done to ensure that sufficient information would result from the survey at both the conceptual and practical levels from which to abstract the sought-after precepts, attributes and mechanisms for the three accountability eras. The result of this effort was the completion in October 1995 of an initial, draft survey instrument.

The draft instrument was reviewed for comment in the second stage by dissertation advisor Professor Newland, the peer committee members, and three other volunteers. A number of comments were received about content, scope, order of questions, clarity and accompanying instructional material for respondents. Revisions made in response to those comments were incorporated into a new version for use in a pre-test.

The revised version was used in a pre-test during December and January 1996. The pre-test had been delayed from the original plan because of a government-wide shut-down and furlough of most federal workers. Nine volunteers with a wide range of backgrounds participated in the pre-test. Seven of the nine were USC doctoral students. All seven were also employed in full time professional-level positions in a variety of fields. Five of the doctoral students had recently completed an information resources management course at USC. Six of the nine participants were information technology professionals, one was a federal official with a public relations background, another was a federal official specializing in military logistics, and the ninth and final participant was a public administration instructor at a state university. The respondents indicated that the questionnaire required 30 to 40 minutes for completion. They also suggested some changes, although not as many as were suggested in the previous draft review. Many of the suggestions were cosmetic in nature and were designed to make the questionnaire easier and faster to complete.

Some final changes and revisions were made to the survey instrument as a result of those comments from the pre-test. A few questions were revised for clarity. Several questions were deleted because of redundancy, and the format was slightly revised for ease of completion. The completion time for the revised version was estimated at 20 to 30 minutes, and it addressed the suggestions received in the pre-test. The final version of the survey instrument was completed on January 12, 1996, and was then prepared for distribution to potential respondents. A copy of the survey instrument is in Appendix C.

C. Conduct of the Survey

The survey was conducted between January 12, 1996, and January 26, 1996, using the methodology previously described in Chapter IV. A description of the specific details about the conduct of the survey is provided, below.

The intention was to consider only those officials who had significant, high-level responsibilities for federal information technology programs for inclusion into the universe of all potential respondents. This meant that a very broad range of senior-level officials could be considered from within the executive branch of the federal government along with those from the legislative and judicial branches. Additionally, it was deemed desirable to include for possible consideration those officials in similar positions in the private sector who had responsibilities for large-scale federal information technology programs. The underpinning idea was that all senior-level officials in either the public or private sectors who had program, technical, contracting, media, marketing, or oversight responsibilities for the federal government's largest and most important information technology programs should be considered as possible respondents.

However, it was quickly determined that identifying the universe of all such possible respondents would be a daunting and, actually, impossible task for at least three reasons. First, there is no central list published or maintained of all such officials. Secondly, any attempt to construct such a list would be quickly outdated to the point of being useless because of rapid job turnover and attrition in both the public and private sectors; in the information technology field new companies start and die almost daily. Thirdly, there is no universally accepted definition of a "senior-level information technology professional with significant responsibilities for the federal government's largest and most important information technology programs."

An attempt to construct such a list would have meant that the credentials of each possible respondent needed to be tested against a newly-devised standard; neither resource availability nor cooperation from agencies and companies would have been likely to materialize in such a quest, potentially involving many thousands of people. "Largest and most important" also presented a definitional problem because a $10 million program would have met that definition for the Railroad Retirement Board, while at least $100 million would have been needed to meet that same test for the Internal Revenue Service. Even a $200 million maintenance program would probably not have met the "most important" test for IRS. Time would also have been an issue with this definition because, for example, former Congressman Jack Brooks would not have qualified because he did not in February 1996 have any "significant responsibilities for the federal government's largest and most important information technology programs." Yet, Jack Brooks's views would certainly have been worthy of consideration, regardless of whether one was his supporter or detractor. Thus, conduct of a statistical survey in the purest sense was not deemed to be possible from both definitional and practicability perspectives.

Therefore, an alternative approach was devised which would be viable, practical and implementable. The chosen methodology employed identification of a smaller universe, specifically, 100 of those federal and private sector officials who were known to have significant responsibilities for at least one of the federal government's largest and most important information technology programs any time during the period 1990 through 1996. "Largest and most important information technology program" was defined as any program which exceeded either $100 million in value or 25% of an agency's annual information technology budget. "Most important" was deemed to mean that the program had high visibility throughout the federal community and the federal information technology media. "Significant responsibility" was defined as either line authority over major portions of the program or known ability to influence such decisions. A concerted effort was made to consider only those private industry officials who also had prior federal experience, at a senior-level, in the information technology arena.

The approach was implemented, and by November 1996, the universe of 100 potential respondents had been selected. A statistical sample of 25 potential respondents was selected on a random basis from this universe to receive survey questionnaires. Each letter transmitting a questionnaire on January 12, 1996 asked the potential respondent to return the completed survey instrument by January 26, 1996, by electronic facsimile or either electronic or postal mail. The last date for acceptance of completed survey instruments was delayed until February 2, 1996 in order to provide sufficient time for mail delivery. The transmittal letter as well as the survey instrument also advised potential respondents that their response could be anonymous, would be held in confidence and that any published results would not be identifiable at the individual response level. The survey instrument also offered the opportunity for an interview.

D. Survey Results

As of February 2, 1996, a total of 23 completed survey instruments had been received out of the 25 issued to potential respondents. This was a response rate of 92 percent. An additional questionnaire was received on March 1, 1996, but it was not included in the overall survey results because it was received after the cut off date.

Respondent Characteristics

Seventy-four percent of the respondents were federal officials; of those 71% were in the executive branch and 29% were in the legislative branch. Respondents classified themselves as 30% Senior Executive Service (SES), 48% as GS-15, and 22% at the GS-14 levels. Twenty-six percent of the respondents were employed in the private sector and they mostly categorized themselves as holding SES-equivalent positions (67%).

Regarding their responsibilities, most respondents (87%) indicated that they had significant roles in both computers and telecommunications. Nine percent had responsibilities only for computers and 4% were restricted to telecommunications. Seventeen percent were oversight, 9% were either media or marketing, and 84% categorized themselves as program, technical or contracting officials. All had significant responsibility for or monitored at least $50 million in federal information technology projects; 55% had those types of responsibilities for projects that exceeded $500 million in value.

Therefore, the group of respondents can be characterized as follows. They were a group of influential, mostly federal, officials who had significant responsibilities for some of the largest and most important federal information technology projects and programs.

The survey instrument had been structured to gather sufficient information to identify: 1) overarching and fundamental information technology precepts, attributes and mechanisms, their classification into each of the three information technology accountability eras, and 3) the likelihood that changed information accountability methods would help federal agencies achieve success in the Transformed era, especially, for their largest and most important, federal information technology programs. In its overall structure, however, the survey instrument allowed for a number of ways to characterize the data. The most important results from the overall findings are provided below, along with some interesting interpretations about the data. Subsequently, in the next two sections, the specific survey findings are refined through analysis in order to identify the sought-after accountability precepts, attributes and mechanisms according to era, as well as respondents' beliefs about the likelihood of success in the Traditional era. The survey instrument is displayed in Appendix C.

Providers of Oversight

Section IA of the survey instrument was intended to determine respondents' perceptions about which organization(s) have provided and should provide oversight in each of the three oversight periods at the government-wide, agency and individual project levels. Three sets of paired questions were employed to accomplish this task.

<u>Government-Wide Oversight:</u> The first set of question pairs sought respondents' perceptions about the providers of government-wide oversight. Specifically, these questions were the following:

1. In your experience, which of the following **HAS** exercised or **WILL** exercise the **MOST** responsibility for federal **GOVERNMENT-WIDE** oversight of information technology? **Choose one and only one in each column.**	**Past**	**Present**	**Future**

and

2. In your experience, which of the following **SHOULD HAVE** the **MOST** responsibility for federal **GOVERNMENT-WIDE** oversight of information technology? **Choose one and only one in each column.**	**Past**	**Present**	**Future**

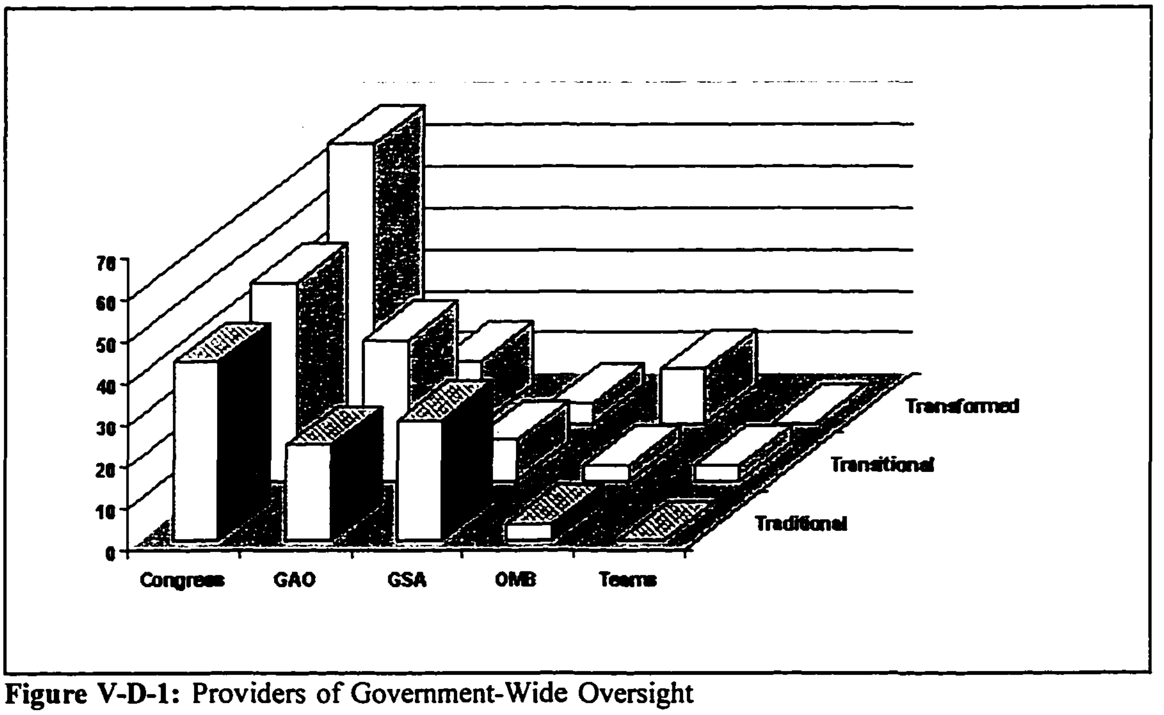

Figure V-D-1: Providers of Government-Wide Oversight

Respondents were given a number of choices ranging over the congressional general management, appropriations and authorizations committees, each of the central management agencies, inter-agency teams, none or other (see Appendix C). Fundamentally, the questions addressed respondents' perceptions about the need for government-wide oversight, the importance of influence of Congress versus central management agencies versus the modern concept of teams. Opportunities to refine and provide granularity within those categories was also provided through identification of specific congressional committees and individual central management agencies. Each of the questions is assessed below.

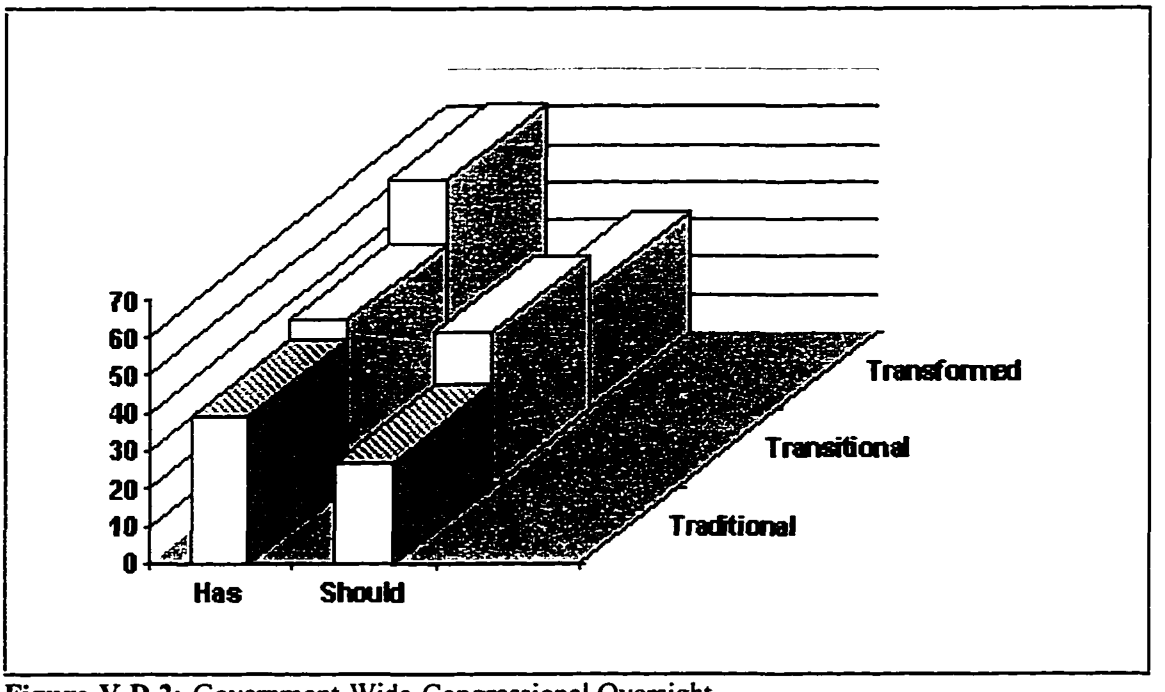

Figure V-D-2: Government-Wide Congressional Oversight

Have Provided Oversight: As shown in figure V-D-1, all except 5% of the respondents allocated all of their selections to either congressional committees or central management agencies. Figure V-D-2 displays the frequency of respondents' allocations between congressional committees, as a group, and for the "Have" and "Should" provide responses.

Several data points are of interest. First, respondents reported a belief that congressional control over federal information technology oversight increased from the Traditional (39%) to the Transitional (44%) eras. Moreover, it was their perception that congressional control will increase to 61% in the Transformed era. Secondly, there was and will continue to be a significant decline in the influence of both the General Accounting Office and the General Services Administration, according to respondents; particularly, this will be true for GSA (down from a Traditional high of 26% to 4% in the Transformed era). Finally, respondents noted some increasing influence for the Office of Management and Budget, but they perceived that any such influence will remain at an overall low level (only 13% gave it a high level of influence).

Should Provide Oversight: Again, all respondents allocated all of their selections to either congressional committees or central management agencies except for 9% in both the Transitional and Transformed eras. Figure V-D-3 displays the frequency of respondents' allocations for the "Have" and "Should" responses for as a group, each of the central management agencies, namely, the Office of Management and Budget, the General Accounting Office and the General Services Administration.

Data points of interest include an observation that congressional influence should have increased from the Traditional (27%) to the Transitional (41%) eras, which agrees with the "Have" data. However, respondents suggested that congressional influence should decline in the Transformed (32%) era which differs from their belief that it will, in fact, increase. That is, respondents suggest that the congressional role should be less than they believe that it will become in the Transformed era. Interviewees suggested that, to perform the transition in oversight, politics was a necessary ingredient However, it appears that in the long term the respondents would prefer a less politicized environment for information technology oversight.

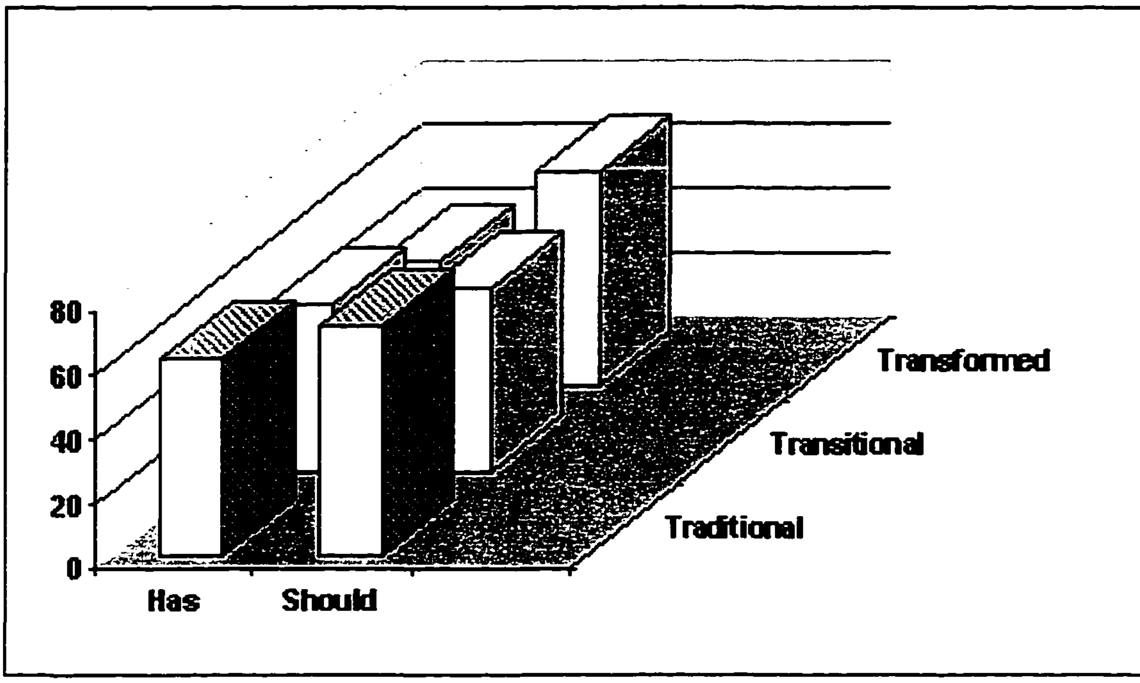

Figure V-D-3: Government-Wide Central Management

From the central management agency perspective respondents concurred with the "Have" information that the General Services Administration's role should diminish, but in contrast to the "Have" data reported above, that the General Accounting Office's influence should increase from a 9% level of influence to 14%. They further concurred that the Office of Management and Budget's role should increase but want a larger enhancement of that role than they believe will actually occur (31 % "should" versus only 13% "will").

Findings: There were three findings. First, respondents strongly recommended that there should be government-wide information technology oversight and that such oversight has been in place. There was only a 9% dissent from this finding for the Transitional and Transformed periods. In the questionnaire choices, three broad forms for oversight were listed, namely, congressional, central management, and inter-agency committees. Interestingly, in the Transformed portion of the 91% recommending government-wide information technology oversight, all respondents opted for the first two, which are traditional forms of oversight. None chose the fashionable 1990s suggestion of inter-agency teams. The comments gave no additional guidance about this phenomenon. However, interviewees suggested some possible reasons.

First, interviewees said that inter-agency committees are facilitative in nature; they have not tended to be oversight mechanisms. They further indicated that some intra-agency committees like Department of Defense Major Acquisition Information Systems Review Committees (MAISRCs) have performed some oversight types of functions. However, they were intra and not inter-agency committees which tended to be cooperative ventures.

Interestingly, the interviewees were not totally enthralled with the inter-agency committee concept, even for facilitation. Some said that, although many had been useful, some past inter-agency committees had proven to be ineffective; discussions had led to either superficial or no meaningful results. Secondly, other inter-agency committees had, in the past, become closed in the sense that only a few key players make the decisions. All indicated that the committees were resource intensive. For those reasons interviewees indicated a reluctance to support inter-agency committees as a primary form of oversight.

In the second finding, respondents suggested that there should be a balance between congressional and central management agencies in the oversight of information technology. In the Transitional period "Should Provide" respondents were evenly split between congressional influence and central management. There was considerable strength in this finding. However, in the Transformed period, 61% of the responses foresaw increasing congressional influence while only 32% made the same choice in the "Should Provide" question. This demonstrated a considerable level of tension in this finding between what should be and what has been. Respondents sought a balance in their "should" responses. However, they foresaw increased congressional involvement in excess of what should be the case. Apparently, respondents perceived that government-wide information technology decisions will become increasingly brokered in congressional committees, in the future, rather than at the agency or central management agency levels. That is, respondents foresaw an increasingly political environment for federal information technology. Figures V-D-2 and V-D-3 portray this tension.

Thirdly, respondents indicated that central management of information technology management should be centralized at the Office of Management and Budget but with supporting (but not oversight) roles for other central management agencies. Of those respondents who selected central management for a key future role in the Transformed era, 59% foresaw OMB with that leadership responsibility. Slightly less than 17% placed the General Services Administration in that role and 25% foresaw such a role for the General Accounting Office. Notably, only 30% foresaw the central management agencies, in their totality, having a significant level of influence in the Transformed era; instead, 61% saw Congress as having that influence.

Comments and interviews indicated that the General Accounting Office's role should be closely associated with "best practices" in the future. Some expressed concern about GAO's audit role because of its (real or perceived) reputation for "gotcha" audits and congressional collusion (*e.g.* NAPA, 1994). While wanting to avoid such hazards, interviewees thought that GAO's breadth of exposure to information technology programs should be harvested on a regular basis to promulgate and promote "best practices" throughout the government.

The General Services Administration roles, according to interviewees, should be both facilitative and as a provider of services. Interviewees suggested that GSA should continue to have a role as a provider of government-wide telecommunications services (e.g. FTS2000), supplier and facilitator of government-wide computer contracts, and as a facilitator of related conferences and workshops.

Therefore, OMB should provide overall direction while GAO and GSA should have supporting roles, according to responses. Interestingly, this suggestion of support closely matches the National Performance Review notion cited in Chapter III that the central management agencies were created to support, not control, the agencies that "do the work."

Agency-Level Oversight: The second set of question pairs sought respondents' perceptions about the providers of oversight at the agency level. Specifically, these questions were the following:

3. Which **HAS** or **WILL HAVE** exercised the **MOST** oversight of your **AGENCY's** IT programs? **Choose one in each column.**	**Past**	**Present**	**Future**

and

4. Which **SHOULD HAVE** the **MOST** oversight of your **AGENCY's** IT programs? **Choose one in each column.**	**Past**	**Present**	**Future**

Respondents were given a similar number of choices ranging over the congressional general management, appropriations and authorizations committees that included each of the central management agencies, inter-agency teams, none or other. However, some additional agency-level choices were added including the Inspector General, Chief Financial (CFO) and Information Officers (CIO) as well as senior program, procurement and information technology officials. Internal peer and management committees were also included. Each of the questions is assessed, below.

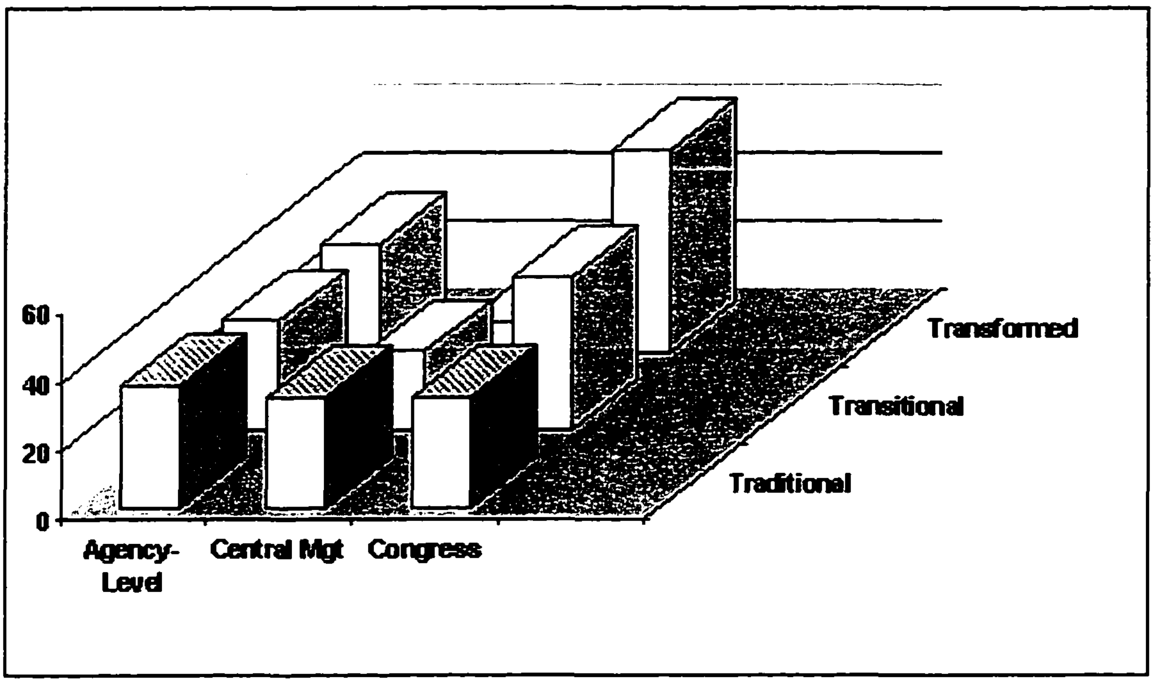

Figure V-D-4: Providers of Agency-Level Oversight

Have Provided Oversight: In the past, according to respondents, oversight was provided somewhat equally by Congress, the central management agencies, and internal agency organizations (32%, 32% and 36%, respectively). A shift was apparently occurring at the time of the study, and respondents thought that, in the future, Congress would provide most oversight (59%) while the central management agencies would decline to a lower level of influence (from a high of 30% to just 9%) and internal agency organizations (from 36% down to 32%) would lose a little of their oversight power.

Thus, the information technology professionals who responded to the survey foresaw a strong shift wherein the power of Congress would both increase and become more visible. (See figure V-D-4 which displays the frequency of respondents' allocations between congressional committees, central management and internal agency-level organizations, each as a group.)

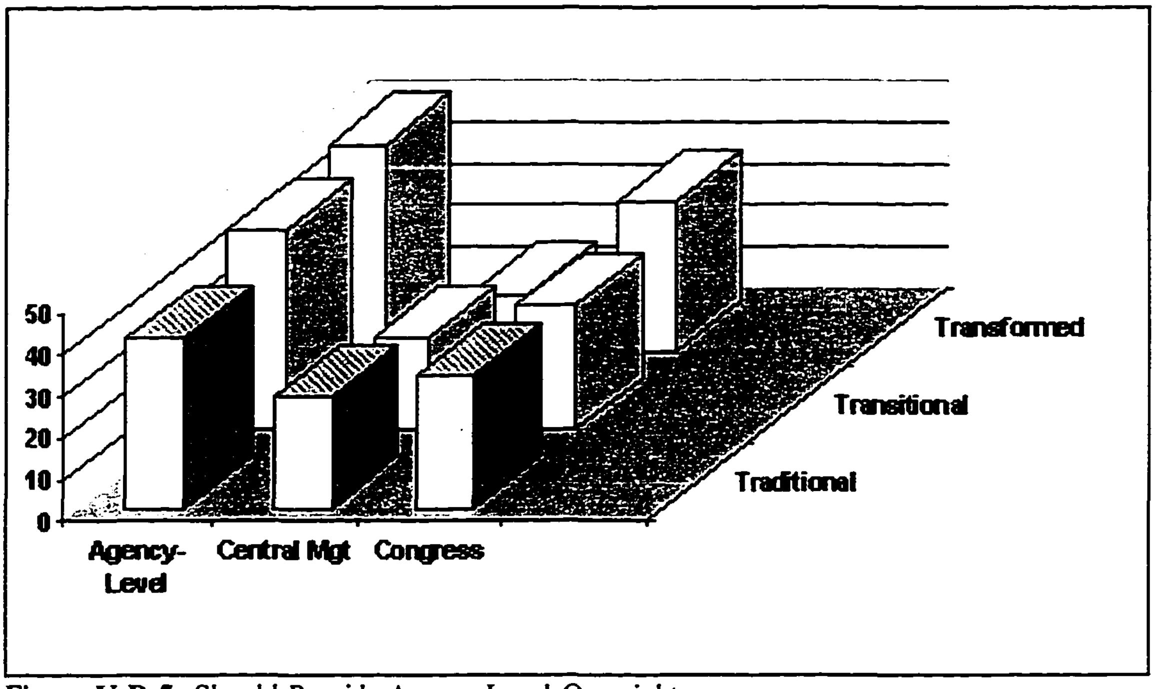

Figure V-D-5: Should Provide Agency-Level Oversight

Should Provide Oversight: In the past, according to respondents, oversight should have been provided by Congress, the central management agencies, and internal agency organizations (32%, 27% and 41%, respectively). However, respondents thought that in the future Congress should provide the most oversight (36%) while the central management agencies should decline (14%) and internal agency organizations (50%) should significantly gain additional oversight power.

Findings: There were two findings. First, the responses indicated that agency-level information technology oversight is necessary. Only 5% of the responses suggested otherwise. The second finding was that respondents reported considerable tension between those organizations that should be and those that will actually be the future providers of oversight. In particular, the responses indicated an increasing politicization of information technology oversight; 36% congressional oversight should occur but 59% will actually occur, according to respondents.

This tension correlates with the government-wide findings of the prior two questions which also suggested an increasing trend in congressional (i.e. political-level) oversight and decision-making.

Interviewees and comments indicated concurrence with these observations. Specifically, interviewees suggested that tight budgets had created circumstances wherein decision-making had increasingly moved up to higher, and particularly, political levels. In that scenario, information technology along with many other areas would have been increasingly moved into the political decision-making arena. Moreover, the responses as well as comments indicated a belief that such practices would continue to increase, rather than diminish, in the upcoming Transformed era.

Project-Level Oversight: The third set of question pairs sought respondents' perceptions about the providers of oversight at the lowest level; that is, the project level. They were:

5. In your experience, which of the following **HAS** or **WILL HAVE** exercised the **MOST** oversight responsibility for the **LARGEST** and most important information technology program or project for which you have had significant responsibility. **Choose only one in each column.**	**Past**	**Present**	**Future**

and

6. In your experience, which of the following **SHOULD HAVE** the **MOST** oversight responsibility for the **LARGEST** and most important information technology program or project for which you have had significant responsibility. **Choose only one in each column.**	**Past**	**Present**	**Future**

Respondents were given the same choices as in questions 3 and 4, and more options were added. Internal and external peer and management committees were also included in questions 5 and 6 as choices. Each of the questions is assessed, below.

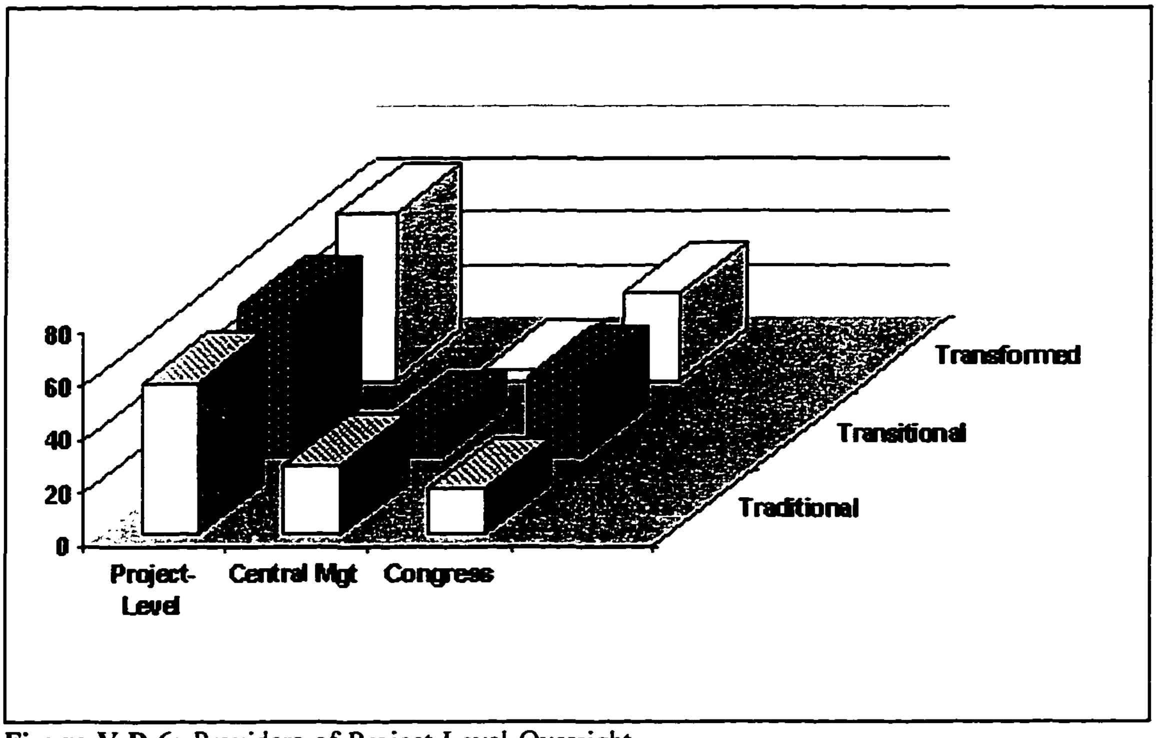

Figure V-D-6: Providers of Project-Level Oversight

Have Provided Oversight: Project-level oversight in the past relied mostly on internal review (57%) while some was provided by Congress (17%), and 26% was provided by the central management agencies, according to respondents. However, in the future Congress would have twice the influence (33%), the central management agencies would precipitously decline to 4%, and agency-level oversight would increase to 63%. (See figure V-D-6 which displays the frequency of respondents' allocations between congressional committees, central management and internal agency-level organizations, each as a group.)

Should Provide Oversight: According to respondents, congressional oversight should not have changed over time. Rather, it should have remained constant at 22%. The portion of oversight allotted to central management and agency-level organizations should also have remained constant at 22% and 56%, respectively (see figure V-D-7). This was a rather interesting

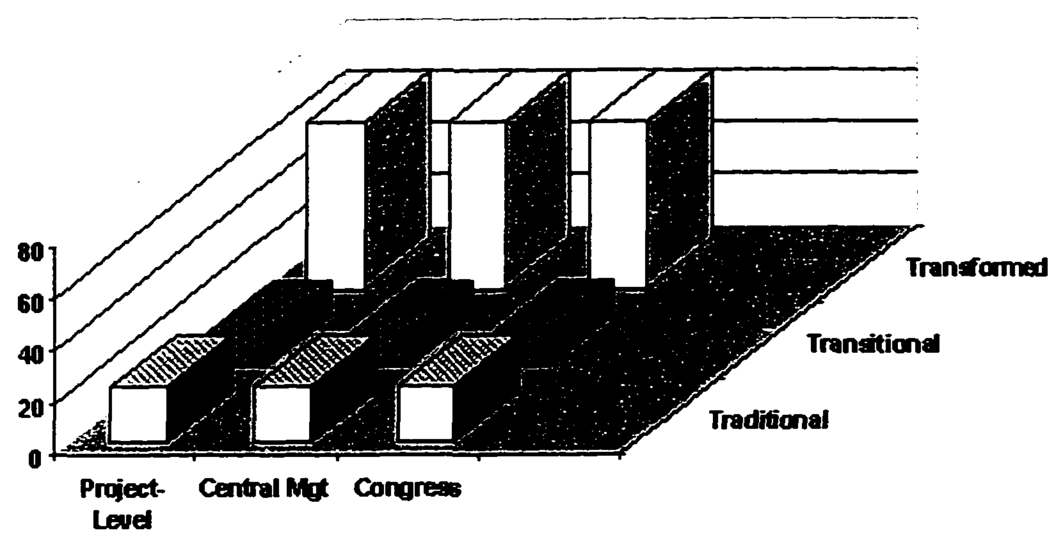

Figure V-D-7: Should Provide Project-Level Oversight

result because of its consistency. Other "Should" responses for the government-wide and agency-level questions tended to vary, somewhat, with respect to the three oversight periods. In the government-wide case, respondents wanted more agency-level autonomy in the future. Here, respondents seemed to be satisfied with the balance.

Findings: These results confirm the tension observed by respondents in the prior questions about what will and what should be the correct level of political involvement in the Transformed era. In analogy to the government-wide and agency-level findings, respondents perceived a need for program-level oversight from the central management agencies as well as Congress.

Practices and Time Periods

Characterizing practices by information technology time period was the focus of section IB of the survey instruments. The question is given, below:

Which time period is **best** associated with each of the following statements or words **(select only the one time period which best characterizes each statement or word)**:	**Past**	**Present**	**Future**

Respondents were requested to choose the time period with the "best fit" for 21 principles or practices which comprised the first 21 statements. In the additional questions respondents were requested to associate each of the listed central management agencies, management committees, councils and concepts (like "best practices") with the three periods.

Table V-D-I: Associated Time Periods

Which time period is **best** associated with each of the following statements or words **(select only the one time period which best characterizes each statement or word)**:	**Past**	**Present**	**Future**
Brooks Act principles or practices	37%	34%	29%
National Performance Review principles or practices	15%	39%	46%
Computer Chaos principles or practices	21%	36%	43%

By construction, the first seven of the 21 principles and practices corresponded with the Traditional era concepts identified in Chapter III. Similarly, the next seven were associated with the Transitional era, and finally, the last seven corresponded to Transformed era concepts. The following table shows how the respondents associated the three time periods with each of those three groups of seven questions.

At first glance there appears to be little correlation in the Brooks Act category between the results and respondents association of those concepts with any of the three oversight periods. However, guidance is available from an assessment of the other two sets of seven questions.

Specifically, the principles or practices grounded in the National Performance Review category showed a clear break point at the Transitional period. A large percentage of respondents also correlated those questions with the Transformed period. However, it is that break point which is important because it shows the point in time when respondents first perceived that a significant change had occurred in oversight practices. Thus, respondents clearly concluded that those principles and practices characterized the beginning of the Transitional era.

The Computer Chaos questions also showed a breakpoint from the Traditional to the Transitional era. Moreover, the results also showed a smaller but still important breakpoint between the Transitional and Traditional periods. Of those responses, an additional 7% selected the Transformed over the Transitional period, an upward trend. Moreover, interviewees always associated Computer Chaos with the upcoming Transformed era. Clearly, the Computer Chaos concepts did not materialize with no background; they were built upon some of the NPR concepts, as well. Therefore, the survey trend coupled with interviewees remarks about the Computer Chaos principles that underpinned those questions indicated that respondents perceived those principles as characteristics of the upcoming Traditional era.

Returning to the Brooks Act questions with that guidance indicates that those principles and practices began in the Traditional period according to respondents. Interestingly, however, respondents clearly thought that those same principles and practices, or a subset, had continued through the Transitional period and would continue into the Transformed era. The evenness of the distribution over the three periods makes this a very strong finding. Thus, Brooks Act concepts had and would continue to play a key role in information technology oversight as per the responses. Interviewees expressed the opinion that central control was one of the Brooks Act concepts that would continue to transcend all three time periods. Since those concepts began the Brooks Act era, they should characterize it.

Findings: Therefore, the Brooks Act, National Performance Review, and Computer Chaos concepts identified in Chapter III and used as the basis for the three sets of questions were correlated by respondents with the Traditional, Transitional, and Transformed periods, respectively. An additional finding was that respondents strongly suggested that Brooks Act concepts were embedded in Transitional practices and would continue to be embedded in Transformed era oversight practices. Similarly, though to a lesser extent, Transitional concepts were embedded in those of the Transformed era.

Practices and Effectiveness

Determining the effectiveness of oversight practices by information technology time period was the focus of section IC of the survey instruments. The question is given, below:

Please rate the following principles and practices according to their success in improving IT programs. **Please mark the appropriate column where 1 is "not effective" and 5 means "highly effective."**	1	2	3	4	5

Respondents were requested to rate the same twenty-one practices listed in question IB. However, they were not requested to rate the central management agencies, management committees, councils or key words describing concepts (like "best practices") that had been listed in question IB.

Table V-D-II: Time Periods and Practices

Please rate the following principles and practices according to their success in improving IT programs. **Please mark the appropriate column where 1 is "not effective" and 5 means "highly effective."**	1	2	3	4	5
Brooks Act principles and practices	9%	19%	35%	23%	14%
National Performance Review principles and practices	1%	16%	23%	29%	31%
Computer Chaos principles and practices	4%	9%	17%	27%	42%

As in the prior pair of questions, by construction, the first seven principles and practices corresponded with the Traditional era, the next seven with the Transitional era, and finally, the last seven corresponded to Transformed era concepts. The intention was to utilize the "benchmark" established by the prior question (that is, association of the principles and practices with each of the oversight time periods) to subsequently establish an effectiveness baseline. This effectiveness baseline is utilized in a subsequent chapter in synthesis with the case studies. The following table shows how the respondents ranked the practices and principles associated those three time periods.

Apparently, in the aggregate, respondents associated Transitional and Transformed era principles and practices with effectiveness by a great degree. Grouping those with a rating of 1 or 2 as "poor," 3 was "satisfactory" and 4 or 5 was "good" indicated that Brooks Act types of principles or practices were regarded as good by 37%, as satisfactory by 35%, and poor by 28% Another way to examine that result is by considering poor as "unacceptable" and satisfactory or good as "acceptable." In that taxonomy Brooks Act practices or principles were considered to be acceptable by the majority, and in fact, a significant percentage of respondents, specifically 72%.

Regarding their effectiveness, respondents rated Transitional types of principles or practices as good by 60%, as satisfactory by 23%, and poor by 17%. Transitional practices or principles were considered to be acceptable by a much larger majority, 82%, than those of the Traditional era.

Transformed types of principles or practices were regarded as good by 69%, as satisfactory by 17%, and as poor by 13%. Transformed practices or principles were considered to be acceptable by a much larger majority, 87%, than those of the Traditional era but about the same as the Transitional period. Interviews and comments confirmed those results.

Using the poor--satisfactory--good scheme, the top five principles or practices are listed below. The parentheses contain the percentage of total responses that rated the principle or practice as good. Ties were broken by selecting the one with a rating of 5 by the most respondents.

1. Reporting to external organizations should be minimal (100%).
2. Only a few organizations or groups should be involved in approving major IT projects (97%).
3. Legal procurement appeal processes should protect the government's interests (97%).
4. Contracting methods should be streamlined (97%).
5. Performance measures should be established up front (97%).

A clear focus by respondents was on internal rather than external controls, as indicated by the first two principles. The next two suggest a belief that procurement methods had been out of balance and favored vendors rather than the government. The fourth and fifth indicated a preference for efficiency by respondents.

The next-highest group of five is also instructive. Again, they were ranked as follows, and ties were broken in the same manner as above.

6. Ensuring conformance to standard operating procedures is replaced by sharing new and improved methods (94%).
7. Organizations are flatter and less approvals should be needed (83%).
8. There should be only one reporting structure for each IT project (70%).
9. IT programs should maximize return on investment (70%).
10. Information specialists should manage all parts of large-scale systems development projects (65%).

Numbers 6, 7 and 8 add substantial emphasis to respondents' suggestion that internal controls should have priority.

The sixth-ranked principle of sharing has an implication that centralized responsibility needs to be taken for facilitation of that sharing process, on a large-scale basis. This fits with respondents' observations in questions 1 and 2 in section IA that the General Accounting Office and the General Services Administration should have facilitative roles in the future. Interviewees also expressed a similar supposition, and pragmatically stated that no individual agency could perform that task; it was one for the central management agencies.

Number 10 has a technocratic flavor which would reasonably be expected to result in any survey of a technical specialty. Yet, the inherent implication in respondents' previously reported desire to include the various central management agencies in the Transformed era (see questions 1 through 6) was clearly grounded in a supposition of technical competence on their parts. Thus, respondents were not expressing a desire for a "closed" environment; rather, they wanted a technically open one operating in a collaborative manner. Clearly, those responses suggested that decision-making should be technically grounded and collaborative for federal agencies' information technology projects and programs.

Findings: The National Performance Review and Computer Chaos concepts identified in Chapter III and used as the basis for the three sets of questions were declared by respondents to be significantly more effective than those of the Brooks Act era. However, rather than discard all of those earlier concepts, respondents reported that some were fundamental and should be retained in the future, particularly the one of centralized oversight. Moreover, respondents suggested an internal rather than external focus on controls, thereby, making facilitation the mission of the central management agencies. They also expressed a belief that procurement methods have been out of balance and favored vendors rather than the government. Finally, respondents indicated a preference for efficiency with a technocratic orientation, and especially in a collaborative decision-making process for information technology programs.

Oversight Roles

In recapitulation, respondents foresaw three broad trends. First, congressional influence over information technology had increased in the Transitional period and would continue to increase in the Transformed era at the expense of the central management agencies. Secondly, the role of the Office of Management and Budget was in its ascendancy; it would emerge as the preeminent central authority in the Transformed era. Thirdly, the oversight role of the other central management agencies would decline in the Transformed era.

However, the second trend raises an important question about motivation and tension. Clearly agencies through their representatives supported a change to the Transformed era and its attendant form of centralized oversight in the Office of Management and Budget. From one perspective, agencies could have sought such centralization from an effectiveness motivation. That is, they would have wanted increased oversight that would be more effective in terms of agencies' purposes. An alternative perspective would be that agencies could have sought centralization in OMB because it was the least onerous of the Traditional and Transitional forms of oversight. That is, the motivation was to support the "least of all evils;" with oversight centered at OMB, all other forms would be eliminated. Thus, from that alternative perspective, agencies were motivated to seek to increase their autonomy (e.g. Wilson, 1989).

Interviewees were questioned about the apparent desire among the federal information technology community for increasing OMB's role. Respondents stated that the problems had been two-fold. Paramount was the General Accounting Office and its "gotcha" audits (see NAPA, 1994, for examples). Interviewees said that they were well aware of situations where GAO, apparently, had acted in bad faith and in collusion with congressional players to maneuver agencies into embarrassing dilemmas.

Another problem was the General Services Administration's transaction-by-transaction review of agencies' information technology programs. GSA's delegation of procurement authority process required agencies to seek outside (i.e. GSA) approval for each project, and again when changes occurred. Interviewees thought that agencies should be autonomous in their information technology programs; outside interference was unwanted. When asked about GSA's "Time Out," some interviewees indicated that it probably had helped by the simple fact of highlighting major problems throughout the community. Their further point was that "Time Out" was management by exception, and such an approach was certainly more desirable because it placed less of a burden on managers; only those with a major problem were placed "under the microscope."

Regarding OMB, interviewees suggested two thoughts. First, OMB was never known to have provided "oversight" in the onerous sense of the word. OMB had provided guidance and direction through circulars which were sometimes burdensome. However, it had not provided a detailed transaction-by-transaction management review of information technology programs. Secondly, OMB was perceived by interviewees as being very politically controlled and motivated. An example cited by one interviewee was the Internal Revenue Service's multi-billion dollar Tax System Modernization program. That program, according to the respondent, was in dire straights (see NRC, 1994 and 1996 which also reflect that same viewpoint). Yet, OMB had continued to support increased funding, "throwing good money after bad" year after year, rather than taking steps to get TSM under control. None of the interviewees cited OMB as an effective provider of oversight.

Thus, the touchstone of the issue about centralizing authority in OMB, from the agency representative perspective, was the question: "OMB, an effective or ineffective provider of information technology oversight?" The clear answer was: "No, OMB had not been an effective provider of oversight;" rather, its decisions were politically motivated to achieve political, and not technical, purposes. It was apparent that interviewees supported centralization of authority in OMB because it would remove the "sting" from the other central oversight agencies; interviewees clearly sought increased autonomy for their agencies' information technology programs. Increased effectiveness of oversight was not their motivation. Instead, they were hoping for facilitative support without the oversight overtones.

However, this finding demonstrates the probability of growing tension between Congress, agencies and the Office of Management and Budget. The reform legislation clearly levied expectations for improved efficiency and economy across all federal agencies and their information technology programs through centralized oversight by OMB.

The old homily about "10% do 90% of the work" and its contra-positive "10% require close supervision 90% of the time" is instructive in this instance. Most information technology programs have achieved results, and without close oversight. Facilitation can only help them do better that which they do well, already. However, it is that select few, the proverbial 10% that require close oversight or "supervision" because they have not "done well." The two case studies in Chapter VI will demonstrate the efficacy of the homily for information technology programs. Therefore, facilitation is certainly a beneficial and even a noble goal in transforming accountability. Yet, it does not account for the proverbial 10% that, for whatever reason, require close management attention. The multiplicity of multi-billion debacles that as of February 1996 had delivered only minimal results but maximized their cost overruns by an average of 50% also demonstrated the verity of that homily. Management is clearly a key to success in the conduct of large-scale information technology programs. The states have found that to be true on a smaller scale, according to Cats-Baril and Thompson (1995).

However, OMB has not had a record of "managing" according to many; there is no "M" in "OMB" according Ronald Moe (1992). Congressman Steve Horn held a number of hearings in early 1996, and embraced a similar theme. For example, at the February 7, 1996 House Management, Information and Technology Subcommittee hearing on OMB2000 reforms, Chairman Horn proposed creation of an Office of Management and a separate Office of the Budget to address those types of problems (an old idea that has surface in NAPA and on the Hill many times). Thus, OMB is faced in the Transformed era with congressional expectations of significantly more effective oversight, on one side, and on the other side all of the agencies have their expectations of greatly reduced oversight. Facing OMB square in the face are the long-standing, multi-billion dollar failures like IRS Tax Systems Modernization that keep consuming dollars and resources on an endless basis, like an astronomic black hole; they demand oversight and control. Such enormously conflicting expectations will be very difficult to balance, especially since there has previously been limited "M" in "OMB."

In summary, the survey instrument produced considerable information to depict the three oversight periods. These findings are consolidated in the next section into the sought-after precepts, attributes and mechanisms which characterize each of the three oversight periods. These results will be used, again, to assist in assessing the case studies in Chapter VI. Finally, the subsequent section in this chapter recapitulates the survey results into respondents' projection of success in the upcoming Transformed era.

E. Information Technology Accountability Precepts

An important result sought by the survey was the identification of specific precepts, attributes and mechanisms for each of the three information technology accountability eras. The table summarizes those items based upon integration of the survey findings and the analytical results from Chapter III. The table will be used as a template in the next chapter to overlay oversight characteristics of two information technology programs.

Briefly, regarding Transformed precepts, centralization of management was a strong theme throughout all of the responses. The Office of Management and Budget was foreseen by respondents as the heir-apparent to that function in the Transformed period. The supporting roles envisioned for the remaining central management agencies by respondents indicated a collaborative responsibility, on a government-wide basis, to work with agencies in both the

Table V-E-I: IT Accountability Precepts

Era	Precepts	Attributes	Mechanisms
Traditional	Centralized IT accountability	Delegation by transaction Audit	GSA procurement delegations GSA IRM audits GAO audits
	Functional IT hierarchical controls	Fractionated oversight	OMB--budget OMB--policy GSA--procurement NIST--Standards
Transitional	Diffused IT accountability	Delegation according to capability Agency-level responsibility	Broad classes of waivers Internal review Independent assessment
	Collaborative responsibility	Business orientation Technocratic decision-making	Inter-agency committees
Transformed	Centralized IT accountability	Single point of control Management by exception	OMB oversight IT Review Board
	Collaborative responsibility	Business orientation Technocratic decision-making	CIO Council Inter-agency committees Inter-agency technology teams

Transitional and Transformed eras through facilitation and "best practices."

Therefore, a centralized accountability precept in the Transformed era must have two attributes, a single point of control (OMB at the government-wide level), and management by exception. The former comes from the 1996 reform legislation (the Defense Authorizations Act); the later from its affirmation of the GSA-created Information Technology Review Board's role reviewing troubled, major information technology programs. Implementing mechanisms would occur through that Information Technology Board, which transferred to and coupled with OMB oversight in February 1996.

The second Transformed precept, collaborative responsibility, really emerged from the Transitional era with its inter-agency committees. Though respondents expressed doubts about their effectiveness in the oversight realm, it was clear that such committees would continue in the

Transformed era and focus on facilitation. One attribute, as shown in the survey results, would be technocratic decision-making. A second is the business orientation displayed by the 1996 reform legislation's creation of Chief Information Officers in the major agencies, and a CIO council created and chaired by OMB. The implementing mechanisms for these attributes are the CIO council, inter-agency committees and technology teams like the Presidential Technology Team announced by OMB in February 1996. That team would consist of top federal technical experts who, on loan from their agencies, would assist with the largest, troubled systems (OMB, 1996).

Working backwards, the Transitional precepts of diffused information technology accountability and collaborative responsibility easily come into view. The second one had the same attributes and mechanisms as in the Transformed era, except there was no CIO council nor were there any technology teams at that time to serve as implementing mechanisms. Diffused accountability clearly came from the National Performance Review maxim that central management agencies should support, not control, agencies that "do the work." Survey respondents identified a strikingly similar view. Implementing mechanisms arose in the Transitional era including broad classes of waivers for "Re-Invention Laboratories." Survey respondents identified others like internal reviews and assessments of their own programs.

Finally, Traditional precepts were centralized accountability and hierarchical controls arrayed by function. Systems of delegations and audits were two attributes. The Brooks Act creation of fractionated oversight (OMB--Budget, GSA--procurement, and Commerce--technical standards) was the second attribute. Implementing mechanisms ranged from GSA's delegations of procurement authority to OMB policy circulars, and National Institute of Technology and Standards technical standards.

The results are summarized in table V-E-I and further indicate that information technology professionals believed that large-scale changes in oversight had occurred in a relatively short span of time. Oversight lurched from a Brooks Act mentality to NPR-type reform on a grand scale, and then in February 1996, "back to the future" with a combination of Brooks era centralized accountability tempered with NPR-like collaborative responsibility. Yet, even in that menage there should continue to remain a specialized and government-wide accountability role, according to survey respondents.

F. Success in the Transformed Era

Recall that the study question is the following:

> *Will mid-1990s Administration and Congressional reform of information technology accountability practices cause improved economy and efficiency in federal agencies' largest and most important information technology programs?*

The survey results indicated an air of optimism by the majority of respondents for the Transformed era. Recalling their responses about the effectiveness of certain practices, they certainly foresaw a better future than past. However, there was only a marginal difference in their optimism for the Transformed future when compared with the Transitional period that they were just completing. They did not foresee regression, but neither did they predict enormous progress. Regardless, respondents displayed a substantial predilection towards the Transitional and Transformed precepts, attributes and mechanisms.

The question was answered affirmatively by survey respondents. However, they cautioned that although oversight for information technology has now been centralized at the Office of Management and Budget in the Transformed era, that particular central management agency will probably not focus its efforts on large-scale, troubled systems and programs. Rather, it will probably seek success through facilitative opportunities. The possibility of success is also examined through case studies in the next chapter.

CHAPTER VI

FEDERAL INFORMATION TECHNOLOGY CASE STUDIES

Two case studies are reviewed in this chapter. The cases selected using the methodology described in Chapter V were the Federal Aviation Administration's Advanced Automation System (AAS), and the National Oceanographic and Atmospheric Administration's Advanced Weather Information Processing System (AWIPS). Each case is described separately, and then the accountability templates identified in the preceding chapter are used to identify the oversight period that most accurately characterizes each program. That is, the templates are used to match the salient characteristics of each case against the accountability precepts from all three eras in order to find the "best fit." Subsequently, the results from the two case studies are contrasted and compared.

A. FAA's Advanced Automation System

The first case studied is one of the most well known examples of information technology problems in the federal arena. Many people in 1993 through 1995 saw newspaper pictures or television interviews with Speaker of the House Newt Gingrich or Vice President Al Gore in which each held a vacuum tube in his hands while decrying the "red tape" that prevented the

Federal Aviation Administration from replacing its 25 year old computers. A brief description of the Federal Aviation Administration's Advanced Automation System (AAS) program for replacing those computers and the associated oversight actions is given below. In the subsequent three parts of this section those oversight actions are overlaid on top of the accountability precepts identified in the previous chapter for each of the Traditional, Transitional and Transformed eras.

A Brief History

The idea for FAA's Advanced Automation System was conceived in the early 1980s, but the pressure for such a system arose during the Johnson and Nixon Administrations, especially after labor disputes in the early 1970s. Later, the furor of President Reagan's 1981 confrontation with 11,000 striking air traffic controllers, coupled with rapidly growing air traffic that threatened to overwhelm the existing system's capacity, caused federal officials to reassess the approach to air traffic control. From those deliberations renewed support developed to use sophisticated technology to automate air traffic control processes, thereby increasing capacity and reducing the size of the air traffic control work force. Thus was born a vast, multi-billion dollar air traffic modernization program encompassing a large expanse of expensive information technology projects.

Overall, the concept of air traffic control would remain unchanged. FAA would, as a federal agency, retain responsibility for United States' air traffic control at all major United States airports and for all in-flight aircraft traversing the United States and its territories. The United States would continue to have the most travelled airspace in the world, by a wide margin. Air traffic controllers would continue to use flight data, radar and weather information to direct commercial and private aircraft from take off through landing. However, the new sophisticated technology would provide significantly enhanced capabilities to integrate and automate existing processes. This would mean that fewer controllers would be able to guide more airplanes. FAA would save billions in personnel costs over the years. Moreover, in this vision of the future controllers would use the new technology to provide pilots with better information to help them fly to their destinations faster and use less fuel. The air traffic industry and FAA both foresaw billions of dollars in annual savings accruing to the airlines from those ambitious modernization plans. Such savings, it was believed, would be a continuing boon to the United States economy for decades to come.

> *"The Advanced Automation System, one component of the Federal Aviation Administration's (FAA) $36 billion effort to modernize the nation's air traffic control system, is intended to replace computer hardware and software, including workstations used by controllers at tower control facilities. The automation should help FAA cope with predicted increases in air traffic and provide operational benefits to users, such as more fuel-efficient routes "* (GAO, 1994).

Modernization was planned for all parts of FAA, from control towers to radar installations and far-flung weather systems. To frame this overarching goal, FAA devised numerous plans throughout the 1980s decade as it developed a $23 billion (later $36 billion) National Airspace System (NAS) vision. However, central in overall importance was the $4 billion Advanced Automation System (AAS) which would be the ultimate interface between all of the enhanced radar and weather systems and the air traffic controllers; AAS was FAA's high-technology plan to automate and upgrade controllers' workstations. The other modernization projects, such as radar and weather enhancements, would not achieve their full potential until AAS was fully deployed. AAS would marry controllers with technology and was, therefore, the centerpiece in FAA's ambitious National Airspace System modernization plans.

Moving rapidly, in 1982 FAA selected two of the top companies in the aviation industry, IBM and Hughes, to build AAS prototypes; the best design and value to the government would make that company the winner of a contract to deploy AAS throughout FAA. However, AAS became stalled for several years just as earlier efforts were in the 1970s. In fact, a delegation of procurement authority was not requested from the General Services Administration to award a contract until 1987; it was granted on July 1, 1987.

Finally, a long seven years after it began, in 1988 International Business Machines (IBM) won the 20 year AAS contract with a bid of $3.5 billion (e.g. GAO, 1994c). Five information technology projects or "segments" were to be completed by IBM's Federal Systems Division; these ranged from developing new controller workstations to installing new mainframe computers (see Table VI-A-I). The key to success, however, was to be IBM's development of new software to replace the 20 year old code. Starting in July 1992 at Seattle, new controller workstations and new software were to be deployed at all FAA flight control centers. FAA's obsolete 1950s and 1960s computers were also to be replaced under that contract. Finally, IBM also won the possibility of delivering the same technology to the Department of Defense, as optional quantities under the AAS contract.

FAA divided air traffic into three categories: Tower (take off and landing), Terminal (within approximately 20 miles of the originating or destination airport) and Enroute (the remaining portion of the flight). Accordingly, AAS would replace the aging computer systems used at the three corresponding types of FAA air traffic control facilities located throughout the United States, namely, the Control Towers (Tower traffic), Terminal Radar Control centers (TRACONs--Terminal Traffic), and Air Route Traffic Control Centers (ARTCC--Enroute Centers).

Table VI-A-I: Five AAS Segments

Segment	Facility	Function
PAMRI	all	radar interface
ISSS	enroute	workstations
TCCC	tower	computers
TAAS	terminal	computers
ACCC	enroute	mainframes

Work was scheduled to begin immediately on four of the five AAS sub-programs, or segments, under the AAS contract. Two of those segments corresponded directly to two of types of facilities which had critical upgrade requirements. One would replace control towers equipment--the Tower Control Computer Complex (TCCC). Another would upgrade the TRACONs or terminal facilities computers--the Terminal Advanced Automation System (TAAS). The smallest segment was the Peripheral Adapter Module Replacement Item (PAMRI) which would provide a new type of radar interface for use at all three types of FAA facilities. Of the four, however, the most costly and critical was the Initial Sector Suite System (ISSS) which would standardize and replace the air traffic controllers workstation consoles at all three types of facilities. A full level of work on those four was to begin immediately upon award of the 1988 contract. In the later years of the contract the bulk of the work was to be performed on the fifth and final segment, the Area Control Computer Complex (ACCC), which was to replace enroute centers' mainframe computers.

The first four segments would benefit FAA, directly and immediately. The old computers were costly, inefficient and had limited capacities. Maintenance of both computer hardware and software was difficult, at best. Software was encoded in archaic languages; few programmers remained in either government or industry who were proficient with that code. Manufacturers had long ago stopped producing FAA-compatible computers. In fact, because of these issues FAA developed in the 1980s an ongoing project to seek out discarded computers which could be cannibalized for spare parts and maintenance.

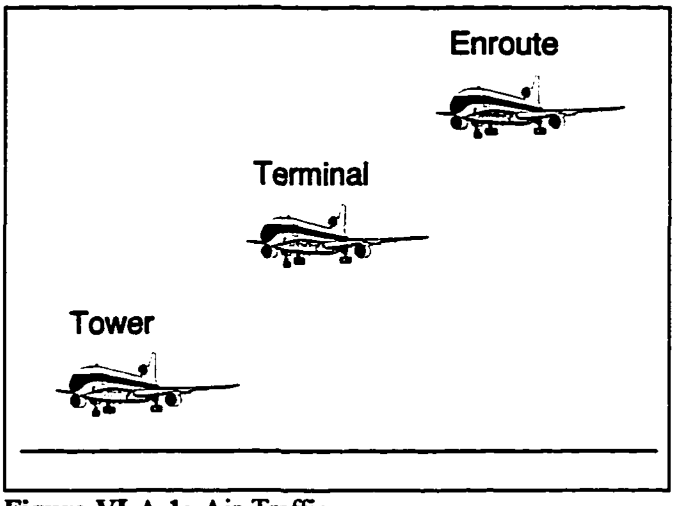

Figure VI-A-1: Air Traffic

Therefore, upon deployment on the first four segments, FAA would be positioned to achieve huge cost savings by discarding its old computers and software, and it could also immediately begin reducing its maintenance and air traffic control work force. In that way billions of dollars had been wagered by FAA on the success of the first four AAS segments.

Industry would accrue savings, too, from the first four segments. Fewer delays in take offs or landings and increased FAA capacity to handle more in-flight aircraft would also translate into more passengers and increased cost savings for airlines. However, the principal benefits were for FAA. For those reasons FAA had scheduled these segments for completion, first, to achieve its own up-front economy and efficiency savings. See figure VI-A-2.

The airline industry would benefit most from the last segment which would be completed during the out years of the contract. Aircraft travelling in the enroute airspace can save or lose enormous amounts of fuel, time and dollars depending upon flexibility and scheduling. FAA's old computers and software were so archaic that even limited changes to an aircraft's flight path required extensive manual intervention by an air traffic controller. With new computers and state-of-the-art software FAA would be able to give the airlines a most sought-after prize, namely, the flexibility to perform sophisticated mid-air course changes and complex corrections that would

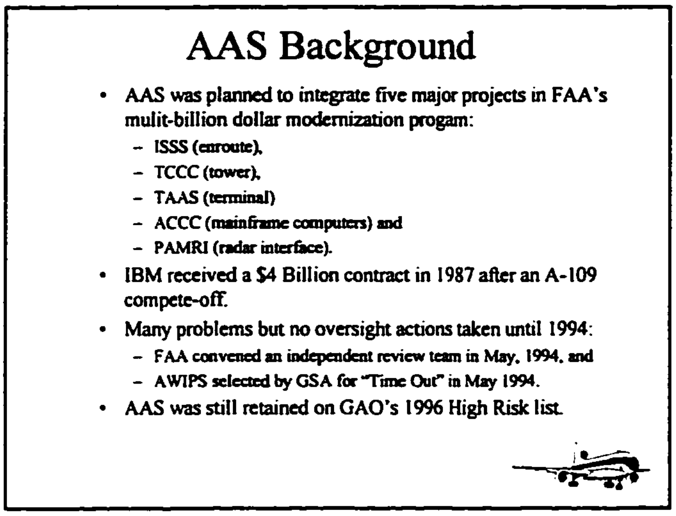

Figure VI-A-2: AAS Background

optimize enroute aircraft's flight paths to save fuel, time and dollars. Both FAA and the industry estimated all the segments and especially the last one would save the airlines billions of dollars, annually, plus refuel the industry's growth by providing badly needed capacity to handle more aircraft in the skies (e.g. GAO, 1993d).

AAS finally appeared to be on track. PAMRI, a low-cost upgraded radar interface, was being completed on schedule, and no public signs of overall AAS weakness emerged until October 1990 when IBM announced a 12 month schedule slip for the ISSS segment. Moreover, AAS costs had also increased according to IBM and FAA; the new estimate was raised from $3.5 to $4.3 billion (FAA, 199b).

GAO issued a number of reports about FAA's modernization projects and even some cautionary reports in the late 1980s and early 1990s but did not suggest stopping the program. As a "watch dog," GAO was more of a toy poodle than a "junkyard dog" when it came to FAA's Advanced Automation System. Providing even less guidance, the Office of Management and Budget continued funding AAS, unabated, and took no steps to institute precautionary control mechanisms. The General Services Administration did not use its Brooks Act authority to take any oversight measures. That is, the three central management agencies with AAS responsibilities took no actions to regulate, audit or adjust any delegated authority for AAS in spite of its problems.

"FAA and IBM, the main contractor, agreed to a plan that was too ambitious, significantly underestimating the technical challenges involved. In addition, FAA oversight of IBM has been weak" (GAO, 1993).

AAS woes were laid low until November 1992 when IBM, again, projected an additional 12 month delay (GAO, 1994c). That time, FAA responded and issued a "cure notice" to IBM. In federal contracting a "cure notice" is a legal step which informs a contractor that the contract may be canceled if specific corrective steps are not taken to abate the problems. "Cure notices" are rare in federal contracting because of legal ramifications; issuance of such a notice for a large information technology contract was almost without precedent.

However, in February 1993 IBM responded by having Federal Systems Division Chairman Gerald W. Ebker, assume direct management of the AAS contract, and in March 1993 raised the AAS cost estimate to \$4.7 billion (FAA, 1994a). This type of senior-level commitment also appeared to be without precedent. Again, neither OMB nor GSA took any action; GAO reported problems but did not call for a halt to the program while problems were corrected.

Just a few months later in December 1993 AAS went from "bad" to "worse." IBM and FAA reported that AAS would be delayed for another 19 months; the first new air traffic controllers' workstations would be deployed in Seattle during January 1996 rather than the initially projected date of July 1992. Even more ominous was an announcement that AAS would now cost \$5.9 billion, an additional \$1.2 billion overrun in just a few months (FAA, 1994). The total overrun was \$2.4 billion greater than the amount in the 1988 contract with IBM. Again, neither OMB, GAO nor GSA took any oversight actions. However, FAA ordered an internal "top-to-bottom" review of AAS and, commissioned the Center for Naval Analysis to conduct a full program review of AAS (FAA, 1994a). Adding to the complexity of the issues, IBM also announced the sale of its Federal Systems Division to Loral Corporation in December 1993.

Continuing its downhill slide, FAA announced even more problems in March 1994, namely, AAS would experience 31 more months of delay and at least $1.4 billion in additional cost overruns were anticipated. FAA pegged the new AAS cost estimate in a range from $5.9 to $7.3 billion with $6.9 billion as the "most likely" cost estimate (FAA, 1994b). Concurrently, FAA replaced its top AAS program managers and suspended all work on the mainframe segment--ACCC. FAA also publicly announced that it had begun seeking specific guarantees before it would consider novating the AAS contract from IBM to Loral Corporation.

Even though the projected cost and schedule had doubled FAA, OMB still took no oversight measures nor did GAO recommend a "stop work." Although both had previously included AAS in their respective "high risk" compendiums, neither took any enforcement measures. However, though late in taking action, GSA did inform FAA in March 1994 that it would withdraw procurement authority for AAS unless FAA provided sufficient rational for the program to continue (GSA, 1994c).

> *"[C]osts have doubled and the schedule has slipped by six years because FAA underestimated the effort required to develop and implement the system. The upshot is that air traffic controllers continue to use 20-year-old equipment, a situation that reduces the margin of safety in the air traffic control system"* (GAO, 1992).

In May 1994 FAA released the Center for Naval Analysis (CNA) report which severely criticized FAA's management of the AAS program and its technical design. Also, GSA selected AAS for a "Time Out" that, in effect, extended procurement authority only through September 30, 1994, at which time FAA would need to obtain GSA's approval of a recovery plan in order for the program to continue (GSA, 1994). GSA reserved "Time Out" for only the largest and most important Federal IT programs that were experiencing substantial cost overruns, significant program delays or had failed to produce expected mission-critical results. While in "Time Out" new program activities, such as new contracting actions, were placed on hold by GSA. Instead, the agency was required to devise a detailed plan of action for recovering from problems. The plan would specify an overall strategy and methodology for redirecting, restructuring or even cancelling the program. A full set of performance measures was to be included in the plan. Also, this recovery plan, in turn, was to be developed using the results of a current assessment of the program conducted by an independent organization with a high reputation for competence and neutrality.

Receiving severe criticism from every corner, FAA responded in June 1994 by taking several program restructuring actions including cancellation of ACCC (mainframes) and TAAS (terminal systems). FAA announced that it would continue TCCC (tower systems) but reduced the number of locations. Finally, FAA commissioned another independent assessment; this time, Lincoln Laboratories of the Massachusetts Institute of Technology was selected to head an assessment to determine the viability of the ISSS (enroute) software (GAO, 1994). At issue was whether Loral would be allowed to continue with ISSS and TCCC.

In September 1994 FAA announced its final plans for restructuring AAS, renamed the Advanced Airspace Plan (AAP), and estimated its new cost at $6 billion which included sunk costs of approximately $2.6 billion. Under the plan TCCC (tower) would remain with Loral with an estimate of $259 million in new costs not including sunk costs. ISSS (workstations) renamed Display System Replacement (DSR) would also remain with Loral if certain key actions were successfully completed by April 1995, including a new design specification. New costs for ISSS now DSR were estimated at $1 billion, not including sunk costs. Moreover, FAA announced that two former AAS segments would be separately re-competed, specifically, the Stand-Alone TRACON Automation Replacement System (STARS) which would replace TAAS (terminal) at an estimated cost of $1 billion, and the Host Computer Replacement which would replace ACCC at an estimated cost of $700 million. Finally, FAA issued the findings of its Lincoln Labs review which found that the ISSS (workstations) software architecture was "good," code was "fair" and documentation was "poor" (Aviation Subcommittee Hearings, 1994).

Responding to FAA's restructuring, GSA initially questioned the wisdom of spending another $1 billion on top of the $1 billion already spent on old ISSS code when a new contract could be awarded for a fresh, state-of-the-art design at less than $1 billion (GSA-DPAs). However, GSA finally extended procurement authority until May 1995, and in April 1995 it sent in a review team comprised of senior officials from several major agencies, its Interagency Technical Review Board, to recommend whether GSA should stop AAS or allow FAA to continue its contract with Loral. With the Board's concurrence, GSA approved FAA's plan for ISSS (DSR) and TCCC in April 1995 (GSA-DPAs). Subsequently, GSA granted procurement authority to FAA for the new TAAS, renamed STARS in August 1995 (GSA-DPAs).

However, GSA's sting was soon removed. In December 1995 FAA became the first agency in 25 years and the only civilian agency to escape GSA's Brooks Act authority (1996 Department of Transportation Appropriations Act). In fact, FAA was exempted from federal procurement regulations, in general, under this law. FAA had previously mounted a campaign, supported by the Clinton Administration, to escape procurement and personnel regulations. Long-time representatives and senators like John Glenn (1995) had resisted the press of the Administration and the Republican-controlled freshman and pointed out that FAA's problems were caused by mismanagement, not regulations. Rhetorically, why was FAA the only agency still to buy computers with vacuum tubes when other agencies were not having that problem, but still following the same regulations as FAA? The answer could only be the mismanagement observed by Senators Glenn, Cohen and others. However, they were a small minority, and, ultimately achieving its goal, FAA became subject only to OMB oversight and GAO audits but not federal procurement regulations starting in January 1996; FAA was tasked with developing its own procurement system by Congress as part of that Act.

Therefore, as of February 1996 when the Transformed era started, only two of the three central management agencies responsible for information technology oversight remained, OMB and GAO. Neither had taken any oversight actions with regard to FAA's AAS program by that date. OMB had not issued any regulations aimed at AAS, withheld funding, redirected the program, or instituted any specially-targeted system of controls over FAA. Although it had issued a number of reports about FAA's modernization efforts, GAO had not called for strong action or recommended a "stop work" for AAS. Prior to January 1996 only GSA of all the central management agencies had taken an oversight action, and then it was at the eleventh hour. GSA never issued a regulation specifically addressing FAA's problems. The Department of Transportation which oversees FAA took no oversight actions for AAS from its inception through January 1996. FAA did not identify or address AAS issues in previous administrations. Instead, it remained for FAA, itself, in the Clinton Administration to take oversight actions for AAS including several hard-hitting audits as well as substantial and far-reaching re-direction of the program. See figure VI-A-3.

Moreover, as of the January 1996 baseline not one line of AAS software code had made its way into FAA's air traffic control operations. After spending $2.6 billion FAA had not deployed any new computer systems; air traffic controllers still sat in darkened rooms and used consoles that would have been at home in an old World War II movie. FAA had just removed its last 1950s computer from service in 1994; it then used only left-over 1960s and 1970s era computers in its air traffic control systems along with archaic software like JOVIAL. FAA's obsolete computers could compete with modern ones about as well as the Wright brothers airplane could compete with a jumbo jet airplane for new customers and passenger miles; JOVIAL code would be to modern software as rudimentary addition was to calculus.

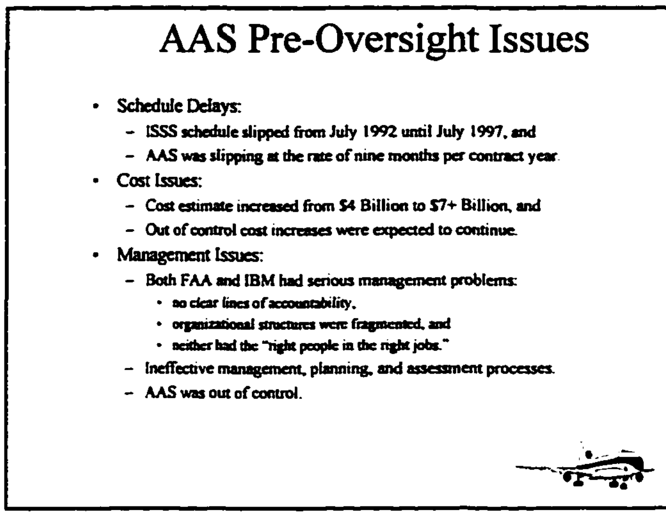

Figure VI-A-3: AAS Pre-Oversight Issues

By January 1996 there had been some improvements in its radar and weather systems, but FAA was still using the same old air traffic control system and computers as it did a quarter of a century ago, but now they were being used in a frail attempt to meet the needs of a much more complex air traffic world. Indeed, FAA was not even using the new Global Positioning System technology in AAS; private industry, state governments and other federal agencies were already deploying low cost, commercial versions of GPS which used signals from government satellites that were already in orbit to determine any user's or vehicle's location with the greatest degree of accuracy. By January 1996 AAS was downsized, de-tuned, employed a decade-old software architecture that was built around old technological ideas rather than new ones like GPS.

Air traffic control systems of countries like Brazil had, as of January 1996, the electronic flight strips that FAA once desired but abandoned as it downsized its requirements and increased its overall AAS costs from $3.5 to $6 billion. Instead, FAA controllers would continue to manually record flight information on paper strips which would move from controller to controller as the flight progressed. The "seven nines" reliability (99.99999%) or no more than three seconds of total down time each year once demanded by FAA of IBM was not achieved anywhere in the world as of January 1996. However, the systems of Germany, Sweden and others were routinely achieving much greater reliability than that of the United States while FAA was still "making the news" with frequent computer crashes and air traffic system outages. Upgrades in tower and terminal control centers that FAA said were desperately needed in the early 1980s were still "on hold" in January 1996 while FAA struggled to obtain any kind of operational results from its downsized and de-tuned program. While FAA continued to lose money when comparing its revenues from landing fees with overall operating costs (1955 Aviation Subcommittee Hearings) other countries like New Zealand were making a profit on their air traffic control technology investments.

AAS remained a multi-billion dollar debacle as of February 1996 when the Transitional period gave way to the Transformed era of information technology oversight with the demise of the 30 year old Brooks Act. At that date AAS prospects appeared clouded, at best, and more than likely would continue down a troubled path. Importantly, AAS was still the linchpin in FAA's $36 billion modernization plan because it remained the interface, or perhaps bottleneck, between air traffic controllers and all of the data that could have been provided by new information technology. Completing a review designed to match actual oversight actions with accountability precepts, AAS oversight actions are overlaid on templates of the Traditional, Transitional and Transformed eras in the sequel.

AAS Oversight Actions

From the above history and description of the Advanced Automation System it is clear that intervention was advanced only through two oversight mechanisms, namely, FAA's own independent assessments of the program and the General Services Administration's "Time Out." Indeed, it was only the FAA of the Clinton Administration that took any action. FAA under prior administrations took no action and surfaced no problems to be examined in the public eye. OMB issued no regulations aimed at AAS, nor did it withhold funding, redirect the program, or institute any specially-targeted system of controls over FAA through February 1996. Although it had issued a number of reports about FAA's modernization efforts, GAO during this same period had neither called for strong action nor recommended a "stop work" for AAS. Though AAS oversight came very late in the process, it did have some positive effects that are summarized in figure VI-A-4. It is important to observe that those benefits were contextual in the sense that FAA had a strong incentive to realize positive improvements only while the oversight actions and underlying problems were in the eye of the public and highlighted to Congress.

Traditional Template: The Traditional era paradigm was one of hierarchical control through delegation and audit. In a full-blown reification of that conceptual setting FAA would have been subject to before-the-fact review of all major AAS decisions through a delegations-based process. Furthermore, audits would have been conducted to ensure that those before-the-fact "orders" were being carried out in the prescribed manner. Also, audits would have been conducted to forestall any waste, fraud and abuse associated with the Advanced Automation System project.

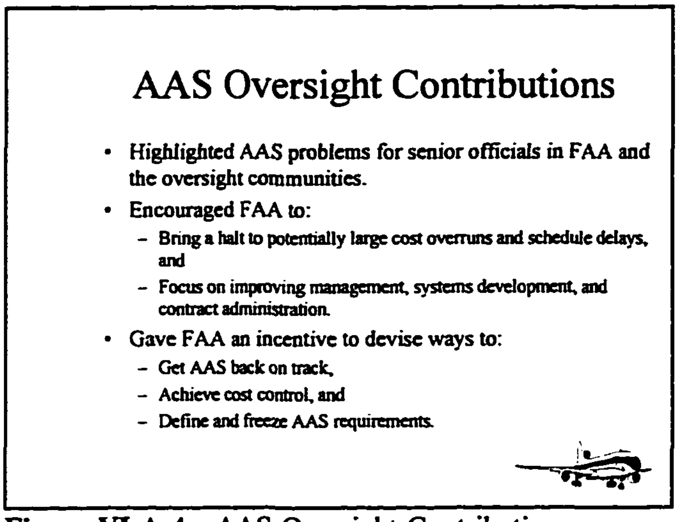

Figure VI-A-4: AAS Oversight Contributions

A review of the oversight actions for AAS indicated that only GSA had instituted a delegations process for AAS. Under that methodology, GSA required the Department of Transportation as well as other departments and independent agencies to obtain a delegation of procurement authority prior to issuance of a Request For Proposals for any information technology project valued in excess of $2.5 million. In that venue only three delegation actions had occurred. One was the 1987 delegation to the Department of Transportation which was redelegated to FAA for the initial contract award to IBM. Regarding the other two, one placed AAS in "Time Out" and the other approved FAA's plan to restructure the program and retain Loral for ISSS (enroute--now DSR) and TCCC (tower).

Regarding audits, the General Accounting Office issued 11 reports about the AAS program between 1986 and February 1996. Six of those were letter reports. GAO also testified 12 times about AAS in that same period and issued three fact sheets. GAO's evaluation of the program varied at different points in time but never raised a hue and cry to halt the program. For example in an April 13, 1994, report entitled Advanced Automation System: Implications of Problems and Recent Changes (GAO, 1994 T-RCED-94-188 April 13, 1994) GAO testified that:

> The Advanced Automation System, one component of the Federal Aviation Administration's (FAA) $36 billion effort to modernize the nation's air traffic control system, is intended to replace computer hardware and software, including

> workstations used by controllers at tower control facilities. The automation should help FAA cope with predicted increases in air traffic and provide operational benefits to users, such as more fuel-efficient routes. FAA's development of the system has been plagued from the start by major schedule delays and cost increases. Although FAA and IBM, the prime contractor, have been trying to overcome these problems, the problems continue and major changes have been made to the system.

Though cautionary, the report hardly was a cry for serious oversight actions on the part of Congress or the central management agencies. Recall that at the time of the testimony FAA had just announced another $1.2 billion cost increase, IBM was no longer the contractor because its Federal Systems Division had been sold to Loral, the FAA had already called in the Center for Naval Analysis to conduct a top to bottom independent assessment of the program and had publicly stated that it was planning to restructure the AAS program. AAS had been dealt extremely dramatic blows, and FAA was readying itself for public flagellation. Yet GAO remained only cautionary about the program. Apparently, GAO audits were not at that time a mechanism for ensuring that before-the-fact "orders" given by central and hierarchical authorities were being carried out, as prescribed. Nor were the audits focused on rooting out waste, fraud and abuse. Rather, GAO was interested in issuing cautionary reports and giving circumspect testimony at regular intervals; there was no cry of alarm or any calls to bring the program to an immediate halt while stringent corrective actions were taken.

Thus, hierarchical control through delegation and audit certainly did not characterize oversight of the FAA's Advance Automation System between the time of its inception and February 1996. Instead, FAA's acceptance of its own agency-level responsibility led to two major independent assessments of AAS. Moreover, the General Services Administration's call for a "Time Out" indicated central oversight through management by exception. These were, therefore, the attributes and mechanisms that were actually applied to AAS between its inception and

February 1996. Table VI-A-II compares the actual AAS precepts, attributes and mechanisms with those of the Traditional era.

Table VI-A-II: AAS Traditional Era Template

Era	Precepts	Attributes	Mechanisms
Traditional	Centralized IT accountability	Delegation by transaction Audit	GSA procurement delegations GSA IRM audits GAO audits
	Functional IT hierarchical controls	Fractionated oversight	OMB--budget OMB--policy GSA--procurement NIST--Standards
FAA's AAS	Diffused IT accountability	Agency-level responsibility	Independent assessments
	Centralized IT accountability	Management by exception	GSA "Time Out"

Transitional Template: Similarly, table VI-A-III uses the Transitional template in comparison with actual AAS oversight practices. An important point to be considered is the distinction between oversight continuity in the Traditional and the Transitional periods. Centralized, hierarchical control through delegation and audit implies continuity in monitoring process. The implication is that audits should correspond to delegations, and there should be a regularity to such a process so that any Traditionally-controlled program would be subjected to repeated delegation and audit processes to ensure that the agency was following "orders" as well as to guard against waste, fraud and abuse.

However, AAS does not fit any such pattern. There was no regularity to delegations; only two were granted by the General Services Administration. Clearly those delegations were not reviewed by audits or else oversight actions would have been taken much earlier than GSA's eleventh-hour "Time Out." Additionally, there was no clear and consistent pattern of audits.

There were many; five reviews and six letter reports over a ten-year period represented a considerable General Accounting Office investment. Providing testimony 12 times in ten years also demonstrated considerable interest on the part of Congress and GAO. However, an implicit thought in the Traditional stereotype was a two-fold supposition that audits should (1) ensure that the agency was following "orders," and (2) guard against waste, fraud and abuse. Thus, audits were supposed to embrace both quantity and quality as maxims; GAO did not do that in the Traditional sense.

Moreover, from the prior recount of AAS, it is clear that something else occurred. Rather than being an omnipresent figure in the Traditional stereotype or a deep-throated, teeth-barred "watchdog" growling "cease and desist" at the first sign of waste-fraud-abuse, instead, GAO was more like a toy poodle sniveling an occasional bark of caution, here or there.

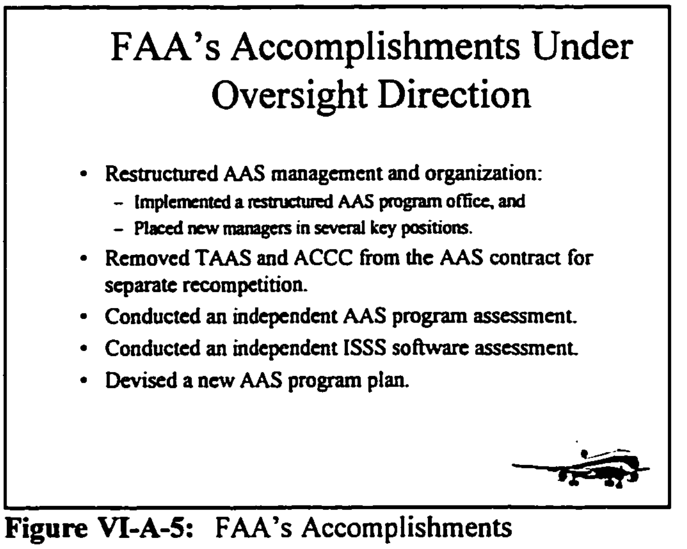

Figure VI-A-5: FAA's Accomplishments

Therefore, rather than regularity in oversight of AAS, the actual practice was an exercise in management by exception, an attribute of the Transitional period. Out of the range of possible participants, only the General Services Administration and FAA, itself, exercised this option, and then, only at the eleventh hour.

FAA exemplified through its own intervention the "internal review" and "independent assessment" mechanisms characteristic of the "agency-level responsibility" attribute (see Figure

VI-A-5). Therefore, AAS oversight was more akin to the Transitional model and definitely not cast in the Traditional mold. This is depicted in table VI-A-III. Diffused accountability was the Transitional era precept behind FAA's action. However, the basis for the method of GSA's intervention, namely an Information Technology Review Board, apparently arose from different and then-emerging thoughts which began at that time to shape a path of entry into the Transformed era.

Table VI-A-III: AAS Transitional Era Template

Era	Precepts	Attributes	Mechanisms
Transitional	Diffused accountability	Delegation according to capability Agency-level responsibility	Broad classes of waivers Internal review Independent assessment
	Collaborative responsibility	Business orientation Technocratic decision-making	Inter-agency committees
FAA's AAS	Diffused IT accountability	Agency-level responsibility	Independent assessment
	Centralized IT accountability	Management by exception	GSA "Time Out"

Transformed Template: Underpinning the Transformed era was an overarching idea that there should be a commonality of government-wide interest in federal information technology. GSA's intervention embraced this idea by employing as its instrument an Information Technology Review Board comprised of senior officials representing a cross section federal expertise. GSA's role was clearly one of fostering a commonality of interest in support of its management by exception tactics. "Management by exception" was previously identified as an attribute of the Transformed era "centralized IT accountability" precept. Apparently, Transformed era oversight precepts played a significant role for AAS. This is depicted in table VI-A-IV.

Table VI-A-IV: AAS Transformed Era Template

Era	Precepts	Attributes	Mechanisms
Transformed	Centralized IT accountability	Single point of control Management by exception	OMB oversight IT Review Board
	Collaborative responsibility	Business orientation Technocratic decision-making	CIO council Inter-agency committees Inter-agency technology teams
FAA's AAS	Diffused IT accountability	Agency-level responsibility	Independent assessment
	Centralized IT accountability	Management by exception	GSA's "Time Out"

Therefore, for over a decade, oversight of FAA's actions really had one leg in the Transitional period and another in the Transformed era. AAS spanned, in time, all three oversight eras. Yet, it had not been rigorously subjected to Traditional oversight practices even though it was conceived and its problems began in the Traditional period. Rather, in a consistent pattern over all of that decade of time its ills were approached exclusively through application of a mixture of Transitional and Transformed era precepts, attributes and practices. Interestingly, the Office of Management and Budget had numerous opportunities and a wide target but failed to act on AAS. Yet, OMB had considerable clout at its disposal in both the Traditional and Transitional eras between its budget and Paperwork Reduction Act authority. This lack of involvement as of February 1996 certainly raised questions for the future wherein OMB was destined to be the single oversight entity over the Federal Aviation Administration and its AAS program in the Transformed era.

AAS Measures

The above findings are utilized in this section to measure the success of the applicable oversight actions. Recall from Chapter IV that four measures were to be applied to the oversight actions. Those measures were the following:

Measure 1: Did the oversight practice help the program meet mission requirements?

Measure 2: Did the oversight practice help the agency acquire technology in a timely manner?

Measure 3: Did the oversight practice help the agency acquire current technology?

Measure 4: Did the oversight practice help the agency receive reduced prices?

Each measure was to assume one of five values: (1) no impact, (2) some impact, (3) moderate impact, (4) significant impact, (5) substantial impact. Tables VI-A-V through VII-B-VIII apply the measures to the precepts, attributes and mechanisms associated which characterize those actual AAS oversight actions.

Table VI-B-V: AAS Measure 1 Ratings

Measure 1	Did the oversight practice help the program meet mission requirements?			
	Precepts	**Attributes**	**Mechanisms**	**Rating**
FAA's AAS	Diffused IT accountability	Agency-level responsibility	Independent assessment	2
	Centralized IT accountability	Management by exception	GSA "Time Out"	2
			Overall Rating:	2

Measure 1: The AAS program had not yet produced any tangible results as of mid-1996 when the case studies for this paper were completed. Therefore, a rating of "Not Available"

(N/A) could have been assigned. However, some other factors permitted a rating. First, and importantly, FAA did not choose to update the AAS development process of the Enroute workstations by including early prototypes to demonstrate the results. Since AAS began, FAA had used mock-ups of both the workstations and code for use with air traffic controllers. However, those were not "live" workstations as would be the case for a prototype located at an actual air traffic control facility. Thus, oversight actions were not able to insert true prototyping into the AAS development process.

Instead, FAA froze its Enroute requirements in response to criticism from the oversight community. FAA significantly increased the probability of success through this action because continual changes to the design, which had characterized the Enroute system in the past, were a prime cause of AAS's failures. This requirements freeze was politically difficult for FAA to accomplish because air traffic controllers and their powerful union were major sources of many requirements changes. Thus, FAA would not have willingly frozen the requirements; it was by facilitation through the impetus of oversight that the freeze action was taken. Oversight played an important role in freezing the requirements, and helped move the Enroute system closer to producing mission-level results.

Moreover, FAA did change its Tower plans and agreed to introduce three prototypes to be tested well in advance of full-scale deployment. Prototyping was a recommendation of the GSA-sponsored Information Technology Review Board (ITRB) that assessed AAS in 1994. Therefore, some measure of redirection had been achieved by oversight actions.

Finally, FAA's new plan had been redesigned to automate, in essence, existing processes. In contrast to the comprehensive re-engineering envisioned under the original plan the new approach was designed to achieve a smaller set of results. Though not ideal, the new plan was more manageable because FAA's requirements were reduced in scope and complexity. The oversight actions had encouraged this type of redesign along with dividing the program into smaller projects in order to make it more manageable; FAA had acquiesced. In short, the new plan had a higher probability of achieving some type of mission requirements because of downsizing and the elimination of leading-edge (or "bleeding-edge") requirements. Oversight actions had made a difference in redesigning AAS.

Therefore, a Measure 1 rating can be assigned to AAS even though mission-level results had not yet been delivered when the case study was completed in mid-1996. This is because oversight actions caused a redirection that increased the probability of mission-level achievements. Although the oversight actions were not successful in causing FAA to plot a new course of action in all areas, the ones that did change were in line with the ITRB's recommendations. The new AAS plan changed and became more akin to obtaining mission-level results.

Table VI-B-V:I AAS Measure 2 Ratings

Measure 2	Did the oversight practice help the agency acquire technology in a timely manner?			
	Precepts	**Attributes**	**Mechanisms**	**Rating**
FAA's AAS	Diffused IT accountability	Agency-level responsibility	Independent assessment	2
	Centralized IT accountability	Management by exception	GSA "Time Out"	2
			Overall Rating:	2

Therefore, a rating of 2 was assigned. It is more appropriate than a rating of 1 because of the increased probability of mission-level results brought about by the oversight actions.

However, the rating of 2 is given with pessimism about the future because there have been no mission-level deployments of Enroute, Tower, Terminal or mainframe systems by AAS as of mid-1996. The Tower prototypes are not scheduled for deployment until early 1997.

Measure 2: The ratings for the second measure were assigned because the two oversight actions forced AAS to identify and adhere to a schedule. Moreover, FAA had announced such a schedule including specific milestones as part of its response to the General Services Administration's "Time Out" requirement for a recovery plan and performance measures (FCW, 1994g). In assessing the viability of the AAS software which had already been produced, FAA was aggressive and conducted several principal studies that included timeliness of action and decision making as performance criteria. Beginning with the oversight actions, FAA publicly announced both its accomplishments and delays through mid-1996 when this case study was completed; accomplishments outnumbered delays. Therefore, those oversight actions had, indeed, achieved timely and tangible results as of mid-1996.

Recall that, of the five AAS segments, one had been completed (radar interface --PAMRI); two remained with the AAS contractor (Tower--TCCC and Enroute--ISSS); and two were to be recompeted (Terminal--TAAS and mainframe computers--ACCC). As of mid-1996 the two remaining with the AAS contractor were reportedly close to maintaining the schedule outlined in the new AAS plan. Thus, a positive rating was indicated because of the increased probability of success in achieving overall timeliness. The oversight actions had a positive effect on the timeliness of those two programs.

However, recompetition of the other two seemed to be slipping. Specifically, a Request For Proposals (RFP) was to have been issued to industry by FAA for TAAS' Tower requirements in August 1995. As of mid-1996 FAA had still not issued the RFP and had changed program managers for TAAS three times in the intervening period. There is certainly cause for concern about timeliness in those two instances.

Therefore, some overall results were achieved. They were a composite of positive response to oversight in the Enroute and Tower segments and negative results for the two segments that were at a further distance of completion in time, namely, the Terminal and mainframe computer replacement projects. Accordingly a mixed rating is in order to reflect the imbalance in results. A level 2 rating is appropriate in this instance because it reflects the fact that there were timeliness improvements in some but not all segments.

Table VI-B-VII: AAS Measure 3 Ratings

Measure 3	Did the oversight practice help the agency acquire current technology?			
FAA's AAS	**Precepts**	**Attributes**	**Mechanisms**	**Rating**
FAA's AAS	Diffused IT accountability	Agency-level responsibility	Independent assessment	3
	Centralized IT accountability	Management by exception	GSA "Time Out"	3
			Overall Rating:	3

However, it is clear that some additional type of oversight action will probably be required in the future for the Terminal and mainframe computer portions of AAS. This indicates that concurrency between oversight and remedial actions is important to effectiveness. An agency like FAA is much more likely to follow through while the oversight attention level is still high rather than later on when such interest has dissipated. Accordingly, the rating of level 2 is assigned for this measure to reflect some impact by oversight, but it is assigned with caution.

<u>Measure 3:</u> Currency of technology was the focus of the third measure. Importantly, both oversight actions had focused on problems with the older design of AAS's architecture. It was almost a decade old and was fully dependent upon the available technology at the time of its development. However, during that decade many significant changes drove and redirected the capabilities of more modern technology. For example, at the time of AAS's genesis local are networks (LANs) were not even a gleam in someone's eye; networking required costly mainframes and customized software designs. The powerful capabilities of LANs could only be included in AAS by reworking the old architecture.

Accordingly, oversight actions focused on updating and validating the architecture to address the currency of technology issue. Moreover, those actions also led to FAA commissioning an independent assessment of the software to determine the viability of its architecture as well as the condition of the code. Thus, the oversight actions had a definite and positive effect by positioning FAA to address the current technology issue by updating and validating its architecture, hardware and software. In that way both oversight actions helped AAS to remain current through the development process.

A level 3 rating is appropriate for this measure because FAA addressed the current technology issue in response to oversight actions. The decade old architecture had not been reassessed since its development. Until oversight actions were taken, FAA was still targeting its developmental efforts towards that structure which ran on outdated technological ideas. Though that design may have been state-of-the-art a decade ago, there was no FAA plan to reassess it even when its design had been already been eclipsed by South American countries like Brazil. A higher rating would be warranted if AAS's segments were closer to deployment. However, for the Enroute and Tower segments in particular, oversight actions made a big difference making a rating of 3 both reasonable and appropriate.

Table VI-B-VIII: AAS Measure 4 Ratings

Measure 4	Did the oversight practice help the agency receive reduced prices?			
	Precepts	**Attributes**	**Mechanisms**	**Rating**
FAA's AAS	Diffused IT accountability	Agency-level responsibility	Independent assessment IG Audits	3
	Centralized IT accountability	Management by exception	GSA "Time Out"	3
			Overall Rating:	3

Measure 4: Cost was the focus of the fourth and final measure. In assigning a rating it is important to note that the considerable focus of both oversight actions on AAS costs caused FAA to dramatically restructure the program to achieve results and, in particular, cost savings. After the restructuring FAA reduced its cost estimate by almost $2 billion. Some of these savings accrued as a result of downsizing AAS's overall requirements. Finally, the oversight actions caused FAA to break requirements valued in excess of $2 billion away from the old IBM (novated to Loral) contract for separate procurement through competition. Such competition would provide an opportunity to reduce the costs even further.

An observation is that FAA seemed to have no real monetary concerns until the oversight actions were taken. Specifically, FAA had awarded an AAS contract for less than $4 billion, and continued to raise the ante without objection for almost a decade. FAA's budget always provided funding, and neither OMB nor Congress withheld decried the increases until the huge cost overruns of 1993 and 1994. Until the overruns FAA did not take any cost savings actions to address the issue.

It was only when those oversight actions focused on the out-of-control AAS cost overruns that FAA responded by revising the program for cost savings. Thus, oversight actions highlighted the issue throughout the federal community and helped to bring them before public's eye. Also, those actions placed FAA for the first time in the predicament of having to address AAS's costs. Ultimately, FAA had to take serious management actions to downsize the program and remove unrealistic requirements in order to achieve cost savings. Oversight clearly made a significant difference in the cost area. For that reason a rating of 3 was assigned; it is warranted in consideration of the cost reduction outcomes resulting from the oversight actions.

This is not to say that all of AAS's cost problems are resolved; more oversight actions may be required in the future. Open issues about AAS are depicted in figure VI-A-6. However, the actions taken did have a significant effect on bringing AAS's costs under control. Thus, oversight played an important role because it headed FAA towards reducing the AAS price tag.

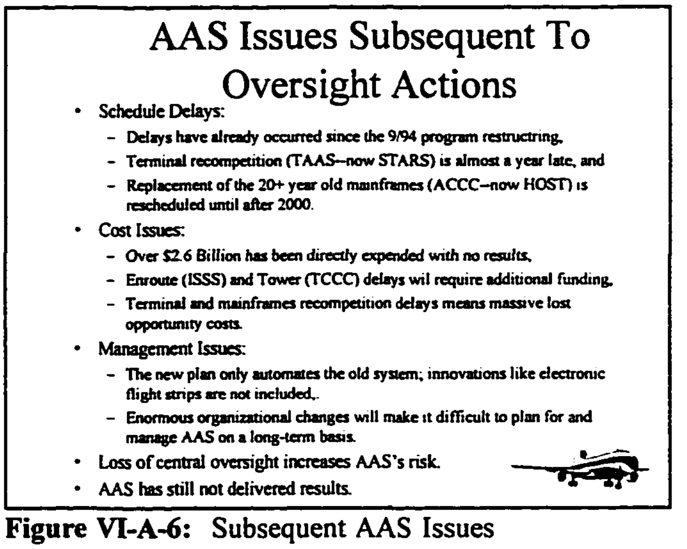

Figure VI-A-6: Subsequent AAS Issues

In summary, the AAS oversight actions did have some positive effects. Specifically, the oversight actions highlighted the issues and caused significant redirection of the AAS program. Importantly, oversight forced some important changes such as updating and validating the architecture as well as agreeing to recompete two of the AAS segments. The Tower prototype systems, general downsizing, and reduction in overall AAS performance requirements were also important achievements. Accordingly, it is clear that benefits and not harm were the result of those oversight actions.

It is important to note that the oversight actions did not cure all of AAS ills, nor did they turn it into a model program. Clearly, this was not a case of transforming a failed program into an unequivocal success. Instead, the oversight actions changed a program with no probability for success into one where some level of success was possible.

Thus, any assessment of the oversight actions' overall impact on AAS must be taken with respect to its overall history and placed in that context. In that scenario, lack of AAS achievement for almost a decade must be factored into any evaluation. Framing the oversight actions in the context of that dismal history places emphasis on the positive nature of the oversight actions. In fact, those oversight actions took an abject failure and made it achieve some cost reductions and produce some results within one year.

Thus, the oversight actions applied to AAS had achieved some moderate successes. It can therefore be concluded that those AAS oversight actions which are carried over into the Traditional era appear to have a likelihood of similar success when applied to troubled information technology programs. Thus, AAS-like oversight actions appear to have a likelihood for achieving some success in the Transformed era.

B. NOAA's Advanced Weather Information Processing System

In the early 1980s the National Weather Service began developing plans to revitalize its weather forecasting capabilities and replace its old Automation of Field Operations and Services

(AFOS) system. The Weather Service already had a long-standing relationship with information technology. Some of the earliest applications of computer technology to the federal sector occurred in the 1950s for solving weather forecasting problems. In fact, IBM's development of 1950s-era multi-processor, 7090 series "super computers" was predicated upon the need for vastly enhanced computation of weather forecasting problems (see Appendix A). At that time increased computer speeds meant better forecasts because weather calculations were (and still are) among the most complex of all practical computational problems.

"[T]he National Weather Service has been modernizing its systems so that it can more accurately and quickly predict severe weather. Efficiencies gained from these systems will also allow a 50-percent reduction in the existing number of field offices and a 17-percent cut in overall staffing levels" (GAO, 1994).

However, by the 1980s the rapidly expanding domain of digital information technologies allowed the National Oceanographic and Atmospheric Administration's (NOAA's) Weather Service to broaden its vision. Instead of just focusing on computer computational power as a separate component of the overall weather forecasting process, NOAA and the Weather Service began to conceive of a plan that would integrate the gathering of sensor-based data with computational modeling and rapid dissemination. The new strategy would enable NOAA and the Weather Service to issue a broader range of highly-accurate forecasts, much faster and with fewer staff and facilities. NOAA and the Weather Service would save billions of dollars.

Moreover, the National Weather Service's ability to accurately forecast severe weather has always had enormous cost, safety and welfare consequences throughout the United States. The first half of the 1990s decade graphically demonstrated that fact through the destruction caused by Hurricane Hugo, the repeated and horrific floodings of the Mississippi River as well as the mid-winter blizzards and Nor'easterners that ravaged New England and the Atlantic seaboard. It has been well documented that hundreds of lives and billions of dollars are lost every year in the United States due to these offsprings of Nature along with more frequent but localized thunderstorms, lightning and tornadoes. Faster and more accurate weather forecasts would, therefore, save hundreds of lives along with billions of dollars each year throughout the United States and its economy, as well. Anticipated savings to the United States economy exceeding $5 billion each year were documented by NOAA (GAO, 1994a).

A Brief History

Under the $2 billion modernization plan that emerged during the mid-1980s, future weather forecasting would rely on four automated systems: the Next Generation Weather Radar (NEXRAD), the Next Generation Geostationary Operational Environmental Satellite (GOES), the Automated Surface Observing System (ASOS), and the Advanced Weather Interactive Processing System (AWIPS). The first three systems would acquire detailed radar, satellite and ground-based sensory data which would be processed and integrated by AWIPS into highly-accurate weather forecasts to give faster advance warnings about severe weather conditions (GAO, 1994c). Even under routine weather conditions the AWIPS provided data would be updated more frequently and made available to a wider variety of users. Therefore, AWIPS was the keystone in NOAA's weather systems modernization project. While useful, none of the other systems could reach their full potential without AWIPS. As the final interface between data and people, AWIPS would put all the data together into forecaster-usable, computerized screens, displays, formats and executable programs; AWIPS was expected to be the integrating piece of this highly complex information technology program.

Also, NOAA anticipated efficiencies from the weather modernization program that would allow a 50-percent reduction in the number of National Weather Service field offices and a 17-percent cut in overall staffing levels. Over the years, billions of taxpayer dollars would be saved. Deployment of all four systems was to be completed by the end of October 1994 at an overall cost just under $2 billion, according to the initial plan (GAO, 1991d).

NOAA was not alone in pushing the plan. Both the Department of Defense and the Federal Aviation Administration have traditionally had preeminent roles in the weather forecasting business. Defense depends heavily upon weather; the often-told stories about timing the Stealth bomber attacks of the 1991 Gulf War, selecting the date for D-Day in World War II or the fate of the Spanish Armada on a stormy day illustrate how even the most critical operations have always depended upon advance knowledge of the weather; mounting an invasion oblivious to an oncoming storm had repeatedly proven to be foolhardy and disastrous. Commercial passengers usually do not like flying through storms, and dangerous wind shears have caused crashes of both small and large aircraft. Snow storms have closed even the most well equipped airports, backing up air traffic from New York's LaGuardia to Los Angeles' LAX. Foul weather had, over the years, been the bane of many airplane flights and had also levied excessive costs in both time and money on FAA and the airline industry. For these reasons both DOD and

Table VI-B-I: Weather Service Modernization

System	**Function**
AWIPS	integrate all systems
NEXRAD	doppler radar
GOES	satellite data
ASOS	surface-level data

the FAA were supporters and had considerable interest and involvement in the modernization effort.

The overall modernization program was underway by 1984. However, numerous delays and cost increases occurred. By 1993 problems had increased to the point that the General Accounting Office reported the cost would be $4.6 billion rather than the original $2 billion projection. Rather than completing and deploying all four systems by October 1994, GAO reported numerous problems with NEXRAD, GOES, and ASOS during the late 1980s through mid-1990s (*e.g.* GAO, 1994a). "Twice as long at twice the cost" seemed to be the state of NOAA's weather systems modernization program by the end of 1995. However, in spite of those problems, OMB had not issued regulations aimed at AWIPS, withheld funding, redirected the program, or instituted any specially-targeted system of controls over NOAA.

In fact, many NEXRAD radar systems and several GOES satellites had been successfully deployed by the end of 1995, though late and with large multi-billion dollar cost increases. As an example, NEXRAD proved its worth in Florida by dramatically and accurately predicting the path of Hurricane Hugo, and it averted much tragedy by giving advance warning to millions of residents. Where installed, NEXRAD also accurately detected wind shear conditions, and it has been subsequently instrumental in helping to prevent rough landings and possible crashes. Only one NOAA

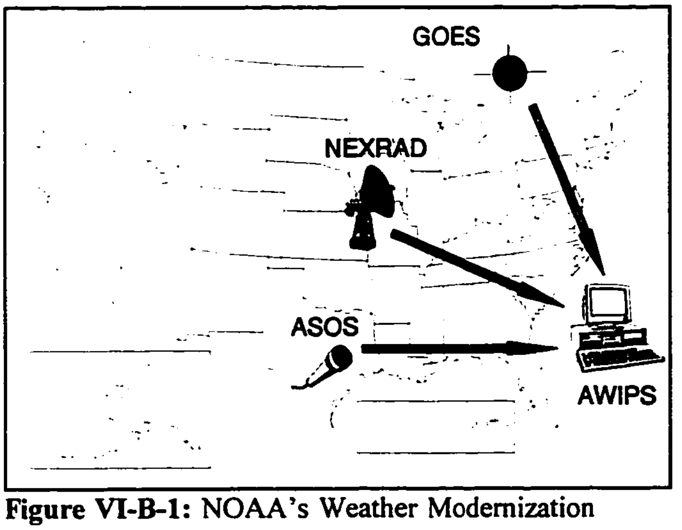

Figure VI-B-1: NOAA's Weather Modernization weather satellite was still operating over the continental United States as late as 1993. It was still in service even though it was in failing health and its planned lifetime had expired. Its failure would have placed the United States in a most dubious position. During 1994 another satellite which had been observing the Atlantic Ocean was repositioned while in orbit to guard against that possible catastrophe and to help observe a portion of the United States. Full coverage was not achieved until December 1995 when the GOES 9 satellite joined the small constellation and began providing usable data.

Regarding AWIPS, which is the focus of this particular case study, a number of other delays had also occurred. It took the Weather Service four years, from 1984 through 1988, just to develop the specifications for AWIPS and award initial contracts. NOAA first received the General Services Administration's approval for AWIPS in June 1986, and it issued a Request For Proposals (RFP) in November 1986. GSA's approval contained a clause requiring Commerce and NOAA to obtain a new approval if there were any significant "material changes" in the conduct or scope of the procurement. Apparently, NOAA's plans had shifted to the point where GSA, acting upon NOAA's request, granted a revision to their delegation of procurement authority in August 1988. Finally, in November 1988 two contractors, Computer Sciences Corporation and Planning Research Corporation, were selected to develop competing system designs. Such an approach was firmly supported by federal procurement regulations which suggested this so-called A-109 method for helping to mitigate risk when agencies developed new technological innovations. The AWIPS background is depicted in figure VI-B-2.

Though finally underway, AWIPS had a rocky start. The two contractors for the so-called design phase were to be evaluated based upon their ability to demonstrate a high likelihood of success for their entire approach including systems design, technical and program management,

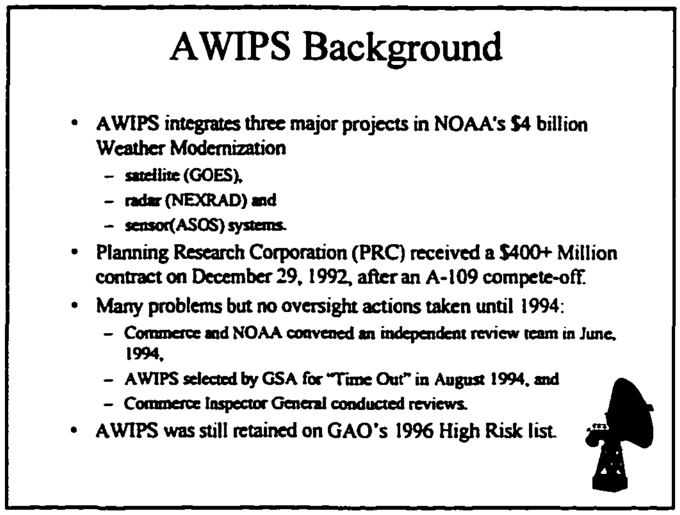

Figure VI-B-2: AWIPS Background

cost control and overall risk abatement. Such an approach in the A-109 method is not intended to fully develop a design; rather, it is intended to give the government a better selection methodology by allowing competing contractors to "demonstrate their wares." Thus, timing became critical for AWIPS. If too short, any government decision would have become risky because insufficient demonstration of contractors' capabilities would have given little assurance about their likelihood of success. However, any lengthy demonstration phase would have become costly because at least one contractor would be paid for unnecessary and avoidable work. Also, it would have further delayed closing the redundant weather forecasting sites.

NOAA chose a reasonable AWIPS demonstration period; selection between the two competing contractors was supposed to occur within 12 months. However, rocks in their path introduced considerable and costly delay. Fifty-two months later, in December 1992, NOAA finally chose between CSC and PRC. The AWIPS contract was finally awarded at that time to PRC for the design phase. Eight long years had elapsed.

Contract award meant that PRC would be able to proceed beyond a preliminary capabilities demonstration and complete the entire project design. Under this A-109 process NOAA could also subsequently exercise an option at a future date, the so-called production phase

"The National Oceanic and Atmospheric Administration (NOAA) lacks a systems architecture, or overall blueprint, to guide the design, development, and evolution of the many subsystems comprising its $4 billion modernization of the National Weather Service's weather observing, information processing, and communications systems . . . Unless a single manager is appointed and an architecture is developed and enforced, the integration of these and potentially other new weather forecasting subsystems will continue to require more time, effort, and money than is necessary" (GAO, 1994).

option, and have PRC deploy AWIPS to all designated weather forecasting offices. Work on AWIPS had begun in earnest.

However, a number of issues and concerns had been made public. GAO, for example, had issued cautionary reports about the entire weather modernization effort, including AWIPS, which contained statements like:

> Initially, the estimated cost of the systems through deployment was pegged at under $2 billion, with deployment to be completed through the end of October 1994. The latest cost estimates for the systems, however, have doubled, and deployment of the systems is not scheduled until 1998--almost four years later (GAO IMTEC-92-12FS, December 17, 1991).

Another indication of the volatility of the program was NOAA's repeated requests to the General Services Administration for revisions to its AWIPS delegation of procurement authority. GSA required Commerce and NOAA to seek such approvals only when there were significant changes in the AWIPS schedule, cost, contract provisions or overall management. NOAA sought and received revised delegations five times during the so-called definition phase: March 1990, August 1990, August 1991, and twice in June 1992. Such a pattern indicated a constantly shifting environment in which major schedule, cost and management decisions had been repeatedly made and revisited at the highest levels in NOAA and Commerce.

The flames behind those smoking images broke into public view in May 1994 when Commerce announced that it had convened a high-level, outside team of experts to perform an independent review of AWIPS. Such teams are rare in the information technology arena, especially in the civilian agencies.

"Initially, the estimated cost of [all four] systems through deployment was pegged at under $2 billion . . . the latest cost estimates for the systems, however, have doubled" (GAO, 1993).

In August 1994 the General Services Administration selected AWIPS for its "Time Out" program. GSA reserved "Time Out" for only the largest and most important federal information technology programs that were experiencing substantial cost overruns and significant program delays or that had failed to produce expected mission-critical results. While in "Time Out," new program activities, such as new contracting actions, were placed on hold by GSA. Instead, the agency was required to devise a detailed plan of action for recovering from problems. The plan would specify an overall strategy and methodology for redirecting, restructuring or even cancelling the program. A full set of performance measures was to be included in the plan. Also, this recovery plan, in turn, was to be developed using the results of a current assessment of the program conducted by an independent organization with a high reputation for competence and neutrality.

Just one month later, in September 1994, the Department of Commerce Inspector General issued a caustic report which attacked AWIPS from three directions. First, the IG found that AWIPS lacked a reliable technical foundation for systems development because it did not evaluate enough of PRC's design in advance of the contract award. Therefore, NOAA did not have sufficient information to make an informed decision. Secondly, according to the IG, AWIPS had an unrealistic schedule and did not have adequate systems engineering support. Finally, the IG concluded that the program office managing AWIPS lacked sufficient authority to manage the program. That is, the program office lacked clear lines of authority, responsibility and accountability. Specifically, according to the IG report entitled Management and Engineering Problems Halt AWIPS Progress, (SED-6623-4-001, p. iv, September 1994):

> The current problems with AWIPS are the legacy of the weather service's previous management history. The weather service lacks personnel with experience and expertise to manage the development and acquisition of major systems. As a result, it has been unwilling to apply the well-known principles and disciplines developed by industry and government for managing large, complex, one-of-a-kind systems . . . .

A few months earlier a General Accounting Office report about the entire weather modernization program had presaged some of those concerns but on a more global basis. Specifically, GAO stated in a report entitled Weather Forecasting: Systems Architecture Needed for National Weather Service Modernization (AIMD-94-28. March 11, 1994):

> The National Oceanic and Atmospheric Administration (NOAA) lacks a systems architecture, or overall blueprint, to guide the design, development, and evolution of the many subsystems [*sic* NEXRAD, GOES, ASOS and AWIPS] comprising its $4 billion modernization of the National Weather Service's weather observing, information processing, and communications systems. This situation arose because NOAA officials have not managed the multiple subsystems as interrelated parts of a single system. As a result, incompatibilities have arisen among the subsystems, including different communication protocols and application languages. The modernization has never had a central manager or chief architect. Consequently, the subsystems continue to be developed and managed in largely the same manner as they were started--as individual systems that must be interconnected after development to meet National Weather Service requirements. Unless a single manager is appointed and an architecture is developed and enforced, the integration of these and potentially other new weather forecasting subsystems will continue to require more time, effort, and money than is necessary.

Over the summer and early fall of 1994, it seemed that NOAA and AWIPS were being lambasted on all sides. However, of all the potential players OMB remained aloof and still failed to take oversight actions aimed at the broad AWIPS target. OMB failed to issue regulations aimed at FAA, withhold funding, redirect the program, or institute any specially-targeted system of controls over NOAA and its troubled AWIPS program.

However, NOAA did take some positive steps beginning with that period. First, starting in the fall of 1994, it announced plans to deploy prototype systems at selected weather forecasting offices to test parts and components of AWIPS as they were developed. By the spring of 1995 the prototypes named "Pathfinder" by NOAA had been deployed at three weather service field offices in Pennsylvania, Illinois and Rhode Island. By February 1995, Commerce and NOAA had apparently made significant progress in reforming the program because they received the General Services Administration's approval to make major structural changes to the AWIPS contract (GSA-DPAs). GSA in its "Time Out" letter had previously precluded any such changes without GSA's explicit "written approval" (GSA, 1994b). The General Accounting Office described the restructured AWIPS contract and program in a December 1994 report as follows (GAO, 1994a, p. 3):

> NWS is now in the process of restructuring the AWIPS program and renegotiating the AWIPS contract with PRC. These changes are in response to AWIPS design problems and program delays . . . the restructured program will . . . assign responsibility for developing AWIPS application to the government. This government-developed application software will then be provided to PRC, which will be responsible for providing the AWIPS platform (that is hardware and systems software engineering environment), integrating the applications with the platforms, and ensuring overall system quality.

Apparently, NOAA had decided that its contractor was not up to the task of writing applications code; NOAA would assume those risks and perform that function, instead. Furthermore, NOAA had clearly concluded that its internal weather service software development processes were up to that task.

Nonetheless, GAO was not confident that the restructured program and contract would achieve success. In fact, GAO specifically criticized NOAA about its software development management which was targeted to play a key role in the new strategy (GAO), 1994a, p.2). GAO stated:

> [T]he laboratories processes are not adequate to achieve NWS' [*i.e.* National Weather Service's] ultimate objective--developing production-quality AFPS [*i.e.* AWIPS Forecast Preparation System] code that NWS can give to the AWIPS contractor for direct integration into AWIPS . . . .

Throughout 1995 the General Accounting Office continued to snipe at AWIPS and the entire weather modernization program by issuing cautionary reports. The Commerce Inspector General issued another scathing report in February 1996. As of that date the General Services Administration had still not released AWIPS from its "Time Out" grasp. However, GSA's role ended that month with the repeal of the old Brooks Act that had given GSA authority over information technology for 30 years. GAO and the Commerce IG were the only remaining oversight bodies that had taken any actions with respect to AWIPS. Although the Office of Management and Budget had previously placed the weather service modernization program on its "high risk" list, it still had taken no oversight actions to enforce its concerns.

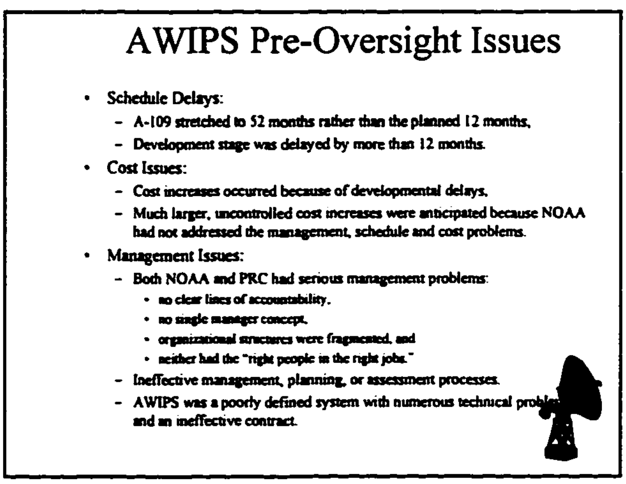

Figure VI-B-3: AWIPS Pre-Oversight Issues

By February 1996, there were no assurances that AWIPS was on track. Rather than coming "on-line" in 1994 as initially planned, it appeared that AWIPS would not be fully deployed until after 2000. Only three prototype systems had been installed. Weather forecasters still had to use separate computers and separate communications systems to access the satellite, radar and ground sensor information provided separately by their separate systems. No integration mechanism was in place; AWIPS was still planned to be that tool, but it was seriously delayed. Over 20,000 NOAA software requirements were still unfilled (DOC IG, 1996). Fifty percent too many weather offices remained open because AWIPS was not in place to close them. Any cost benefits attributable to the National Weather Service had passed far into the budget out years. The hundreds of lives and billions of dollars lost every year in the United States due to the deprecating perturbations of Nature still loomed large over the Weather Service with its AWIPS albatross. AWIPS issues prior to oversight actions are depicted in figure VI-B-3.

The Office of Management and Budget had still not taken oversight actions directly associated with the AWIPS problems and issues as of February 1996. OMB had not issued regulations aimed at AWIPS, withheld funding, redirected the program, or instituted any specially-targeted system of controls over NOAA. However, the new legislation repealing the Brooks Act gave OMB specific responsibilities for managing correction of information technology problem systems in addition to its Paperwork Reduction Act authorities over information technology and long-standing budget powers. Thus, OMB became exclusively responsible for curing AWIPS problems--or culpable for their continuation--as of the February 1996 when the Transitional period changed into the Transformed era of information technology oversight.

Completing a review to match actual oversight actions with accountability precepts, AWIPS oversight actions are overlaid in the sequel on top of the Traditional, Transitional and Transformed era templates previously developed in Chapter V.

AWIPS Oversight Actions

Interest by members of the oversight community in AWIPS was cumulative over time. Initially, there was a dearth of interest which gradually grew in both composition and tenor until, in 1994 every possible oversight player, except the Office of Management and Budget, was "champing at the bit" to get a piece of AWIPS. By February 1996, at the start of the Transformed era, that readiness for action and air of watchfulness continued as the oversight community waited for signs of success--or failure--in NOAA's new approach to AWIPS under the restructured program. Figure VI-B-4 summarizes the effects of oversight actions.

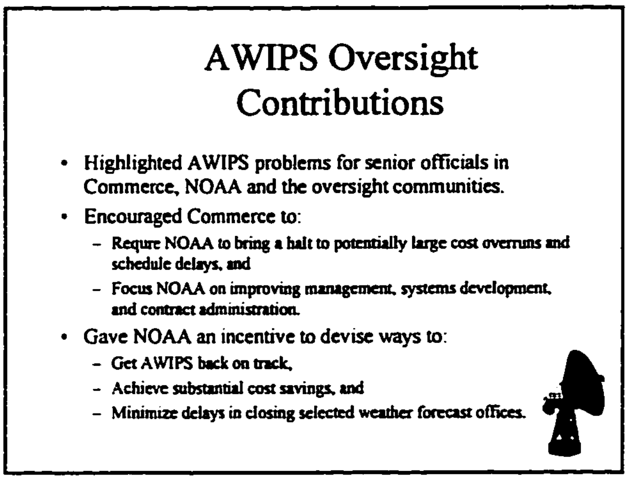

Figure VI-B-4: AWIPS Oversight Contributions

Recall that the Traditional era paradigm was one of hierarchical control through delegation and audit. NOAA in a Traditional setting would have been subject to before-the-fact review of all major AWIPS decisions under a hierarchical, delegations-based process. Furthermore, corresponding audits would have been conducted to ensure that those before-the-fact "orders" were, in fact, being carried out in the prescribed manner. Also, audits would have been conducted to forestall any waste, fraud and abuse associated with the Advanced Weather Information Processing System as well as the entire weather modernization program.

A review indicated that only the General Services Administration had, indeed, instituted a delegations process for AWIPS. Under that methodology GSA required Commerce as well as other departments and independent agencies to obtain a delegation of procurement authority prior to issuance of a Request For Proposals for any information technology project valued in excess of $2.5 million. Under that requirement, Commerce had obtained the initial delegation on behalf of NOAA on June 5, 1986. GSA granted a number of amendments to that delegation.

Specifically, until GSA took an oversight action which placed AWIPS in "Time Out" it had granted a total of seven delegation amendments on August 31, 1988, September 13, 1989, March 5, 1990, August 21, 1990, August 22, 1991, June 26, 1992 and June 30, 1992, respectively (GSA-DPAs). Over a 74-month period between granting the initial delegation and placing AWIPS in "Time Out" GSA granted amended delegations at a rate of almost one per 10 months.

Such a high rate could indicate the imposition of Traditional era controls by GSA, or it could indicate that Commerce and NOAA management was repeatedly revisiting major decisions about a fluctuating program with shifting mission, management, technical or contractual issues.

The key to separating purpose from conjecture was two information resources management reviews of the Department of Commerce which had been conducted by GSA in 1989 and 1993. Chapter III described how the Office of Management and Budget was obligated under the Paperwork Reduction Act reauthorization in 1986 to conduct audits of individual agencies' information resources management practices. In turn, OMB had GSA conduct these audits as its agent.

The outcome of GSA's 1989 audit was an extremely favorable report which also raised the Department's authority to procure information technology without prior GSA approval from a standard level of $2.5 million to an unprecedented $17.5 million, the highest level granted to any agency at that time. That decision was reaffirmed in the 1993 review and Commerce retained the highest level of authority granted to any department or agency. No caveats or restrictions were placed on that authority, not even for NOAA and AWIPS. This elevated view retained Commerce in a position of special GSA trust even after GSA had instituted its three-tiered agency threshold system in April 1995. Commerce was a mid-sized agency and should have rightfully had a $10 million level of authority. Instead, GSA raised it to $25 million which was the same as the standard level for the largest departments and agencies in the federal government. Clearly, GSA took no issue with Commerce or NOAA's management of their information technology programs during that time period (GSA-Reviews).

Therefore, it is apparent that the seven delegation amendments were not indicative of GSA oversight action. Rather, they indicated that Commerce and NOAA were repeatedly revisiting major decisions about a fluctuating AWIPS program with shifting mission, management, technical or contractual issues.

Regarding audits, the General Accounting Office issued four reports about the AWIPS program between 1988 and February 1996. A December 1991 report entitled Weather Forecasting: Cost Growth and Delays in Billion-Dollar Weather Service Modernization issued a first alarm (GAO, IMTEC-92-12FS. December 17, 1991):

> [C]ost estimates for the [AWIPS, NEXRAD, GOES and ASOS] systems, however, have doubled, and deployment of the systems is not scheduled until 1998--almost four years later [than planned].

GAO continued from that time forward to monitor the entire weather modernization program including AWIPS. As another example, in a January 1993 report entitled Weather Forecasting: Important Issues on Automated Weather Processing System Needs Resolution, GAO counseled (GAO, IMTEC-93-12BR, January 1993):

> AWIPS still faces some important issues that have yet to be resolved. These are 1) unclear government versus contractor responsibilities, 2) vague portability requirements, 3) unspecified security arrangements, 4) no configuration management plan for locally developed software, 5) no standardized and structured approach to guide software development, and 6) limited government involvement in testing.

GAO also highlighted AWIPS' unusual software development approach by stating on page 3 that:

> The government normally specifies its needs and a contractor designs and develops a system to meet those needs. The AWIPS acquisition follows a

> different approach. Specifically NWS is both the user and developer of the system.

GAO went on to express its concern about this unusual approach.

In March 1994 GAO issued a tough report which had as principal findings that the overall modernization did not have a systems architecture, the lack of an architecture had impacted both cost and performance, and finally "no one in NWS is responsible for the modernization." Though not calling for a "cease and desist" order, the series of General Accounting Office reports made plain both important issues about AWIPS and the overall importance of these issues with respect to the entire weather forecasting modernization effort. Though in the Traditional mode, GAO did not follow the model to its logical end. Given a program wherein "costs . . . had doubled . . . and . . . deployment . . . was [delayed] four years" any Traditionally-oriented central management agency worth its hierarchy would have called for an immediate halt to the program to prevent even more waste-fraud-abuse. GAO did not do so, and therefore, its methods were only a partial reflection of Traditional maxims. Apparently, GAO did not employ a Traditional era stereotype as its guide in auditing AWIPS and NOAA from 1986 through February 1996.

Traditional Template: Moreover, neither GAO nor any other central management agency audited AWIPS to ensure that NOAA was carrying out delegated authority in a manner consistent with "marching orders." Apparently, GAO audits were not at that time a mechanism for ensuring that before-the-fact "orders" given by central and hierarchal authorities were being carried out, as prescribed. Thus, hierarchical control through delegation and audit certainly did not characterize oversight of NOAA's Advanced Weather Information Processing System between the time of its inception and February 1996. Clearly, AWIPS was not managed through Traditional era oversight practices. Table VI-B-II is an overlay of actual AWIPS oversight mechanisms on top of the Traditional era template.

Table VI-B-II: AWIPS Traditional Era Template

Era	Precepts	Attributes	Mechanisms
Traditional	Centralized IT accountability	Delegation by transaction Audit	GSA procurement delegations GSA IRM audits GAO audits
	Functional IT hierarchical controls	Fractionated oversight	OMB--budget OMB--policy GSA--procurement NIST--Standards
NOAA's AWIPS	Diffused IT accountability	Agency-level responsibility	Independent assessments
	Centralized IT accountability	Management by exception	GSA "Time Out"
	Collaborative responsibility	Technocratic decision-making	GAO recommendation

In fact, actual AWIPS oversight practices reinforced the previous image of Commerce and NOAA repeatedly revisiting major decisions replete with shifting mission, management, technical or contractual issues. Table VI-B-III displays the Transitional template in comparison with those actual AAS oversight practices. There were no oversight continuity of delegation and audit processes as would be expected in the Traditional oversight mode. Centralized, hierarchical control through delegation and audit would have clearly implied repetition in corresponding delegation and audit processes to ensure that the agency was following "orders" as well as to guard against waste, fraud and abuse. No, the Traditional model did not fit AWIPS oversight from its birth through the start of the Transformed period in February 1996.

Transitional Template: Rather, actual AWIPS oversight took three forms. The first originated within the Department of Commerce. The second was the previously described series of General Accounting Office audits, and the third was the General Services Administration's "Time Out."

From within the Department of Commerce came two thrusts. In the first the Department established an Independent Review Team that conducted an extremely rapid review in June 1994. Commerce and NOAA adopted the team's recommendations which included a major redirection of the program and restructuring of the AWIPS contract with PRC. This team review was indicative of the Department's and NOAA's intention to resolve their own problems, internally, and without the intervention of the central management agencies. Such an action was characteristic of the "agency-level responsibility" attribute which underpinned the "diffused IT accountability" precept of the Transitional era. NOAA's accomplishments in response to the oversight actions is depicted in figure VI-B-5.

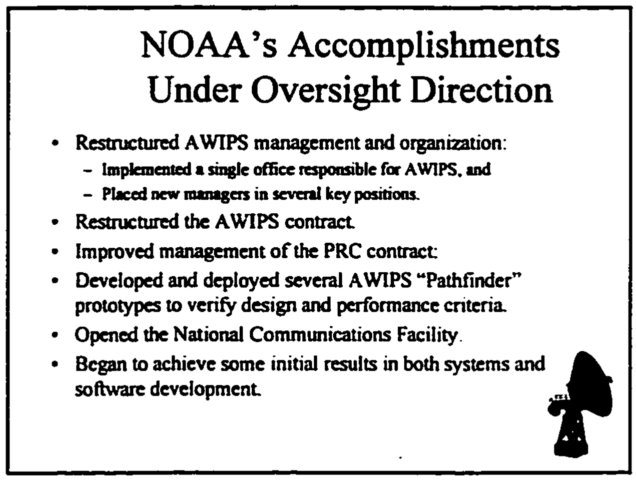

Figure VI-B-5: NOAA's Accomplishments

The second Department of Commerce thrust was a series of concerted reviews by the Commerce Inspector General. Three reports were issued; one was issued in May 1992 and the other two in September 1994 and February 1996, respectively. Although the reports were of a "watch dog" nature, they did originate from within Commerce and not from the central management agencies. Therefore, this second thrust was, in fact, characteristic of the Traditional oversight stereotype. Yet, it drew no response, in kind, from the central management agencies indicating that they had moved away from Traditional methods and into another paradigm.

Table VI-B-III: AWIPS Transitional Era Template

Era	Precepts	Attributes	Mechanisms
Transitional	Diffused accountability	Delegation according to capability Agency-level responsibility	Broad classes of waivers Internal review Independent assessment
	Collaborative responsibility	Business orientation Technocratic decision-making	Inter-agency committees
NOAA's AWIPS	Diffused IT accountability	Agency-level responsibility	Independent assessment
	Centralized IT accountability	Management by exception	GSA "Time Out"
	Collaborative responsibility	Technocratic decision-making	GAO recommendation

Transformed Template: The next form of AWIPS oversight was the General Accounting Office's series of audits. A recommendation from one of them is particularly insightful. The March 1994 General Accounting Office report entitled Weather Forecasting: Systems Architecture Needed for National Weather Service Modernization (GAO, AIMD-94-28, 1994) stated:

> *To help ensure the success of the NWS modernization, GAO recommends that the Secretary of Commerce direct the Deputy Under Secretary for Oceans and Atmosphere to designate a single manager or chief architect for the modernization with the responsibility and authority to define and enforce adherence to an overall systems architecture.*

A message of technocratic management for AWIPS underpinned these remarks marking a close relationship between the "technocratic decision-making" attribute of the Transitional and Transformed eras and their commonly held precept of "collaborative responsibility." Though it stopped short of being global in the government-wide sense, the GAO report described with some detail the collaborative role that the chief architect would play across NOAA and result in closer coordination with the Departments of Transportation and Defense, both of which had heavily invested resources in the modernization effort. Thus, the GAO recommendation built its collaboration proposal from the bottom up, rather than starting at a higher-level, inter-agency vantage point. In this way GAO oversight was also pointed in the Transformed direction. Table VI-B-IV depicts this result.

Table VI-B-IV: AWIPS Transformed Era Template

Era	Precepts	Attributes	Mechanisms
Transformed	Centralized IT accountability	Single point of control Management by exception	OMB oversight IT Review Board
	Collaborative responsibility	Business orientation Technocratic decision-making	CIO council Inter-agency committees Inter-agency technology teams
NOAA's AWIPS	Diffused IT accountability	Agency-level responsibility	Independent assessment
	Centralized IT accountability	Management by exception	GSA's "Time Out"
	Collaborative responsibility	Technocratic decision-making	GAO recommendation

The third and final form of AWIPS oversight was the General Services Administration's "Time Out." In its August 11, 1994, "Time Out" letter to Commerce, GSA imposed a Traditional-like control by requiring the Department to obtain GSA's approval before restructuring AWIPS. Yet, it was not grounded in pure delegation and audit; rather, GSA recognized that the independent assessment of two months earlier had led to a new plan and GSA wanted to review that plan before it was implemented. Thus, GSA had acceded to the "agency-level responsibility" attribute of the Transitional and Transformed eras, as well as the "management by exception" attribute of the Transformed era. Precepts of "diffused IT accountability" and "central IT accountability" followed these attributes, respectively.

Although the Office of Management and Budget had numerous opportunities and plenty of clout, it had not acted on AWIPS or its problems. OMB's clout included both its control over budgets and its Paperwork Reduction Act authority. This lack of involvement as of mid-1996 certainly raised questions for the future wherein OMB was destined to be the single oversight entity over the National Oceanographic and Atmospheric Administration and its Advanced Weather Information Processing System program in the Transformed era..

In summary, actual AWIPS oversight practices were immersed in both Transitional and Transformed precepts even though AWIPS spanned, in time, all three oversight eras. In particular, it leaned heavily towards the Transformed precepts. Only the Commerce inspector general had attempted to subject the program to Traditional oversight practices. None of the central management agencies employed such a strategy.

AWIPS Measures

Recall from Chapter IV that certain measures were to be applied to the oversight actions imposed on each of the information technology programs in the case studies. Those measures were the following:

Measure 1: Did the oversight practice help the program meet mission requirements?

Measure 2: Did the oversight practice help the agency acquire technology in a timely manner?

Measure 3: Did the oversight practice help the agency acquire current technology?

Measure 4: Did the oversight practice help the agency receive reduced prices?

Furthermore, each measure was determined to fit one of five values: (1) no impact, (2) some impact, (3) moderate impact, (4) significant impact, (5) substantial impact. Tables VI-B-IV through VI-B-VII apply the measures to the precepts, attributes and mechanisms associated which characterize those actual AWIPS oversight actions.

Measure 1: The AWIPS program had not yet produced any tangible results as of mid-1996 when the case studies for this paper were completed. Therefore, a rating of "Not Available"

Table VI-B-IV: AWIPS Measure 1 Ratings

Measure 1	Did the oversight practice help the program meet mission requirements?			
	Precepts	**Attributes**	**Mechanisms**	**Rating**
NOAA's AWIPS	Diffused IT accountability	Agency-level responsibility	Independent assessment IG Audits	N/A N/A
	Centralized IT accountability	Management by exception	GSA "Time Out"	N/A
	Collaborative responsibility	Technocratic decision-making	GAO recommendation	N/A
			Overall Rating:	N/A

(N/A) was assigned.

However, it should be noted that, though not included in the original plan, AWIPS did deploy three prototypes in late 1995. Apparently, those prototypes came about as a result of oversight actions, and were designed to benchmark AWIPS's progress throughout the development cycle. The concept of prototyping was new to AWIPS. In the original design AWIPS would be developed, built and deployed; there was to have been no interlude for field testing one or more preliminary systems. Accordingly, prototyping was a significant change to the AWIPS program. Inclusion of prototypes certainly reduced the overall risk because it allowed early detection of problems. Therefore, although N/A was an appropriate rating at the time of the study, the oversight actions will have certainly contributed to any future success that is enjoyed by AWIPS.

Measure 2: Timeliness of information technology acquisition was the focus of this measure. The ratings for the second measure were assigned because all four oversight actions forced AWIPS to identify and adhere to a schedule. The importance of adherence to a schedule cannot be understated for AWIPS. After all, the program had floated along in a lackadaisical

Table VI-B-V: AWIPS Measure 2 Ratings

Measure 2	Did the oversight practice help the agency acquire technology in a timely manner?			
	Precepts	**Attributes**	**Mechanisms**	**Rating**
NOAA's AWIPS	Diffused IT accountability	Agency-level responsibility	Independent assessment IG Audits	3 3
	Centralized IT accountability	Management by exception	GSA "Time Out"	3
	Collaborative responsibility	Technocratic decision-making	GAO recommendation	3
			Overall Rating:	3

manner for a decade. Milestones had routinely slipped, often by years. Thus, any move to force explicit identification of a schedule and adherence to it was a plus.

Recall that it took NOAA 52 months to complete a 12 month A-109 process before awarding the development contract. NOAA seemed to have no concept of timeliness nor a sense of urgency to complete that initial task. Yet, by December 1995 the three oversight actions had already achieved a measure of success in less than a year, as demonstrated by NOAA's mid-1995 delivery of three prototypes. Those systems were successfully deployed, and started immediately to forecast the weather. Those oversight actions had, indeed, achieved timely and tangible results as of mid-1996 when the AWIPS case study was completed. All of the oversight actions had been aggressive, and it was not possible to distinguish between them. Importantly, all called for follow up actions making them very credible, and enhancing the potential of their effectiveness.

As another indicator, in response to oversight demands NOAA had committed to an early 1995 deployment of a National Communications Center to initially broadcast GOES satellite data and other weather information to the prototype locations and eventually to all weather forecasting offices in the coterminous states. NOAA delivered on that commitment very close to schedule. Importantly, these were the first real AWIPS deliverables; a few tangible results had finally been achieved.

Thus, a rating of 3 was assigned to this measure because oversight actions had required an explicit schedule and forced NOAA to adhere to it when delivering the three prototypes. That is, the oversight actions enjoyed more success than just "some impact" which would have corresponded to a level 2 rating. An assessment of "moderate impact" rating of level 3 is, therefore, appropriate because tangible results in the form of the prototypes and the National Communications Center had been delivered close to schedule.

Table VI-B-VI: AWIPS Measure 3 Ratings

Measure 3	Did the oversight practice help the agency acquire current technology?			
	Precepts	**Attributes**	**Mechanisms**	**Rating**
NOAA's AWIPS	Diffused IT accountability	Agency-level responsibility	Independent assessment IG Audits	3 N/R
	Centralized IT accountability	Management by exception	GSA "Time Out"	3
	Collaborative responsibility	Technocratic decision-making	GAO recommendation	3
			Overall Rating:	3

Measure 3: The acquisition of current technology was the focus of this measure. AWIPS had not yet been deployed to all weather forecasting offices because it was still in development. However, oversight caused the restructured program to deploy three prototypes which tested new

software, as it was built, and experimented with new hardware configurations for future production and full-scale deployment.

The very concept of a prototype is to test and ensure that a developmental system works before it is deployed. However, an additional benefit is that this approach also drives the architecture towards current technology. Information technology is renowned for rapid improvements in performance that correspond with declining prices for newer products. Thus, prototyping gives impetus to swap older and more costly hardware and software for newer items. On a parallel track, newer information products with their increased capabilities mean that such commercial off-the-shelf items can often do jobs that previously required specially developed or customized products. Thus, prototyping tends to drive towards current technology because it is usually less expensive and has increased capabilities.

Thus, by maneuvering AWIPS into a systematic approach of constantly testing developmental products through prototypes, the oversight actions also forced AWIPS to acquire current technology. This action increased the likelihood that current technology would be acquired for production systems when they are finally deployed to field locations. Therefore, a rating of 3 is indicative of that level of success, and was assigned to this measure.

Measure 4: The AWIPS portion of the weather modernization program had not been cited for cost overruns as of mid-1996 when the case study was completed (the other three projects in the weather modernization program had been cited, however, for a total of $2+ billion in cost overruns). The cost problem with AWIPS had always been two-fold: (1) it had the potential of very large cost overruns because of technical issues, and (2) its delay prevented the majority of the entire weather modernization programs cost savings (closing of field offices, personnel reductions). Moreover, since AWIPS was not in production, only development, just a modicum

Table VI-B-VII: AWIPS Measure 4 Ratings

Measure 4	Did the oversight practice help the agency receive reduced prices?			
	Precepts	**Attributes**	**Mechanisms**	**Rating**
NOAA's AWIPS	Diffused IT accountability	Agency-level responsibility	Independent assessment IG Audits	N/A N/A
	Centralized IT accountability	Management by exception	GSA "Time Out"	N/A
	Collaborative responsibility	Technocratic decision-making	GAO recommendation	N/A
			Overall Rating:	N/A

of hardware had been delivered, primarily for developmental purposes. Thus, any assignment of a rating for this measure would have been premature in mid-1996 when the case study was completed.

From the above, it is clear that oversight actions taken in the case of AWIPS did have some positive effects. Specifically, the oversight actions caused significant redirection of the AWIPS program, and forced the delivery of some tangible results, namely, the prototype systems and the National Communications Center. Accordingly, it is clear that benefits and not harm were the result of those actions.

The oversight actions did not cure all of AWIPS ills, nor did they turn it into a well managed program. This was not a case of transforming abject failure into pristine success. Rather, it was one of taking a program with no probability for success and changing it into one where some level of success was possible. Mid-1996 issues about AWIPS are shown in figure VI-B-6.

Thus, any assessment of the overall impact of oversight on AWIPS must be taken in context. This means that AWIPS's decade-old record of a lack of action, no results, and constant delays must be factored into any assessment equation. When compared with that dismal history the changes brought about as a result of the oversight actions appear more positive. In fact, those oversight actions took an intransigent program which had achieved nothing for a decade and made it produce some results within one year. The actions actually achieved positive benefits. Moreover, those accomplishments were strategic because they positioned NOAA to achieve more successes in the future.

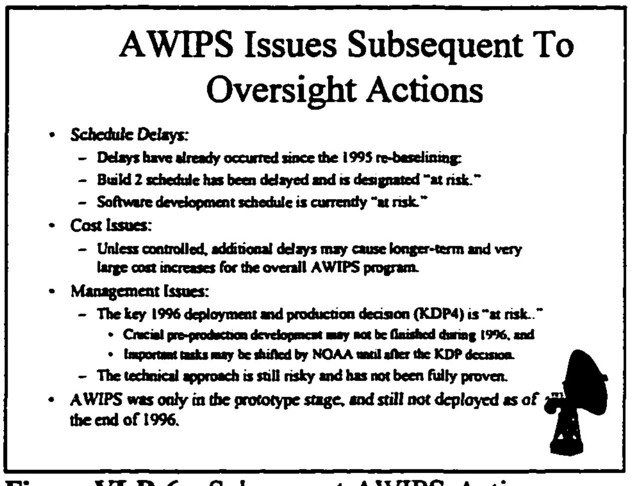

Figure VI-B-6: Subsequent AWIPS Actions

In that context it is seen that the oversight actions applied to AWIPS had a modicum of success. Thus, those AWIPS oversight actions which are carried over into the Traditional era appear to have a likelihood of similar success when applied to similarly troubled information technology programs.

C. Summary Case Study Findings

Two case studies were reviewed in this chapter, the Federal Aviation Administration's Advanced Automation System and the National Oceanographic and Atmospheric Administration's Advanced Weather Information Processing System. As of the start of the Transformed oversight era in February 1996 both were still the keystones in their respective agency's overall information technology programs. Both had experienced severe problems including significant cost overruns and schedule delays. Both spanned, in time, all three oversight time periods, namely, the Traditional, Transitional, and Transformed eras. There were four major findings:

Case Study Finding 1: The central management agencies had not applied Traditional controls to either program, even when major problems had become apparent.

Case Study Finding 2: An admixture of Transitional and Transformed controls was applied, with varying degrees of success and no harm, to both programs on a management-by-exception basis.

Case Study Finding 3: Two overarching precepts, Diffused Accountability and Centralized Accountability, characterized oversight of the two information technology programs. A third, Collaborative Responsibility, was applied to a lesser degree.

Case Study Finding 4: Two mechanisms proved to be the most effective, namely, independent assessmentscommissioned by the agencies, and external intervention by the General Services Administration through its "Time Out" program.

The case studies demonstrated that the Traditional form of accountability and oversight had not been applied to either program over the period ranging from their respective births in the Traditional period, into their problems in the Transitional era, and finally upon their entry into the Transformed era which began in February 1996. Therefore, their ills could not have been a result of Traditional era methods which were previously identified as being grounded in hierarchical control implemented through systems of delegation and audit at the central management agency level.

Instead, for over a decade oversight of FAA's oversight really had one leg in the Transitional period and another in the Transformed era. Actual AWIPS oversight practices were immersed in both Transitional and Transformed precepts, and in particular, leaned heavily towards the Transformed precepts. In a consistent pattern from their births in the mid-1980s their oversight was approached exclusively through application of a mixture of Transitional and Transformed era precepts, attributes and practices.

Exercising oversight mechanisms and controls were the agencies, themselves. The General Services Administration, which had exclusive authority for information technology procurements under the Brooks Act, intervened in both, but only at the eleventh hour. The General Accounting Office did not issue a call to "cease and desist" even when both programs were obviously out of control. Rather, GAO only counseled with words of caution about AAS, although it was more aggressive in the case of AWIPS wherein GAO sought high-level support to institute technocratic direction of the modernization effort. Interestingly, the Office of Management and Budget had clout, numerous opportunities and wide targets in both cases but did not institute oversight controls. This lack of involvement through mid-1996 certainly has raised questions about the future wherein OMB is destined to be the single central oversight entity in the Transformed era.

Moreover, application of the four efficiency and economy measures to both case studies indicated that those information technology programs had received some benefits from oversight actions. Those results are integrated with the ones from the survey in the next chapter.

CHAPTER VII

SYNTHESIS

The results of the two case studies from Chapter VI are integrated and synthesized with the survey findings from Chapter V in this chapter. Through the survey, program officials' "insider" knowledge was tapped and incorporated with the "outsider" perspective of the oversight community. The case studies brought to bear an "independent" perspective because of their observer status. Synthesis of those three perspectives relies on the previously outlined measures used in both the survey and case studies to focus on information technology programs' economy and efficiency. Those measures are listed, below, for reference:

Measure 1: Did the oversight practice help the program meet mission requirements?

Measure 2: Did the oversight practice facilitate timely agency acquisitions?

Measure 3: Did the oversight practice help the agency acquire current technology?

Measure 4: Did the oversight practice help the agency receive reduced prices?

Each measure was determined to fit one of five values: (1) no impact, (2) some impact, (3) moderate impact, (4) significant impact, (5) substantial impact. Recall the research question for this study:

Will mid-1990s Administration and Congressional reform of information technology accountability practices cause improved economy and efficiency in federal agencies' largest and most important information technology programs?

For reference, the table lists the Transformed era precepts, attributes and mechanisms identified in Chapter V that had resulted from mid-1990s reform of information technology accountability.

Table VII-I: Transformed Era Accountability Precepts

	Precepts	Attributes	Mechanisms
Transformed Era	Centralized IT accountability	Single point of control Management by exception	OMB oversight IT Review Board
	Collaborative responsibility	Business orientation Technocratic decision-making	CIO Council Inter-agency committees Inter-agency technology teams

Synthesis of the "insider," "outsider" and "observer" perspectives about the possibility of success for those reforms is given a formal treatment in the following

A. Stage I

Recall that the first stage of this study garnered the perspectives of the federal information technology communities. Data was collected using a survey instrument completed by a sample taken from the universe of program, technical, contracting and oversight officials who comprised that community. Those results were reported in Chapter V.

The results of the survey were intended to accomplish three tasks: (1) identify oversight concepts for use as inputs to the research model as well as, (2) associate each of the three possible types of inputs, namely, precept, attribute or mechanism, with its respective Traditional, Transitional, or Transformed period, and (3) forecast the success of new oversight methods in the Transformed period. The first and second tasks were completed in Chapter V. Using those perspectives to predict the success of new oversight methods in the Transformed period, the third task, is the subject of this section. That is, the survey results will help to answer the research question and indicate whether Transformed era principles and practices will improve the economy and efficiency in federal agencies' largest and most important information technology programs.

Recall that, in the survey, responses from the information technology community approached that particular problem from two different directions. The sample had been constructed to obtain responses from two broad segments of the community. Specifically, the sample queried those very people who had been directly involved in program decisions; this segment garnered an "insider" perspective for analysis. Another part of the sample was directed towards members of the oversight community who were responsible for monitoring those programs; this segment ensured that an "outsider" perspective would be included in the analysis.

Table VII-A-I: Aggregated Responses

Aggregated Responses	**1**	**2**	**3**	**4**	**5**
Traditional principles and practices	9%	19%	35%	23%	14%
Transitional principles and practices	4%	16%	23%	30%	26%
Transformed principles and practices	4%	9%	16%	26%	45%

Also recollect that the survey questionnaire (Appendix A) outlined certain principles and practices associated with the three federal information technology oversight periods. In turn, those principles and practices were ranked by the survey respondents, and the results were described in

Chapter V. Table VII-A-I aggregates those responses, and shows how the information technology representatives ranked the effectiveness of the practices for each of the time periods. A rating of 1 means "not effective" and 5 is "highly effective."

These rankings were taken over all respondents. Thus, the results represent a composite of both program ("insider") and oversight ("outsider") observations about the effectiveness of those information technology principles and practices.

However, it is instructive to further separate those "insider" and "outsider" reports to identify similarities or discrepancies in their perspectives. Such an approach is taken in the following.

Program-Level Perspective

This viewpoint represents the program or "insider" set of observations about the effectiveness of information technology principles and practices for each of the three time periods. Specifically, program level officials ratings, when extracted from the aggregate, indicate a perspective that remains consistent with the above aggregate findings. Specifically,table VII-A-II shows the "insider" findings.

Table VII-A-II: Insider Responses

Program-Level or "Insider" Responses	**1**	**2**	**3**	**4**	**5**
Traditional principles and practices	6%	17%	33%	22%	12%
Transitional principles and practices	6%	11%	33%	33%	17%
Transformed principles and practices	6%	6%	17%	22%	49%

Clearly, program officials rated both the Transitional and Transformed practices very highly in comparison with those of the Traditional era. In fact, "insiders" rated the Transformed principles and practices higher than those of the Transitional era. This is a very strong finding because of its close correspondence with that of the oversight or "outsider" community which is displayed in the next section. Accordingly, both "insiders" and "outsiders" had confidence in those principles and practices. This consistency of response is important because it arises from diametrically opposite vantage points, namely, one of program management-in-action and another of oversight and review.

Thus, the "insider" answer to the survey question is: "Yes, Transformed era principles and practices will improve the economy and efficiency in federal agencies' largest and most important information technology programs."

Oversight Perspective

It is important to identify any discontinuities between "insider" and "outsider" perspectives. However, as shown by table VII-A-II oversight officials similarly rated those practices very

Table VII-A-II: Outsider Responses

Oversight-Level or "Outsider" Responses	**1**	**2**	**3**	**4**	**5**
Traditional principles and practices	5%	20%	40%	20%	20%
Transitional principles and practices	0%	20%	20%	20%	40%
Transformed principles and practices	0%	20%	20%	20%	40%

highly. Their specific perspective, when extracted from the aggregate, generally had a close correspondence in each category to those of program officials who participated in the survey.

Interestingly, oversight officials rated both Transitional and Transformed practices very highly in comparison with those of the Traditional era. Yet, they still had a slightly higher predilection towards Traditional practices than did the program officials who participated in the survey.

However, oversight officials were unequivocal in their support for Transformed practices over Traditional ones. Specifically, their responses indicated that they sought both Transitional and Transformed practices as a preferred way to approach information technology oversight. Therefore, when contrasted with Traditional practices their "outsider" answer to the survey question would clearly be: "Yes, Transformed era principles and practices will improve the economy and efficiency in federal agencies' largest and most important information technology programs."

Aggregated Perspective

Both "insiders" and "outsiders" expressed optimism about the upcoming Transformed practices. They also thought highly of Transitional oversight when contrasted with the older Traditional format. However, an important observation is that, in the aggregate, 37% of the respondents rated Traditional practices at levels 4 or 5--"highly effective." Such a large percentage cannot be summarily dismissed. Apparently, neither an aversion to the old ways nor the lure of radical reform drew respondents to Transformed practices. Rather, those "new" practices had evolved from, and still retained some of the old Traditional thinking; particularly, as previously discussed in Chapter V, the precept of centralized accountability.

Thus, survey respondents, in the aggregate endorsed the Transformed changes. Both "insiders" at the program level and "outsider" members of the oversight community concurred in that affirmation. Together, they answered the study question with a strong: "Yes, Transformed era principles and practices will improve the economy and efficiency in federal agencies' largest and most important information technology programs." Moreover, both "insiders" and "outsiders" counseled that Traditional practices should not be abandoned in their entirety; the underpinning concept of centralized accountability had, indeed, previously proven its worth from their perspective.

However, survey respondents' strong response to the study question begs the question of motivation. Recall from Chapter V that respondents foresaw three broad trends. First, congressional influence over information technology had increased in the Transitional period and would continue to increase in the Transformed era at the expense of the central management agencies. Secondly, the role of the Office of Management and Budget was in its ascendancy; it would emerge as the preeminent central authority in the Transformed era. Thirdly, the oversight role of the other central management agencies would decline in the Transformed era.

Chapter V assessed the second trend in terms of motivation and tension and concluded that alternate explanations exist for the responses received in the survey. Clearly agencies through their representatives indicated strong support for changing to the Transformed era and its attendant form of centralized oversight in the Office of Management and Budget. However, using the results of Chapter V for an examination of two particular explanations is instructive.

One line of reasoning is that agencies would have sought such centralization from an effectiveness motivation. That is, they would have wanted increased oversight that would be more effective in managing agencies' programs at the government-wide level. "Hard to believe" would be the intuitive response of almost any seasoned student of bureaucracy because agencies tend to seek autonomy and not oversight (*e.g.* Wilson, 1989). It certainly does not seem reasonable to adopt this view which suggests that agencies seek the imposition of controls and increased oversight of their programs.

A more plausible perspective would be that agencies sought centralization in OMB because it was the least onerous of the three forms of oversight. That is, the motivation was to support the "least of all evils;" with oversight centered at OMB all other central management forms would be eliminated. While the Traditional and Transitional forms retained a diversity of oversight mechanisms and authorities, only OMB would have such authorities in the Transformed era. The prospect of having fewer actors to "look over one's shoulder" would certainly be compelling to almost any official.

Moreover, OMB was well known through anecdotes to be budget centered and not heavily oriented towards management. That task would presumably devolve to the agencies in large part. Fewer overseers coupled with a diminished focus on supervision of agency management would be attractive from a parochial vantage point. Thus, from this alternative perspective, agencies were most likely motivated to seek to increase their autonomy (e.g. Wilson, 1989) by declaring allegiance to Transformed principles.

In fact, such an explanation was confirmed in Chapter V which presented the survey results. Briefly recapitulating, survey interviewees suggested two thoughts about OMB and its management capabilities. First, OMB was not known ever to have provided "oversight" in the onerous sense of the word. It was known that OMB had provided guidance and direction through circulars which were sometimes burdensome. However, it had not provided a detailed transaction-by-transaction management review of information technology programs. Secondly, OMB was regarded by interviewees as very politically controlled and motivated. In summary, none of the interviewees cited OMB as a paragon of management or an effective provider of oversight.

Thus, the survey's affirmation of Transformed accountability must be tempered with respondents' motivations. Specifically, respondents probably saw Transformed methods as a way to gain autonomy over their programs when compared with either preceding period and especially the Traditional one. Such self management is appealing from many perspectives. However, it would tend to preclude the intrusion of higher oversight in the event of an out-of-control program. Accordingly, the Stage I survey response to the study question must be:

Stage I Finding: *Yes, Transformed methods resulting from mid-1990s Administration and Congressional reform of information technology accountability practices will cause improved economy and efficiency in many federal agencies' largest and most important information technology programs. However, troubled programs will not receive much management attention, thereby placing them at further risk with a high chance of failure.*

Information technology programs that would have been headed for success under any set of oversight conditions could only do as well or better with the removal of process oriented controls. Those that were not achieving results could only tend to do worse when management controls are removed.

Those observations become a tautologically correct triad when coupled with survey respondents' observations that OMB was not a rationally-oriented manager but rather a politically-motivated budget shop. Moreover, in its present incarnation, OMB is not yet an information technology manager and certainly not an adept overseer of troubled programs. Thus, the facilitative bent of the Transformed era will probably help healthy information technology programs achieve better results, but that same predilection will decrease the likelihood of improvement in troubled programs. Accordingly, there is no expectation for OMB success in dealing with troubled programs in the Transformed era.

B. Stage II

The case study findings form the third and final part of the "insider"--"outsider"--"observer" triad. The two selected cases provided an opportunity to assess the actual oversight experiences of large-scale information technology programs. The Federal Aviation Administration's (FAA's) Advanced Automation System (AAS) and the National Oceanographic and Atmospheric Administration's (NOAA's) Advanced Weather Information Processing System (AWIPS) were the two cases, and both were previously described in Chapter VI.

Specifically, this second stage was used to identify successful or unsuccessful oversight practices based on actual program experiences. Chapter VI provided those results. In turn, those cases were also used to predict the expected results of accountability in the Transformed era. The two programs selected met three predetermined criteria. They were: (1) at least $100 million in value or 25% of an agency's information technology budget, (2) critical to the agency's mission, and 3) had high visibility within the agency. These two major information technology programs also spanned the Traditional, Transitional, and Transformed periods. Thus, the second stage was designed to provide an objective, "independent" observer perspective through case studies.

Measures

Recall that four measures were applied to both case studies in Chapter VI. These were the same measures outlined in the planning for the study, and were previously specified in Chapter V. They were listed at the beginning of this chapter, and all four are directly related to the economy and efficiency of large-scale information technology programs. The measures and their scoring for the two cases are briefly recapitulated and integrated in the following tables.

Table VII-B-I: Aggregated Measure 1 Ratings

Measure 1	Did the oversight practice help the program meet mission requirements?			
	Precepts	**Attributes**	**Mechanisms**	**Rating**
Aggregate Ratings	Diffused IT accountability	Agency-level responsibility	Independent assessment	N/A (AWIPS) 2 (AAS)
			IG Audits	N/A (AWIPS)
	Centralized IT accountability	Management by exception	GSA "Time Out"	N/A (AWIPS) 2 (AAS)
	Collaborative responsibility	Technocratic decision-making	GAO recommendation	N/A (AWIPS)
			Overall Rating:	2

<u>Measure 1:</u> This measure was associated with the effect of oversight actions in meeting mission requirements. As described in Chapter VI, AWIPS had not yet produced any tangible results as of mid-1996. Thus, a rating of "Not Available" (N/A) was applicable and assigned in that chapter's assessment. However, central management agencies' oversight attempts to redirect FAA's AAS did achieve some results (see chapters V and VI). Thus, Measure 1 oversight practices were not harmful. Rather, they were beneficial but not overly so (see table VII-B-I). Accordingly, the scoring of the AWIPS and AAS measures is indicative that some positive effects occurred as a result of mechanisms employed in support of certain accountability precepts. Thus, the aggregated score supports a view that some positive effects occurred as a result of oversight intervention through the associated precepts, attributes and mechanisms.

Table VII-B-II: Aggregated Measure 2 Ratings

Measure 2	Did the oversight practice help the agency acquire technology in a timely manner?			
	Precepts	**Attributes**	**Mechanisms**	**Rating**
Aggregate Ratings	Diffused IT accountability	Agency-level responsibility	Independent assessment	3 (AWIPS) 2 (AAS)
			IG Audits	3 (AWIPS)
	Centralized IT accountability	Management by exception	GSA "Time Out"	3 (AWIPS) 2 (AAS)
	Collaborative responsibility	Technocratic decision-making	GAO recommendation	3 (AWIPS)
			Overall Rating:	2.5

Measure 2: A greater degree of success was enjoyed by those practices with respect to the second measure. This measure dealt with the timeliness of information technology acquisitions. It is especially true in the field of information technology that economy and efficiency strongly correlate with the timeliness of acquisitions. Since information technology changes so rapidly, delayed acquisition means old solutions to newer problems. Prices increase when old technology must be supported, and stale architectures mean lower efficiencies.

A lack of meaningful progress was one of the major reasons why both FAA's AAS and NOAA's AWIPS were in trouble. Neither had acquired information technology on a timely basis. In fact, delays were a continuing source of concern and a cause of embarrassment for both agencies.

However, the oversight actions taken in both programs did have a degree of success. Both FAA and NOAA demonstrated some forward movement. In particular, NOAA actually deployed AWIPS prototypes as an outgrowth of its response to oversight demands. Apparently, the identified practices were successful, in some measure, in both cases (see table VII-B-II). Accordingly, the aggregated scores were averaged and reflect the positive effects of the oversight actions.

Table VII-B-III: Aggregated Measure 3 Ratings

Measure 3	Did the oversight practice help the agency acquire current technology?			
	Precepts	**Attributes**	**Mechanisms**	**Rating**
Aggregated Ratings	Diffused IT accountability	Agency-level responsibility	Independent assessment	3 (AWIPS) 3 (AAS)
			IG Audits	N/R (AWIPS)
	Centralized IT accountability	Management by exception	GSA "Time Out"	3 (AWIPS) 3 (AAS)
	Collaborative responsibility	Technocratic decision-making	GAO recommendation	3 (AWIPS)
			Overall Rating:	3

Measure 3: Acquisition of current technology was the focus of the third measure. Currency of technology is not the same as its timely acquisition. Tales are legion in the federal arena about agencies still buying old technology just because they have a contract in place and no vehicle to acquire newer hardware or software. At the time that oversight actions were taken, the word "Advanced" in AAS and AWIPS appeared to be an oxymoron. Like timeliness in the second measure, currency is a very important issue because old technology is neither economical nor efficient when compared with newer versions.

Both NOAA and FAA achieved some results in this area after the institution of oversight controls. This was especially significant because both programs were so old that numerous computer generations had been born and gone to their graves in the intervening period from when both programs were conceived until oversight actions were taken. They were both operating with

Table VII-B-IV: Aggregated Measure 4 Ratings

Measure 4	Did the oversight practice help the agency receive reduced prices?			
	Precepts	**Attributes**	**Mechanisms**	**Rating**
Aggregated Ratings	Diffused IT accountability	Agency-level responsibility	Independent assessment IG Audits	N/A (AWIPS) 3 (AAS) N/A (AWIPS)
	Centralized IT accountability	Management by exception	GSA "Time Out"	N/A (AWIPS) 3 (AAS)
	Collaborative responsibility	Technocratic decision-making	GAO recommendation	N/A (AWIPS) N/A (AAS)
			Overall Rating:	3

archaic designs.

As reported in Chapter VI better management methods had been developed by the respective agencies to update the designs for both AAS and AWIPS in response to oversight demands. Thus, some positive actions had occurred. Therefore, the third measure demonstrated a moderate success rating of level 3 for those practices (table VII-B-III).

Measure 4: Reduced costs was the thrust of the fourth and final measure. Information technology has been renowned for a steady trend of increased performance at declining costs.

Thus, the continuously increasing costs of FAA's AAS and NOAA's AWIPS were clearly anathema to agencies and overseers, alike.

As recounted in the Chapter VI assessment, it was too early to assess AWIPS with respect to the fourth measure. Nonetheless, the practices had achieved a relatively high impact in redirecting FAA's AAS. Therefore, in the aggregate some positive effects accrued, and they are noted in table VII-B-IV. Thus, a moderate rating of level 3 was appropriate for this fourth area of measure. See table VII-B-IV.

Composite Synopsis

Recall from Chapter VI that both cases were grounded in Transitional and Transformed oversight practices; Traditional controls had not been applied to either by the government-wide oversight communities. Specifically, the previously derived precepts, attributes and mechanisms for the Transitional and Transformed oversight periods are listed in table VII-B-V.

The table also highlights those precepts, attributes and mechanisms embraced by the oversight community for the Federal Aviation Administration's AAS and the National Oceanographic and Atmospheric Administration's AWIPS. Both cases clearly demonstrated that Transitional and Transformed practices can be successful.

Therefore, the answer to the study question from the "observer" perspective of the two case studies appears to be: "Yes, Transformed era principles and practices will improve the economy and efficiency in federal agencies' largest and most important information technology programs." Moreover, the case studies strongly caution that the Transitional idea of agency-level responsibility, which is concomitant with the Diffused Authority precept, is both important and effective. Implicit within that caution is an understanding that oversight differs from facilitation; troubled programs need the former as much and possibly more than the latter. The studies suggest

Table VII-B-V: Transitional and Transformed Accountability Precepts

Era	Precepts	Attributes	Mechanisms
Transitional	**Diffused IT accountability**	Delegation according to capability **Agency-level responsibility**	Broad classes of waivers Internal review **Independent assessment**
	Collaborative responsibility	Business orientation Technocratic decision-making	Inter-agency committees
Transformed	**Centralized IT accountability**	Single point of control **Management by exception**	OMB oversight **IT Review Board**
	Collaborative responsibility	Business orientation **Technocratic decision-making**	CIO Council Inter-agency committees Inter-agency technology teams

that opportunities for Transformed era success can be improved by embedding that idea, and particularly the Independent Assessment mechanism, in the "new" Transformed approach. The table reflects a synopsis of those observations and highlights the effective oversight practices.

Nonetheless, those oversight actions which produced varying levels of results were taken in a far different environment than is anticipated in the Transformed era. Specifically, the Transitional era was the setting for both AWIPS and AAS oversight actions. In that era, there were still several oversight agencies that were politically able to take actions against those two programs. The taking of oversight actions was still viable in that maelstrom of fragmented authority and shifting bases of power.

In the Transformed era there will be only one such central management agency, namely, OMB. For the reasons previously recounted OMB seemingly has had no real credibility as a technology manager or an effective provider of information oversight, particularly for troubled programs. The taking of oversight actions appears not to be within OMB's Transformed repertoire; it certainly was not there in the Traditional or Transformed eras. Thus, the case studies' affirmation of Transformed accountability precepts must be tempered with the realities of OMB's probable capabilities of rising to the task. OMB's ability to perform oversight is doubtful. Accordingly, the Stage II case study response to the study question must be the same as the Stage I perspective, namely:

> Stage II Finding: *Yes, Transformed methods resulting from mid-1990s Administration and Congressional reform of information technology accountability practices will cause improved economy and efficiency in many federal agencies' largest and most important information technology programs. However, troubled programs will not receive much central management attention, thereby placing them at further risk with a high chance of failure.*

Such a response to the study question recognizes that some important Transformed precepts, attributes and mechanisms identified in the case studies do have proven merit. However, the reality is that OMB is not yet a solid information technology manager and certainly not an adept overseer of troubled programs. Therefore, troubled programs seem to be at greater risk than in the prior two oversight eras.

C. Response to the Study Question

The case studies demonstrated that oversight actions taken with respect to both the Federal Aviation Administration's Advanced Automation System (AAS) and the National Oceanographic and Atmospheric Administration's Advanced Weather Information Processing System (AWIPS) had proven beneficial, and not harmful. Moreover, both case studies showed that those programs had not been subjected to Traditional forms of oversight during the decade-long histories of both programs. Rather, they were characterized by an admixture of Transitional and Transformed controls applied on a management by exception basis. Thus, both cases indicated a likelihood of some measure of success if those same types of oversight actions were to be applied in the same way during the Transformed period.

Comparatively, the survey results indicated an air of optimism on the part of most respondents for the Transitional and Transformed era methods of oversight. Recalling their responses about the effectiveness of certain practices indicated that they certainly foresaw a better future than past. Their optimism about the Transformed future was almost the same, at the time of the study, as the Transitional period that they had just completed. Apparently, the respondents' perspectives were synchronized with those of the upcoming era. The breadth of the optimism was strong and cut across respondents' viewpoints at the government-wide, agency and project levels.

However, assessment of the data in both stages counseled that success of those practices will depend on OMB in the Transformed era; fractionated oversight saw its demise with enactment of the Information Technology Management Reform Act in February 1996. Facilitation rather than oversight appears to be the new watchword. In those circumstances, information technology programs that would have been headed for success under any set of oversight conditions could only do as well or better with the removal of process oriented controls. Routine oversight was clearly scheduled for demolition in the Transformed era.

Notwithstanding such prospects in successful activities, those programs that are not achieving results can only do worse when management controls are removed. Such an observation has important implications for the "10% that require close supervision 90% of the time," to use the old homily. Most information technology programs have achieved results, and without close oversight. Facilitation can only help them do better that which they do well, already. However, it is that select few, the proverbial 10% that require close oversight or "supervision" because they have not "done well." The two case studies in Chapter VI demonstrated the efficacy of that homily for information technology programs. Management attention is clearly a key to success in the conduct of large-scale information technology programs and holding agencies accountable for those programs.

However, OMB does not appear to have a record of managing; it has been budget oriented with a political mien. Thus, OMB will be faced in the Transformed era with congressional expectations of significantly more effective oversight, on one side, and on the other side all of the agencies seemingly have expectations of greatly reduced oversight. OMB will be in the middle of those pincers with the concomitant realization that it has not demonstrated management expertise, endowed itself with an information technology reputation or established an oversight credibility with any organization. Unfortunately for OMB, long-standing, multi-billion dollar failures like FAA's AAS or NOAA's AWIPS that keep consuming dollars and resources on an endless basis demand oversight and control. OMB has never been of the information technology management ilk, and it will find that such enormously conflicting expectations will be difficult to balance. Thus, the probability of OMB successfully managing troubled programs appears dismal, especially since there has previously been limited "M" in "OMB."

OMB's reputation for acting based upon political motivations rather than solid management principles may also hurt its chances for success in the Transformed era. One early example indicates that such politics still make up OMB's mien. Recall that the Information Technology Review Board (ITRB) is supposed to be OMB's oversight tool for large, troubled information technology programs in the Transformed era. One would suspect from a review of General Accounting Office reports or Congressional testimony in mid-1996 that OMB would be chartering the ITRB to review the Internal Revenue Service's Tax Systems Modernization (TSM), FAA's AAS or NOAA's AWIPS. At that time those were the largest, most publicly visible, highest risk, and most costly troubled programs in the federal information technology community. Surely, OMB would have risen to its new role with technocratic acumen and a sense of responsibility for curing at least one of those large systems that were besmirching the federal reputation and wasting billions of taxpayer dollars.

However, that logic would have been mistaken because the ITRB's first assignment since passage of the 1996 reform legislation was to review the Office of Personnel Management's computer modernization program. On a comparative scale, that program is but a flea on the back of the federal information technology elephant. It was generally unknown in the federal information technology world; a small agency with a small problem. Apparently, OMB found it to be more politically viable to attack the weak and the lame rather than to apply oversight to the most troubled programs before the public eye like TSM, AAS or AWIPS.

Such actions not only make OMB's management acumen questionable, but also insinuate that its motivations were and probably still are politically suspect. Even the slightest indication that OMB could be leveraging its political goals through oversight actions could be damaging to the entire concept of Transformed information technology management. Even the most pristine ITRB would have difficulties in gaining acceptance of its findings in that setting. The taint of politics levied against the purest technocratic analysis in such circumstances would leave it sullied, soiled and lacking in credibility. Clearly, the risk would continue to be one of neutering the ITRB as well as damaging any opportunity for oversight of troubled programs. OMB is by reputation heavily politicized, and it will continue to run that risk with every ITRB assignment.

Therefore, success will be likely in the Transformed era if and only if the practices identified in this study (table VII-C-I) are consistently applied through well-managed methods that have no taint of political motivation or machinations. Such a finding clearly holds for troubled systems. However, that observation also applies directly to those programs that are on a track towards success. Clearly, even the best managed program proceeding down a successful track can be fatally damaged through untoward political interference. An even and respected hand is required in administering oversight. Thus, it is questionable whether OMB can rise to the task; its history would not agree with that charter.

Table VII-C-I: Answer to the Study Question

Era	Precepts	Attributes	Mechanisms
Traditional	Centralized IT accountability	Delegation by transaction Audit	GSA procurement delegations GSA IRM audits GAO audits
	Functional IT hierarchical controls	Fractionated oversight	OMB--budget OMB--policy GSA--procurement NIST--Standards
Transitional	•Diffused IT accountability	Delegation according to capability •Agency-level responsibility	Broad classes of waivers Internal review •Independent assessment
	Collaborative responsibility	Business orientation Technocratic decision-making	Inter-agency committees
Transformed ✓	**Centralized IT accountability**	**Single point of control** **Management by exception**	**OMB oversight** **IT Review Board**
	Collaborative responsibility	**Business orientation** **Technocratic decision-making**	**CIO Council** **Inter-agency committees** **Inter-agency technology teams**

Moving away from the caveats about success in the Transformed era, it is necessary to reach closure about the successful practices identified in the study. Stages I and II provided a listing of practices that proved effective or were perceived to be effective by members of the information technology community. Those specific practices are shown in contrast to the other two oversight periods in table VII-C-I.

Apparently, the Stage I and II results indicate that the highlighted practices can be used to achieve successful results with large-scale information technology systems when administered by an effective oversight organization. That observation applies to troubled programs as well as those that are on a track towards success. Thus, the Transformed practices are viable and, if managed appropriately, can be used with skill to positively affect the largest and most important federal information technology programs.

However, the previous caveats about opportunities for success in the Transformed era must be incorporated into the overall findings. These include consideration of the Transitional precept annotated with a star in the table, namely, the one about Diffused IT Accountability. Its link with successful practices was previously demonstrated and discussed in the case studies. By incorporating those caveats and considerations, the answer to the study question becomes:

> Study Question Response: *Yes, Transformed methods resulting from mid-1990s Administration and Congressional reform of information technology accountability practices will cause improved economy and efficiency in many federal agencies' largest and most important information technology programs. However, troubled programs will not receive much central management attention, thereby placing them at further risk with a high chance of failure.*

Regarding the question's associated propositions, the answers are given by the following:

> *"Yes, information technology accountability can be classified in three time periods, namely Traditional, Transitional, and Transformed, because of overarching changes in beliefs about administration"* (Proposition One),

"Yes, transformations of the central oversight agencies' information technology roles and methods will substantively cause specific and identifiable changes in information technology outcomes" (Proposition Two), and

"No, Transformed accountability changes will not focus central management agencies on holding individual federal agencies accountable for the outcomes of their information technology programs; instead OMB's facilitative approach will leave agencies to fend for themselves without viable central oversight in managing their most troubled programs" (Proposition Three).

As a further caveat to the affirmative response to the research question, opportunities for Transformed era success can be further improved by embedding the Transitional idea of agency-level responsibility, which is concomitant with the Diffused Authority precept--and particularly the Independent Assessment mechanism, in the "new" Transformed approach. From the earlier observations about OMB and its role, three added cautions augment the negative answer to the last proposition. They are in the following.

First Caution: The first area of caution is the understanding that facilitation is not the same as oversight. The proverbial 10% that require 90% of all management attention are also in need of oversight. Facilitation can be very helpful in those instances but cannot replace the oversight attention brought about through independent assessments or "time outs" as shown by the case studies.

Second Caution: A second caution is given about the concept of centralization versus fragmented authority. This is the old issue of Hamilton versus Madison with efficiency and economy the injunction of the first and distrust of concentrated power the watchword of the second. The loss of fragmented accountability for information technology may have some rather undemocratic implications. Dwight Waldo (1985) called democracy a "striving towards freedom and equality." Dispersed authority means a multiplicity of opportunities to sway outcomes; dispersion is open and promotes freedom through pluralism. Centralized power, on the other hand, tends to be constrictive; there may be no opportunity for point and counterpoint to sway the balance.

In the old Traditional and Transformed eras, citizens and vendors had multiple forums in which to make input or seek redress in the case of information technology procurements. Such multiplicity promoted equality because almost anyone could find an "ear" that would listen. The Transformed era with its reliance on committees means that decision-making tends to become a back room affair; for citizens the participatory opportunities of rule-making can become obscured in that scenario. Thus, a word of caution must ensue about seeking a reasonable balance between Hamilton and Madison; that is, between the closed coldness of political back rooms or technocratic economy and efficiency and a need for freedom and equality by way of openness to citizens for their input, participation and redress.

Third Caution: The third and final caution is one given about the role of the Office of Management and Budget because, as shown in the case studies, it remained ineffective throughout the Traditional and Transitional periods for large programs; it had failed to use its considerable "clout" in dealing with those large-scale debacles like the troubled FAA Advanced Automation System or the NOAA Advanced Weather Information Processing System information technology programs. Though the survey and case studies suggest that success is likely for many programs in the Transformed era, such a projection is predicated upon OMB also applying those precepts, attributes and mechanisms identified in this study to troubled systems. A note of caution is clearly in order because such actions have not been, as of mid-1996, in OMB's repertoire. For all of the reasons described earlier in this section, it is not likely that OMB will be able to do so, and thus problems with troubled systems will probably not be effectively addressed.

Yet, OMB is charged with taking the lead responsibility for information technology oversight under the 1996 reform legislation. The survey and case study findings show that OMB could possibly be successful if it disavows political machinations and straightforwardly applies the identified precepts, attributes and mechanisms in a well-managed way. OMB's past belies its ability to fulfill that injunction.

Further, by focusing on management through committees, OMB as of mid-1996 telegraphed its facilitative intentions. Moreover, by launching its first ITRB since the 1996 enactment of reform legislation to the Office of Personnel Management rather than major information technology debacles raised very serious questions about OMB's political motivations.

Thus, it remains to be seen if OMB can maneuver its way through mine fields consisting of minimal staff, no in-house technical expertise as well as political machinations and catharsis, and learn how to successfully apply oversight to large-scale, multi-billion dollar debacles like FAA's Advanced Automation System or IRS' Tax Systems Modernization. If OMB can become adept at those skills and still "transform" itself into a new, facilitative role, then the Transformed era will, indeed, be one of success and accomplishment for information technology. However, OMB's past does not auger well for success in its assumption of these new roles and responsibilities. Troubled programs will probably be fending for themselves in the new era.

D. Study Findings

In summary, seven overarching findings stem from synthesis of the results of Stage I and Stage II. Specifically, these study findings were the following:

Study Finding 1: There is a continuing need in the mid-1990s for central management of information technology accountability and oversight.

Study Finding 2: Accountability should focus on two Transformed era precepts, Centralized Accountability and Collaborative Responsibility, and their associated attributes and mechanisms.

Study Finding 3: The Transitional era precept of Dispersed Accountability and particularly its independent assessment mechanism should also be incorporated into the new, Transformed model.

Study Finding 4: The two most effective oversight mechanisms for problem programs were those associated with the first two precepts, namely, independent assessments commissioned by the agencies, and external intervention by an Information Technology Review Board under the aegis of a key central management agency.

Study Finding 5: Overall, congressional influence over information technology at the government-wide, agency and even project levels appears to be on the rise, at the expense of the central management agencies which, in the aggregate, are on the wane in their overall degree of influence.

Study Finding 6: Although facilitation is becoming the hallmark of the Transformed era, there are still a number of large-scale, multi-billion dollar information technology programs whose failures need to be dealt with through oversight controls and more management-oriented methods.

Study Finding 7: All central management authority for information technology oversight resides in the Office of Management and Budget in the Transformed period. However, given it's past history plagued by politicization and a lack of management focus it appears unlikely that OMB can rise to the task of effectively overseeing those large-scale, troubled information technology programs in the Transformed era. Such programs will probably be left to fend for themselves in large part, thereby, increasing the risk of their overall failures.

Accordingly, transformation of federal information technology appears to be headed in a generally positive direction in the mid-1990s for those programs that would benefit from facilitation and do not need oversight from a central management agency. Such programs will benefit from the removal of most controls and increased opportunities for collaboration. The challenge of achieving results through facilitation rather than oversight controls will probably be the high water mark of this new government-wide approach in the Transformed era. OMB's skill at orchestrating such facilitation will be its determinant for improved success in those types of programs.

However, while OMB may have some successes in facilitating inter-agency collaboration on information technology issues, its past history suggests that it is probably not up to the task of managing troubled programs. Several such troubled programs valued at billions of dollars are already before the public's eye; OMB must demonstrate its worth early in the new era in order to obtain even a modicum of credibility. It will be the response to this area of caution coupled with the one about there being no "M" in OMB that will make or break the reform hallmarks of the Transformed era. Success or failure with its inheritance of troubled information technology programs like the Federal Aviation Administration's Advanced Automation System or the National Oceanographic and Atmospheric Administration's Advanced Weather Information Processing System will be the test of the new Transformed approach.

Moreover, the true nature of the overall information technology accountability transformation will be tested by the way in which it balances through implementation its innate technocratic economy and efficiency motivation with the democratic needs of the United States citizenry for input, participation and redress. Rather than promoting citizen freedoms and equality, the new era has seemed to start with a "closed-to-the-public" approach to implementing a "bottom-line" focus on dollars and cents. The Transformed era will certainly be a time of testing for Congress as well as the entire federal information technology community in determining if the new accountability can promote rather than detract from democracy.

It is expressly true that early successes are needed by the Office of Management and Budget in facilitating resolution of issues, in implementing collaborative efforts to improve agencies' information technology management programs, and in addressing troubled systems. Especially the third challenge needs an early demonstration of OMB prowess or else the Transformed era's inheritance of troubled systems could easily become its legacy; Congress could readily take what it had bestowed on OMB in the event of failure. Power and authority over federal information technology could be transformed, again.

E. Conclusions

This paper explored centralized management and oversight in federal information technology, which is one of today's important public administration issues. Specifically, this study assessed whether mid-1990s Clinton Administration and 104th Congressional reform of information technology accountability practices will cause improved economy and efficiency in federal agencies' largest and most important information technology programs.

Major changes occurred with the enactment of reform legislation that will transform federal information technology oversight mechanisms. However, it was shown that the overall federal-level focus on information technology will not diminish. Instead the new reform direction will centralize and strengthen statutory authority for information technology oversight in the Office of Management and Budget at the government-wide level. Those changes as implemented are facilitative rather than oversight oriented. Accordingly, they seek to manage through collaborative responsibility rather than control by means of oversight.

Nonetheless, without oversight and an "M" in OMB those changes may find success to be elusive when addressing endemic problems such as the multi-billion dollar cost overruns of some major information technology systems. Thus, Transformed era reforms will probably not improve the success of large-scale, troubled information technology programs. Instead, the new facilitative approach will likely leave agencies to fend for themselves without viable oversight in managing their largest and most troubled programs. This lack of central management and oversight will probably cause a continued pattern of failure for those large and troubled systems.

Notwithstanding, taken together all of the changes have a good probability of improving the success of many of the largest federal information technology programs including their timely and cost-effective delivery of mission-level results. In particular, those programs which encounter only easily correctable problems will have an opportunity for improved efficiency and economy through the speed of reduced oversight and the collaborative opportunities of the new facilitative era. Successes in this area will probably prove to be the high water mark of the new approach.

F. Suggested Topics for Additional Research

The topic of this dissertation, transformations of federal information technology accountability, will undoubtedly remain a cutting-edge public administration topic in the foreseeable future. The whole information technology oversight concept and its breadth of impact place it among today's leading administration issues. Though this study added new knowledge, many additional opportunities for research also have broad administration and policy implications. Examples include:

Follow-on Research: The results of this study are predictive. It will be both interesting and instructive to contrast these findings with actual experiences of the Transformed era in a few years.

Agency-Level Research: Agencies of the United States government are both required and empowered to reform their internal oversight practices as a result of the 1996 government-wide information technology reform legislation. Accordingly, opportunities are open for a number of specialized and comparative studies.

C^2I Research: A similar approach could be applied to command and control system programs, or to those in the intelligence community. While many difficulties would ensue because of the classified nature of a number of these systems, the resulting knowledge could provide new models for action.

Collaborative Research: The Brooks Act had a profound effect on federal information technology procurement practices for almost 30 years. New results could come, for example, from a study of the collaborative relationship and joint effect of GSA's Brooks Act policies on overall federal procurement policies, in historic perspective. Such a study could form a baseline for assessing reform efforts in other federal arenas.

Comparative Research: Comparative research with other governments' accountability and control programs could bring important knowledge and might identify new significant models, propositions and issues.

Decision-Making Research: Appendix B provided a mathematical analogy to the precept-attribute-mechanism decision-making model. The approach suggests that advanced mathematics may provide additional research opportunities for deriving other types of decision models which could be used in the accountability problem, information technology management or public administration, in general.

In conclusion, it is clear that federal information technology oversight will continue to offer many public administration research opportunities

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APPENDICES

Appendix A: Information Technology Primer

This primer is not intended to describe the use of personal computers (PCs) or telecommunications in modern public organizations. Nor was it designed to introduce the reader to local area networks (LANs), the Internet or the myriad array of software products. Most people have at least a modicum of knowledge about those products; books with names like *Windows for Dummies* can be easily be used by a reader for that type of instruction.

Rather, the purpose of this appendix is to briefly describe information technology as a field of study in the context of its historical development. A multitude of disciplines which cut across almost all of human endeavor are the sources of knowledge about this field. They range from very theoretical mathematics used to design computer logic and algorithms to complex physics employed in the design of computer chips. The social sciences also come into play because they contribute design criteria for ergonomics and applications programs. Both the social and natural sciences have driven information technology developments due to their unquenched needs for processing and communicating data. Accordingly, this appendix approaches the task of describing the field's breadth from three perspectives, namely, requirements, abstraction and technology. Together, they present a holistic perspective about the development and growth of information technology.

Requirements

The point is simply that information technology cannot be described as just "hardware and software." Rather, advances in information technology are caused by specific requirements that necessitate an information technology solution. As an example, Augustus Caesar wanted "all the world . . . to be enrolled." Caesar's requirement was clear. Regarding requirements, it is specificity and functionality are the keys. As another example: "Compute the *n*th root of 2" is only a legitimate requirement for a known *n*. A requirement must be viable. In any such case, both a sufficient level of mathematical abstraction and appropriate hardware and software are necessary to act on a viable requirement and derive an information technology solution.

Abstracting a mathematical model from the requirement assumes that there must be a theory-based solution to that problem. Since this is not true in general (it is trivial to show that the probability is zero for any arbitrary problem to have a solution), it may often be necessary to identify an acceptable level of approximation for "solving" the requirement. These two thoughts demonstrate the importance of placing abstracted requirements in a systemic framework because such an approach, for example, excludes "propitiating the gods" as a way to achieve a solution. Rather, it places theoretic approaches in the realm of analytic solutions or algorithms which converge (actually or heuristically) to solutions. Theoretic methods must also be tractable in the sense that solutions (approximate or actual) can be found in an acceptable and finite amount of time; "acceptable" must be determined with respect to the requirement at hand.

Regarding technology, appropriate equipment or "hardware" and "software" must be available. Hardware necessary to solve the problem: "divide 70 acres into 9 parcels" could range from one's innate intellect to a computer displaying a screen: "**Press The Button Labeled Enter To Solve The Problem**," depending upon the individual person's skills. The point is that "hardware" is not universal with respect to any given requirement; development and selection of hardware must be contextual. Further, hardware may not exist to solve any given problem. As an example, there is no hardware currently available which can, in a tractable period of time, solve the problem posed by the requirement of balancing the United States government's budget in seven years, to the satisfaction of both Democrats and Republicans.

Abstraction

The essence of any tangible, real-world problem needs to abstracted and placed in a conceptual, quantitative framework before an information technology solution can be developed. A few brief examples of important personages and events in computational mathematics are given in the following.

George Boole: Some very important theoretic foundations of computing were laid in an algebra devised by George Boole (1815-1864) which used true and false statements to identify basic logic rules. Although of no practicality for the information technologies of his era, Boolean algebra relying on binary choices (*i.e.* "true" and "false") would later provide the foundation for the information age's digital computer and communications systems which use two-state electronic devices.

Alan Turing: A British mathematician who lived from 1912 through 1954, Turing introduced an abstract model of a computer that satisfied two criteria of "reasonableness": 1) the machine should not store answers to all possible problems, and 2) it should process instructions at a finite speed (Hayes, 1988). There were two key components in his "Turing machine" model, namely, a processor and memory. Only a finite number or states could be assumed by the processor in his model which had an unlimited memory. Turing showed that any well-defined process could be replicated by a machine. He further proved the existence of a (theoretical) universal Turing machine which could simulate any other Turing computing machine.

Alonzo Church: The American mathematician Alonzo Church in the 1930s showed that such a universal Turing machine need only have s processor states and t memory symbols where $s\,t < 30$ in order to perform all possible calculations required of Turing's "reasonable" computer. The vagaries of a "reasonable" computer (*i.e.* what is meant by finite processing speed) makes it impossible to devise a rigorous proof of "Church's Thesis" (Hayes, 1988, pp. 4-6). Yet Church's Thesis was a major contribution because it provided a bound and a definition for such computational problems.

Kurt Gödel: A further theoretical development occurred when Kurt Gödel (1906-1978) in 1931 defined the computability of a function in terms of Turing machines. In his definition a function is computable if and only if it can be evaluated in a finite number of steps by a Turing machine. He also showed that there are a surprising amount of functions that do not meet this definition. Developing criteria for determining the computability of problems was his major contribution (Hayes, 1988, pp. 7-8).

Claude Shannon: Information theory arose principally from the World War II cryptographic studies of Claude Shannon. Publication in 1948 of "A Mathematical Theory of Communications" (Shannon, 1948) gave further impetus to researchers like Kotél'nikov, Wolfowitz, Fano, Gallagher and others (*e.g.* Blahut, 1987) who extended his initial results. Of all his contemporaries, Shannon laid the broadest base for understanding communications as a probabilistic process which is completely generalizable even to uncountably infinite (*i.e.* continuous or analog) signals. Before Shannon, people generally believed that perfect transmission and reception of information was not possible when there was noise in a communications channel. Shannon proved, instead, that each channel, noisy or not, has a calculable capacity, and data rates below that capacity can theoretically (with proper encoding) provide errorless communications (Blahut, 1987).

Norbert Weiner: His cybernetics concepts are used in the design of digital computers and communications systems. Norbert Weiner devised the term *cybernetics* in 1947 to signify a theory of control systems which is applicable at the animal, human or mechanical levels. He envisioned its purpose as one of developing and classifying broad ideas and techniques for control and communications (Schoderbek, 1990). According to Stanford Beer (in Schoderbek, 1990, p. 71) "The central thesis of cybernetics might be expressed thus: that there are natural laws governing the behavior of large interactive systems--in the flesh, in the metal, in the social and economic fabric." Numerous other contributors include Kenneth Boulding, T. Kailath, Otto Myr, Arthur Porter and Warren Weaver. Cybernetics has been applied to communications and computer design problems utilizing its feedback and control principles

George Danzig: Problem abstraction and iterative solution techniques were enhanced by Danzig's development of linear programming. His Simplex algorithm was computer implementable and applied to very broad classes of problems in both the social and natural sciences. It really gave major impetus to a very broad area of quantitative and computer-implementable techniques known as operations research. Optimal decision-making through developing and solving a systems model is the focus of operations research according to Hillier and Lieberman (1980). The name "operations research" indicates its World War II origins when its methods were applied to real-life wartime problems or "operations." After World War II, "British and American military services continued to have active operations research groups;" also "some of their techniques involve quite sophisticated ideas in political science, mathematics, economics," according to Hillier and Lieberman (1980).

Abstraction Summary: All of those advances demonstrate a tremendous growth in problem abstraction techniques and the theoretical foundations of computing over the last 50 years. The above mentioned contributors were only a few of the many people who have contributed and continue to do so, today. They continue to build upon the rich heritage of quantitative methods for problem abstraction and computer theory that developed over the four referenced eras. Since an important characteristic of many modern problems is their innate complexity, such methods have made many problems susceptible to solution with the aid of computers. It is the hardware and software described in the next section that enables computers to produce those solutions tractably and in reasonable periods of time.

Technology

A progression of hardware and software advances are arrayed, below. The intention is to chronicle a few important technology events and personages important to the development of mainstream computing and communications.

Charles Babbage: He lived from 1791 to 1871, and his celebrated contributions are well known. They included design of his Difference Machine and Analytic Engine. Especially the later set forth many of the general principles used in modern computers. For example, Babbage partitioned his Analytic Engine into a *Store Area* which maintained operating instructions and variables, and a *Mill Area* which processed the data through performance of arithmetic instructions. Although never built by Babbage, a Difference Engine was built by Peter Scheutz in 1854 based on Babbage's work. No known efforts to construct a general purpose computer occurred, again, until the 1930s (Hayes, 1988, p.16)

Herman Hollerith: During his years from 1860 to 1926 he not only developed an operational tabulating machine, but also applied it to a large-scale job, namely, the 1890 United States census. His tabulating machines processed about 60 million punched cards for that census in two years; the prior census results had taken six years. Hollerith's tabulating machines also performed the 1900 census. Later, in 1911, his company merged with several others to form the Computing-Tabulating-Recording Company which became the International Business Machines (IBM) Company in 1924 (Hayes, 1988). This technology held sway over the industry for many years. As an example, IBM won a major contract using Hollerith's technology as late as the mid-1930s. It was with the Social Security Administration for large-scale computation and tabulation requirements.

Howard Aiken: Several war-time electro-mechanical computers were built in the United States during the early 1940s, and provided a bridge between older mechanical tabulating machines and future electronic computers. The first was the Mark I or Automatic Sequence Controlled Calculator, designed by Howard Aiken (1900-1973) and built at Harvard University between 1939 and 1944. George Stibitz at Bell Telephone Laboratories designed the Model I through Model V computers between 1939 and 1946. All used electro-mechanical, telephone-type relays for completing circuits and adding to counters. Mechanical means were used for representing data and counting. Interestingly these machines all shared design similarities with Babbage's Analytic Engine; apparently, Aiken had some awareness of Babbage's work at that time (Hayes, 1988, pp. 16).

Konrad Zuse: In Germany, Konrad Zuse built a mechanical computer in 1938 named the Z1. His machine was the first to use binary rather than decimal numbers for computation. He was probably unaware of Babbage's prior work. His 1943 Z3 was the first operational, general-purpose, program controlled computer, according to Hayes (1988, p. 16). Like the American efforts, it also employed electro-mechanical relays for completing circuits and adding to counters. However, Zuse's work had little effect on future computers because his work was abruptly ended during World War II.

ENIAC: In the United States electronic or digital computing made its appearance when the general purpose Electronic Numerical Integrator and Computer (ENIAC) was built between 1943 and 1946, and later, Electronic Discrete Variable Computer (EDVAC) between 1944 and 1951 (Hayes, 1988, pp. 18-20). ENIAC's task was to calculate ballistics tables for the U.S. Army Ordnance Department. Like Babbage's Analytic Engine and the Mark I, it stored programs and data in separate memories. It was programmed by manually setting switches. Such arrangements made it difficult to alter the programs. A unique characteristic of EDVAC countered this drawback by using the same memory for storing both the program and data for control of its operations. This stored program concept was suggested by John von Neumann (1903-1957) to automate that process. These operational computers were both designed by John Mauchly (1907-1980) and J. Presper Eckert. Less well known, but slightly earlier, the so-called ABC electronic computer was designed by John Atanasoff at Iowa State between 1939 and 1942 as a special purpose device to solve linear equations.

First generation computers are those built during the 1940s and 50s which employed a single processor, the central processing unit or CPU, to control all operations; they relied on vacuum tubes for their electronic technology (Hayes, 1988, pp. 23-33). Programs were originally written in binary code or *machine language*; a later innovation used symbolic programming or *assembly language*. Examples of such first generation computers include the Universal

Automatic Computer (UNIVAC) designed by Mauchly and Eckert which also was the first commercial computer. One was sold to the Census Bureau in 1951 (Mills in Rabin, 1987, p. 38). IBM delivered its first commercial computer, a first generation one named the 701, in 1953.

Second generation computers were built between approximately 1955 and 1964. They were primarily characterized by their use of: 1) transistors rather than vacuum tubes, 2) special processors for input-output functions thus freeing the CPU for its main functions, 3) ferrite core rather than delay-line or cathode ray memories, and 4) higher-level programming languages such as FORTRAN, ALGOL and COBOL to simplify their programming (Hayes, 1988, pp. 30-35). IBM developed FORTRAN (FORmula TRANslation) between 1954 to 1957 using a team led by John Backus. COBOL (COmmon Business Oriented Language) was sponsored by the Department of Defense through the Conference on Data Systems Languages in 1959; Grace Hopper played a key role. Lincoln Laboratories at the Massachusetts Institute of Technology built the first experimental transistorized computer in 1953. IBM models 7090 and 7094 are examples of second generation commercial systems.

Third generation computers were built from 1965 through the early 1980s. The principle differences were the use of: 1) integrated circuits rather than transistors, 2) semiconductor rather than ferrite core memories, and 3) operating systems to control and share resources as well as concurrently execute multiple programs (Hayes, 1988, pp. 40-49). The IBM 360 line of computers typified this generation. The term "super computer" also originated in this generation, originally to denote specialized machines that employed multiple central processing units (CPUs) to increase computation speed for complexity-intense functions like weather forecasting or in certain nuclear research areas. Examples included the UNIVAC LARC, ILLIAC IV and the IBM 7030 (the "Stretch"). Multiple CPUs and specialized processors were later used to provide other third generation computers with their characteristic concurrent processing capabilities. Apparently, third generation computers represented significant advances from both the hardware and software perspectives.

Fourth generation computers. Afterwards, computers starting in the late 1970s through present are sometimes labeled as fourth or fifth generation because of changes in technology which have, in turn, caused significant performance improvements and cost reductions. Two additional significant trends have also impacted the technical directions of large-scale main frame computing. These are newer types of super computers and parallel processing. Over the last decade super computers have dominated the research arena market for special purposes such as aero-space or nuclear research. The other trend, parallel processing, utilizes multiple CPUs to execute the same program in a shorter period of time. This is a difficult area of development because parallel algorithms and software are a relatively new area of research. Considerable hardware and software research and developments continue in both areas.

Digital telecommunications. The case for digital telephony was strong in the 1950s and 60s. There were enormous cost and performance advantages including smaller space requirements, large reductions in operational and maintenance personnel, more telephone calls per pair of wires, and faster switching times resulting in increased capacities. AT&T began experimenting with digital techniques for both switching and inter-city carrier facilities in the 1950s and early 1960s. By employing the mathematical results of H. Nyquist and Claude Shannon developed during the 1920s through the 1940s, AT&T was able to successfully convert analog voice into digital transmission signals. Briefly, Nyquist showed that an entire waveform need not be sent in order to transmit all of its information; only a specifically-determinable finite sample of the waveform was needed. Shannon's Information Theory showed how to take the sample, encode it and transmit the voice conversation within any specified degree of fidelity or error.

AT&T began deploying the new digital technology in the mid-1960s and 1970s with introduction of the Number 1 ESS (Electronic Switching System) at its largest central exchanges, and T-1 carrier systems. ESS was the first true electronic switching system in the United States telephone industry. Its tremendously increased capacity meant that one ESS could replace several crossbar exchanges. A single T-1 carrier could replace 24 separate telephone circuits. T-1s required new digital modems (modulator-demodulators); the telephone companies had already been using older analog modem-like devices for their microwave and coaxial cable facilities. The potential for cost savings was enormous, performance was enhanced, and there were huge gains in reliability--an important factor for the risk-adverse telephone industry. In fact, AT&T devised a long-term strategy to digitize the entire telephone network because of these benefits.

However, AT&T failed to take advantage of its technological prowess in the customer premise arena. Rolm, not Bell, was the first company to introduce digital customer-premise private branch exchanges (PBXs) in 1975. In fact, the closest AT&T product was an older-technology PBX. Named Dimension, that PBX used pulse amplitude modulation, a hybrid analog-digital arrangement which did not provide true digital switching. However, by 1983 when the court-ordered divestiture of the Bell Operating Companies by AT&T occurred, there were a number of digital PBX manufacturers including Rolm, AT&T, Northern Telecom, Siemens and others.

A brief remark about telephony reliability. Telephone switching systems and facilities have always been built to perform very reliably, and for long periods of time. As an example, the Federal Telecommunications System 2000 (FTS2000) and its predecessor, the 1960s vintage FTS, both used many step-by-step, panel and crossbar switching systems as well as the newer digital ESS systems. Moreover, new step-by-step systems were obsolete in the 1930s and were not manufactured since the 1940s. Still, at least one remained in service as a primary backbone node on the FTS2000 as late as 1987. Although ENIAC and its cousins were all unplugged decades ago, telephone exchanges of all vintages have continued to provide reliable service. Many have continued in operation for decades.

Today, in the mid-1990s, digital communications are the rule. Telephone companies now deploy even more sophisticated digital devices such as AT&T's number 5 ESS. Large organizations purchase digital PBXs or digital services from their local telephone company and one of many competing long-distance (inter-LATA--local access transportation area) carriers. Competition for some types of local services is even possible in some locations. Modems are a common addition to home computer systems and allow anyone to "surf" the Internet. Even the lowly telephone has developed new functionalities such as call-waiting, caller-identification, one-touch memory dialing, and so forth. All of these advances are based on the same electronic or digital technological principles employed in the computer industry.

Personal computers (PCs). Regarding personal computers, probably everyone in the United States has been impacted by the personal computer revolution; it would not be an overstatement to say that the history of the human race is even now being radically transformed by its advent. The story of its spawning is briefly highlighted, below, followed by a short survey of current personal computer technology and capabilities.

Technology improvements such as large scale integration (LSI) and very large scale integration (VLSI) integrated circuits changed the course of computing. Starting in 1970 it became possible to produce an entire CPU on a single integrated circuit (Hayes, 1988, p. 69). In 1971 Intel Corporation introduced the first commercial microprocessor, the 4004, which could process four bits of information at the same time. In 1974 Motorola introduced an eight bit chip, the 6800, a year after Intel introduced the 8080, its eight bit chip.

In 1981 IBM initiated one of the most important and widespread changes in computing's direction when it introduced its personal computer (PC). Soon their were a large number of PC manufacturers competing for a share of the market. However, IBM and Apple have emerged as the two major standards for the industry. Apple maintained a closed architecture until recently, while IBM's more open approach caused a large number of vendors to manufacture so-called "clones" in competition with IBM. In fact, IBM lost its dominance of the marketplace relatively early as a testament to the effectiveness of such competition.

Early PCs used the above mentioned eight bit microprocessors to provide an impressive amount of computing capability to users. Almost immediately 16 bit processors such as the Intel 8086 became available. In those days a typical PC came equipped with a video display and at least two input devices, namely, a key board and at least one disk drive. Three factors made early PCs under both the IBM and Apple standards a success. Within each standard these were: 1) the compatibility of most hardware with most software, 2) the availability of a relatively wide variety of software applications, and 3) affordable pricing. Even early word processing programs provided considerably more capabilities than sophisticated electronic typewriters. Spreadsheets enabled mathematically unskilled users to perform relatively complex accounting and tabulating functions. Graphics programs provided display capabilities without the services of an artist or draftsman. A large market concurrently emerged for peripheral devices such as printers or data storage and backup devices.

In this way commercial success has driven hardware which has driven software which, in turn, continues to drive hardware research and development. Increased processor speed and large memory capacities enables PCs to run increasingly complex software which is needed to meet more sophisticated user requirements. And so the business cycle continues to push development of faster and more complex PC products in the drive for faster, smaller, better performing and less costly personal computing.

In the decade and one-half since the first IBM PC was shipped in 1981 huge changes have occurred in the industry. On the technology side, early processors could only operate on four or eight bits of information at one time. These soon gave way to processors operating on 16 and 32 and even 64 bits of information at one time; higher bit rates will surely be common in the future. Additionally, rates at which software instructions are processed have risen from eight in the earlier years to close to 200 MHz at present; higher speeds are in the offing. Many processors such as the Intel 80486, AMD or Cyrix 486 and 586, and Pentium are familiar names to a growing class of PC consumers. Their technical processing speeds, functions and special features are very familiar to a wide cross section of consumers of all ages.

PC Software: The evolution of software has also been phenomenal, and has paralleled the hardware progression in its rapidity and breadth. Rudimentary operating systems barely able to load a program have given way to sophisticated ones with multi-tasking capabilities that enable them to execute multiple programs, concurrently. Advertisements in newspapers, mailers and on television entice consumers to purchase the latest version of Windows™, WordPerfect™, Excel™, or MicroSoft Word™ as well as an entire panoply of software to balance check books, prepare income taxes, devise new recipes from the kitchen, teach a child how to type or just play games with eerie graphics of exotic characters. Though not as close together as hardware, software generations are also short lived. New ones have increased functionality, and typically use nuances of the latest hardware to leverage overall performance improvements.

From the business perspective information technology has blossomed with incredible growth into a multi-billion dollar business that spans the globe. It was always tough; it is now a fierce, cut-throat business. Customers demand state-of-the-art hardware and software; they do not like to be left behind. Former leading-edge hardware manufacturers like KayPro™ and Sinclair™ or software brand names like WordStar™, VisiCalc™, MultiMate™ and PFS™ have now passed from most users' memories. WordPerfect was the word processing program of choice as recently as 1992 and commanded the largest share of the market. An "also-ran" with only a small fraction of the market at that time, MicroSoft Word™, now has engulfed over 65% of the word processing market. WordPerfect™ now has less than 30%; as of December 1995 it was anxiously for sale by its owner, Novell™. It was sold in February 1996 to Corel™. There is currently only one superpower in the software arena; MicroSoft dominates in the mid-1990s. Intel is the mid-1990s giant in microprocessors. There is no leader of that stature in PC manufacturing. However, numerous other hardware and software vendors still compete for the remaining business in all areas.

LANs. Before ending this section, client server architectures must be mentioned. High speed local area networks (LANs) are used to link PCs together using a high-powered PC which is called a server. There are several advantages. First, networked PCs can communicate, thereby, providing electronic mail or email capabilities to users. Numerous other productivity enhancements are possible such as sharing calendars, spreadsheets, reports and even standard forms or letters to reduce business errors through standardization. Significant cost savings and economies can also be achieved in both large and small organizations because of software vendors' pricing strategies. It is typically less costly to purchase software for the server and a license for each user than it is to purchase the same number of individual copies of the software. Finally, in such an environment the LAN manager can use the server to change, reconfigure and update all PCs on the network quickly and in a standard manner. Thus, maintenance costs and personnel requirements can be greatly reduced. For these reasons client server architectures have become preferable to individual (*i.e.* stand alone) PCs or even most mainframe computing environments from the cost, performance and functional perspectives.

Summary

This appendix briefly described information technology which is a broad field of study. It was seen to draw upon a multitude of disciplines that cut across almost all areas of human endeavor. Additionally, a discussion of some important contributors and their contributions showed the range of the field to extend from highly theoretical mathematics used to design computer logic and algorithms to complex physics employed in the design of computer chips, and from there to the social sciences which have contributed design criteria for ergonomics and applications programs.

Appendix B: Decision-Making

This appendix provides a mathematical analogy to the public administration accountability architecture developed in Chapter V which consisted of three tiers, namely, precepts, attributes and mechanisms. The application of the three-tiered architecture to federal information technology accountability was described in Chapter V. However, that three-tiered architecture also has a close correspondence with mathematical and statistical decision making. The correspondence, described below, suggests that advanced statistical and mathematical analogies can be used to develop models of other public administration accountability processes and decision making areas.

Authors such as Herbert Simon, Robert Behn and others have long called for public administration to expand its usage of mathematics and statistics; in particular, some have suggested that the application of advanced mathematical techniques would be of significant benefit to modeling public administration phenomena. The three-tiered accountability architecture described in Chapter V provides an opportunity to demonstrate the efficacy of that suggestion because it can be modeled using advanced mathematical techniques from information theory. To demonstrate that thought, one such approach is extracted from an information theory article by Wolfe (1995), and it is used to develop an advanced mathematical model of the decision making aspects of the three-tiered architecture in the following. Subsequently, the results of exercising that model are assessed from another mathematical perspective to complete the modeling process.

This appendix is self contained. That is, it develops the relationship between the precept-attribute-mechanism problem and the mathematical analogy through non-mathematical description, and it also provides the mathematical details. For convenience, this appendix is structured so that the mathematical analogy is accessible to non-mathematical readers through conceptual description and examples. Mathematical completeness is provided for those interested in the quantitative specifics of modeling the precept-attribute-mechanism problem using the suggested mathematical approach.

Two Problems

Information is a fundamental concept for general problems in public administration decision making. Complete information about the circumstances surrounding a decision leads to certainty about its causes and effects. However, decision making typically operates in an vacuous environment where knowledge about causes and effects is incomplete; uncertainty seems to characterize the reality of a decision-maker's lack of complete knowledge in most cases. Thus, the generalized decision making problem in an environment of uncertainty can simply be expressed as follows: Given only a certain amount of information, how should a decision-maker render a decision in a particular situation? That is, the problem is really one of modeling the decision making process in a situation where the decision-maker has less than perfect knowledge. Allison, Linblom and Simon are only a few researchers who have developed models of the public administration decision making problem under such circumstances.

Decision making is not solely restricted to public administration. Instead, it is a very broad concept that seems to stretch across all of nature. That concept is replete throughout social and natural phenomena. Its underpinning issue is one of the method of selection between various alternatives subject to identifiable constraints. Of particular interest in the development of a mathematical analogy to the accountability architecture is the applicability of the generalized decision making concept as it comes to bear on the field of information technology, specifically, in the design and construct of various communications and computational devices. Decision making in that context means choosing between alternative explanations about the transmission or reception of a signal when less than complete information is available due to the effects of noise on hardware components or the system, in general. Therefore, in the communications arena the problem is also one of modeling the decision making process in a situation where there is less than perfect knowledge subject to some identifiable constraints. Information theory is the mathematical tool used by researchers to model such decision making problems.

Accordingly, there is a direct correlation between public administration and computational decision making problems. Clearly, one can be used to develop a model in analogy to the other. One such mathematical model is suggested by an approach in (Wolfe, 1995). A mathematical model based upon information theory can be developed from that approach which, in turn, corresponds to the precept-attribute-mechanism problem from Chapter V. This is true because the concept of a precept is closely associated with the concept of a class of information sources in the classical information-theoretic sense. That correspondence is explained in the following.

Decision Making

Any decision-maker has beliefs about the world; each operates from a value-based perspective when rendering decisions and choosing between alternatives. Another way to express the thought is that in any decision making situation one or more precepts are identified for optimization (or "satisficing," *et cetera*, depending upon the model), and which are based upon the decision-maker's values. That is, the decision-maker selects a particular precept because it fits his or her belief about the desired or actual and true state of the world in the ontological sense.

By selecting a precept of "Eliminate Poverty in the United States," for example, a decision-maker is really making an ontological statement that the world (*i.e.* people in the United States) is correctly modeled by a presumption about impoverishment (or wealth) ranging over all such people. The decision-maker's goal is to eliminate that poverty. To effectuate that goal, the decision-maker must first select one or more qualities (attributes) of that precept "Eliminate Poverty in the United States" upon which to focus. As an example, "Ensure that each child receives at least a nutritional level of y each day" could be an attribute of that precept. Thus, attributes are not generalized, but focused and, in fact, are the essence of that precept with respect to some value-based criteria. Prospectively, the decision-maker will devise implementing mechanisms for those attributes. That is, the chosen mechanisms are selected in an attempt to implement the attributes rather than to directly implement the precept, itself.

Retrospectively, the decision-maker will look back after implementing the mechanisms to ascertain if expectations related to those attributes have been met. Thus, performance measures may generally be directly applied at the attribute level, but not at the precept level. So, another way of looking at precepts-attributes-mechanisms is from the performance measurement perspective. In that venue, attributes (mission-level goals) are chosen to characterize precepts (agency mission). Mechanisms implement those attributes. Mechanisms can also be measured, but typically only at the process level. Attributes correspond to mission-level performance measures, *e.g.* "Ensure that the each child receives at least a nutritional level of y each day," and where the percentage of children receiving nutrition at the y-level can be measured.

Look at another example. "Stop Crime" is a precept, and a decision-maker could select an attribute of "double the penalty for crimes committed with guns" in response to a political criterion arising from the gun-control lobby. [Crime has a certain distribution over the ontological world (precept); too many crimes are committed with guns is its essence (attribute) in this example.] An implementing mechanism could be "more on-foot police patrols in the inner cities." "Stop Crime" cannot be measured; "double the penalty for crimes committed with guns" can be measured at the mission-level. "More on-foot police patrols in the inner cities" can be measured, but only at the process level.

The precept-attribute-mechanism problem can now be summarized as follows. Based upon his or her values a decision-maker selects a precept which is really a ontologically statement about how the world is distributed with respect to some desired (or not desired) commodity or trait. Subsequently, the decision-maker extracts qualities or attributes from that precept which optimally (with respect to some criteria) characterize that precept. Then the decision-maker assigns implementing mechanisms for those attributes.

That same precept-attribute-mechanism problem can be modeled and restated mathematically, as follows. The decision-maker assumes that the world has a certain mathematical form in the functional sense. That is, the mathematical form assumed by the decision-maker for the state of the world actually takes the shape of a probability distribution which ontologically characterizes the world, and its structure is based upon the values of the decision-maker.

In the case of the "Eliminate Poverty in the United States" example, the ontological form of the world assumed by decision-maker was really a probability distribution--there was too high a probability of people living in poverty in the United States! However, what is poverty for one person may not be so for another. Owning only a few clothing outfits might characterize "poverty" for one, while dietary constraints might be the touchstone of the issue for another person, and so forth. While the decision-maker might assume a certain general form of a probability distribution (i.e. precept) for the "Eliminate Poverty in the United States" problem, the qualities (i.e. attributes) which define "poverty" are still an issue because of individual interpretations. Thus, the decision-maker must extract qualities (attributes) which further define the specific probability distributions upon which to focus. As an example, "Ensure that each child receives at least a nutritional level of y each day" could be an attribute extracted from the probability distribution (precept) that there was too high a probability of people living in poverty in the United States. Thus, precepts can be mathematically modeled as classes of probability distributions. What remains is to model their attributes in a mathematical manner.

One way to mathematically model the attributes part of the problem is by viewing them as parameters of the probability distribution which characterizes the given precept. Using the "Eliminate Poverty in the United States" example, let the probability distribution that "there is too high a probability of people living in poverty in the United States" have a parameter that takes a value of "clothing." Now, let that same probability distribution's parameter take the value of "diet." If the question is then asked: "What is the probability of people living in poverty in the United States?" it is clear that two entirely different answers may result; two different attributes (parameter values) were used to evaluate the likelihood of poverty.

Mathematically, what happened is that $f(x)$, the probability distribution "there is too high a probability of people living in poverty in the United States," had an associated parameter θ that could take different values. (In this example x is "time," and the probability distribution really describes the assertion: "There is too high a probability of people living in poverty in the United States at time x.") Moreover, each different value of the parameter really generated a different probability distribution, $f^{\theta}(x)$. (For a specific parameter value of "clothing," for example, the probability distribution became: "There is too high a probability of poverty in the United States with respect to clothing at time x.") Therefore, modeling attributes as values of a parameter really meant that the model became a class of probability distributions $\{f^{\theta}(x)\}_{\theta \in Z}$ where Z is the set of all possible parameter values. Apparently, each value of the parameter produced an individual probability distribution $f^{\theta}(x)$, and the mathematical problem of selecting the attributes became one of selecting the "right" values of the parameter.

Since it is now a functional (i.e. class of functions) problem, the decision-maker must select one or more parameters--which, in turn, determine specific and individual functions--as optimal (with respect to some criteria) representatives to characterize that class of functions. That is, the precept-attribute-mechanism problem is now mathematically modeled as choosing specific parameter values (attributes) to characterize the precept (parameterized class of probability distributions). Subsequently, the decision-maker can use those individual probability distribution functions given by the selected parameters (attributes) to devise an implementation solution (mechanism).

A method for modeling the precept-attribute-mechanism problem can now be concisely and mathematically stated. In the mathematical sense, therefore, the problem becomes one of using some performance criterion to select from a class of probability distributions (*i.e.* a precept) certain individual distributions given by parameter values (*i.e.* attributes) to represent that class. Once the representatives (attributes) are known, then implementing mechanisms can be chosen by the decision-maker. It is in this way that the model is developed, and the mathematical problem is analogous to the precept-attribute-mechanism one. An example demonstrates the concept.

Modeling Example

Some insights about the suggested modeling method are seen by returning to the example where "Eliminate Poverty in the United States" was the precept, and two possible attributes were identified as "clothing" and "nutrition." Two implementing mechanisms for the "nutrition" attribute were "food stamps" and "subsidized school lunches." Two implementing mechanisms for the "clothing" attribute are identified as "tax free status for charitable organizations that supply clothing to the needy" and "clothes are not counted as assets in determining welfare payments."

In the following, it is assumed that the problem to be solved requires "Attributes" to be the parameter space, "Precepts" to be a class of information sources where "Mechanisms" attempt to reproduce the intent of those given attributes of the precept. Note that the problem to be solved directs the assignment of precepts, attributes and mechanisms to appropriate roles. The suggested approach is quite resilient, in that way, because it permits modeling of any variation of the precept-attribute-mechanism problem through interchange of each of their roles, and construction of appropriate probability distributions. That is, other precept-attribute-mechanism problems can be modeled by simply interchanging their roles and constructing appropriate probability distributions. Moreover, other factors such as time, geography or politics can be included as variables and arguments of parameterized functions, or as parameters. This indicates the richness of the suggested approach in modeling public administration precept-attribute-mechanism phenomena while accounting for a range of social, economic and political factors.

To begin explication of this example, recall that each precept is a collection of information sources and, therefore, a class of probability distributions. For instance, any attribute or quality extracted from the "Eliminate Poverty" precept can be said to have a certain probability that can be assigned to each poverty-related event; it can be specifically written in mathematical notation as: Pr (poverty event). For ease of explanation in this example it is assumed that there are three possible events: (1) the poverty rate is "good," (2) it is "marginal," and (3) it is "poor."

Recall that the attributes for this example were already given as "nutrition" and "clothing." Each attribute is a parameter value for the precept's probability function; it provides the value-basis for determining whether the poverty rate is good, marginal or poor. Therefore, the probability distribution should be rewritten to show this dependence on attributes which are its parameters; the applicable notation is: $\mathrm{Pr}^{\mathrm{attribute}}$ (poverty event). Clearly, any precept is, therefore, a collection of information sources that is really a class of parametric probability distributions, and each such distribution is given by an attribute.

In a similar vein, and by utilizing the concepts in earlier sections, it is clear that information about the success of using mechanism i to achieve the intent of precept value j can be written as a conditional probability distribution. (Notice that "success" can be defined in many ways; it could, for instance, be the probability of funding a particular mechanism or the probability that a program would be "downsized.") This is true because, as discussed above, any information source is equivalent to a probability distribution, and the outcomes of any mechanism provide information about successful achievement of the intent of any precept. Thus, the modeling process also relies upon construction of appropriate conditional probability distribution(s). To demonstrate this concept, five possible conditional probability distributions for one simple instance of the "Eliminate Poverty in the United States" precept-attribute-mechanism problem are shown below. Clearly, many other conditional distributions could be constructed depending upon the specifics of the problem. The basic idea in constructing these simple distributions is whether the mechanisms are successful (in this case: "yes" or "no") with respect to an attribute, and for a given value of a particular precept.

<u>Conditional Probability Distribution 1:</u> $\mathrm{Pr}^{\mathrm{attribute}\ k}$ (mechanism i | precept value j) is defined as the probability with respect to the kth attribute that mechanism i achieves success consonant with the jth value of the given precept. This is a conditional probability. Note that the number of attributes, k, is finite in this case; in the simplest instance it is a single-valued parameter. (Further observe that "achieves success" really means "achieves success at some point in time, x. For simplicity, any statement about time is omitted, but implied, in the remainder of this part of the example.) Using the "Eliminate Poverty" precept one such instance could be:

$\mathrm{Pr}^{\mathrm{attribute}\ k\,=\,\mathrm{nutrition}}$ (mechanism i, subsidized lunches, is successful | precept value j is "marginal");

where the equation can be read as the probability that the "subsidized school lunches" mechanism achieves success with respect to an attribute of "nutrition" when the value of the precept is that the poverty level in the United States is "Marginal." The following sample distributions build upon this simple structure.

<u>Conditional Probability Distribution 2:</u> $\mathrm{Pr}^{\mathrm{gradations\ of\ attribute}\ k}$ (mechanism i | precept value j) is defined as the probability with respect to a continuum of gradations of the kth attribute that mechanism i achieves success given the jth value of the precept. The problem becomes one of determining which level(s) of the attribute is best for determining overall success and tracking progress for the given precept over all of its value. Note that attribute k has (uncountable)

gradations; its range would probably be over a continuum of acceptable values. Using the "Eliminate Poverty" precept one such instance could be:

$\Pr^{\text{attribute } k = \text{clothing gradations}}$ (mechanism i, subsidized lunches, is successful | precept value j is "marginal").

Conditional Probability Distribution 3: Basically the same, but with a vector construction of an array of k attributes. The problem becomes one of selecting at least one value for each of the k attributes for determining overall success and tracking progress for the given precept.

Conditional Probability Distribution 4: $\Pr^{\text{gradations of } k \text{ ordered attributes}}$(mechanism i | precept j) is defined as the probability with respect to the some level of one of k ranked attributes that mechanism i achieves success given the jth precept. The problem becomes one of determining which level(s) of each attribute is best for the precept with j values to be monitored to determine overall success and track progress. Note that each of the k attributes has (uncountable) gradations; the range for each one would probably be one of acceptable values. Their ranges would be concatenated. Using the "Eliminate Poverty" precept one such instance could be:

$\Pr^{\text{attributes=clothing\&nutrition gradations}}$ (subsidized lunches mechanism is successful | precept value is "marginal").

Conditional Probability Distribution 5: Basically the same, but with a vector array construction of n precepts. The problem becomes one of selecting at least one value for each of the k attributes for determining overall success and tracking progress for the j possible values for each of the n precepts. Observe that in this model any mechanism could conceivably contribute to the success of any precept value in the vector array of j precepts.

These distributions show how information theoretic concepts can be applied to the basics of the precept-attribute-mechanism problem. The first distribution will be used, later, to develop a model of one specific instance of the "Eliminate Poverty" problem. Clearly, there are many other possible variations of those distributions for use in developing models for other instances and types of the precept-attribute-mechanism problem.

Distortion:

An important concept is necessary to complete the preliminaries of the modeling process. It is the criterion that is used in this particular instance of the precept-attribute-mechanism problem to choose between the precept's attributes. Observe that, in general, mechanism i does not completely and unequivocally implement and fulfill the intent of precept value j. That is, there is usually some *distortion* between the intent of j and the outcome rendered by i. This fact can be restated by saying that, in general, mechanism i does not usually *reproduce* the intent of precept value j without some loss of *fidelity*. It is really the latitude or slippage permitted by the decision-maker between the intent of the precept and the actual results achieved by the implementing mechanisms.

This terminology is insightful because it places the modeling problem in information theoretic terms. That is, a measure of distortion can be assigned to the reproduction of precept value j by mechanism i. It can be denoted by $d(i,j)$ and assigned a value for a specific mechanism i and precept value j. For example, where:

$\Pr^{\text{attribute } k \text{ - nutrition}}$ (mechanism i, subsidized school lunches, is successful | precept value j is "marginal"),

$d(i,j)$ could be rated on a scale from one to 10, or it could be set equal to a fraction of the mechanism's cost. Many other ways can be devised to assign a value to $d(i,j)$; without loss of generality, only positive values are assigned to be consistent with an information theory convention. In that way, larger values indicate a "penalty" when mechanism i does a poor job of reproducing the intent of precept value j. However, what is really of interest is not the distortion for individual measures. Rather, it is the average distortion for multiple mechanisms and values of the precept. That is:

$$D = \sum_{i,j} \Pr^{\text{attribute } k}(\text{precept value j, mechanism i}) \cdot d(i,j).$$

$\sum_{i,j} \Pr^{\text{attribute } k}$(precept value j) $\cdot \Pr^{\text{attribute } k}$(mechanism i | precept value j) gives the joint probability distribution of $\Pr^{\text{attribute } k}$(precept value j, mechanism i). Clearly, the distortion concept indicates permissible slippage between a precept and its mechanisms; it is this example's selection criterion.

Modeling:

With those preliminaries, the modeling process can now be completed. The distributions showed how information theoretic concepts can be applied to the basics of the precept-attribute-mechanism problem. However, the problem selected for this example is one of determining which of the k attributes is best for determining overall success and tracking progress for the given j values of a precept when there are i implementing mechanisms.

For this particular problem, the attributes are really parametric values of a probability function. That is, multiple attributes mean that there are multiple probability distributions for each precept, one for each attribute. Also recollect that the distortion between precept j by mechanism i indicates just how well the mechanism implemented the intent of that value of the given precept. The average distortion, D, can be used as a criterion for choosing between possible attributes or qualities to emphasize in fulfillment of the intent of all the precept values. With those thoughts in mind, it is apparent that the problem is one of selecting values of the parameter (attributes) which "best represent" the probability of success over all of the precept's class of probability distributions subject to an average distortion level of D. ("Success" might be the mix of funding rates over all mechanisms, for instance.)

If the problem has only a single attribute for a precept, it turns out to be the classical *rate distortion* problem in the mathematical information theory literature. If there are multiple attributes then the problem becomes more difficult; it is one of determining the rate distortion function for a class of information sources (each attribute is a parameter of the precept; each is thus an information source represented by a probability distribution). A more precise mathematical definition of the rate distortion problem is given in the subsequent sections of this appendix. Those sections also show how to solve both types of problems.

However, the concept of the rate distortion problem can easily be expressed using the terminology developed in this example as one of finding the highest possible level of correspondence (*i.e.* best rate of success) between the given precept values and implementing mechanisms subject to an average mismatch between the two (*i.e.* distortion) that is less than a given level of D. Thus, it turns out that solving the rate distortion problem also solves the associated precept-attribute-mechanism problem. Continuing with the "Eliminate Poverty" example, which is of the more complex ilk, a demonstration of the modeling approach is shown below to make this concept clear.

Using the Model:

For simplicity, Probability Distribution 1 is used to construct the following model of a precept-attribute-mechanism problem which has a precept of, "Eliminate Poverty" with multiple attributes. The problem is one of determining which of the attributes is best for determining overall success and tracking progress for the given precept when there are i implementing mechanisms. Let there be one precept and two each of the attributes and mechanisms. Reviewing the two attributes with respect to the "Eliminate Poverty" precept it is now clear that there are now two instances of the probability distribution for the first attribute:

$\Pr^{\text{attribute = clothing}}$ (mechanism 1 = subsidized school lunches | precept 1 = "Eliminate Poverty"),

and

$\Pr^{\text{attribute } k \text{ = clothing}}$ (mechanism 2 = food stamps | precept 1 = "Eliminate Poverty"),

as well as two instances of the probability distribution for the second attribute:

$\Pr^{\text{attribute = nutrition}}$ (mechanism 1 = subsidized school lunches | precept 1 = "Eliminate Poverty"),

and

$\Pr^{\text{attribute } k \text{ = nutrition}}$ (mechanism 2 = food stamps | precept 1 = "Eliminate Poverty"),

for a total of two instances of two conditional probability distributions. An average distortion level of D is also presumed to be given which describes the highest permissible level of mismatch between the intent of each attribute and its fulfillment by the implementing mechanisms.

This is a rate distortion problem for a class of two precept information sources (one for each attribute). It is one of finding the highest possible level of correspondence (*i.e.* best rate of success) between the given precept values and implementing mechanisms subject to a constraint that the average mismatch between the two (*i.e.* distortion) must be less than a given level of D. Thus, the model for this specific instance of the precept-attribute-mechanism problem is really one of solving the rate distortion problem for a class of information sources corresponding to all attributes of a given precept, and subject to a given average mismatch or distortion constraint between outcomes of the mechanisms and the intentions of the precept. The model for this particular example is, therefore, summarized by the following.

> A precept is characterized by a class of probability distributions: $\{\Pr^{\text{attribute=nutrition}}$ (precept value j) and $\Pr^{\text{attribute=clothing}}$ (precept value $j)\}_{j \in \{\text{good, marginal, bad}\}}$, and there is also an associated class of conditional probability distributions, namely: $\{\Pr^{\text{attribute } k}$ (mechanism i | precept value $j)\}_{k \in \{\text{clothing, nutrition}\}}$. As a selection criterion, there is given an average level D which represents the mismatch or distortion between results to be achieved by the implementing mechanisms and the original intent of the given precept. Then the problem is one of determining which attribute(s) will best represent the overall intentions of the precept, and then choosing those implementing mechanisms which will provide the corresponding best rate of success subject to a constraint that the mismatch or distortion between results achieved by implementing mechanisms and the intent of the precept and its values does not exceed a previously determined average level D.

Notice that the above is a model of one particular instance of the overall precept-attribute-mechanism problem. It is a very simple instance of the "class of information sources" problem, and it demonstrated the basic concepts. The model would need to be varied and reformulated for other problems. Clearly, much more sophisticated problems also arise with increasing cardinality levels for values taken by variables.

It is also instructive to recall the introductory observation about the "Eliminate Poverty" example that "achieves success" really means "achieves success at some point in time, *x*. Success can be defined in many ways to fit the needs of any particular problem. Apparently, time, geography or other qualities can also play the roles of precepts, attributes or mechanisms, may be the arguments of such a model's parametric functions. Political nuances and other factors can also be assigned those roles. That is, there are enormous possibilities for variation of the basic precept-attribute-mechanism problem. Therefore, other and more complicated problems can be modeled by interchanging variables' roles, identifying functional arguments, and constructing appropriate probability distributions.

Such an approach further emphasizes the richness and complexity of the above information theory based model for the three-tiered precept-attribute-mechanism accountability architecture. In information theory a probability distribution represents "information;" conversely, all examples of information, certainly and uncertainty can be represented by probability distributions. That concept is intuitive because it demonstrates how certainty and information in their most fundamental senses are contextual, and depend on situations and circumstances. Clearly, the three-tiered accountability architecture is based on making decisions in an environment of uncertainty and contextual information. Thus, there is an apparent duality between the public administration problem and the mathematical one.

It now becomes important to further explicate this modeling process in information theoretic terms. This is made precise in the following sections which provide mathematical detail about the construction and solution of the fundamental (and generalized) problem which analogous to the precept-attribute-mechanism model; it is one of finding the rate distortion function for a class of information sources. The problem is examined, in mathematical terms, in the next few sections. Subsequently, the problem is revisited from a different perspective, and an other mathematical modeling approach is identified. In both instances, some of the mathematical notation is changed from the above to make the respective methods clear.

Mathematical Perspective

This section shows how the suggested mathematical modeling method for the precept-attribute-mechanism problem can be developed using a mathematical information theory technique developed by this author in (Wolfe, 1995). It was seen in the prior example that the three-tiered accountability architecture public administration problem can really be presented as an information theoretical one. In fact, mathematical information theory, as originally proposed by Claude Shannon (1948), may be used as the fundamental basis to develop a quantitative analysis of that particular problem, and to suggest a method for its solution.

First, recall that any probability distribution is really an information source; it gives the probability that specific information will be transmitted or received at each increment of time. Then, there is a way to model the precept-attribute-mechanism problem as an information-theoretic rate distortion problem, as will be specified in this section. The basic concept of the rate distortion problem, according to Shannon, is one of finding the best rate for transmitting information so that it will be received at no more than a pre-determined error rate; that is, information is transmitted with an error rate that is fixed at a certain fidelity level.

Examine the problem from a mathematical perspective. In analogy to the precept-attribute-mechanism problem, the basic rate distortion problem can be modified so that it is no longer the rate for an individual information source that is sought; rather, it is the "best" rate (and corresponding mix of individual sources) from a class of information sources that is to be found. Clearly, a class of information sources is analogous to a precept which can be characterized as a class of information probability distributions. Then, the attributes can be found by selecting the individual distribution(s) (*i.e* attributes) which give the "best" rate with respect to some criteria. When distortion is used as a criterion, then the rate distortion model applies. That is, solving the rate distortion problem also solves the associated one for the mathematical model of the precept-attribute-mechanism problem outlined in this and the prior section.

If there are only a finite number of information sources in the class (*i.e* attributes) a solution can be found through exhaustive comparison. However, that is not usually the case in practice. For example, there are really an infinite number of gradations that shade and color all of the possible "qualities" or attributes of the "Eliminate Poverty" precept *(e.g.* an attribute of "clothing" can have many gradations in quantity, style, *et cetera*). Similarly, in the mathematical rate distortion problem the class of information sources is, in general, very large, and can be assumed to be uncountably infinite in size. In that instance, there are an uncountably infinite number of possible solutions, and the problem appears impossible to solve in a finite amount of time; it appears to be intractable.

However, a way to approach that particular problem was given by this author in (Wolfe, 1995). The approach utilized David Sakrison's (1968) extension of the rate distortion concept from Shannon's individual information sources to entire classes of information sources to frame the problem. Thus, finding Sakrison's rate distortion function in the information problem is equivalent to finding the attributes in the precept-attribute-mechanism problem. The approach in (Wolfe, 1995) for finding Sakrison's rate distortion function is extracted from that article and reframed, herein, for completeness of the analogy. Specifically, using that method to solve that particular rate distortion problem also solves the associated one for the mathematical model of the precept-attribute-mechanism problem. The extract provides a full range of mathematical detail to format and model the problem, and to describe the suggested mathematical approach for its solution. Those excerpts and a description of the approach taken from (Wolfe 1995), and adapted from (Wolfe 1996a, b, and c) follows, below.

The Mathematical Rate Distortion Problem

Formally, Sakrison extended Shannon's notion of the rate distortion function to parameterized classes of sources by taking a minimax approach and defining a measure of the minimum rate required for information reconstruction subject to a prescribed fidelity level D. Unfortunately, calculation of Sakrison's rate distortion function may be very difficult because analytic solutions do not generally exist and there has been a lack of a constructive method for finding the rate. However, an approach presented in the following may be used to calculate an approximation to Sakrison's rate distortion function for classes of sources with a finite, discrete input space and a continuous parameter space.

Mathematical Background

Shannon (1948) had previously defined the rate distortion function $R^{\theta}(D)$ for an individual source θ which measures the minimum amount of information that must be preserved by any code to allow reproduction of the compressed data with average distortion less than or equal to a given D. According to Sakrison (1968), the rate distortion function $R^{\Lambda}(D)$ for a class of sources with compact parameter space Λ may be defined as the supremum over all rate distortion functions $R^{\theta}(D)$ in the class. However, calculation of $R^{\Lambda}(D)$ for a continuous Λ is not generally tractable because any solution would involve an uncountable number of integrals.

Apparently, Sakrison's $R^{\Lambda}(D)$ can be approximated for continuous Λ by performing an exhaustive search after selecting for some M, a finite set of parameters $\{\theta_j\}_{j=1}^{M}$ to represent the class of sources with finite, discrete input spaces, where $\theta_j \in \Lambda$. In fact, it is shown later in this paper that under some general conditions and a specific value of M, there exists an optimal set $\{\theta_j^*\}_{j=1}^{M}$ yielding the most accurate approximation to Sakrison's $R^{\Lambda}(D)$. However, finding the $\{\theta_j^*\}_{j=1}^{M}$ is not trivial because it would involve computation of an infinite number of integrals and the lack of a general computational method. Therefore, a procedure is needed for selecting a set $\{\theta_j\}_{j=1}^{N}$ which contains a subset that accurately approximates $\{\theta_j^*\}_{j=1}^{M}$ for some $M \leq N$. Such a procedure is given in the next section and employs an approach which selects $\{\theta_j\}_{j=1}^{N}$ from Λ by using relative entropy to group within N subclasses, all sources in Λ whose entropies are within a previously assigned level of similarity.

Mathematical Preliminaries

Sakrison extended the notion of the rate distortion function for individual sources to parameterized classes of sources by taking a minimax approach and defining a measure of the minimum rate required for information reconstruction subject to a prescribed fidelity level D. Shannon had previously defined the rate distortion function $R^{\theta}(D)$ for an individual, discrete ergodic memoryless source with probability measure p^{θ} with parameter θ and respective source and reproduction spaces $A=\{0,..,J\text{-}1\}$ and $B=\{0,..,K\text{-}1\}$ as:

$$R^{\theta}(D) = \min_{Q \in Q(D)} I(p^{\theta};Q) \tag{1}$$

where

$$I(p^{\theta};Q) = \sum_{j \in A} \sum_{k \in B} p_j^{\theta} \cdot Q_{k|j} \cdot \log\left(\frac{Q_{k|j}}{\sum_{i \in A} p_i^{\theta} \cdot Q_{k|i}}\right), \tag{2}$$

and

$$Q(D) = \{Q_{k|j} | \sum_{j\in A}\sum_{k\in B} p_j^{\theta} \cdot Q_{k|j} \cdot d_{jk} \leq D\}. \tag{3}$$

A distortion matrix $[d_{jk}]$ assigns a non-negative penalty value for the reproduction of input j by output k and $Q(D)$ is the set of all such matrices. Observe that equation (2) can also be written as:

$$\begin{aligned} I(p^{\theta};Q) &= \sum_{j\in A} p_j^{\theta} \cdot \sum_{k\in B} Q_{k|j} \cdot \log \frac{Q_{k|j}}{q_k} \\ &= \sum_{j\in A} p_j^{\theta} \cdot H(Q;q) \end{aligned}, \tag{4}$$

where:

$$q_k \equiv \sum_{i\in A} p_i^{\theta} \cdot Q_{k|i} , \tag{5}$$

and $H(Q;q)$ is the relative entropy which measures the similarity (or difference) between probability measures Q and q over the reproduction space.

Apparently, analytic solutions to equation (1) do not exist in general, and a minimization technique must be used to find a solution. One such technique was given by Blahut (1972) and is briefly reviewed for reference because it is used in Sections 3 and 4. Blahut's algorithm formulates an associated minimization problem in terms of a LaGrange multiplier s:

$$R^{\theta}(D) = \min_{Q\in Q(D)} \left(\sum_{j\in A}\sum_{k\in B} p_j^{\theta} \cdot Q_{k|j} \cdot \log \frac{Q_{k|j}}{\sum_{i\in A} p_i^{\theta} \cdot Q_{k|i}} - s \cdot \left(\sum_{j\in A}\sum_{k\in B} p_j^{\theta} \cdot Q_{k|j} \cdot d_{jk} - D \right) \right), \tag{6}$$

where:

$$D = \sum_{j\in A}\sum_{k\in B} p_j^{\theta} \cdot Q_{k|j}^{*} \cdot d_{jk} , \tag{7}$$

and Q^{*} is the channel transition matrix in a compact space $Q(D)$ which achieves the minimum. Using this parametric form, Blahut formulated a double minimum problem by defining:

$$F(p^{\theta},Q,q) = \sum_{j\in A}\sum_{k\in B} p_j^{\theta} \cdot Q_{k|j} \cdot \log \frac{Q_{k|j}}{q_k} - s \cdot \sum_{j\in A}\sum_{k\in B} p_j^{\theta} \cdot Q_{k|j} \cdot d_{jk} , \tag{8}$$

with the result that:

1. $R^{\theta}(D) = s \cdot D + \min_{Q,q} F(p_j^{\theta}, Q_{k|j}, q)$.

2. For a fixed $Q_{k|j}$ in $Q(D)$, $F(p_j^\theta, Q_{k|j}, q)$ is minimized by:

$$q_k = \sum_{j \in A} p_j^\theta \cdot Q_{k|j} \ . \tag{9}$$

3. For a fixed q, $F(p_j^\theta, Q_{k|j}, q)$ is minimized by:

$$Q_{k|j} = \frac{q_k \cdot e^{s \cdot d_{jk}}}{\sum_{i \in A} q_i \cdot e^{s \cdot d_{ji}}} \ . \tag{10}$$

The results show that Blahut's calculation of Shannon's $R^\theta(D)$ must depend on a parameter s.

However, in order to extend Shannon's rate distortion function to a class of sources Λ, Sakrison considered the mutual information $I(p^\theta, Q)$ for each $\theta \in \Lambda$ and defined the extended rate distortion function for a class of sources Λ as:

$$R^\Lambda(D) = \inf_{Q \in Q(D)} \sup_{\theta \in \Lambda} I(p^\theta; Q). \tag{11}$$

Sakrison (1968) also proved that if the parameter space Λ is compact, then:

$$\begin{aligned} R^\Lambda(D) &\equiv \inf_{Q \in Q(D)} \sup_{\theta \in \Lambda} I(p^\theta; Q) \\ &= \sup_{\theta \in \Lambda} \inf_{Q \in Q(D)} I(p^\theta; Q) \\ &= \sup_{\theta \in \Lambda} R^\theta(D). \end{aligned} \tag{12}$$

Apparently, equations (11) and (12) show that calculating $R^\Lambda(D)$ is equivalent to solving a minimax problem. Although such problems are generally difficult to solve, the well known minimax theorem as given in (Ferguson, 1967) shows that a solution may be obtained by finding a least favorable distribution and the corresponding Bayes risk. Using (12), consider a Bayes problem with a given prior distribution $\tau(\theta)$ over Λ and a weighted mutual information function $r(\tau, Q)$:

$$r(\tau, Q) \equiv \int_{\theta \in A} I(p^\theta, Q) \cdot \tau(\theta)\, d\theta \ . \tag{13}$$

Following a source matching approach presented by Davisson *et al.* (1980) and combining equations (12) and (13) it can be shown that a solution is given by:

$$R^{\Lambda}(D) = \inf_{Q \in Q(D)} \sup_{\theta \in \Lambda} I(p^{\theta},Q) = \sup_{\tau \in \Xi} \inf_{Q \in Q(D)} r(\tau,Q) \;, \tag{14}$$

where Ξ is the class of all prior distributions defined on Λ.

When Λ and $Q(D)$ are compact and both the input and output spaces are discrete, the infimum and supremum in equation (14) can actually be replaced by the minimum and maximum. Furthermore, if the class of sources Λ is finite the minimax problem may be solved by calculating $R^{\theta}(D)$ for each $\theta \varepsilon \Lambda$. $R^{\Lambda}(D)$ may then be determined by an exhaustive search over all $\theta \varepsilon \Lambda$.

Unfortunately, this approach cannot be directly applied to finding Sakrison's $R^{\Lambda}(D)$ when the class of sources Λ is continuous since an uncountable number of solutions of (11), (12) and (14) would be required; one for each θ. Furthermore, analytic solutions for $R^{\Lambda}(D)$ are not generally available and calculating $R^{\Lambda}(D)$ may be very difficult because of the lack of a general computational approach. However, an approach presented in the next Section may be used to calculate an approximation to $R^{\Lambda}(D)$.

A Mathematical Approach For Calculating $R^{\Lambda}(D)$

The approach comes from the recognition that Sakrison's rate distortion function $R^{\Lambda}(D)$ for a continuous class of sources Λ can be approximated by performing an exhaustive search after selecting for some M, a finite set of parameters $\{\theta_j\}_{j=1}^{M}$ to represent the class, where $\theta_j \in \Lambda$. Consider only classes with a finite, discrete source space A of size J. Under certain conditions later specified, it is shown this Section that for a specific value of M, there exists a set $\{\theta_j^*\}_{j=1}^{M}$ which yields the most accurate approximation to Sakrison's $R^{\Lambda}(D)$. However, finding the $\{\theta_j^*\}_{j=1}^{M}$ is not trivial because of the lack of a general computational method. Therefore, a procedure is needed for selecting a set $\{\theta_j\}_{j=1}^{N}$ which contains a subset that accurately approximates $\{\theta_j^*\}_{j=1}^{M}$ for some $M \leq N$. Such a procedure is presented in this Section. The procedure uses relative entropy (*i.e.* Kullback distance, cross entropy, discrimination information) to group within subclasses, all sources in a continuous parameter class whose entropies are within a previously assigned level of similarity. A finite set of N representative sources is then selected from the N subclasses, namely $\{\theta_j\}_{j=1}^{N}$, which is subsequently used to derive an approximation to Sakrison's rate distortion function.

First begin by describing an algorithm to partition a continuous class of sources Λ into N subclasses and select a set of N representatives; one from each subclass. An error threshold ϵ_{SP} can be adjusted in the algorithm such that N can assume any positive integer value. For simplicity of discussion, the algorithm will be given assuming that each parameter $\theta \in \Lambda$ lies on the real line in the closed interval $[a,b]$. Furthermore, assume that $H(\theta;\theta')$ varies smoothly with θ, for all $\theta \in \Lambda$. Also assume that Λ is compact; and if it is not, add the hull to the space for purposes of computation and subsequently restrict our choice to only those sources which lie in Λ for inclusion in the finite set of subclasses. Also, the algorithm can readily be adapted to higher dimensions under similar, general conditions.

The Source Partition algorithm given below groups all sources into N subclasses using relative entropy to measure the similarity between any two sources. Thus, the algorithm produces a finite set of N parameters $\{\theta_\gamma\}_{\gamma=1}^{N}$, which partitions $[a,b]$ into N subclasses $\{S_\gamma\}_{\gamma=1}^{N}$ where $S_\gamma = [\theta_{\gamma-1}, \theta_\gamma]$. The $\{S_\gamma\}_{\gamma=1}^{N}$ are chosen such that the relative entropy between any two sources in a subclass is less than a given tolerance ϵ_{SP}. Clearly, the number of subclasses produced, N, can assume any positive integer value by appropriately varying ϵ_{SP}.

Algorithm SP (Source Partition)

1. Initialization: Set ϵ_{SP} = an assigned error tolerance; $\theta_l = a$ and N=1.
2. Set N=N+1. Find $\theta_N > \theta_{N-1}$ such that $H(\theta_N ;\theta_{N-1}) = \epsilon_{SP}$.
3. If $\theta_N \geq b$ output the set $b \cup \{\theta_\gamma\}$; γ=1,..,N-1.
4. If $\theta_N < b$, go to step 2.

An approximation to Sakrison's rate distortion function $R^\Lambda(D)$ could in concept be calculated with any finite set of representative sources $\{\theta_\gamma\}_{\gamma=1}^{N}$, produced by *Algorithm SP*. In fact, $R_N^\Lambda(D)$, the rate distortion function calculated using these N representative sources, must converge to Sakrison's rate distortion function $R^\Lambda(D)$ as $N \to \infty$, as will be shown later in this Section. However, the validity of approximating Sakrison's $R^\Lambda(D)$ in this way depends on the proper choice of N, as shown in the following theorem.

Theorem 1: Let Λ be a continuous, compact parameter space for a class of sources with input space A of size J. Further, assume that each parameter $\theta \in \Lambda$ lies on the real line in the closed interval $[a,b]$ and that $H(\theta;\theta')$ varies smoothly with θ, for all $\theta \in \Lambda$. For a given distortion measure d, there exists a finite set of sources $\{\theta_i^* \in \Lambda\}_{i=1}^{M}$ where $M \leq J$, which gives rise to Sakrison's rate distortion function, $R^\Lambda(D)$.

Proof: Let Q^* be the channel given by solution of equation (11) thereby generating Sakrison's rate distortion function, $R^\Lambda(D)$. However, Q^* along with all $\theta \in \Lambda$ gives rise to a new class of sources W with probability distributions given by:

$$w_k^\theta = \sum_{j \in A} Q_{k|j}^* \cdot p_j^\theta \ . \tag{15}$$

Therefore W is a class of discrete sources with parameter given by $\theta \in \Lambda$. Let $H(W^\theta)$ denote the average length of the best code for W^θ and define the redundancy between any two codes as:

$$r(W^{\theta_i}, W^{\theta_j}) = |H(W^{\theta_i}) - H(W^{\theta_j})| \ . \tag{16}$$

The problem becomes one of minimizing the maximum redundancy over W by finding a source best matched to the class of sources. However this is a source matching problem which, as shown in (Davisson, 1980), is solved by finding the channel capacity between the parameter space Λ and the output space A. The solution of this source matching problem also produces an associated least favorable distribution τ^* over Λ. The validity of utilizing a finite set $\{\theta_i \in \Lambda\}_{i=1}^{M}$ chosen from an uncountable number of sources can now be seen for the source matching problem by applying (Gallagher, Corollary 3, p. 96) which states that for a finite output space A there is a distribution τ^* over Λ that assigns a non-zero probability to only a minimal number of sources $\{\theta_i \in \Lambda\}_{i=1}^{M}$ and τ^* gives rise to the channel capacity between Λ and A. Furthermore M, can be no larger than the size of the output set, i.e., $M \leq J$.

Observe that there exists a one-to-one correspondence between each W^θ and some p^θ and that W maps onto the class of all $\{p^\theta\}$ By construction, the quantization and source matching problems correspond directly and solution of one implies solution of the other. *QED.*

The suggested approach may now be summarized as follows:

Algorithm 1

1. Apply *Algorithm SP* to produce N representative sources $\{\theta_j\}_{j=1}^N$, which contains a subset that approximates $\{\theta_j^*\}_{j=1}^M$, the optimal set of M source representatives, where $M \leq J \leq N$.
2. Calculate Shannon's rate distortion function for each $\theta_j \in \{\theta_j\}_{j=1}^N$ and find the maximum by exhaustive search, which is the approximation to Sakrison's rate distortion function $R^\Lambda(D)$.

One of the most well known ways of calculating Shannon's rate distortion function as in step (2) is by using Blahut's algorithm (1972). Before showing convergence of the approach, observe that there may be a difficulty in directly applying Blahut's rate distortion algorithm (1972) to step (2). Blahut's algorithm uses a LaGrange multiplier s which is the slope of the rate distortion function, to determine the information rate required at distortion level D for a channel transition matrix Q.

Therefore, a direct application of Blahut's algorithm to a set of representative sources will produce a comparison based upon slope s. Unfortunately, the respective rate distortion functions at slope s may actually have dissimilar distortions D; thereby rendering the comparison invalid. That is; two different sources may require two different slopes s in order to produce the same distortion D. Therefore, application of Blahut's algorithm to this problem must be modified to ensure that the rate distortion functions of any two sources are compared only at the same level D.

A modification in using Blahut's algorithm can apparently be made by selecting slope s_j as a function of D, for each source θ_j in the set of N representative sources $\{\theta_j\}_{j=1}^N$. There are simple techniques available to approximate s for a particular value of D. An example of one such method is obtainable from (Gray, page 95) in the case of the difference distortion measure $[d_{jk}] \equiv \rho(k-j)$, for some measure ρ. Employing this or a similar method applicable to the given distortion measure d, enables calculation of $R^{\theta_j}(D)$ for each $j = 1,\ldots,N$ which gives rise to the set $\{R^{\theta_j}(D)\}_{j=1}^N$. Taking the maximum over this set determines the sought after approximation to Sakrison's rate distortion function, $R^\Lambda(D)$.

It is clear that any set of N representative sources $\{\theta_j\}_{j=1}^N$, $M \leq J \leq N$ produced by *Algorithm SP* does not necessarily contain the optimal M sources. However, since relative entropy is used as a measure of similarity to construct the subclasses, the jth optimal source must be in some subclass represented by θ_k, for some k. Therefore, the set $\{\theta_j\}_{j=1}^N$ contains a subset which approximates the optimal $\{\theta_j^*\}_{j=1}^M$ that determines Sakrison's rate distortion function $R^\Lambda(D)$.

Clearly, the error depends upon the relative entropy threshold ϵ_{SP} used to determine the subclasses. Thus for each increasing value of N, $\{\theta_j\}_{j=1}^N$ must contain a subset which more closely approximates the optimal $\{\theta_j^*\}_{j=1}^M$ because of our assumption that $H(\theta;\theta')$ varies smoothly with θ, for all $\theta \in \Lambda$. Therefore even though only M sources are required to represent the class of sources Λ, it is apparent that the accuracy of the approximation increases with smaller ϵ_{SP} and corresponding larger N, as shown in the following theorem.

Theorem 2: Let $R_N^\Lambda(D)$ be the rate distortion function for a compact class Λ, that is determined by exhaustive search over the set $\{R^{\theta_j}(D)\}_{j=1}^N$ produced when $N \geq M$ representative sources are selected by *Algorithm SP*. Further, assume that each parameter $\theta \in \Lambda$ lies on the real line in the closed interval $[a,b]$ and that $H(\theta;\theta')$ varies smoothly with θ, for all $\theta \in \Lambda$. The sequence $\{R_N^\Lambda(D)\}$ converges in the limit to $R^\Lambda(D)$ as $N \to \infty$. ∎

Proof: It suffices to show that $R^{\Lambda}_{N+1}(D) \geq R^{\Lambda}_{N}(D)$ for all N because $R^{\Lambda}(D)$ achieves the supremum over all $R^{\theta}(D)$ in the compact space Λ. Consider the approximation produced by N representative sources $\{\theta_\gamma\}^{N}_{\gamma=1}$. Let $\theta_s \in \{\theta_\gamma\}^{N}_{\gamma=1}$ produce the smallest mutual information. Case 1: find a $\theta_g \in \{\theta_\gamma\}^{N+1}_{\gamma=1}$ that produces the greatest mutual information, such that $\theta_g \notin \{\theta_\gamma\}^{N}_{\gamma=1}$ and where the mutual information produced by θ_g is greater than or equal to that produced by θ_s. Thus, equation (17), given in the following, is true.

$$
\begin{aligned}
R^{\Lambda}_{N}(D) &= \sup_{\tau^N \in \Xi^N} \inf_{Q \in Q(D)} r(\tau^N, Q) \\
&= \sup_{\tau^N \in \Xi^N} \inf_{Q \in Q(D)} \int_{\theta \in \Lambda} I(p^{\theta};Q) \cdot \tau^N(\theta)\, d\theta \\
&= \max_{\tau^N \in \Xi^N} \min_{Q \in Q(D)} \sum_{\theta \in \Lambda} I(p^{\theta};Q) \cdot \tau^N(\theta) \\
&\leq \max_{\tau^N \in \Xi^N} \min_{Q \in Q(D)} \sum_{\theta \in \{\Lambda - \theta_s\}} \tau^N(\theta) \cdot I(p^{\theta};Q) + \tau^N(\theta_s) \cdot I(p^{\theta_g};Q) \\
&\leq \max_{\tau^{N+1} \in \Xi^{N+1}} \min_{Q \in Q(D)} \sum_{\theta \in \Lambda} \tau^{N+1}(\theta) \cdot I(p^{\theta};Q) \\
&= R^{\Lambda}_{N+1}(D) \ .
\end{aligned} \tag{17}
$$

The third equality in (17) occurs because the N representative sources form a finite class. The first inequality is true because the mutual information produced by θ_g is greater than that of θ_s. The second inequality is a result of (14). Case 2: There does not exist a $\theta_g \in \{\theta_\gamma\}^{N+1}_{\gamma=1}$ that produces the greatest mutual information, such that $\theta_g \notin \{\theta_\gamma\}^{N}_{\gamma=1}$ and where the mutual information produced by θ_g is greater than or equal to that produced by θ_s. Clearly in this case, $R^{\Lambda}_{N}(D) = R^{\Lambda}_{N+1}(D)$. In both cases the sequence $\{R^{\Lambda}_{N}(D)\}^{\infty}_{N=1}$ is non-decreasing; in fact $\{R^{\Lambda}_{N}(D)\}^{\infty}_{N=1}$ is monotonically increasing because of our assumption that $H(\theta;\theta')$ varies smoothly with θ, for all $\theta \in \Lambda$. $\{R^{\Lambda}_{N}(D)\}^{\infty}_{N=1}$ is also bounded since $R^{\Lambda}(D)$ achieves the supremum over all $R^{\theta}(D)$ in the compact space Λ. Therefore, $\{R^{\Lambda}_{N}(D)\}^{\infty}_{N=1}$ converges to $R^{\Lambda}(D)$ and the theorem follows. *QED.*

Returning to the analogy between the three-tiered accountability architecture and the information theoretic rate distortion problem, it is now clear that the following correspondence exists:

> A precept is characterized by a given class of parameterized probability distributions as follows: $\{\Pr^{\text{attribute } k}(\text{precept value } j)\}_{k \in \{\text{attributes}\}, j \in \{\text{precept values}\}}$. There is an associated class of conditional probability distributions, namely: $\{\Pr^{\text{attribute } k}(\text{mechanism } i \mid \text{precept value } j)\}_{k \in \{\text{attributes}\}, j \in \{\text{precept values}\}, i \in \{\text{mechanisms}\}}$. As a selection criterion, there is given an average level D which represents the mismatch or distortion between results to be achieved by the implementing mechanisms and the original intent of the given precept. Then the problem is one of determining which attribute(s) will best represent the overall intentions of the precept, and then choosing those implementing mechanisms which will provide the corresponding best rate of success subject to a constraint that the mismatch or distortion between results achieved by implementing mechanisms and the intent of the precept and its values does not exceed a previously determined average level D;

which was the essence of what was to have been demonstrated in this appendix. Other relationships can be easily developed by interchange of the roles of precepts, attributes and mechanisms, and appropriate construction of the probability distributions. However, even though the generality of those associations was demonstrated in the above, the task is not yet finished.

Finding the Best Matched Attribute

Return to the "Eliminate Poverty" example. The solution $\{k^*\}$ to the rate distortion problem that corresponds to the three-tiered architecture identifies the conditional probability(s) given by: $\{\Pr^{\text{attribute } k^*}(\text{mechanism } i \mid \text{precept value } j)\}_{k^* \in \{\text{optimal attributes}\}, j \in \{\text{precept values}\}, i \in \{\text{mechanisms}\}}$ for the class of probability distributions $\{\Pr^{\text{attribute } k}(\text{precept value } j)\}_{k \in \{\text{attributes}\}, j \in \{\text{precept values}\}}$ which corresponds to the precept. $\{k^*\}$ denotes the set of attributes that best represent the precept. This is true subject to a given constraint that the mismatch or distortion between results achieved by implementing mechanisms and the intent of the precept and its values does not exceed a previously determined average level D.

That is, the model when solved identifies: (1) the attributes which best represent the overall intent of the precept, and (2) the conditional probability(s) associating that attribute(s) with the implementing mechanisms. However, those attributes and conditional probabilities are optimal only with respect to the pre-determined mismatch or distortion D that the decision-maker is willing to tolerate between the intent of the precept and its implementation by the mechanisms. Thus, the rate of effectiveness of the mechanisms given by the selected conditional probability is really subject to two constraints, namely, (1) an acceptable distortion level, D, and (2) a requirement to best represent *all* of the attributes which characterize the given precept.

Given a conditional distribution that best represents, in total, all the attributes, an obvious question is: "Of all the precept's attributes, which one is best achieved, or emphasized, by that particular conditional distribution?" That part of the original problem still needs to be answered in order to complete the mathematical analogy. The explication begins, as follows.

$\Pr^{\text{attribute } k}(\text{mechanism } i \mid \text{precept value } j)\}_{k \in \{\text{attributes}\}, j \in \{\text{precept values}\}, i \in \{\text{mechanisms}\}}$ from above is the optimal relationship of the implementing mechanisms to the intent of the given precept. The way that conditional probability was chosen relied upon specific constraints, namely, (1) an acceptable distortion level, D, and (2) a requirement to best represent *all* of the attributes which characterize the given precept. If that conditional probability is retained, but all of the constraints are removed, the question becomes: "Of all the attributes, which one is best achieved, or emphasized, by the optimal relationship of the implementing mechanisms to the intent of the given precept?"

The problem can be solved by viewing the conditional probability distribution as a predetermined, optimal information transfer device, and finding the attribute to which it is best matched. Such a problem can be viewed as one in which a specific attribute must be selected, up front, that is optimal with respect to predetermined relationships between implementing mechanisms and the overall intent of the precept. For example, in the "Eliminate Poverty" case, food stamps, subsidized school lunches, and other programs (implementing mechanisms) may already be in place, and studies already conducted that show their relationships and outcomes with respect to that precept. Which attribute (nutrition, clothing, *et cetera*) is best served by that arrangement? Clearly, that attribute is the one that best communicates its intentions to the in-place mechanisms. The seed of that thought shows how to answer the remaining question, and mathematically complete the analogy.

Communications is the crux of the answer. Using the concepts outlined at the beginning of this appendix it can be seen that such a problem corresponds to the one of calculating a communication channel's capacity in information theory. Briefly, the conditional probability, as the optimal transfer device, is really a communications channel in information theory. Finding the attribute best matched to that channel is the same as finding the capacity of that channel. As shown earlier any attribute corresponds to a probability distribution which is an information source. Thus, the problem is one of finding the information source (attribute) that maximizes the transfer of information (intent of the precept with respect to that attribute) over a given communications channel (pre-determined relationships between the precept and given implementing mechanisms). With that correspondence in mind, solving the information theoretic channel capacity problem also finds the best matched attribute.

An algorithm developed separately by Arimoto (1972) and Blahut (1972) can be used to solve the channel capacity problem associated with the best attribute one. However, for complicated problems their method can be replaced by one shown below which produces a solution at an exponentially faster rate. The suggested approach has a further advantage because it provides a refinement that is useful in modeling the precept-attribute-mechanism problem, namely, one that permits an implementing mechanism to achieve the goals of multiple attributes. For instance, a welfare program (implementing mechanism) could possible achieve both nutrition and clothing (attributes) goals for a given precept of "Eliminate Poverty."

Since each attribute has an associated probability distribution $\mathrm{Pr}^{\text{attribute } k}$ (precept value j), it is also an information source that can take any of j values. In the "Eliminate Poverty" example, for instance, "nutrition" could be identified as the optimal attribute with most likely values of "marginal" and "good," in that order, for some given conditional distribution that related the in-place mechanisms to precept values of "good," "marginal," and "poor." Thus, in addition to identifying the optimal attribute, this approach also identifies the specific values of the optimal information source that are most likely to occur, and their probabilities. The suggested method, first developed by this author (1995), is described in mathematical detail, below. The notation is somewhat different from the prior sections in order to simplify the mathematical explanation.

Channel Capacity Background

The following presents an approach and algorithm for finding only those source inputs (*i.e.* attributes) which are sufficient to compute the capacity of large channels where calculation of capacity is computationally intensive. Precept values correspond to source inputs, and implementing mechanisms correspond to reproduction space outputs. Not all of the source inputs need be used in the computation according to Cheng (1974) who showed that capacity may depend only on a submatrix of the channel matrix. Cheng's criteria for selecting the submatrix were later proven to be necessary and sufficient by Takano (1979) but, their method cannot be implemented on a computer.

However, a computer implementable approach can be achieved by finding only those source inputs which are sufficient to calculate capacity. Finding channel capacity is equivalent to finding the attribute that achieves optimal performance for a given set of relationships between precept values and implementing mechanisms, and thus solves the problem. The suggested approach to find channel capacity is presented below.

Mathematical Channel Capacity Preliminaries

Let $X=\{1,\ldots,m\}$ and $Y=\{1,\ldots,n\}$ be given source and reproduction spaces, respectively, where a corresponding discrete memoryless channel is specified by a matrix $P_{mxn} = [P(j \mid i)]$, such that

$P(j \mid i)$ is the probability of channel output j given that i was transmitted. Let $\underline{p}=[p(1),...,p(m)]$ be a probability vector defined on X. Then, the mutual information between X and Y is given by:

$$I_p(X;Y) = \sum_{i=1}^{m} \sum_{j=1}^{n} p(i) \cdot P(j|i) \cdot \log \frac{P(j|i)}{\sum_{k=1}^{m} p(k) \cdot P(j|k)} \ , \tag{18}$$

where the probability of channel output j is given by:

$$q_p(j) = \sum_{i=1}^{m} p(i) \cdot P(j|i) \ . \tag{19}$$

The channel capacity C is defined as the maximum mutual information over all possible input probability vectors $\underline{p}$; that is:

$$C = \max_{\underline{p}} I_p(X;Y) \ . \tag{20}$$

Since the entropy of $\underline{p}$ is given by:

$$H(\underline{p}) = -\sum_{i=1}^{m} p(i) \cdot \log(p(i)) \ , \tag{21}$$

then $I_p(X;Y)$ can be rewritten as:

$$I_p(X;Y) = H(\underline{q}_p) - \sum_{i=1}^{m} p(i) \cdot H(\underline{r}_i) \ , \tag{22}$$

where $\underline{r}_i$ is the ith row in P_{mxn} and $H(\underline{r}_i)$ is the entropy of $\underline{r}_i$ defined by:

$$H(\underline{r}_i) = -\sum_{j=1}^{n} P(j|i) \cdot \log(P(j|i)) \ . \tag{23}$$

Cheng proved that capacity is achieved by an appropriately chosen channel submatrix consisting of only t linearly independent rows of P_{mxn}, where t is the rank of P_{mxn}. Cheng also gave criteria that were later proven to be necessary and sufficient by Takano for selection of the submatrix:

1. Let T be a set of source inputs which denote the indices of all rows in P_{mxn}. Arbitrarily choose an initial set of t linearly independent rows and denote the set of their indices by T^1. Then, every row $\underline{r}_j$ with index $j \varepsilon \{T\text{-}T^1\}$ can be expressed as a linear combination of the rows given by the set T^1 by finding a set of coefficients $\{\lambda_s\}$ where $s \varepsilon \{1,...,t\}$, such that $\underline{r}_j = \sum_s \lambda_s \cdot \underline{r}_s$ and $\sum_s \lambda_s = 1$.
2. For all $\underline{r}_j$ in $T\text{-}T^1$, test whether:

$$\sum_{s=1}^{t} \lambda_s \cdot H(\underline{r}_s) < H(\underline{r}_j) \ . \tag{24}$$

3. If (7) is not true for some $j \ \varepsilon \ T\text{-}T^1$, then repeat steps 1 and 2 for a new set T^2 of size t.
4. Otherwise, apply the Arimoto-Blahut algorithm [3,4] to generate an input probability vector $\underline{p}^*=[p^*(1),...,p^*(t)]$ and check for the following conditions:
   - (a). If $p^*(s)>0$ for all $s=1,2,...,t$; then stop.
   - (b). Otherwise, let M be the subset of T^1 containing all rows s such that $p^*(s)=0$.
     - (i). If $\lambda_s=0$ for all s in M, then stop.
     - (ii). Otherwise, repeat steps (1) and (2) with a new set T^2 of size t.

However, the procedure cannot be implemented on a computer because of several drawbacks. First, the rank t of P_{mxn} must be initially known. Also, t linearly independent rows must be initially selected and t coefficients $\{\lambda_s\}$ must be found to express each $\underline{r}_j$ where $j \varepsilon \{T\text{-}T^1\}$, as a linear combination of the rows with indices in T^1. Finally, the procedure provides no rule for selecting a new set of t linearly independent rows with indices given by set T^2, when the trial set T^1 does not satisfy the stopping rules given in step 4.

This procedure is not readily implemented on a computer for several reasons. The first two drawbacks mean that additional computation is required while the third means that the procedure may exhaust all possible choices of t out of m rows before achieving a solution. Thus, Cheng's procedure becomes computationally intensive for large channels, and not easily implemented on a computer. However, a computer implementable approach and efficient algorithm is presented in the next Section.

Finding Sufficient Source Inputs to Calculate Channel Capacity

In this Section, an approach is presented to find sufficient source inputs to calculate channel capacity C. Instead of calculating C directly as in equation (20), utilize relative entropy to find only those sources which are necessary to the computation.

More precisely, given the ith source input, let $\underline{r}_i$ be the corresponding ith row of P_{mxn}. The mutual information of the ith input and the channel; that is between $\underline{r}_i$ and reproduction space Y is given by:

$$I_p(\underline{r}_i;Y) \equiv \sum_{j=1}^{n} P(j|i) \cdot \log \frac{P(j|i)}{q_p(j)} . \tag{25}$$

Therefore, channel capacity is the weighted sum over all such inputs and equation (18) can be rewritten as:

$$I_p(X;Y) = \sum_{i=1}^{m} p(i) \cdot I_p(\underline{r}_i;Y) . \tag{26}$$

Recalling Theorem 4.5.1 by Gallagher (1968), observe that given a channel matrix P_{mxn} with rank t, a probability vector $\underline{p}$ over t linearly independent rows can achieve capacity C if and only if equation (27) holds true. Therefore, that equation implies that if a probability vector $\underline{p}$ over the source inputs achieves capacity, then any channel input j must have probability zero if $I_p(\underline{r}_j;Y)<C$. Conversely, $I_p(\underline{r}_j;Y)$ cannot exceed C when $p(j)=0$. Also, each row in the set of all rows with non-zero probability must have mutual information equal to C; that is $I_p(\underline{r}_j;Y) = C$ for each $\underline{r}_j \varepsilon \{\underline{r}_j$:

$$\begin{aligned} I_p(\underline{r}_i;Y) &= C, \quad \text{if } p(i)>0 \text{ and,} \\ &\le C, \quad \text{if } p(i)=0 . \end{aligned} \tag{27}$$

$p(j)>0\}$. Apparently, any input and associated channel matrix row with zero probability or with mutual information less than C does not contribute to the channel capacity and should be eliminated from the computation and replaced with another source input and corresponding row that has greater mutual information.

This observation suggests an approach to find only those source inputs which give rise to channel capacity. That is; eliminate any source input and corresponding matrix row $\underline{r}_j$ from the computation that has zero probability or has mutual information less than C and replace it with the source input and corresponding matrix row $\underline{r}^*$ which has the greatest mutual information, $I_p(\underline{r}^*;Y)$. This approach can also be viewed as a replacement rule for Cheng-Takano's method, namely if the t linearly independent rows given by set T^k do not achieve capacity, then use the source inputs with the greatest mutual information to select a new trial set of t rows, T^{k+1}. Clearly, the procedure must stop when the mutual information $I_p(\underline{r}_j;Y)$ equals a constant C for each source input j and corresponding $\underline{r}_j \varepsilon \{\underline{r}_j$: $p(j)>0\}$ and C must be the channel capacity.

To complete this approach, another result by Gallagher (Corollary 3 p.96 1968) can be used to avoid determining the channel matrix rank. There, he showed that for any input probability vector that achieves capacity, the minimum number of inputs (*i.e.* rows) cannot exceed the number of outputs (*i.e.* columns). Thus, there is no need to calculate t, the rank of P_{mxn} nor Cheng's coefficients $\{\lambda_r\}$.

The following algorithm summarizes the above approach assuming, without loss of generality, that each channel output can be reached by at least one input.

Algorithm 1 (An algorithm for finding sufficient source inputs to compute capacity.)

1. Initialization. Let T be the set of source inputs which index the rows in channel matrix P_{mxn} and let T^1 be a trial set which consists of all indices of an arbitrarily chosen set of n rows of P_{mxn}. Let Z^k be the set of indices of all rows at the kth iteration which have a zero probability, *i.e.* $Z^k = \{\underline{r}_j: p(j)=0\}$. Initially, Z^1 is null. Set $k=1$.
2. Finding the channel capacity given by the kth trial set T^k. Apply the Arimoto-Blahut algorithm [1,2] to the kth test channel to find the corresponding probability input and output vectors $\underline{p}^k=[p^k(1),...,p^k(n)]$ and $\underline{q}_p=[q_p(1),...,q_p(n)]$ that achieve test channel capacity C^k.
3. Stopping rule. Compute the greatest mutual information among all rows of matrix P_{mxn}:

$$C^* = \max_{j\in T} \left(I_{\underline{p}^k}(\underline{r}_j;Y)\right) . \tag{28}$$

Let the source input with corresponding row $\underline{r}^*$ be a solution to equation (28). If:

$$C^k = I_{\underline{p}^k}(\underline{r}^*;Y), \tag{29}$$

then output C^k, which is the channel capacity and, stop.

4. Otherwise, apply the following selection and replacement rules.
   - (a) *Case 1:* For all inputs $j\varepsilon T^k$, rows $\underline{r}_j$ have positive probabilities $p^k(j)>0$ and the size of set T^k equals n; that is $|T^k|=n$. Write $\underline{r}_i$ $(i\in T^k)$ as $\underline{r}_i^k$. Let $\underline{r}_s^k$ be the row with smallest probability. Then, set $T^{k+1}=\{T^k-\underline{r}_s^k\}\cup\{\underline{r}^*\}$. Set $k=k+1$. Go to (2).
   - (b) *Case 2:* Either $|T^k|<n$ or $|T^k|=n$ and there exists at least one source input and corresponding row with zero probability. Let Z^k denote the set of source inputs which index the rows with zero probability (Z^k may be null). Set $T^{k+1}=\{T^k-Z^k\}\cup\{\underline{r}^*\}$. Observe that $|T^{k+1}| \leq n$. Set $k=k+1$ and go to (2).

The first two parts of a theorem by Blahut (Theorem 1, 1972) will be used in the proof of converge of *Algorithm 1*, and are therefore restated, below.

Theorem (Blahut): Suppose that the channel matrix P is m x n. For any n x m matrix Q, let:

$$J(p,P,Q) = \sum_i \sum_j p(i) \cdot P(j|i) \cdot \log \frac{Q(i|j)}{p(i)} . \tag{30}$$

Then the following is true (part a).

$$C = \max_p \max_P \; J(p,P,Q) . \tag{31}$$

For fixed p, $J(p,P,Q)$ is maximized by (part b).

$$Q^*(i|j) = \frac{p(i) \cdot P(j|i)}{\sum_i p(i) \cdot P(j|i)} \quad . \tag{32}$$

Proof: See (Theorem 1, 1972).

In the sequel sometimes the same quantity is written in the following different ways:

$$I_{\underline{p}^k}(\underline{r}_i^k; Y) = I(i; \underline{q}_{\underline{p}^k}) = I(\underline{r}_i^k; \underline{q}_{p^k}) \ , \tag{33}$$

to emphasize the dependence of the optimal output distribution $\underline{q}_{p^k}$ on row $\underline{r}_i^k$ or a particular source input i, or to focus attention on distribution $\underline{p}^k$ which achieves capacity on the test channel given by T^k over P_{mxn} at the kth iteration of the algorithm.

With this notational background, the convergence of *Algorithm 1* is now shown below.

Theorem 1: The set of sufficient source inputs $\{T^k\}$ gives rise to a corresponding sequence $\{C^k\}$ given by Algorithm 1 which converges to capacity C for channel P_{mxn}.

Proof: Clearly, the sequence $\{C^k\}$ converges to channel capacity C if and only if the selection procedure replacing T^k with T^{k+1} implies that $C^{k+1} \geq C^k$, monotonically, for all k. In Step 4 Case 2 observe that if $|T^k| = n$ then there must exist at least one source input and corresponding row that has zero probability, and therefore the new test set becomes $T^{k+1} = \{T^k - Z^k\} \cup \{\underline{r}^*\}$ where $|T^{k+1}| = \hat{n} \leq n$ and all $\underline{r}_i^k$ such that $p^k(i) > 0$ are retained in T^{k+1}. Apparently, one can define a new probability vector $\hat{\underline{p}}^{k+1} = [\hat{p}^{k+1}(1), \ldots, \hat{p}^{k+1}(\hat{n})]$ as follows:

$$\begin{aligned} \hat{p}^{k+1}(i) &= p^k(i), \quad \forall\, \underline{r}_i^k : p^k(i) > 0 \,; \\ &= 0, \quad \text{for } \underline{r}^* \,. \end{aligned} \tag{34}$$

Therefore:

$$\begin{aligned} C^k &= \sum_{i \in T^k} p^k(i) \cdot I(i; \underline{q}_{p^k}) \\ &= \sum_{i \in \{T^k - Z^k\}} p^k(i) \cdot I(i; \underline{q}_{p^k}) + 0 \cdot I(\underline{r}^*; \underline{q}_{p^k}) \\ &= \sum_{i \in T^{k+1}} \hat{p}^{k+1}(i) \cdot I(i; \underline{q}_{\hat{p}^{k+1}}) \\ &\leq \sum_{i \in T^{k+1}} p^{k+1}(i) \cdot I^{k+1}(i; q_{p^{k+1}}) \\ &= C^{k+1} \ , \end{aligned} \tag{35}$$

where it is clear that:

$$q_{\tilde{p}^{k+1}}(j) = q_{p^k}(j), \quad \forall\, j=1,\ldots,n \; . \tag{36}$$

The third equality holds true because of equation (34) and the inequality is true because $\underline{p}^{k+1}$ achieves the $k+1$st test channel capacity as in equation (20). Therefore, $C^k \le C^{k+1}$.

In Case 1, all $p^k(i)$ are strictly positive and $|T^k| = n$. In the kth iteration, $\underline{r}^*$ replaces the row in the computation, say $\underline{r}_s^k$, that has the smallest input probability; $p^k(s) \le p^k(j)$ for all $j=1,\ldots,n$.

The following two lemmas are used to complete the proof.

Lemma 1: Define an arbitrary probability vector $\underline{v}^{k+1} = [v^{k+1}(1),\ldots,v^{k+1}(n)]$ on T^{k+1} and define:

$$S(\underline{v}^{k+1}, \underline{q}_{p^k}, T^{k+1}) \equiv \sum_{i \in T^{k+1}} v^{k+1}(i) \cdot I(i; \underline{q}_{p^k}) \; . \tag{37}$$

Then, the following inequality holds true:

$$S(\underline{v}^{k+1}, \underline{q}_{p^k}, T^{k+1}) \ge C^k = \sum_{i \in T^{k+1}} p^k(i) \cdot I(i; \underline{q}_{p^k}) \; . \tag{38}$$

Proof of Lemma 1: Selection of the source input and corresponding channel row $\underline{r}^*$ yielding the maximum mutual information means that:

$$I(\underline{r}^*; \underline{q}_{p^k}) \ge I(\underline{r}_\gamma; \underline{q}_{p^k}), \quad \forall\, \gamma \in T^k \; . \tag{39}$$

Let $\underline{r}_s$ yield the smallest such mutual information. Then:

$$\begin{aligned} S(\underline{v}^{k+1}, \underline{q}_{p^k}, T^{k+1}) &= \sum_{i \in T^{k+1}} v^{k+1}(i) \cdot I(i; \underline{q}_{p^k}) \\ &= \sum_{i \in T^k} v^{k+1}(i) \cdot I(i; \underline{q}_{p^k}) + v^{k+1}(s) \cdot \left(I(\underline{r}^*; \underline{q}_{p^k}) - I(\underline{r}_s; \underline{q}_{p^k}) \right) \\ &= C^k + v^{k+1}(s) \cdot \left(I(\underline{r}^*; \underline{q}_{p^k}) - I(\underline{r}_s; \underline{q}_{p^k}) \right) \\ &\ge C^k \; . \end{aligned} \tag{40}$$

and the lemma follows.

Rather than preceding directly to show that the sequence $\{C^k\}$ monotonically converges to channel capacity C, it is convenient to take another intermediate step with a second lemma. Using this approach, Lemma 1 bounds C^k from above; likewise, Lemma 2 bounds Lemma 1 from above. Therefor, the combination of both lemmas in the sequel will complete the proof, and show that the selection procedure of replacing T^k with T^{k+1} implies that $C^{k+1} \ge C^k$, monotonically, for all $k>0$.

Lemma 2: There exists a probability vector $\underline{w}^{k+1}$ on T^{k+1} such that the following is true:

$$S(\underline{v}^{k+1}, \underline{q}_{p^k}, T^{k+1}) \le S(\underline{w}^{k+1}, \underline{q}_{w^{k+1}}, T^{k+1}) \; . \tag{41}$$

Proof of Lemma 2: Let s be the input associated with row $\underline{r}^*$ which replaced the row with the smallest input probability, $p_{minimum}$, at the end of the kth iteration. Find a row $\underline{r}_b^k$ with a larger probability: $p^k(s) \le p^k(b)$. Observe that $I(s;\underline{q}_{p^k}) > I(b;\underline{q}_{p^k})$ by Algorithm 1's replacement rule, and must be a strict inequality unless $\underline{p}^k$ achieves capacity in which case the algorithm would have already stopped. Construct a probability distribution vector $\underline{v}^{k+1}$ over T^{k+1} as follows. Let $v^{k+1}(s) = p_{minimum}$ and $v^{k+1}(b) = p^k(b)$. Also, arbitrarily select the remaining $v^{k+1}(i)$ over T^{k+1} such that it is true that $\sum_i v^{k+1}(i) = 1$.

Find a δ such that:

$$\frac{\sum_{j=1}^{n} P(j|s) \cdot \log \dfrac{Q^*_{p^k}(s|j)}{p^k(s) + \delta}}{\sum_{j=1}^{n} P(j|s) \cdot \log \dfrac{Q^*_{p^k}(s|j)}{p^k(s)}} \ge \frac{\sum_{j=1}^{n} P(j|b) \cdot \log \dfrac{Q^*_{p^k}(b|j)}{p^k(b) - \delta}}{\sum_{j=1}^{n} P(j|b) \cdot \log \dfrac{Q^*_{p^k}(b|j)}{p^k(b)}} \; , \tag{42}$$

where $0<\delta<1$; also: $0 < v^{k+1}(s) + \delta < 1$, and $0 < v^{k+1}(s) - \delta < 1$. Such a vector must always exist because of the definition of $v^{k+1}(s)$ and $v^{k+1}(b)$, and also due to the strict inequality between $I(s;\underline{q}_{p^k}) < I(b;\underline{q}_{p^k})$. Now, define vector $\underline{w}^{k+1}$ as:

$$\begin{aligned} w^{k+1}(i) &= v^{k+1}(i), \quad \forall\, \underline{r}_i^{k+1} : i \in \{T^{k+1} - s - b\} \; ; \\ w^{k+1}(s) &= \delta + v^{k+1}(s) \; ; \quad \text{and} \\ w^{k+1}(b) &= v^{k+1}(b) - \delta \quad . \end{aligned} \tag{43}$$

Also, define the following matrix:

$$Q^*_{v^k}(i|j) \equiv \frac{v^k(i) \cdot P(j|i)}{\sum_{i \in T^k} v^k(i) \cdot P(j|i)} \quad ; \tag{44}$$

and it is the backwards channel matrix given by P_{mxn} and an input distribution $(\underline{v}_k)$, at the kth iteration of *Algorithm 1*. The validity of the lemma can now be seen from equation (45) in the following.

$$\begin{aligned} S(\underline{v}^{k+1}, q_{p^k}, T^{k+1}) &\equiv \sum_{i \in T^{k+1}} v^{k+1}(i) \cdot I^k(i; q_{p^k}) \\ &= \sum_{i \in T^{k+1}} v^{k+1}(i) \cdot \sum_{j=1}^{n} P(j|i) \cdot \log \frac{P(j|i)}{q_{p^k}(j)} \\ &= \sum_{i \in T^{k+1}} v^{k+1}(i) \cdot \sum_{j=1}^{n} P(j|i) \cdot \log \frac{Q^*_{p^k}(i|j)}{p^k(i)} \\ &\le \sum_{i \in T^{k+1}} w^{k+1}(i) \cdot \sum_{j=1}^{n} P(j|i) \cdot \log \frac{Q^*_{p^k}(i|j)}{w^{k+1}(i)} \\ &\le \sum_{i \in T^{k+1}} w^{k+1}(i) \cdot \sum_{j=1}^{n} P(j|i) \cdot \log \frac{Q^*_{w^{k+1}}(i|j)}{w^{k+1}(i)} \\ &= S(\underline{w}^{k+1}, q_{w^{k+1}}, T^{k+1}) \quad . \end{aligned} \tag{45}$$

The first inequality can be seen by making a term-by-term comparison with the preceding line of the equation. Clearly, from the definitions of $\underline{p}^k$, $\underline{w}^{k+1}$, and $\underline{w}^{k+1}$ all terms in the third and fourth lines of equation (45) must be equal except for those terms indexed by s and b because they are modified by δ in the definition of $\underline{w}^{k+1}$.

Equation (42) shows the effect which gives rise to the inequality. The second inequality arises as a consequence of equation (15) which corresponds directly to Blahut's Theorem 1b in (1972). This can be seen by treating $Q^*_{p^k}(i\,|\,j)$ in the preceding line as a dummy variable Q. In this case, according to (32) and (Theorem 1, 1972), the maximum of the associated function with dummy variable Q and fixed vector $\underline{w}^{k+1}$ is achieved by $Q^*_{w^{k+1}}(i\,|\,j)$, which proves the lemma.

Finally, the two lemmas allow us to conclude the result shown in equation (46) where the first inequality follows from Lemma 1 and the second arises from Lemma 2. The third inequality holds because $\underline{p}^{k+1}$ achieves channel capacity C^{k+1} and therefore must maximize $S(\cdot)$. Thus, equation (45) shows that the sequence $\{C^k\}$ is monotonically increasing; since it is bounded from above by channel capacity C for P_{mxn} the theorem follows. *QED.*

Empirical results show that *Algorithm 1* requires decreasingly less iterations (*i.e.* calculating C^{k+1} from C^k) than Arimoto-Blahut's algorithm. The above approach was finds only the source inputs which are sufficient and necessary to compute the capacity of large channels. The approach and associated algorithm requires no *a priori* knowledge of the rank of the channel matrix P but instead use a comparison of the sizes of the source and reproduction alphabets to find the sufficient source inputs which can then be used to calculate channel capacity. The algorithm was shown to be convergent and a numerical example was presented which demonstrated its efficiency. (The algorithm is clearly appropriate for use in information technology, and specifically in telecommunications, to efficiently calculate the capacity of communications channels with very large source and reproduction alphabets, such as those with intersymbol interference, where calculation of channel capacity is computationally intensive.)

$$
\begin{aligned}
C^k &= \sum_{i \in T^k} p^k(i) \cdot I^k(\underline{r}_i ; \underline{q}_{p^k}) \\
&\le S(\underline{v}^{k+1}, \underline{q}_{p^k}, T^{k+1}) \\
&\le S(\underline{w}^{k+1}, \underline{q}_{w^{k+1}}, T^{k+1}) \\
&\le \sum_{i \in T^{k+1}} p^{k+1}(i) \cdot I(\underline{r}_i ; \underline{q}_{p^{k+1}}) \\
&= S(\underline{p}^{k+1}, \underline{q}_{p^{k+1}}, T^{k+1}) \\
&= C^{k+1} .
\end{aligned}
\tag{46}
$$

The above approach for calculating channel capacity also answered the associated question from the precept-attribute-mechanism problem: "Of all the attributes, which one is best achieved, or emphasized, by the optimal relationship of the implementing mechanisms to the intent of the given precept?" It was shown that this mathematical approach also provided modeling capability to determine the effects of each implementing mechanism on each of the precept's possible values. Therefore, taken together the channel capacity and rate distortion problems provide a complete mathematical analogy to the precept-attributes-mechanisms one.

In the preceding, it was assumed that the problem to be solved requires "Attributes" to be the parameter space, "Precepts" to be a class of information sources where "Mechanisms" attempt to reproduce the intent of those given attributes of the precept. Clearly, that the problem to be solved directed the assignment of precepts, attributes and mechanisms to particular roles. However, the suggested modeling approach was shown to be quite resilient, in that way, because it permits modeling of any variation of the precept-attribute-mechanism problem through interchange of each of their roles, and construction of appropriate probability distributions. It is apparent that other precept-attribute-mechanism problems can be modeled by simply interchanging their roles and constructing appropriate probability distributions. Moreover, other factors such as time, geography or nuances of politics can obviously be included as variables and arguments of parameterized functions, or as parameters. This indicates the richness of possibilities for the suggested approach in modeling public administration precept-attribute-mechanism phenomena while accounting for a range of social, economic and political factors.

Summary

In summary, from the above, a clear relationship between the public administration three-tiered accountability architecture, namely, the precept-attributes-mechanisms problem, and the rate distortion problem was described in the above. A mathematical model was developed for that problem based upon an information theoretic approach taken by Wolfe (1995) for solution of a generalized rate distortion problem. The channel capacity problem completed the mathematical analogy by demonstrating the relationship between mechanisms and their best matched attributes.

It is intuitive from this example that other mathematical decision-making approaches can also be contrasted or modeled and used in analogy to social ones, particularly those of the precept-attribute-mechanism vein in public administration. Clearly, there remain considerable other opportunities for incorporation of advanced mathematical techniques, such as the one above, within the overall venue of public administration and its research methods.

Appendix C: Survey Instrument

Questionnaire About Federal Information Technology Oversight

Study Background Information

Purpose Of The Study: The study has been designed to identify the beliefs and perceptions of senior information professionals about changes that have occurred and others that will be occurring in oversight of major federal information technology (IT) programs. The results of the study will be used to predict how these oversight changes will affect the success of future federal information technology programs. Your organization was selected to participate in the study because it has program, technical, contracting or oversight responsibilities for one or more major federal information technology programs. You are being asked to participate in the study and complete a questionnaire because of your senior level experience and your key role in managing those IT responsibilities.

How The Study Results Will Be Used: This study is being conducted strictly for academic research purposes. The intention is to summarize the results of the study data for scholarly publication. The resulting contribution to the literature will be useful in its own right, and it should also help other researchers understand information professionals' beliefs about today's IT oversight changes. No federal agency has sponsored this study. Neither is there any private industry involvement or funding connected with this research.

Your Response is Completely Confidential: Please be assured that your response will be held in strictest confidence, and only the composite data will be published.

Time To Complete The Questionnaire: It takes approximately 20 to 30 minutes to complete this Questionnaire. This was determined by a preliminary study in which a number of professionals completed an earlier version of this Questionnaire.

Please Participate: The questionnaire is an opportunity for you to help identify some of today's important changes and trends in information technology oversight, and how they will affect federal IT programs in the future. Your views are very important to the study results because of your senior level experience and your program, technical, contracting, media, marketing, or oversight responsibilities for major federal IT programs. Please take advantage of this opportunity to express your views. Thank you in advance for taking the time to help by completing the questionnaire.

Questionnaire For Study Of Federal Information Technology Oversight

Section I: Your Views About Federal Information Technology Oversight

Please provide your views about information technology accountability and oversight practices. This Section is divided into four parts.

Part A: Specific Views About Information Technology Oversight

This Part asks for your views about specific information technology oversight practices in the past, present and future. Please place check marks or an "x" in the appropriate space.

	Past	Present	Future
1. In your experience, which of the following **HAS** exercised or **WILL** exercise the **MOST** responsibility for federal **GOVERNMENT-WIDE** oversight of information technology? **Choose one and only one in each column.**			
Congressional authorizations committees			
Congressional appropriations committees			
Congressional general government committees			
General Accounting Office			
General Services Administration			
Office of Management and Budget			
INTER-Agency teams (please specify) ___________			
Other (please specify) ______________________			
None--there has been no government-wide oversight			
2. In your experience, which of the following **SHOULD HAVE** the **MOST** responsibility for federal **GOVERNMENT-WIDE** oversight of information technology? **Choose only one in each column.**			
Congressional authorizations committees			
Congressional appropriations committees			
Congressional general government committees			
General Accounting Office			
General Services Administration			
Office of Management and Budget			
Government-Wide Chief Information Officer (CIO)			
INTER-Agency teams (please specify) ___________			
Other (please specify) ______________________			
None			

Section I, Part A continued	Past	Present	Future
3. Which **HAS** or **WILL HAVE** exercised the **MOST** oversight of your **AGENCY's** IT programs? **Choose one in each column.**			
Congressional Authorizations Committee(s)			
Congressional Appropriations Committee(s)			
General Accounting Office			
General Services Administration			
Office of Management and Budget			
Chief Information Officer (CIO)			
Chief Financial Officer (CFO)			
Senior Information Resources Management Official			
Senior Procurement Official			
Senior Program Official			
Inspector General (IG)			
Other (please specify) ____________________			
None			
4. Which **SHOULD HAVE** the **MOST** oversight of your **AGENCY's** IT programs? **Choose one in each column.**			
Congressional Authorizations Committee(s)			
Congressional Appropriations Committee(s)			
General Accounting Office			
General Services Administration			
Office of Management and Budget			
Chief Information Officer (CIO)			
Chief Financial Officer (CFO)			
Senior Information Resources Management Official			
Senior Procurement Official			
Senior Program Official			
Inspector General (IG)			
Other (please specify) ____________________			
None			

Section I, Part A continued	**Past**	**Present**	**Future**
5. In your experience, which of the following **HAS** or **WILL HAVE** exercised the **MOST** oversight responsibility for the **LARGEST** and most important information technology program or project for which you have had significant responsibility. **Choose only one in each column.**			
Congressional Authorizations Committee(s)			
Congressional Appropriations Committee(s)			
General Accounting Office			
General Services Administration			
Office of Management and Budget			
Chief Information Officer (CIO)			
Chief Financial Officer (CFO)			
Senior Information Resources Management Official			
Senior Procurement Official			
Senior Program Official			
Users of IT Systems			
Inspector General (IG)			
Internal peer review committees			
Internal management review committees or Boards (*e.g.* MAISRC)			
One-time **INTERNAL** review teams (*e.g.* Tiger Teams)			
One-time **EXTERNAL** review teams (*e.g.* National Academy of Sciences review)			
None			
Other (please specify which organization assumed responsibility for oversight and describe how its oversight methods) ______ ______ ______ ______ ______ ______			

Section I, Part A continued	Past	Present	Future
6. In your experience, which of the following **SHOULD HAVE** the **MOST** oversight responsibility for the **LARGEST** and most important information technology program or project for which you have had significant responsibility. **Choose only one in each column.**			
Congressional Authorizations Committee(s)			
Congressional Appropriations Committee(s)			
General Accounting Office			
Office of Management and Budget			
General Services Administration			
Chief Information Officer (CIO)			
Chief Financial Officer (CFO)			
Senior Information Resources Management (IRM) Official			
Senior Procurement Official			
Senior Program Official			
Inspector General (IG)			
Internal peer review committees			
Internal management review committees or Boards (*e.g.* MAISRC)			
One-time **INTERNAL** review teams (*e.g.* Tiger Teams)			
One-time **EXTERNAL** review teams (*e.g.* National Academy of Sciences review)			
None			
Other (please specify which organization should assume responsibility for oversight and describe those methods it should use for oversight) ______ ______ ______ ______ ______ ______			

Section I, Part B: Characterizing Information Technology Practices

Which time period is **best** associated with each of the following statements or words **(select only the one time period which best characterizes each statement or word)**:	**Past**	**Present**	**Future**
Authority should be requested and delegated from higher levels for specific IT projects.			
Audits should be initiated and conducted by external organizations.			
Before they can proceed, major IT projects should usually be reviewed by higher authority at key milestones.			
There should be only one reporting structure for each IT project			
Contracting procedures should be fair to industry			
Information technology is an expense.			
Information specialists should manage all parts of large-scale systems development projects			
Organizations should be flatter, and less approvals should be needed.			
Ensuring conformity to standard procedures should be replaced by sharing new and improved methods			
The effects of IT projects on agency missions should be periodically measured and reported.			
Many groups need to be kept informed about IT projects progress.			
Contracting methods should be streamlined.			
Information technology should be treated as an investment.			
IT managers should be responsive to political leaders' direction when planning their projects.			
Only a few organizations or groups should be involved in approving major IT projects.			
Groups of federal, academic and/or industry experts should be formed to review major IT projects, and make recommendations.			

Section I, Part B continued:	Past	Present	Future
Performance measures should be established up-front			
Reporting to external organizations should be minimal.			
Legal appeal processes should protect the government's interests.			
IT programs should maximize return on investment.			
IT should be combined with fiscal and program management.			
General Services Administration			
Management councils			
Chief Information Officer (CIO)			
General Accounting Office			
Facilitate			
Inter-agency committees			
Business case			
Best practices			
Measurable results			
Management			
Re-engineering			
Leadership			
Checks and balances			
Streamline			
Reduced vendor appeal rights			
Economy			
Efficiency			
Effectiveness			
National Institute of Standards and Technology			
Chief Executive Officer (CEO)			
Office of Management and Budget			

Section I, Part C: Effectiveness of Information Technology Practices
Please rate the following principles and practices according to their success in improving IT programs. **Please mark the appropriate column where 1 is "not effective" and 5 means "highly effective."**

	1	2	3	4	5
Authority should be requested and delegated from higher levels for specific IT projects.					
Audits are initiated and conducted by external organizations.					
Before they can proceed, major IT projects should usually be reviewed by higher authority at key milestones.					
There should be only one reporting structure for each IT project					
Contracting procedures should be fair to industry					
Information technology is an expense.					
Information specialists should manage all parts of large-scale systems development projects					
Organizations are flatter, and less approvals should be needed.					
Ensuring conformance to standard procedures is replaced by sharing new and improved methods					
The effects of IT projects on agency missions should be periodically measured and reported.					
Many groups should be kept informed about IT projects progress.					
Contracting methods should be streamlined.					
Information technology should be treated as an investment.					
IT managers should be responsive to political leaders' direction when planning their projects.					
Only a few organizations or groups should be involved in approving major IT projects.					
Groups of federal, academic and/or industry experts should review major IT projects, and make recommendations.					
Performance measures should be established up-front					
Reporting to external organizations should be minimal.					
Legal appeal processes should protect the government's interests.					
IT programs should maximize return on investment.					
IT should be combined with fiscal and program management.					

Section I, Part D: General Questions About Your Information Technology Oversight Views

This Part asks why your choices about oversight, above, would do a reasonable job of ensuring that federal agencies are held accountable for the success of their largest and most important information technology programs and projects. Please provide narrative answers for the following questions.

1. Which oversight practices do you feel are the most effective? Please give some examples:

2. What makes these oversight practices so successful? Please describe:

3. When would these oversight practices be most effective-- before or after-the-fact? Please explain:

4. Who should be responsible for implementing the oversight practices you chose? Please describe each of the executive, legislative or judicial organizations you think should have a major role:

Section II: Information About Your Information Technology Responsibilities

Please provide some information about your current information technology responsibilities. This information is confidential and not identifiable at the individual level. This information will help identify common beliefs about IT from people with diverse professional experiences. Please place a check mark or "x" in the appropriate space.

1. I currently work in:
   - The federal executive branch: ___ A federal quasi-government organization: ___
   - The federal legislative branch: ___ State or local government: ___
   - The federal judicial branch: ___ The private sector: ___
2. Choose the best description for the level of your current position (complete a. or b.)
   - a. If you are a federal employee please indicate your highest grade level:
     Senior Executive Service:___ GS-15:___ GS-14:___Other (please specify): ________
   - b. If you are currently in the private sector please choose the federal grade level which most closely matches your current position's responsibilities:
     Senior Executive Service:___ GS-15:___ GS-14:___Other (please specify): ________
3. Your current position includes significant responsibilities mostly for:
   - Computers (ADP--automatic data processing) ___
   - Telecommunications ___
   - Significant responsibilities for both ___
4. Which of the following most closely characterizes your current responsibilities:
   - Program ___ Oversight ___
   - Technical ___ Public relations--News media ___
   - Contracting ___ Marketing ___
5. What is the approximate **TOTAL** dollar value (life cycle costs) of **ALL** information programs or projects for which you currently have significant responsibilities or monitor. Please choose one:
   Less than $25 million ___, $25 to $49 million ___, $50 to $99 million ___,
   $100 to $499 million ___, $500 to $999 million ___, or greater than $1 billion ___.
6. What is the approximate dollar value (life cycle costs) of the **LARGEST** single information program or project for which you now have significant responsibilities or monitor. Please choose one:
   Less than $25 million ___, $25 to $49 million ___, $50 to $99 million ___,
   $100 to $499 million ___, $500 to $999 million ___, or greater than $1 billion ___.
7. Describe the **LARGEST** single information program or project for which you currently have significant responsibilities or monitor. Please choose one from the following:
   - a. The program or project can be best described as (choose only one):
     - mostly computers (ADP--automatic data processing) ___
     - mostly telecommunications ___
     - has significant portions of both ___
   - b. This program or project can be best described as (choose only one):
     - mostly hardware (new, upgrade or replacement) ___
     - mostly software development ___
     - has significant portions of both ___
8. Please provide any other information about your responsibilities that you would like to share:

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Section III: Additional Comments

Would you like to provide additional comments, or are there some important questions that were not asked? Please share any other information which you believe should be included in this study.

Part A: Questions that were not asked, and your views:

Part B: Additional comments:

Section IV Information About You--Optional

This Section is OPTIONAL. However, it would be helpful if you would provide some limited information about yourself. This information will not be identifiable by individual but it will help to identify common beliefs about information technology (IT) accountability from people with similar backgrounds. There are two parts in this section.

Part A: This part is OPTIONAL. The following questions ask for information about your professional information technology background. (Please enter "0" where not applicable.)

1. Over your entire federal career in information technology what are your:
   a. Total number of years in the executive branch: ________
   b. Total number of years in the legislative branch: ________
   c. Total number of years in the judicial branch: ________
   d. Total years in a quasi-government organization: ________
2. Total years worked in state or local government information technology: ________
3. Total number of years worked in private sector information technology: ________
4. Over all of your positions throughout your entire working career what are your:
   a. Total number of years in information technology: ________
   b. Total years in other than information technology: ________
5. Major field of study at highest education level:
   - Information Management ___
   - Computer Science ___
   - Engineering ___
   - Mathematics ___
   - A Natural Science ___
   - A Social Science ___
   - Business Administration ___
   - Public Administration ___
   - Law ___
   - Other discipline ___ Please describe:________________________
6. Please provide any other information about your background that you would like to share:

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Part B: This part is also OPTIONAL. May I interview you about your views? If "yes" please provide your name and telephone number, below, and indicate a good time to contact you by telephone.

Name: ____

Telephone Number: ______________________________________

Date and time to contact you: ________________________________

Thank you for sharing your views and completing this Questionnaire. The information that you provided will contribute to better understanding federal responsibilities for oversight and accountability of information technology.