SCIENCE AND TECHNOLOGY POLICY IN THE AVIATION INDUSTRY: THE DEVELOPMENT OF KOREAN CIVIL AVIATION TECHNOLOGY

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Abstract

The aviation industry has been dominated by several developed countries, notably the United States, the United Kingdom, France and Germany. They have made efforts to maintain the competitiveness of their aviation industry through strong government support of the industry, the establishment of technology barriers and the consolidation of their aviation companies. In this environment, Korea, a developing country, seems to have recognised the necessity of developing its aviation industry in order to continue the development of its economy. However, the Korean government has not supported the industry consistently with a feasible long-term development strategy, and seems not to have given a high level of priorities to develop the aviation industry. The Korean aviation industry may be difficult in achieving competitiveness under the government's low support compared to those of developed countries.

The effective implementation of aviation development policy seems to be an important factor for organisations relevant to the development of the Korean aviation industry in maximising their capabilities in the current situation of lack of government support, low technological capability and small sized companies. This research aims to recommend policy options for the efficient implementation of Korean aviation technology policy. It is expected to be useful for me, a government official in the Ministry of Science and Technology of Korea, moreover, hopefully it will be helpful for the development of the Korean aviation industry.

The thesis aims to propose policy option for the efficient implementation of Korean aviation technology policy with focus on co-operation, co-ordination and motivation factors (the CCM factors). To achieve this goal literature on science and technology policy was studied, and the aviation technology policies of the three developed countries of the UK, the US and Japan, as well as that of Korea were examined. In addition, an original survey on the efficient implementation of Korean aviation technology policy was carried out with a combination of questionnaires and interviews.

The research confirms that the CCM factors are important for the efficient implementation of Korean aviation technology policy, and that Korea needs to emphasise the efficient *implementation* of its aviation technology policy. In addition, it seems that Korean government needs to maintain stability of policy implementation with a solid determination in supporting the aviation industry with proper procurement and R&D strategies. It also should establish an efficient *working environment* for officials, who can do their best in implementing the policy in order to achieve policy purpose.

Declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Copyright Information

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Chapter 1: Introduction

1.1 Research Purpose and Background

This thesis aims to recommend policy options for the efficient implementation of Korean aviation technology policy. To do this, the thesis has three sub-purposes. Firstly, it aims to establish the academic background of science and technology policy and aviation technology policy through a literature review. Secondly, it aims to identify potential lessons from the aviation technology policies of the developed countries by analysing their aviation development systems, together with supplementary sources in periodicals and articles. Finally, the research aims to examine what degree of efficiency exists in the implementation of Korean aviation technology policy through the examination of references and through original fieldwork, using a combination of questionnaires and interviews.

Korea has developed rapidly over the last three decades, but no longer enjoys competitiveness through a lower wage system, which was one of the significant factors in its fast economic development in the past. Therefore, it has placed emphasis on the establishment of a highly advanced technological industry, in order to ensure continuous economic development in the future. Currently the aviation industry is of particular interest to Korea, since it wishes to establish advanced technological Korean industry through the development of the aviation industry. This is because it considers that the aviation industry has a high value-added effect and will produce a large benefit for the national economy (S.R, Lee, 1998, p. 170).

The development of the aviation industry seems to be very important to Korea for the purpose of establishing an advanced technological industry and of achieving national security. In this respect, aviation technology policy was chosen as a research area in order to propose policy options for the development of the Korean aviation industry.

However, the Korean aviation industry is experiencing difficulties in gaining competitiveness in the world aviation industry. This is because it has low technological capability and small scale aviation companies (Gyeongsang University, 1995, p. 22), and because large scale foreign aviation companies have merged in order to improve their competitiveness and to secure more market share. In fact, Boeing, the largest civil aviation company, and McDonnell Douglas were merged in August 1997. British Aerospace and Marconi Electronic Systems were merged into a company, BAe Systems, in November 1999 (http://www.baesystems.com/dynamic, December 2, 1999). In addition, DaimlerChrysler Aerospace (DASA), Aerospatiale Matra and Construcciones Aeronauticas S.A (CASA) announced the creation of the European Aeronautic, Defence and Space Company (EADS) in October 1999 (*Defence News*, December 20, 1999., *Financial Times*, January 3, 2000). The Korean aviation industry will find it difficult to become competitive with the giant companies. It seems to need an effective aviation development strategy in order to develop its aviation industry.

Korea, a latecomer to the aviation industry, has four major aviation companies, but their competitiveness is much lower than those of the developed aviation industry countries. Korea had only one company, Samsung Aerospace, among the world top 100 companies by 1997 sales: its ranking was 74^{th} (*Flight International* 2-8 September, 1998). Currently three major aviation companies, Samsung Aerospace, Hyundai Space & Aircraft, and Daewoo Heavy Industries have merged into a single company, the Korea Aerospace Industries (KAI), in October 1999 (*Korea Herald*, February 23, 2000), but another major company, Korea Air, did not join in KAI. However, they do not have sufficient aviation development projects for the Korean aviation industry to develop. In fact, KAI has only one active aviation production project, the KT-1 (MOIR, 1999).

To overcome these difficulties, Korea needs to understand the changes in the world aviation industry, and to learn lessons from aviation development policies adopted in the developed countries. However, it is not easy for Korea to successfully imitate an aviation development policy from the developed countries, due to the differences of economic and technological capability and culture between countries. In addition, a developing country can sometimes mistakenly emphasise only *performance* of policy in order to catch up with the developed countries' technological capabilities in a short period, without paying sufficient attention to the efficient *implementation* of policy.

We will discuss in more detail in chapter 7 the Korean innovation system and in chapter 2 the review of, and lessons from, the literature on science and technology policy. But, by way of initial introduction to the core approach taken in the thesis, we now discuss briefly some features of recent Korean steps to strengthen its technology base.

Korea is said to be one of 6 technological leader countries, which include Germany, the US, Switzerland, Japan and Sweden (Soete, 1991), although it has opened its gate to the modern world economy only since the mid-1940s. The modern Korean economy seems to have developed since the First Five-Year Economic Development Plan led by former president Park in 1962. It grew by almost 9% annually over the three decades since the initiative of the Plan (Nelson, 1993, p. 358). Through rapid economic development, several of Korea's industries became competitive world-wide. In 1994, the Korean shipbuilding industry was second in terms of world market share, the semiconductor industry was third, and the electronics, petrochemical and textile industry were fifth (OECD, 1996, p. 177).

Korea's R&D investment has recently increased more rapidly than that of the developed countries. Korea's annual increase of R&D investment was 19.6% during 1992-97, while that of the US was 4.5%, that of Japan 3.0% and that of the UK 2.2%. However, its R&D fund is still small compared with the developed countries. In 1996, R&D funds in Korea was \$12.8 billion, while those of the US, the Japan and the UK were \$184.7 billion, \$130.1 billion and \$22.4 billion respectively (The 1998 MOST White Paper, p. 398). Moreover, the Korean government provides lower level of R&D fund for industrial technology development. Its R&D funding support covered 23.4% of total national R&D funds in 1997, while those of the UK, the US and Japan were 36.4%, 35.4% and 26.5% respectively. The trend of Korean R&D is shown in Table 1.1.

Table 1.1 R&D Investment Trend in Korea, 1994-97

US$, (%): annual increase rate

	'94	'95	'96	'97
1. GDP ($bil)	321,4 (14.5%)	369.7 (15.3%)	409.4 (10.8%)	442.2 (8.0%)
2. GNP ($bil)	319.0 (14.4%)	366.5 (14.8%)	405.9 (10.8%)	436.9 (7.7%)
3. R&D fund ($bil)	8.3 (28.3%)	9.9 (19.6%)	11.4 (15.2%)	12.8 (12.05)
R&D rate (3/1)	2.58%	2.68%	2.79%	2.89%
R&D rate (3/2)	2.60%	2.71%	2.81%	2.93%
4. R&D funds (Public : Private)	16:84	19:81	22:78	23:77
-Public ($bil)	1.3	1.9	2.5	3.0
-private ($bil)	6.9	8.0	8.9	9.8
-foreign countries ($bil)	-	-	0.01	0.01

Source: *The 1998 Science and Technology White Paper (*MOST, 1999*)*, p. 112.
Remarks: US$ is calculated by Korean Won/952.

Korea's public R&D funds have been provided mainly from five ministries, including the MOST, the KMOD, the MOIR, the Ministry of Information and Communication (MOIC), and the Ministry of Education (MOE). In 1995, the R&D budget of MOST was $835.1 million (34.4%) and that of KMOD was $446.7 million (17.1%), while those of MOIR, MOIC, MOE and others were $367.7 million (15.0%), $14.6 million (0.6%), $290.1 million (11.9%) and $509.7 million (21.0%) respectively (OECD, 1996, p. 148).

Major national R&D projects have been supported by two ministries: MOST and MOIR. National R&D projects supported by MOST can be categorised mainly into basic science research and the specific R&D projects. The basic science research aims to support oriented basic research, the science research centres (SRC), the engineering research centres (ERC), the regional co-operative research centres (RRC), and researcher exchange. The specific R&D projects include leading technology development, nationally-oriented R&D, the promotion of creative research, the internationalisation of science and technology, the advancement of co-usable research facilities, and R&D planning and evaluation projects. MOIR has administered the industrial base technology development project (MOST, 1999, pp. 145-163).

Both schemes, supported by MOST and MOIR, designate target technologies and offer direct R&D subsidies to R&D organisations (Nelson, 1993, p. 373). The national R&D programmes mentioned above are summarised in Table 1.2.

Table 1.2 Major Korean Government-Supported R&D Projects

Korean Won billion

National R&D Project	Sub-R&D projects	'98 budget
The basic science research project (MOST)	• Oriented basic research	39.9
	• Support of SRC and ERC	42.4
	• Support of RRC	8.0
	• Others	25.8
	(Total)	(116.1)
The specific R&D Project (MOST)	• Leading technology development	100.1
	• Nationally-oriented R&D	140.8
	• The promotion of creative research	36.0
	• The globalisation of science and technology	21.1
	• The advancement of co-usable research facilities	1.5
	• R&D planning and evaluation	6.5
	(Total)	(330.1)
The industrial base technology development project (MOIR)	• Generic core technology development	85.2
	• Middle-term oriented technology development	74.2
	• Leading technology development	56.9
	• Aerospace technology development	12.5
	• Others	24.3
	(Total)	(253.1)

Source: *The 1998 Science and Technology White Paper* (MOST, 1999), p. 146, 160, 173.

The Korean government has made many efforts in establishing an effective R&D environment. MOST has formulated various support programmes including researcher development and establishing an industrial R&D environment.

The number of researchers, excluding engineers who support research activity and managers in support divisions, was 138,438 in 1997, while those in the US, Japan and the UK there were 962,700 ('93), 617,365 ('96) and 143,000 ('96) (MOST, 1998, p. 54). During 1993-97, the number of researchers increased by 40% in Korea. That in universities has substantially increased by 69%. However, it did not increase in the case of research institutes, as shown Table 1.3.

Table 1.3 Trend of the Number of Researchers

(1,000 persons)

The number of researchers	1993	1994	1995	1996	1997
Total	98.7	117.4	128.3	132.0	138.4
Research Institutes	16.0	15.4	15.0	15.5	15.1
Universities	28.6	42.7	44.6	45.3	48.5
Industry	54.0	59.2	68.6	71.1	74.6
PhD	26.8	33.9	35.1	36.1	37.8

Source: The 1998 Science and Technology White Paper, MOST, 1999, p. 379.

To secure high level research capabilities, MOST established two research-oriented science and engineering universities. The Korea Advanced Institute of Science and Technology (KAIST) had produced 2,011 Ph.Ds and 8,200 M.Scs during 1971-94. The Kwang-Ju Institute of Science and Technology opened in 1995 (MOST, 1995, pp.31-32).

To promote R&D activities in private enterprises, MOST has provided firms with tax incentives. The maximum tax deductible reserve is 4% of the total sales. Private enterprises may take advantage of tax deduction of up to 15% of their total expenditures, on training and in-house technical colleges, and they are allowed tax deduction of up to 10% of their investments for research facilities and to depreciate the total investment for research and test facilities at the rate of 90% a year. The government provides up to 50% of the total R&D expenditures when firms are involved in national R&D projects, also the government provides financial support for up to 80% ~ 90% of total cost to individuals or small firms to help commercialise new technology. In addition, the Korean government has made many efforts in order to achieve an effective R&D activity through the strengthening of information services, intellectual property right protection, collaborative R&D among industry, academia, and research institutes and through international collaboration (MOST, 1995, pp.30-40).

Linking this discussion to the wider literature on national systems of innovation (on which more in chapter 2), Nelson (1993, pp. 359-364), has pointed out five positive factors influencing Korea's rapid development. First, human resource development may be a most basic and critical determinant. Over 30 per cent of all Korean high school students enter into under graduate courses currently. Second, Korean's hard working habits in long hours may be another factor accounting for the fast acquisition of technological capability. Third, Korea has been relatively effective in acquiring technological capability through the promotion of technology transfer by means of the procurement of turnkey plants rather than direct foreign investment (DFI) and foreign licensing (FL) which were quite restrictive in the early years (the 1960s and 1970s). Fourth, the Korean government designed so-called strategic industries for import substitution and export promotion in order to overcome a disadvantage of a small-sized domestic market. Fifth, the Korean government intentionally created large, *chaebols*, as an instrument to bring abort the economy of scale in mature technologies and in turn to develop strategic industries and to lead export and national economy. Amsden (1989. p. 8) also describes the positive factors as an interventionist state, large diversified business groups, and abundant supply of competent salaried managers, low cost and well educated labours.

On the other hand, OECD (1996, pp. 187-191) has identified seven weaknesses of Korea in developing its technological capability as follows:

i) Korea seems to lack co-ordination between those ministries in implementing science and technology policy.
ii) Korea seems to have difficulty establishing conditions that foster initiative and creativity.
iii) Contributions from the government supported research institutes (GSRIs) are weak, although those were larger in the 1970s and 1980s.
iv) Major national R&D projects cannot be supported effectively without great strengthening of the science and technology base.
v) Efforts are not made to diffuse technology.
vi) Korea has protection barriers and obstacles to foreign investment.
vii) The role of the university sector is weak in developing technological capability.

As can be seen from the above discussion, the problem is not primarily about lack of investment in R&D and human resources, but is more about effective implementation. The OECD mentions two weak sectors whose contribution to Korea's national system of innovation could be improved: the universities and the GSRIS. It mentions lack of initiative and creativity and lack of emphasis on diffusion of technology. Lack of co-ordination between different parts of government is a key problem. All of these issues can be seen to be elements of implementation, or realising, a successful NIS. This thesis focuses on co-operation, co-ordination and motivation, as aspects of policy implementation, which have been selected from the above reflections (co-ordination of activities, co-operation to achieve common goals of science and technology capabilities, motivation for creativity and commercial exploitation) and the consideration of Korean aviation policy, and from the literature review in chapter 2.

In addition, the Korean government did not successfully implement its previously established aviation development strategies. In 1978, it announced in the President's Annual Message that Korea would produce aircraft by the mid-1980s, and established the Aerospace Industry Promotion Act (Korea Institute for Economy and Technology (KIET), 1990, pp. 45-46). In 1989, the government announced again that Korea would become a developed aviation industry country by 2005 (KIET, 1994, pp. 117-118). However, the current level of development of the Korean aviation industry is much lower than that of the developed countries. Korea has not yet produced any commercial aircraft. It has only begun to produce the KT-1, the first domestically developed military basic trainer, since late 1999.

The Korean government, research institutes, universities and the aviation industry seem to need to refocus on the implementation stage of the aviation development policy that has been established. This thesis has chosen to address the three factors of *co-operation, co-ordination* and *motivation* identified through the literature on science and technology policy as being major components of successful science and technology policies. These factors are used as core concepts in exploring the conditions for efficient implementation of aviation technology policy through the examination of aviation development systems. Such research seems to be highly necessary for the Korean government, including this researcher, a government official in the Korean Ministry of Science and Technology (MOST), in order to achieve the efficient implementation of Korean aviation development policy.

2.1 Research Design

Co-operation, co-ordination and motivation seem to be important factors in the efficient implementation of science and technology policy. By these terms I mean:

1) Co-operation is the activity of two or more individuals to achieve their purposes, about which they set out to achieve a shared gaol. It is an indispensable factor in gaining synergy between organisations which can benefit both parties. A high level of co-operation activity can be achieved through a well organised information exchange system, joint research and development (R&D), technology transfer and international collaboration (Tidd *at al.*, 1997, Grayson, 1995).
2) Co-ordination is the activity of two or more individuals, which may not necessary share a common goal, to achieve their purposes. Co-ordination is also a very important factor in achieving an overall purpose effectively. To achieve efficient co-ordination, it is necessary to consider various elements including the stability of policy, a sufficiently long-term outlook (Petrella, 1994), the establishment of goals and priorities (Tisdell, 1981), and the understanding of economic and technological capability (Strasser and Simons, 1973).
3) Motivation is encouragement to the person or group being motivated to do what the motivator wants. It can be established through both mental and economic satisfaction with the motivator's job. Effective team leadership, the resolution of conflicts (Tidd *at al.*, 1997), the minimising the burden of formal structure, rewards for innovative behaviour (Hjornevuk, 1973), adequate communication in all direction, supportive superiors and personally warm relations with superiors and peers (Likert, 1977) are important elements for establishing a high level of motivation.

The three factors of co-operation, co-ordination and motivation (hereinafter CCM) are used as a framework in this thesis through the examination of aviation technology policy adopted in the several countries' aviation technology policies. In addition, each factor has within it three or four subsidiary elements that are used as key measures in identifying the degree of efficiency of the CCM activity conducted in implementing Korean aviation technology policy through questionnaires given to researchers working in the aviation technology area (see chapter 8). These elements are also selected on the basis of the literature review of science and technology policy and of a pilot survey of Korean aviation technology policy.

The co-operation factor sub-divides into four elements as follows:

(i) the holding of seminars by or for researchers
(ii) the dissemination of R&D results
(iii) joint R&D, and
(iv) international collaboration.

Researchers can gain valuable R&D information by attending seminars related to their R&D area, and they can also open up the opportunity to co-operate with those present. The dissemination of R&D results seems to be regarded as an important factor of science and technology policy, which can be achieved by technology transfer, the training of students, and lectures conducted by researchers in universities. Joint R&D is also one of the most important elements in developing science and technology through the synergy of capabilities. International collaboration may be an indispensable factor in the aviation industry of a developing country, due to the huge R&D funding required in developing advanced aviation technologies. In fact, a very fast way to KAI in acquiring advanced aviation technologies from the developed countries can include a close collaboration with a foreign partner which will be selected from several aviation companies in developed countries. Those include the two joint investment bids for KAI of a US-UK consortium between Boeing and BAe Systems and a US-France consortium between Lockheed Martin (US) and Aerospatiale and Dassault Aviation (France), and one German aviation company, DaimlerChrysler Aerospace (DASA) (*Korea Herald,* February 23, 2000).

The co-ordination factor will be divided into three elements as follows:

(i) the short-term rotation of officials
(ii) the existence of conflicts, and
(iii) the survey of technology development trends.

The frequent rotation of officials working for aviation development affairs, in particular government officials, seems to be one of the barriers in co-ordinating the different opinions of the ministries concerned or between the government and the industry. This element was chosen on the basis of a pilot survey of Korean aviation development policy and of this researcher's fifteen years' experience of working for the Korean government. A new official may need much time for his work in order to be properly recognised. Efficient co-ordination can be established on the basis of good communication without conflicts between related persons. The survey of technology development trends also seems to be an element necessary for an understanding of the environment related to the co-ordination of different opinions.

Finally, the motivation factor will be divided into four elements as follows:

(i) participation in decision-making processes
(ii) incentive systems
(iii) R&D evaluation systems, and
(iv) trust relations

An appropriate participation in decision making processes related to policy, a proper incentive system including a grant and merit system, an efficient R&D evaluation system, and the establishment of trust relations between persons related to R&D activity are important elements in motivating researchers to achieve the organisational goal.

It is often not easy to establish whether a given policy issue pertains to a particular factor of the CCM factors, because the boundaries of factors frequently overlap in actuality, even though they are distinct in principle. The elements of the CCM factors explained above can be summarised as shown in Table 1.4.

Table 1.4 The Elements of the CCM Factors

Factors	Elements
Co-operation Factor	Holding of seminars Dissemination of R&D results Conduct of joint R&D activity International collaboration
Co-ordination Factor	Short-term rotation of officials Existence of conflicts Survey of technology development trends
Motivation Factor	Participation in decision-making processes Incentive systems R&D evaluation systems Establishment of trust relations

The relations between this model and the structure of this thesis can be expressed as shown in Figure 1.1.

Figure 1.1 Research Model and Thesis Structure

The Implementation Stage of S&T Policy	Literature on S&T policy
(*The Stage of Policy focused upon*)	(*Chapter 2*)

- Chosen to emphasise the efficient implementation of S&T policy. (*One of the research purposes*)

Aviation Technology Policy	Literature on Aviation Technology policy
(*The Technology Area researched*)	(*Chapter 3*)

- Chosen to recommend policy options for the efficient implementation of Korean aviation technology policy. (*One of the research purposes*)

The CCM Factors - Co-operation - Co-ordination - Motivation	Aviation Technology (AT) Policies: - the UK (*Chapter 4*) - the US (*Chapter 5*) - Japan (*Chapter 6*) - Korea (*Chapter 7*)
(*Core Concepts of the Research*)	(*Countries Chosen*)

- Selected through the literature on science and technology (S&T) policy.
- Used in examining aviation technology policies of the four countries in order to gain **lessons** from the developed countries and understand AT policies

Elements of the Co-operation Factor - *the holding of seminars* - *the dissemination of R&D results* - *joint R&D* - *international collaboration* Elements of the Co-ordination Factor - *the short-term rotation of officials* - *the existence of conflicts* - *the survey of technology development trends* Elements of the Motivation Factor - *participation in decision-making processes* - *incentive systems* - *R&D evaluation systems* - *trust relations*	Surveys on Korean Aviation Technology Policy (Questionnaires and Interviews) (*Chapter 8*)
(*Elements for Surveys on Korean AT Policy*)	

- Selected through the literature on science and technology policy and aviation technology policy, and a pilot survey.
- Used in surveying the **degree of efficiency** of the CCM activities conducted in the implementation of Korean aviation technology policy.

Recommendation of Policy Options	Conclusion (*Chapter 9*)

- For the efficient implementation of Korean aviation technology policy.

In order to propose policy options, it is necessary to consider various aspects related to a policy in principle. Those aspects can include the stages of policy, the fixed factors of policy and the flexible factors, and the various sectors of science and technology policy.

The stages of policy include the establishment, implementation and evaluation stages. The fixed factors of policy may relate to the given environments which are difficult to change in the short term, and include economic and technological capability and culture. The flexible factors of policy include the factors that can be easily changed in the short term by the everyday efforts of persons involved in the policy. It is here, we will argue, that co-operation, co-ordination and motivation activities are located. This thesis focuses on the implementation stage and the flexible factors.

Science and technology policy relates to various sectors including R&D, organisational management, international collaboration, evaluation and foresight. As we will see in chapter 2, the importance of R&D, organisational management and international collaboration is indicated in the literature on science and technology policy. R&D is a critical factor in developing technological capability, which is one of the most important purposes of science and technology policy (Walker, 1995, p. 39). Organisational management is a significant sector in achieving the purpose of science and technology policy, which includes the balance between autonomy and involvement and the allocation of funds, time and manpower (Churchman, 1973, p. 172). In addition, international collaboration is also a critical sector in developing technological capability, and it can enable the industry to reduce R&D costs and development risks (Dodgson 1993, p. 12). This thesis emphasises R&D, organisational management and international collaboration conducted in the implementation stage of the policy.

In short, as shown in the above figure, the aim of the thesis is to recommend policy options for the efficient implementation of Korean aviation technology policy. Accordingly the thesis focuses on the implementation stage of science and technology policy process. The CCM factors are selected in order to gain lessons from the developed countries' aviation technology policies. In addition, several elements are chosen to survey the degree of efficiency of CCM activities conducted in implementation of Korean aviation technology policy

1.3 Research Framework

1.3.1 Research Methods

This thesis employs two research methods: the examination of literature; and an original survey. The first research method was involved in studying the literature on science /and technology policy and aviation technology policy, and the analysis of the aviation technology policies of the UK, the US, Japan and Korea. Literature included a variety of sources, such as texts, periodicals, articles, theses, and the Internet. In particular, several periodicals, namely, *Aviation Week & Space Technology*, *Flight International* and *Bimonthly Aerospace Industry* (in Korean) were very helpful in providing an understanding of the current world industry. In addition, Internet searches were regularly conducted to gain up-to-date information.

The literature on science and technology policy was reviewed in order to establish academic knowledge on the efficient implementation of science and technology policy, and the literature on aviation technology policy was also reviewed to understand its background. In addition, the aviation development policies of the three developed countries, the UK, the US and Japan, were examined in order to learn lessons for the efficient implementation of Korean aviation industry.

The second research method, the survey, was conducted as original fieldwork using a combination of questionnaires and interviews. The survey aimed to identify the degree of co-operation, co-ordination and motivation activities in implementing Korean aviation development policy. The questionnaires were given to researchers working in aviation research institutes.

The questions used for this purpose were structured around the elements on the CCM factors. The content of the questionnaire is given in Annex 5. The questionnaire was piloted with two Korean experts in aviation technology policy. One was a government official who had worked in the area of aviation technology policy for three years in the Aerospace Industry Division of the Ministry of Industry and Resources. The other was a policy planner who have worked in the area of aviation technology policy in the Policy & Planning Section of Korea Aerospace Research Institute (KARI) since 1992. In addition, the content of the questionnaire was also piloted with one expert in Korea science and technology policy, who is working for Milyang National University.

Interviews were used in order to complement the quantitative surveys. They were conducted with policy managers undertaking the planning affairs for aviation technology development in relevant organisations, such as the ministries concerned, aviation research institutes, aviation companies and a university. Interviews were conducted in two ways: structured, and open discussion. Structured interviews, which involve discussion with a simple questionnaire, were conducted for the purpose of gathering data on a consistent basis. Open interviews, on the other hand, aimed to understand the background of Korean aviation technology policy, via free discussions. The content of the interviews was divided into two categories. One was to explore in more detail the background of Korean aviation technology policy. The other was to explore the possibilities for applying the CCM factors to the efficient implementation of Korean aviation technology policy. A list of interviewees is given in Annex 7.

1.3.2 Main Research Questions

The main research questions in the thesis can be divided into two categories, one related to the establishment of the academic background, and the other related to the recommendation of policy options. First, the main questions related to the establishment of the academic background were as follows:

(i) What are the characteristics and major issues of science and technology policy?

(ii) What are the characteristics of R&D, organisational management and international collaboration related to the implementation of science and technology policy?

(iii) What are the characteristics and development trajectories of the aviation industry?

(iv) What are the major aviation technology development strategies adopted in the developed countries?

Second, the main questions related to the recommendation of policy options were as follows:

(i) What is the background and current situation of aviation technology policy in the three developed countries chosen and Korea?

(ii) What kinds of the CCM activity are carried out for the efficient implementation of the policy in the developed countries and Korea?

(iii) What are the lessons to be learnt by Korea from the developed countries' aviation policies?

(iv) What is the degree of efficiency of the CCM activity conducted in the implementation of Koran aviation technology policy?

(v) What are the impediments to the CCM activity conducted in the implementation of Koran aviation technology policy?

These main questions have been focused in reviewing the literature on science and technology policy and aviation technology policy, examining aviation technology policies of the three developed countries and Korea, and carrying out surveys on the CCM activity conducted in the implementation of Korean aviation technology policy.

1.3.3 Research Scope

The research carried out falls into the three categories of literature review, the examination of the four countries' aviation technology policies, and survey.

Firstly, the review of literature is focused on R&D, organisational management and international collaboration in the implementation of science and technology policy. A definition of each sector is given together with its characteristics and development direction.

Secondly, the developed countries' aviation technology policies are analysed in two ways. One is to examine the aviation industry in order to identify potential lessons from its development trajectory and to understand the background of its development policy. The other is to examine each country's aviation development policy, focusing on its aviation development system, in order to identify potential lessons from those systems. In addition, each country's aviation development system is presented under the categories of co-operation, co-ordination and motivation systems. Each system includes organisations, regulations and programmes related to aviation industry development.

The United Kingdom, the United States of America and Japan were chosen in order to learn from their experience with advanced aviation development policies. The United Kingdom has historically been a leading country in aviation technological development. Its aviation industry has become stronger in the world aviation market through the merger between British Aerospace and Marconi Electronic Systems. Moreover, the study of UK aviation development systems seems to be helpful in understanding European countries' aviation policies. The United States stands at the top of world aviation technological capability. It has supported its aviation industry through the provision of aviation R&D projects and procurement of aircraft produced by US companies. Its aviation support systems may give Korea helpful lessons. Korea has had close political relations with the US since the Korean War. Hence, Korea needs to observe the changes in U.S aviation policy carefully in order to implement its aviation technology policy efficiently. Finally, Japan may be a convenient country with which to co-operate within the aviation technology development because of its geographical closeness and cultural similarity. Its aviation industry has grown to a similar level with those of other developed countries through overcoming the devastation of its aviation industry due to the defeat in

World War II. Such development trajectories and aviation development systems are also expected to give helpful lessons for the development of the Korean aviation industry.

Thirdly, the surveys on Korean aviation development policy were conducted with a sample of researchers and policy managers related to aviation industry development. Regarding the questionnaire survey, 57 researchers were chosen from all the leading aviation technology research institutes in Korea, of which one was a government support research institute (GSRI), namely, Korea Aerospace Research Institute (KARI), and four were business research institutes (BRIs) belonging to the four leading aviation manufacturing companies, namely, Korea Air, Daewoo Heavy Industries, Samsung Aerospace and Hyundai Space & Aircraft.

Interviews were undertaken with the two ways of structured, and open interviews. The sample of the structure interviews included 31 policy managers, who were selected from 11 major organisations concerned with the development of Korean aviation technology. They included the five research institutes mentioned above in the sample of questionnaires, the two ministries of the Ministry of Science and Technology (MOST) and the Ministry of Industry and Resources (MOIR), and the four organisations of the Korea Institute for Defence Analyses (KIDA), Hankuk Aviation University (HAU), the Korea Aerospace Industries Association (KAIA), and the Aerospace Consolidation Office (ACO). In addition, the sample of open discussion included 17 policy managers selected from the above 11 organisations and the Korean Society for Aeronautical & Space Sciences (KSASS).[1] They were involved in establishing or implementing Korean aviation technology. The content of sample for the surveys is mentioned in detail in chapter 8.

1.4 Thesis Structure

This thesis consists of nine chapters, with chapter 1 providing the introduction and background to the research study. Chapters 2 and 3 form the main theoretical base of the thesis. Chapter 2 introduces the academic background of science and technology policy, including the definition, characteristics and major issues of science and technology policy. Chapter 3 presents the characteristics, classification and current situation of the aviation industry, and major aviation development strategies adopted in the developed countries.

Chapters 4,5 and 6 examine the aviation technology policies of the three developed countries. Chapter 4 presents UK aviation technology policy, chapter 5 US aviation technology policy and chapter 6 Japanese aviation technology policy. Chapter 7 examines Korean aviation technology policy. The current Korean aviation industry and related technology policy are examined in order to provide an understanding of the degree of the CCM activities in implementing aviation technology policy. Chapter 8, the survey of Korean aviation technology policy, consists of two sections, namely, an account of the survey design and analysis of the results. Finally, chapter 9 summarises the research results and recommends policy options.

1.5 Contribution of the Thesis

This thesis expects to contribute to our understanding of its field in two ways: first, in making an academic contribution, secondly, in making a practical contribution. The academic contribution may come from the emphasis on importance of the implementation stage of science and technology policy through adopting the CCM factors. In fact, the implementation stage of policy seems to be the most important among policy stages in achieving the policy purpose, because generally this stage needs more time, funds and effort than any other policy stages. In addition, the

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[1] Most of 17 policy managers were recommended as interviewees by Jin-Young, Hwang, who has been involved in the affairs of Korean aviation technology policy since 1992 as a senior researcher in the KARI, when a pilot survey was conducted in July 1998.

concepts of co-operation, co-ordination and motivation are employed as critical factors for the implementation stage of policy.

The practical contribution of this thesis may come from the policy options for the efficient implementation of Korean aviation technology policy. In particular, the policy options are expected to assist officials in charge of matters relating to Korean aviation industry development, including government officials and policy managers in aviation research institutes and the industry.

It seems not to be easy to establish a high level of co-operation, co-ordination and motivation activities, although these activities seem to be basic factors in implementing science and technology policy efficiently. This is because many countries and organisations face difficulties resulting from limited budget, personnel and natural resources, which may lead to conflicts in allocating them. Therefore, this thesis aims to emphasise the importance of the CCM activity in implementing policy in order to maximise the utilisation of limited resources, in particular, in developing countries.

Chapter 2:
Science and Technology Policy

This chapter aims to review academic knowledge on science and technology policy with particular reference to R&D, organisational management and international collaboration. These themes are chosen in order to explore how the concepts of co-operation, co-ordination and motivation which, as explained in chapter 1, are the core concepts for this thesis, are related to the efficient implementation of science and technology policy. In addition, the chapter aims to explore what elements are useful, according to the literature, in conducting co-operation, co-ordination and motivation activities efficiently. It is divided into the five sections: overview of science and technology policy; research and development; the management of technological organisation; international technological collaboration; and main findings.

The first section, the overview of science and technology policy, aims to explore what elements are important in implementing that policy efficiently. The second section, research and development, aims to explore what elements are necessary for efficient R&D activity, through an examination of the characteristics of R&D activity and technological innovation. Innovation may be closely related to R&D and is one of the most important concepts in science and technology policy. The third section, the management of technological organisation, aims to explore what elements in efficient organisational management are important in motivating researchers to do their best in researching. Organisational management may be a necessary element to develop a science and technology capability in the long-term. The fourth section, international technological collaboration, aims to explore what elements are necessary for the efficient conduct of international collaboration. Currently, the development of a science and technology capability in a country may not be anticipated without international collaboration. In the final section, the main findings from reviewing the literature on science and technology will be outlined.

2.1 Overview of Science and Technology Policy

A nation's science and technology policy may be affected by important changes occurring in world society, such as economic recession, exacerbated economic competition among countries, intensified concerns over the social fabric and environment, the rise of unemployment, and so forth. Accordingly, it may be necessary that policy maker obtains a proper understanding of the background of policy, including other countries policies and academic knowledge, in order to establish a proper science and technology policy.

This section presents the factors that are significant for the efficient implementation of science and technology policy, and the elements that are important for the efficient conduct of co-operation, co-ordination and motivation activity, by reviewing the literature on science and technology policy. The section is divided into the two parts, the first relating to the characteristics and the second devoted to major issues for the efficient conduct of science and technology policy.

2.1.1 Characteristics of Science and Technology Policy

The ultimate goal of science and technology policy may be said to be to contribute to the improvement of human welfare including the enhancement of the quality of life, working and environmental condition, and the growth of GDP, by developing a national technological capability. Science and technology policy can be defined variously. For example, it is defined by the European Commission (1994) as the establishment of the framework of public actions regarding the production, dissemination and adoption of new knowledge and know-how. As another example, it can be said to be to decide the goals, priorities, level of R&D funding, and schedule of developing a national science and technology capability by coping with broader social, political and economic needs (Strasser and Simons, 1973, p. 276).

Given these variations in definition, it seems permissible to define science and technology policy as a government plan for the development of a national science and technology capability through a strengthening of R&D activity, efficient organisational management and international collaboration on the basis of efficient co-operation, co-ordination, and motivation activity.[2] Various elements included in the definition may be important in implementing science and technology policy.

The elements that require to be considered in reviewing science and technology policy have also been variously discussed in the literature. According to Grayson (1995, pp. i-vi) science and technology policy consists of various elements, such as technological transition, international collaboration, and science in the industrial setting. The OECD (1994, pp. 18-29) states that the elements comprise budget allocation and priority setting, institutional reorganisation including policy co-ordination, the restructuring of science and technology (S&T) institutions and university reforms, programmes and instruments including the scientific base, the technological and industrial research, services and infrastructure, the relation between S&T, the defence sector and society, and technical training. Lastly, according to the OECD (1992, pp. 6-9), the elements include technological innovation, technology diffusion, co-operation, organisational management, human resources, environment and competitiveness.

The definition and elements of science and technology policy show that they include the CCM factors, the three sectors of science and technology policy including R&D, organisational management and international collaboration, and several elements including technical training, the dissemination of R&D performance and the adoption of information. These seem to be significant in the efficient implementation of science and technology policy.

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[2] Science and technology policy can be divided into science policy and technology policy, although it has been used as a compound word. For Dodgson and Bessant (1996), science policy focuses on scientific education, basic research in universities and governmental institutes, including large scale projects, technology foresight, and international collaboration. Technology policy concerns support for the creation of strategic or generic technology, such as the encouragement of new technology-based firms, R&D collaboration, and environmental issues. On the other hand, innovation policy focuses on facilitating the diffusion and acquisition of technology, network-building and the management of technological systems.

2.1.2 Major Issues of Science and Technology Policy

The major issues related to science and technology policy may include the priorities, barriers and direction of science and technology policy. According to Tisdell (1981, p. 15), the priorities in establishing science and technology policy include the encouragement of innovation, the diffusion of new technology, the replacement of technology, the spill-over or side-effects of alternative technologies, and decisions on whether to import new technology or to produce it at home. In addition, Strasser and Simons (1973, p. 129) argue that science and technology policy needs to respond to the current needs of the people and democratic institutional pressures, and to assure technological growth in order to maintain national competitiveness in the international market. To accomplish this, universities, industry, research institutes, and government must co-operate with each other.

Petrella (1994, p. 60) points out that barriers to the efficient implementation of science and technology policy can come from differences of culture and economic scale, the complexity and instability of political requirement, the lack of R&D and technology, competition, the protection of technology, resistance to change, a short-term outlook, and the lack of indigenous skill, institutional control and co-ordination.

Science and technology policy may be decided differently according to national background and the kind of programmes being undertaken. National background can comprise the condition of the capital market, the attitude of the workforce, and the current position of economic strength and the technological position (Strasser and Simon, 1973, p. 206). In addition, it may need to consider financial pressures, technological transition (Grayson, 1995, p. i), the managerial system, the goals and priorities of the policy (Tisdell, 1981. P. 2), in order to establish feasible policy. The major issues involved in establishing a science and technology policy suggested by this set of authors are summarised in Table 2.1.

Table 2.1 Major Issues of Science and Technology Policy

Authors	Major issues of science and technology policy
Strasser and Simons (1973, p. 206)	1. What are the boundaries of the problem and the potential solution? 2. What are the resources available for the solution and the best or optimal solution? 3. What is the current position in terms of economic strength, international competitiveness, and a technological capability? 4. What is the condition of capital plant, and the attitudes of the workforce? What are the levels of funds, technological management, efficiency in government and the quality of life?
Tisdell (1981, p. 2)	1. What context and constraints exist in government managerial system in adapting scientific and technological change? 2. How to organise and administer policy under the constraints which exist? 3. What technological, economic and social goals and priorities are Required in formulating science and technology policy?
Grayson (1995, p. i)	1. How to solve the financial pressures? 2. How to gain technological transition efficiently? 3. How to achieve efficient international collaboration? 4. What is the role of science in an industrial setting? 5. What criteria should be chosen among competing priorities? 6. What is the balance of power in the decision making process? 7. How to organise and manage public-funded research to ensure effectiveness and value for money? 8. What are the best mechanisms for ensuring a fruitful exchange of ideas between the science base and industries? 9. Is there greater international collaboration in conducting science and technology policy? 10. Is there a hearing system in the policy-making process?

The policy may be decided and implemented by coping with the national situation, because each country can have its characteristics including social systems, technological capability and economic level. Major issues of science and technology policy indicated include co-operation, co-ordination, international collaboration, technology transfer, communication, the R&D programme, technical training, innovation, the dissemination of new technology, the development of indigenous technology, the stability of policy, technology barriers, a short-term outlook and the lack of infrastructure.

2.1.3 Government Role in Science and Technology Policy

There have been growing community demands for scientific and technological effort from government, who, in response, have been involved in supporting national industry by providing a high proportion of R&D funding, even though government involvement may appear to contravene the principle of the primacy of the market. The reasons that may justify government involvement are sixfold. First, individuals or individual companies may be unable to gain appropriate benefits from investment in basic science. Second, private agencies may avoid R&D investment due to the high risks and uncertainties associated it in large-scale projects. Third, failures in the transmission of scientific and technological information can be associated with backward and relatively ignorant groups. Fourth, imperfections in capital markets can prevent the provision of funds for scientific effort and technological change. Fifth, private agencies may avoid the necessary duplication in developing scientific services and the need to consider national security and to encourage external industry-wide economies of development required due to the failure of markets. Sixth, private agencies tend to invest in a selective field or a selective industry (Tisdell, 1981, p. 4).

Government's role in science and technology policy has changed. Governments have demonstrated their firm commitment by maintaining support for science and technology, allocated much funding to innovation, and made serious efforts to facilitate their research and development systems, and there is a growing emphasis on directing science and technology towards the needs of society. In addition, within the framework of a knowledge-intensive economy, scientific education and technical training have led to educational reforms at the university level (OECD, 1994, p. 13).

For the efficient implementation of science and technology policy, government needs to make efforts towards (1) examining the interaction of science with higher education, social change, international collaboration, technical development and economic growth, (2) assessing the nation's investment in R&D, (3) formulating a model for R&D investment that reckons with society's new problems and needs

(Staats and Carey, 1973, p. 188). In addition, the same authors suggest the major issues of governments considered in policy-making are also sixfold. First, government should consider various dimensions such as long-range and short-range objectives, the existence of multiple purpose, and the plural nature of our society. Second, it should examine the law and the actions of the regulatory agencies, and gain the support of the legislative body and industry. Third, because most scientists have a tendency to emphasise their own research field, government should ignore their selfishness and prejudices in selecting R&D projects. Fourth, basic research in universities should be strengthened. Newly occurring problems cannot be solved through existing educational channels. Fifth, government has to undertake risk-sharing projects in its very large programmes of national importance, and stimulate technological innovation. Sixth, it needs to consider creating a market and the development of dual usage technology, for example for defence and commercial purposes.

Grayson (1995, p. i) argues that a proper involvement of government is a general trend in science and technology policy currently, but the involvement should be as a support to activate R&D activity not as an intervention. In addition, government needs to have an ability to identify the context of policy, because a suitable science and technology policy may only be established by reflecting national goals and inevitably limited resources. Failed attempts to transplant the Japanese "miracle" to Western settings and to recreate Silicon Valley in depressed industrial regions provide good evidence that each country has to find its own way towards a more prosperous future.

An examination of the government role in science and technology policy identified the support of basic R&D, industry and university, information flow, innovation, scientific education and technical training having a long-term objective, the ignorance of researchers' selfishness and prejudice in selecting R&D projects, the creation of demand for technology, and the development of a dual usage technology as important elements of science and technology policy.

2.1.4 Science and Technology Policy in the Developing Countries

Science and technology policy seems to be regarded world-wide as an important resource in developing a national economy. However, a developing country's policy may be differently conducted from those of developed countries. This is because it has different characteristics in social and educational cultures, government intervention, business strategy, technological capability and resource capability (J.J, Lee, 1988). Developing countries including Korea may need to recognise their different characteristics from other countries in implementing science and technology policy.

In fact, it is said that Korea has made efforts in developing indigenous technology capability while Brazil seems to have placed emphasis on the imitation of highly developed countries' industrial systems, although it is one of the newly industrialising countries (NICs) (Tunzelmann, 1995). Several developing countries may face various restrictions from developed countries, including technology and trade barriers. Korea has developed with imported technologies, but currently developed countries have restricted its access to their technologies, due to the fact that it has a small gap in technology capability with developed countries in several areas (OECD, 1992). On the other hand, there seems to be a strong government involvement in developing science and technology in developing countries. In fact, Korea had strongly supported a few selected companies and areas during its initial stage of industrialisation, while Taiwan has emphasised fiscal incentives to selective firms (OECD, 1992). It seems to be indispensable to developing countries to develop their science and technology capabilities in order to survive and grow in increasing competitive environments (I.S, Kim, *at al.* 1983). This is because, as Malecki (1991, p. 279) argues, in general the technological lag between advanced countries and underdevelopment countries is growing larger.

In order to overcome weak situations, developing countries may need to consider various factors. Burch (1998, pp. 206-229) points out that developing countries need to have self-reliant strategic approaches including an emphasis on small industry and incremental development in developing their R&D capability. For Malecki (1991, p. 278), they may need to improve education and training capabilities for the support of science and technology development and to combine indigenous technological capabilities and foreign technological elements. Udgaonkar (1984, pp. 331-332) mentions that developing countries need systematic efforts to assimilate imported technologies and intensified co-operative actions and programmes for their technological development. In addition, Sardar and Rosser-Owen (1977) say that developing countries need a set of flexible policies according to the types of technology involved, and that they are necessary to take account of the need for technological activities, the distortions introduced by ownership structures, the number and size of enterprises and the characteristics of the technology market. He also points out that they need to implement policy gradually, due to the changing pace of external and internal factors.

On the other hand, developing countries may face difficulties in developing technological capabilities without technology transfer from the developed countries. For Spiegel-Rosing and Price (1977), developing countries seem to need to consider the following factors in order to achieve successful technology transfer.

(i) Resistance to scientific change on the basis of philosophical and religious beliefs must be overcome and replaced by the positive encouragement of scientific research.
(ii) Social role and place of the scientist must be determined on the basis of society's approval.
(iii) The relationship between scientific organisation and government should be clarified, because most scientific organisations are closely linked with government by receiving financial support and encouragement from government.
(iv) The teaching of science should be introduced at all levels of the educational system.
(v) National scientific organisations devoted to the promotion of science should be founded.
(vi) Communication channels must be opened to facilitate national and international scientific co-operation.
(vii) A proper technology base should be established for the growth of science.

A successful technology transfer may depend upon the absorptive capability of the recipient. Hence, the development of indigenous technological capability seems to be a significant factor for the development of a national technological capability. In addition, the establishment of self-confidence may also be one of the important factors for developing countries in domesticating transferred technology. This is because the lack of self-confidence may often lead to a lack of selectivity in relation to the technologies they want to acquire, as well as creating a tendency for policy-makers and researchers to avoid the adaptation and modification of import technologies

Examination of science and technology policy in the developing countries confirmed that co-operation, co-ordination, motivation, the development of indigenous technology capability, communication, the participation of relevant organisations in decision making processes, scientific education, flexible attitude to change, and government involvement were necessary elements in implementing science and technology policy efficiently, as several authors previously pointed out their importance.

2.2 Research and Development (R&D)

R&D activity may play an important role in developing a national science and technology capability in most countries nowadays. This section aims to explore the elements that are significant in conducting R&D activity efficiently, through an examination of the characteristics of R&D, technological innovation and national systems.

2.2.1 Research and Development

R&D seems to be at the heart of technological society, because it may be the origin of a large proportion of the new or improved materials, products, processes and system that are the ultimate source of economic advance. For Freeman (1982, p. 5), R&D is closely related to the dissemination of knowledge through the education system, industrial training, the mass media and information service. It is said by

Teich and Lambright (1977, p. 167) that, writing of the US, the government has assumed the role of the nation's principal sponsor of R&D since World War II.

The term research and development (R&D) is usually used as a single term, but it is a compound of two concepts, 'research' and 'development.' The term 'research' seems to be related more closely to the academic sphere and to be found much less in industry, and the term 'development' seems to be related closely to the production of new products or processes largely in the province of industry (Teich and Lambright, 1977, p. 167). According to the OECD (1994), R&D is a term covering the three activities of basic research, applied research and experimental development.[3] The term 'research and development' may be defined as creative work undertaken on a systematic basis in order to increase the stock of knowledge of man, culture and society, and the use of this knowledge to devise new application.

R&D activity may be influenced by many institutional factors, including the size of the productive units, the competitiveness of the market and the effectiveness of patent law. In fact, Staats and Carey (1973, pp. 182-186) argue that the allocation of R&D funds is determined by three broad categories of social values: economic, cultural and political ones. According to them, economic value can include the advancement of health and welfare, technological gain, business expansion, job creation, the conservation of natural resources and personnel resource and return on investment. Cultural value can include the exploration of the unknown, the understanding of man's environment, the enrichment of education and cultural improvement. In addition, political value can comprise national prestige, international understanding and the solution of national problems.

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[3] Although distinguishing the boundary of basic research, applied research and development is difficult and inherently ambiguous, Freeman (1982, p. 225) gives a definition of them: basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view; Applied research is also original investigation undertaken in order to acquire new knowledge. It is directed primarily towards a specific practical aim or objective; Development is systematic work, drawing on existing knowledge gained from research and practical experience, that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

National R&D activity, supported by government and public organisations, has different characteristics from business R&D activity supported by enterprises. National R&D activity may need to consider various aspects such as the facts that

- National R&D should be focused on long-term, non-commercial research and development with potential for great scientific discoveries, leaving the questions of economic feasibility and commercialisation to the market place.
- National R&D funding on specific processes and technologies should not be carried out beyond demonstrations of technical feasibility.
- Revolutionary new ideas and pioneering capabilities, which can create a possibility that has never been created before, should be pursued.
- All R&D programmes should be relevant and tightly focused on the agency's stated mission and should disseminate the results of the programmes to potential users (Walker, 1995, p. 39).

R&D activity seems to be very important in science and technology policy, but it may be influenced by various elements such as the capability of the production unit, market competition, and economic, cultural and political values. Through examining the characteristics of R&D, it seems that long-term strategy, non-commercial R&D projects, and the dissemination of R&D performance are necessary elements in conducting national R&D, and that co-operation, communication, information, education, training, organisational management, a long-term strategy and the dissemination of R&D performance are also significant elements in implementing science and technology policy.

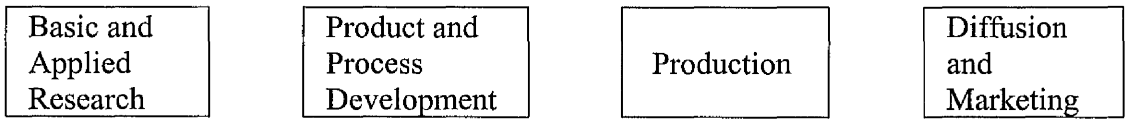
2.2.2 Technological Innovation

Although innovation is increasingly seen as a powerful way of securing competitive advantage and a more secure approach to defending strategic positions, its success is not guaranteed. In a process as uncertain and complex as innovation, luck plays a part, but real success lies in repeating and managing the innovation process consistently (Tidd *at al.*, 1997, pp. 10-13). This sub-section aims to find important elements for science and technology policy through examining the definition, classification and model of innovation and the major issues for successful innovation.

Technological innovation can be defined as the first application of science and technology in a new way with commercial success, such as in the development of products and production processes (OECD, 1992, p. 24). It may be achieved by scanning the environment for the threat of and opportunity for change, adopting a strategic view of how the enterprise can best develop, obtaining resources through creating something new and R&D and technology transfer. According to Tidd *at al.* (1997, p. 7), innovation can be classified into product, service and process innovation according to what is changed. Freeman (1986) argues that innovation includes the four types of incremental, radical, technological system and technological revolution. According to him, incremental innovation is the gradual changes that occur fairly continuously in most branches of industry and in services. It often results from suggestions from users and production workers rather than R&D effort, and is the principal example of 'demand-led' innovation. This type of innovation represents the majority of patents. Radical innovation is represented by discontinuous events that occur unevenly across sectors and through time. This innovation provides new market opportunities and leads to significant advantages in terms of production costs and quality. It may involve the combination of product and process innovation and organisational innovation. Freeman's third category of innovation is the technological system. This is the combination of radical innovations coupled with organisational innovations across many firms. The technological system affects more than one branch of the economy and may itself spawn new sectors. Freeman's final category is technological revolution, or change in the techno-economic paradigm.

The model of innovation has changed. For almost three decades, the linear model dominated. In this model, the development, production and marketing of new technologies were said to follow a well-defined time sequence that originated in research activities. This model fitted well with the "science push" approach which prevailed overwhelmingly in the 1950s and 1960s (OECD, 1992, pp. 24-26). The 'linear model' assumes that the progression is linear and proceeds in discrete stages, such as the order, research→development →production→ marketing, as shown in Figure 2.1. However, such a view is not supported by historical evidence in any general sense (Malecki, 1991, p. 114).

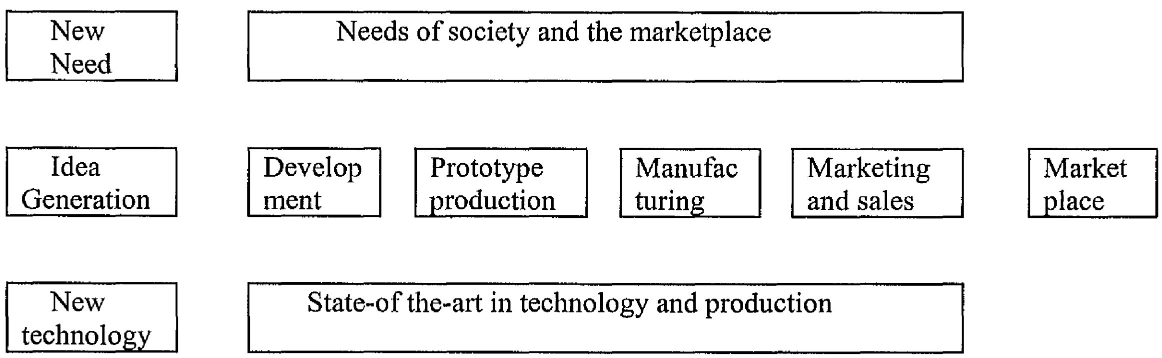
Figure 2.1 The Linear Model of Innovation



Sources: Malecki (1991), p. 115.

Rather, the innovation process has come to be characterised by continuing interaction and feedback. The 'coupling' model of innovation suggested by Rothwell shows that the innovation process interacts with redesign and re-development following testing and evaluation. This model of innovation is shown in Figure 2.2

Figure 2.2 The 'Coupling' Model of Innovation



Source: Dodgson (1993), p. 58.

Rothwell provides a useful perspective on innovation, suggesting that the innovation process has been evolving from such simple linear models through to increasingly complex interactive models. His fifth generation innovation concept sees innovation as a multi-factor process which requires high levels of integration at both intra- and inter firm levels, which is increasingly facilitated by information technology based networking (Tidd *at al.*, pp. 29-30). Rothwell's five generations of innovation model are shown in Table 2.2.

Table 2.2 Rothwell's Five Generations of Innovation Model

Generation	Key features
First/second	Simple linear models; need pull, technology push
Third	Coupling model; recognising interaction between different elements and feed back loops between them
Fourth	Parallel model; integration within the firm, upstream with key suppliers and downstream with demanding and active customers, and emphasis on linkages and alliance
Fifth	Systems integration and extensive networking, flexible and customised response, and continuous innovation

Source: Tidd *at al.*, (1997), p. 30.

In order to achieve successful innovation, the four influencing organisations, namely, universities, public sector institutions, industry, and policy-making institutions should participate and collaborate in the process. Universities and public sector institutions can supply scientists and develop basic research and are funded principally by government. Industries operate their technological laboratories. Finally, the policy making institutions need to monitor the execution of public R&D and possibly ensure some degree of co-ordination with enterprise sector R&D (Nelson, 1993, pp. 17-18).

Major issues for successful innovation can be summarised as follows:

1) Strong in-house professional R&D, the performance of basic research, and close connections in conducting such R&D.
2) The use of patents to gain protection and to bargain with competitors, and the readiness to take high risks.
3) Large size of R&D expenditure over long periods.
4) Early and imaginative identification of a potential market.
5) Careful attention to the potential market and the education and the assistance of customers.
6) Entrepreneurship to co-ordinate R&D, production and marketing.
7) Good communications with the outside organisations and customers (Freeman, 1982, p. 112).

8) The establishment of joint research institutes in order to avoid risk in innovation.
9) A tax benefit system to facilitate R&D activities of innovative firms.
10) The scientific community should be supported through fellowships, grants and heightened educational opportunities. In addition, the scientific community needs to participate in innovation activity (Strasser and Simons, 1973, p. 52).

11) Taking a strategic approach to innovation and management.
12) Developing and using effective implementing mechanisms and structures.
13) Building and maintaining effective external linkages (Tidd *at al.*, 1997, p. 48)

In establishing innovation policy, a country may need to consider its technological situation and what innovation strategy is available, for example, incremental or radical innovation, and offensive or imitation strategy. Technological innovation has been regarded as a very important concept for overcoming severe international competition and for improving the national economy. However, innovation does not occur in firms in isolation. It may require the re-examination of national value systems, national priorities and many of the untoward side effects of innovation, such as environmental pollution, congestion and the depletion of our natural resources. In addition, the motivation of researchers is also required for establishing an innovative environment. Such motivation can be achieved through the provision them with economic and mental satisfaction with their work, including proper incentive and wage systems.

2.2.3 National Innovation Systems

Many countries have deliberately followed policies designed to encourage technological innovation on the assumption that it will ultimately help improve the standard of living. The concept of "national systems of innovation" has become well established as a leading paradigm for analysing innovation processes. However, it has also come under attack for being both too broad and insufficiently theorised (Reppy, 2000, p. 1). This sub-section introduces the overview and international comparison of national innovation systems (NIS). The overview of the NIS are explained with the definition, the background of emerging its importance, the advantages and weaknesses in the NIS approach, and the characteristics of the NIS.

A national system of innovation can be defined as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987, p. 1). However, the NIS may be differently defined according to research purposes and national context. The NIS approach provides a framework rather than rigid definitions, and so is interpreted differently its detail.

The importance of national innovation systems has been recognised since the 1970s, even if the term was not common until the 1980s, when a more systems based view was taken. There was no strong competitor to the USA as a model of how a nation could achieve leading competitiveness status based upon technological innovation until the 1970s. This standing as a model system was a natural reflection of the U.S. technological pre-eminence that marked the post-war years, although earlier the United States had been an imitator in many respects. The American research university that arose early in the twentieth century was consciously modelled on the German university system, and the R&D organisation of American chemical companies was similarly patterned on a German model. However, since the early 1970s, there has been a slowdown of growth in all of the advanced industrial nations, the rise of Japan as a major economic and technological power, widespread concerns in Europe about being behind the US and Japan, and the emergence of Korea, Taiwan and other NICs as competitive players in technologically-based industries. There clearly is a strong belief that the technological capabilities of a nation are a key source of their competitive prowess. It is this climate that has given rise to the current strong interest in different innovation systems. The attraction of the American model has waned, and that of Japanese institutions have waxed as targets for emulation. Many strongly held beliefs about the Japanese innovation system are, at best, only partly correct (Nelson, 1993).

We can consider advantages and weaknesses in the approach of the NIS. The first advantage is the weight it gives to institutions. The NIS approach can provide space for the role of government policy, legal institutions, educational and training institutions. Success or failure in innovation can be affected by any of the constituent elements of the system, and weaknesses in one area may be compensated for by strength in another. The quality of human resources, such as well-trained and motivated technicians, get particular attention. The NIS approach is particularly well suited to analyses of technology policy. It has focused on government R&D funding and support for education. A nation's NIS is affected by those of other countries, but we need to take into account cross-national differences among competing systems. The weakness of the NIS approach seems to be the difficulty of selecting priorities, limits and boundaries of the many factors which it identifies as important. So, many factors may play a role, but it is difficult to assign relative weight to particular institutions or relations between them. What are the limits to the system? Can national borders really be a limit? How can cross-national comparisons be sustained, when the constituent elements of the national systems of innovation may have little in common? Although attempts have been made to address these weaknesses by imposing more restricted definitions, they are still at an early stage (Reppy, 2000, pp. 2-4). The NIS approach is a conceptual framework to find and develop an optimal solution towards social matters rather than a mechanical principle. However, it recognises that interactions among policies, systems and programmes are important over the traditional focus that government funding of basic research is enough for innovation.

The characteristics of national innovation systems can be explained by examining seven aspects of the system.

First, we should refer to the inputs and outputs of innovation jointly in establishing innovation policy. The inputs include R&D expenditures and the share of the labour force taking part in R&D and innovation. The outputs can be divided into an intermediate and a final output. The intermediate output includes patents, and the final output can be measured through the significance and quality of the innovations (Audretsch, 1995, pp. 27-29). For Rothwell (1981, p. 94), the policy target for innovation can be divided into supply and demand sides. The supply side for innovation can include five factors, such as technical knowledge and manpower, R&D, market information and management skills, financial resources and R&D environment. The demand side includes domestic and international market and their environment. In addition, for Audretsch (1995, p. 30), the significance of innovation according to the final outputs of innovation, includes following four categories:

1) the innovation established an entirely new categories of products;
2) the innovation is the first of its type on the market in a product category already in existence;
3) the innovation represents a significant improvement in existing technology; and
4) the innovation is a modest improvement designed to update an existing product.

Second, governments can use a combination of various tools in order to achieve the goals of national innovation policy. Those tools are:

- Public enterprise, of which example is innovation by publicly owned industry
- Scientific and technical research laboratories
- Education
- Financial support including grants, loans, subsidies, provision of equipment and loan guarantees
- Information support
- Taxation
- Legal and regulatory including patents and regulation
- Political support including planning, consultation and the encouragement of merger
- Procurement
- Public service, such as purchases and maintenance
- Commercial supports, including trade agreement, tariffs and currency regulation
- Overseas agents (Rothwell, 1981, p. 61)

Third, governments need to reflect the areas of concern, including insufficient innovation, declining international competitiveness, balance of payment, unemployment, declining growth rate, need for better quality goods, low productivity, industrial inefficiency, inflation, need to conserve natural resources, low-skill jobs, need for better public services, foreign ownership and technical dependence (Rothwell, 1981, p. 62).

Fourth, governments should keep in mind the cause of problems in relation to national innovation systems. Those causes include:

- Too few engineers and concentration on science rather than engineering
- Concentration on high technology rather than improved production processes and products
- Lack of rapport between users and supplying industries
- Shortage of venture capital for R&D and innovation
- Low and decreasing profits
- Concentration on short-term return
- Non consistent national industrial strategy by the government
- Complex, burdensome legislation and bureaucracy
- Poor co-ordination between public and private sectors
- Emphasis on raw material processing and intermediate goods rather than advanced technology-intensive goods
- Industry energy and resource-intensive
- Traditional industries challenged by developing countries with cheaper labour and natural resources; and
- Lack of sufficiently concentrated markets (Rothwell, 1981, pp. 64-65).

Fifth, nations differ in the mix of industries and these differences alone strongly influence the shape of national innovation systems (Nelson, 1993, p. 14). Although there are many areas of similarity between the systems of countries in comparable economic settings, there still are some striking differences as well. The national innovation systems of Korea and Taiwan have been very different and so too are their present organisations of industry and structure of R&D. The reasons for these differences reside, to a significant degree, in differences in national histories and cultures, including the timing of a country's entry into the industrialisation process.

Sixth, although there certainly are durable and important differences in national characteristics that shape national innovation systems, these systems have shown striking adaptability. Countries clearly copy each other. The American copying of German higher education was repaid when the Europeans later copied American large-scale public finance of university research. Europeans and Americans recently have in recent decades been attempting to copy what they see as successful co-operative research programmes in Japan.

Seventh, governments need to consider their national situations in establishing innovation policy, such as historical social and economic background, nature and role of technological innovation, strengths and weaknesses of national industry and economy, trends in international trade and division of labour, trends in technological development, and identification of new and potential markets (Rothwell, 1981, p. 67).

National innovation systems of the UK, the US and Japan will now be compared on the basis of goals and measures of their innovation policy, with reference of the arguments of Rothwell (1981, pp. 70-71).

Firstly, the overalls goal of innovation policies in the UK are more towards industrial innovation, improved international competitiveness in UK industry, improved economic performance, and more and better jobs. Those of the US are mentioned as more industrial innovation to achieve and improved international competitiveness in

US industry. Those of Japan are more industrial innovation to achieve, and security in defence, energy and employment.

Secondly, tactical objectives of the UK are strategies for industrial sectors, national policy to co-ordinate for employment, increased technological research, better consultation and information services and more and better trained manpower. Those of the US are improved technology transfer, technological knowledge, patent system, anti-trust policy, federal procurement and regulatory system, fostering the development of small innovative firms, facilitating labour and management adjustment, and a supportive attitude to innovation. Those of Japan are gradual change in industrial structure, identification of future are as of growth in industry, and construction of innovation policies after public consultation.

Thirdly, the UK's main policy measures for innovation are the co-ordination of public and private sector, technology foresight, the monitoring of technological changes abroad, co-ordinated national strategy, better consulting services and technology transfer, and better university industry liaison. The US's main policy measures are information centres on federally supported R&D and technology, generic technology centres, improved university-industry co-operation, uniform government patent policy, improved patent service, fund for small firms, increased venture capital, uniform procurement policies, developed technology forecasting system, and award for innovation.

The challenge is to develop a science and technology policy that responds to the current wants of the people, responds to democratic institutional pressures, and assures the kind of technological growth that will keep nations competitive in international markets. To accomplish this, the universities, industry, independent laboratories, and the government must each "do what he does best." In particular, universities should stick to producing qualified human resources and long-range research. Industry must capitalise on technology to utilise resources efficiently while protecting the environment and remaining intensely competitive. The independent laboratories have to do creative and pioneering research in social and technical areas and serves as a bridge between government agencies and industry. Finally, the government should nurture science base via greater support of university research, and provide stimulation for a technical effort that is big enough to give nations a sound international competitive position (Nelson, 1993).

2.3 Management of Technological Organisation

The purpose of science and technology policy can only be achieved with an appropriate management of technological organisation. Although an excellent programme is established, the purpose of science and technology policy may not be achieved without proper organisational management. In practice, the efficient implementation of science and technology policy may be closely linked with quality of management. Therefore, this section aims to explore important elements in implementing science and technology efficiently, by examining the characteristics of and major issues involved in organisational management.

2.3.1 Characteristics of Organisational Management

The formulation and implementation of science and technology policy typically involve or influence all the various organisations related to the development of science and technology. The related organisations may include governmental policy units and executive ministries, research facilities, universities and industry. In addition, managerial factors can be discussed variously. Ruivo (1997, pp. 7-8) mentions that the process of science and technology policy consists of the formulation, implementation, exploitation of research results and international collaboration. The formulation stage may need to stress the participation of different interests to formulate general goals and the identification of scientific opportunities, and the implementation stage needs to emphasise on co-operation, co-ordination and motivation. The instruments of science and technology policy can include foresight, planning, programming, funding and evaluation.

Churchman (1973, pp. 172, 215) argues that the manager can be faced with two types of error: (1) changing the plan when no change is really necessary and (2) not changing the plan when a change is necessary. In addition, he argues that managerial tasks involve: (1) determining when to intervene and challenge the course of the policy process; (2) designing information sources and channel; (3) allocating funds, time, and manpower to components of the policy; (4) developing policies that fit the capabilities and the needs of users; and (5) coping with system size.

The reasons why organisational management is important in implementing science and technology policy efficiently can be established through an examination of the characteristics of government organisations, the scientific community and managers.

First, government organisations seem to need to avoid the imperfections of political and administrative mechanisms in the decision-making process. Tisdell (1981, p. 25) points out that the reasons for the imperfect managerial activities conducted in government are as follows:

- Government departments have a symbiotic relationship with client groups and large producers. This implies that they can impartially influence government policies. So, there can be risks and biases in science and technology policy through the symbiotic relationship.
- Distortions in government support for science and technology may arise from the selfishness of individual government departments to try to maximise their budgets and roles over available resources.
- Informational barriers between and within ministries and departments in a government block co-operation, and the finite capacity of individuals may prevent a common goal from being efficiently pursued.
- Bureaucrats may be even more imperfect than company managers in their prediction of future events, since they may not be skilled at picking winners.

Second, the scientific community may have certain characteristics, such as specialisation, complex diversity, interdependent movement and the high level of information demanded. Specialisation is an inevitable commitment of the growth of knowledge and technique, communication and co-operation require more attention (Caldwell, 1973, p. 37). Mulkay (1977, p. 111) argues that the information that the scientific community needs is diffuse and difficult to identify, that there is often more information potentially available on a given problem, and that information can be conveyed in a great variety of ways. He also mentioned that the main institutionalised form of communication in scientific research is through professional journals.

Third, a manager's attributes may influence the implementation of policy. Caldwell (1973, p. 61) points out the attributes required by a manager as the following:

- A manager needs to have the abilities to co-operate with others, in the identification of priorities, in communication for organisational goals, in the synthesis of diverse views of both peers and experts, and in the interpretation of the views, activities and needs of the personnel and the organisation.
- A manager requires leadership quality and the ability to persuade and inspire people to work to their potential abilities.
- A manager should be sensitive to the restraints of law, bureaucracy, politics and public opinion.
- A manager also requires an ability to perceive the effects of an operational decision or policy change.

An examination of the characteristics of government indicated that the understanding of scientific organisations and manager, organisational management are indispensable factors in order to remove a government organisation's symbiotic relation with a client group, the selfishness of individual departments, information barriers and blocks to co-operation. In addition, the scientific organisation seems to have a high degree of autonomy, communication and an innovative environment. Accordingly, through the examination of the characteristics of organisational management, it was indicated that co-operation, co-ordination, motivation, communication, the removal of selfishness, autonomy, information flow and incentive system are critical elements for the efficient management of science and technology policy.

2.3.2 Major Issues of Organisational Management

Organisational management can be divided into four aspects: (1) general requirements for management; (2) necessary elements for the successful management of scientific community; (3) necessary elements for a successful manager; and (4) the criteria for evaluating organisational management.

Firstly, the various general requirements for successful management can be summarised as follows:

- Clearer guidelines should be established to encourage and influence the R&D and innovation process.
- The legislation, regulations, funding and reward structures should reflect policy purposes.
- A systematic audit should be established to provide guidance on how the R&D innovation process is working in various sectors (Rubenstein, 1977, pp. 194-195).

- A better coupling of resources and strategies is needed between universities, industries, research institutes and government, and between scientists, engineers and managers in internal and external organisations. Scientists and technologists must strive to become much more acutely responsive and adaptable to the needs of today's and tomorrow's society.
- Co-ordination and persuasion processes are required. The consensus of concerned opinions should be an important procedure in making national science policy.
- The process of idea selection may be a central feature of science policy. The initial evaluation of ideas must take place within the scientific community, because they stay in close contact with the updated information by telephone and site visits, through reading technical articles, and by attending the meetings of professional societies (Strasser and Simons, 1973. p. 140).

- Clearly defined tasks and objectives.
- Effective team leadership.
- A good balance of team roles and match to individual behavioural style.
- Effective conflict resolution mechanisms within the group
- Continuing liaison with external organisation (Tidd *at al.*, 1997, pp. 324-325)

Secondly, the necessary elements for the successful management of scientific community can be defined as follows:

- Distributing authority and decision-making functions as widely as possible.
- Recognising that risk-taking is a necessary component of innovation.
- Establishing an effective and comprehensive communication system.
- Minimising the burden of formal structure as much as possible.
- Rewarding innovative behaviour (Hjornevuk, 1973, p. 117)

Thirdly, necessary elements for the successful manager can be defined as follows:

- Adequate and accurate communication in all direction, especially upward
- The capacity to influence in all directions to achieve objectives
- Supportive superiors

- A personally warm relation with superiors and peers, even though they differ vigorously on scientific and technical matters (Likert, 1977, pp. 154-156)

Finally, there seems to be a need for the continual evaluation of the managerial system and its performance. This is because technical brilliance can be seldom gained in a poorly managed organisation. On the contrary, technical failures can occur in well-managed organisations. Wenk Jr. and Kuhn (1977, pp. 160-161) explain the evaluation criteria for organisational management, dividing them into the three categories of structural, behavioural and normative criteria. According to them, structural criteria include the stability of institutional components, the availability of technical, human and natural resources, the compatibility of the organisation having the decision making authority with the scope of the output function, information flow and distortion, channel capacity, feedback and control, the integration of government policy and the political capacity to generate coherence. Behavioural criteria involve impacts on social behaviour, the mood of innovation and progressiveness, the rate of change and adjustment, the participant's satisfaction or frustration, the level of conflict and resolution, the conservation of social opportunity and choice, accountability for decisions and actions, the continued ability to steer and economic and technological efficiency. In addition, normative criteria cover impacts on human values and norms, the distribution of costs, risks and benefits, the distribution of political and economic power, participation in decision making, industrial freedom and privacy, and the preservation of present and future.

In addition, Tidd *at al.*, (1997. P. 326) argue that barriers to efficient organisational management include the dominance of restrictive vertical relationships, poor lateral communication, limited tools and resources, top-down dictates, the rigidity of change, reinforcing a culture of inferiority (for example, innovation always has to come from outside) and unfocused innovative activity.

Organisational management seems to be a critical factor in implementing science and technology policy. It may need short term and long term strategies according to characteristics of policy. In fact, the restructuring of organisation and modifying regulation may need to be conducted on the basis of a long-term strategy, because the social system cannot be changed in a short period. However, the formulation of efficient co-operation, co-ordination and motivation may need to be conducted on the basis of a short-term strategy, because such activities can be improved by persons' efforts, although this may not be easy. Effective management may need the understanding of the characteristics of programmes, organisations, the employed scientists and the scientific community, and the improvement of the quality of managers.

Thus, an examination of the major issues of organisational management showed that co-operation, co-ordination, motivation, the stability of policy, communication, participation in decision-making process, the resolution of conflict, incentive systems, autonomy, R&D, innovation, the acquisition of information and communication were significant elements for science and technology policy.

2.4 International Technology Collaboration

Nowadays, the development of new high technologies generally requires large scale R&D funding and is very uncertain of success in acquiring a market and gaining economic benefits. Therefore, international collaboration has largely been carried out on a wider scale in many developed countries. However, international collaboration seems to be a blend of co-operation and competition. This section aims to explore what elements are important for efficient international collaboration by examining its characteristics and the major issues related.

2.4.1 Characteristics of International Collaboration

The aims, elements and process of international collaboration will now be presented. The aims of technological collaboration can be said to be: (1) to improve the technological ability and production efficiencies, (2) to gain discrete technologies,

(3) to learn through information exchange, (4) to reduce the cost, risk and uncertainty of technological innovation, (5) and to find synergy between partners (Dodgson, 1993, p. 12, 24). In addition, Skolnikoff (1977) argue that the motives for conducting international collaboration as follows:

- All the countries become mutually interdependent. Technological systems have interacted internationally in their operation or application, especially in the area of space technologies, transportation and communications.
- New patterns of interactions have appeared, as the appearance of new actors including international companies, international organisations of all kinds, and cross-national interest groups.
- Domestic policy processes are influenced by world technological trends. Technological collaboration has also contributed directly and massively to the changes in the policy making processes in all countries.

For Tidd *et al* (1997, p. 201), collaboration happens in response to key customer needs, a market need, technology changes, competitors and management initiatives, in order to broaden product range, and to be more innovative in product development. In addition, Georghiou (1998, pp. 620-622) points out that international collaboration occurs in order to gain direct and indirect benefits. Direct benefits include access to complementary expertise, knowledge or skills to enhance scientific or technological excellence, unique sites, facilities and population group, sharing costs and risks, addressing standards or international problems and establishing standards. In addition, indirect benefits include the enhancement of reputations, learning opportunities, and political, economic and cultural relationships. All of the above benefits may be founded upon the long term friendships which may be formed during a collaboration.

Tidd *at al.* (1997, p. 199) suggest that collaboration follows the process of motives → technology → organisation → design of alliance → learning. It is brought about for strategic and tactical motives, and the parties to it need to decide whether to 'make or buy' a technology taking into account the organisations involved and their technological capability. They also need to decide how to design the alliance before finally carrying out the international collaboration, as shown in Figure 2.3.

Figure 2.3 A Model for Collaboration

Motives
- Strategic- leadership and learning - Tactical-cost, time and risk

Technology
- Competitive significance - Complexity - Codifiability

Learning
- Intent to learn - Receptivity to knowledge - Transparency of partner

Organisation
- Existing competencies - Corporate culture - Management comfort

Design of alliance
- Partner selection - Trust and communication - Objectives and rewards

Source: Joe Tidd *et al.* (1997), p. 199.

International collaboration can include various activities, such as technology transfer, technological consulting (OECD, 1992), sub-contracting, cross-licensing, consortia, strategic alliances and joint ventures (Tidd *et al.*, 1997, p. 204), researcher exchange, co-operative projects or networks, the offering of access to, or sharing the cost of scientific instruments of large-scale facilities, long-term relationships between laboratories, participation in national programmes of the collaborating country and the establishment of subsidiary laboratories in other countries (Georghiou, 1998, p. 612).

An examination of the characteristics of international collaboration indicated that co-operation, co-ordination, motivation, organisational management, technology transfer, scientific education and technical training, communication, trust, partner selection, incentive, long-range strategy, R&D, and innovation as important elements for science and technology policy.

2.4.2 Major Issues of International Collaboration

This sub-section will present major issues related to the conduct of international collaboration, including the positive and negative results from the conduct of international collaboration, barriers to an effective collaboration, the direction for collaboration, international collaboration in developing countries and the future perspectives of international collaboration.

International collaboration can have both positive and negative consequences. The positive influences of international collaboration are as follows:

- International collaboration encourages firms to learn the theory and practice of collaboration and plays an important role in stimulating technological and organisational learning.
- International collaboration can reduce the unnecessary duplication of R&D efforts and help to share the high costs of technological development. In addition, it may reduce political uncertainties and impediments which firms frequently encounter in accessing foreign markets (Dodgson, 1993, pp. 25-36).
- Fields of general interest or fields with non-marketable applications extending beyond any single country can be researched though international collaboration.
- A nation can co-operate to ensure that experts meet regularly and exchange ideas related to organisational structure, management styles, technologies and markets (Tisdell, 1981, p. 67).
- Firms can identify, monitor and leading-edge technologies, and innovation and motivation systems (Malecki, 1991, p. 194).

Dodgson (1993, pp. 25-36) argues that international collaboration can have three negative results. First, collaboration may reduce innovation activity and increase non-competitiveness. This is because it often promotes cartelisation and oligopoly, and raises barriers against new entrants and because it is often used as a strategic tool which forms a competitive block involving a scale of resources preventing other firms from trying to compete. Second, collaboration can be used as a tool for analysing the information on counterparts before mergers, because mergers have a very high failure rate and co-operation is a cheaper option than a merger, particularly between firms in unrelated areas. Third, firms can often place too much reliance and too high expectations on collaboration.

It should be understood that international collaboration may provide a supplement to internal technological know-how and its scale is very limited in comparison with internal R&D efforts in principle. Thus, it may be unwise to see it as an alternative, since it is no substitute for in-house technological efforts.

Georghiou (1998, pp. 622-623) mentions that the barriers to an effective international collaboration can include the establishment of rival trading blocks, the mismatch of collaborative counterparts, including agencies and individual members, the restrictions imposed by governmental activities, the inconsistency of public funding support, and broad policies which impinge upon collaboration, such as nuclear nonproliferation agreements, trade friction and other controls on the export of technology. In addition, OECD (1992, p. 233) points out that developing countries may face difficulties in conducting international collaboration, because over the past decade, it has been carried out between several developed countries such as the triad of the EU, the US and Japan, and that the technological gap has broadened between developed countries and other countries excluded from international collaboration.

Major issues for successful international collaboration may include a long-term approach towards collaboration, the participation of managers, scientists and engineers in collaboration, a high level of trust relationships between partners, the management of networks, governmental support, good project managers, interpersonal communication, and human resources (Dodgson, 1993, p. 98, 159). According to Mytelka (1991, p. 46, 59), information flow, especially networks, is regarded as the core of international collaboration. In addition, the analysis of the reputation of partners, the establishment of trust relations between collaborative partners and the understanding of partners seem to be basic factors for effective international collaboration.

International collaboration in small firms and in developing countries will now be discussed, because this is expected to be useful for Korea having small scale aviation companies. Small firms can also have both advantage and disadvantage in conducting collaboration. Their advantages may include the ability to react quickly to fast changing market requirements, flexibility in operating organisations, better communication and stronger motivation (Freeman, 1982, p. 254). On the other hand, the disadvantages can include that small firms often lack qualified resources, such as specialists, funds, time and information, and can suffer from the fear of unwelcome take-over. They also can suffer from an imbalance in the significance of a linkage with partners, because the major activities of small firms may be closely related to a minor or marginal project of a large firm. In addition, small firms cannot bear the high management cost of negotiation, because they cannot afford the high level of legal protection of intellectual property rights through patents which are very expensive (Dodgson, 1993, p. 160).

International collaboration may be one of the most available ways for the developing countries to obtain the technology they need from developed countries. To conduct efficient collaboration, developing countries may need to develop an indigenous science and technology capability, because they cannot select the proper technology they want, and cannot adapt the technology transferred from the developed countries without possessing a certain degree of technological capability. Also, international collaboration raises many questions associated with the uncertainties of the transfer of technology. For example, Skolnikoff (1997) points out that the developing countries may have difficulties due to their lower level of scientific and technological infrastructure formulation, the lack of knowledge to adapt high technology, the lack of adequate resources devoted to R&D, and the instability of social and political environments.

For Dodgson (1993, p. 164), the important factors of international collaboration in the future are as follows. First, the role of information technology may become more important in the adaptation and the diffusion of new technologies. Information technology may not only facilitate various forms of networking, but increase technological collaboration. Second, the emphasis on the quantity of collaboration will give way to greater quality with cost-sharing remains an important motive for many firms. Third, scientific knowledge will continue to grow and to be disseminated. Therefore, industrial investment in the R&D of universities continues to increase. Moreover, the dissemination of scientific and technological knowledge will expand through the greater number and range of journals, and through the possibility of electronic access.

An examining of the considerations of international collaboration identified that a long-term strategy, participation, trust relations, organisational management, communication, an incentive system, technology transfer, joint R&D, proper partner selection, flexibility in management, and technological information were important factors in conducting international collaboration efficiently.

2.5 Main Findings

The main findings relate to the four areas of the overview of science and technology policy, R&D, organisational management and international collaboration. Theses will now be summarised in turn.

First, science and technology policy can be said to be a government plan for the development of a national science and technology capability, through strengthening R&D activity, efficient organisational management and international collaboration. Various elements, that are previously pointed out by many authors as significant ones in achieving the efficient implementation of science and technology policy, include co-operation between related organisations including government and industry, institutional control and co-ordination, the selection of priorities and programmes in the establishment and implementation of policy, the restructure of S&T institutions and university reforms, technical training and scientific education, technological innovation and technology diffusion, the acquisition of information and communication, organisational management, international collaboration, the difference of culture and economic scale, the complexity and instability of political requirement, the lack of R&D and technology, the competition and protection of technology, resistance to change, a short-term interest and the lack of indigenous skill.

Accordingly, an examination of the overview of science and technology policy confirmed that co-operation, co-ordination and motivation factors were critical factors for the efficient implementation of science and technology policy. In addition, R&D, organisational management and international collaboration were also identified as important sectors in science and technology policy.

Second, R&D seems to be at the heart of the technological society, because it may be the origin of a large proportion of new or improved materials, products, processes and systems. Several elements are confirmed to be critical in science and technology policy through understanding of the characteristics of R&D. Those elements comprise the competitiveness of the market, the effectiveness of regulations, economic, cultural and political values, national missions, long-term and non-commercial R&D areas, technological feasibility, revolutionary new ideas, in-house research and the dissemination of R&D results.

In addition, technological innovation seems to be closely linked with R&D activity. Through the examination of the characteristics of innovation, it was confirmed that various elements are important in science and technology policy. These elements include strong in-house professional R&D, performance of basic research, sufficient R&D expenditures over long periods, the identification of a potential market, education, the co-ordination of R&D, production and marketing, good communications, the overcoming of fierce international competition, the scientific community's participation in innovation activity, political supports and long-range national technology strategy.

Third, organisational management seems to be one of the fundamental elements for the achievement of policy purposes. However, it requires to consider various factors, such as qualified persons, effective working environment and programmes. A successful management needs to take into consideration various factors, including clearer guidelines, the encouragement of R&D and innovation, the effectiveness of R&D processes, a systematic audit, a better coupling of resources and strategies, co-ordination and persuasion processes, clearly defined tasks and objectives, effective team leadership, a good balance of team roles, a match to individual behavioural styles, effective conflict resolution mechanisms, innovation, establishing an effective and comprehensive communication system, minimising the burden of formal structure as much as possible, rewarding innovative behaviour, adequate and accurate communication in all directions, especially upward, the capacity to influence in all directions in order to achieve objectives, supportive superiors and a personally warm relationships with superiors and peers.

Fourth, international collaboration can improve the technological ability and production efficiencies through information exchange, the reduction of R&D cost, risk and uncertainty and synergy between partners. It may include technology transfer, technological consulting, sub-contracting, cross-licensing, consortia, strategic alliance, joint venture, researcher exchange and co-operative projects and networks. In addition, various elements may need to be considered for successful international collaboration, including a long-term approach towards collaborations, the participation of managers, collaboration between scientists and engineers, a high level of trust relationships between partners, the management of networks, governmental support, good project managers, interpersonal communication, human resources, the development of indigenous science and technology capability.

In conclusion, as many authors pointed out previously in the literature on science and technology, it was identified that R&D, organisational management and international collaboration are significant factors in improving science and technology capabilities. In addition, co-operation, co-ordination and motivation, the core concepts of this thesis, were also identified as significant factors for the efficient implementation of science and technology policy. In fact, the three factors of co-operation, co-ordination and motivation, and the three sectors of R&D, organisational management and international collaboration were very frequently mentioned in the literature.

In addition, each element of the three CCM factors, chosen as the subject of questions in the questionnaires which were used in the surveys on Korean aviation technology policy, were also confirmed to be properly selected as elements for examining the degree of efficiency of each CCM activity conducted in implementing Korean aviation technology policy. This is because those elements were frequently mentioned by many authors as important ones in the literature on science and technology policy, as shown in Table 2.3.

Table 2.3 Elements discussed in a Literature of Science and Technology Policy

Sector	S&T Policy		R&D		OM		IC	
Elements of CCM Factors	Chtr	Main	Chtr	Main	Chtr	Main	Chtr	Main
O Elements of co-operation								
- Holding of seminars	O	O		O			O	O
- Dissemination of R&D	O	O	O	O			O	O
- Joint R&D	O	O	O	O			O	O
- International collaboration	O	O	O	O			O	O
O Elements of co-operation								
- Short-term rotation		O	O	O	O	O		O
- Existence of conflicts					O	O		O
- Survey of technology		O	O	O	O	O	O	O
O Elements of Motivation								
- Participation		O		O	O	O		O
- Incentive system		O		O	O	O	O	O
- R&D evaluation system		O	O	O	O	O		
- Trust relation					O	O	O	O

Remarks

1. OM is an abbreviation for organisational management, and IC for international collaboration.
2. Chtr is an abbreviation for characteristics, and 'Main' for main issues.
3. O in the table means that an element is mentioned in a certain sector of the literature by authors as important one for the efficient implementation of science and technology policy.

Co-operation, co-ordination and motivation activities will provide a framework in researching the implementation of aviation technology policies. Hence, each country's aviation development policy is presented in chapters 4, 5, 6 and 7 respectively on the basis of the three factors of co-operation, co-ordination and motivation. In addition, the questions in the questionnaire are also consistent with these three factors.

Chapter 3
Civil Aviation Technology Policy

A number of very large scale consolidations were undertaken in the world aviation industry in the 1990s. The world's largest and third largest aviation manufacturing companies, Boeing and McDonnell Douglas, were merged in August 1997, and this consolidation sent a strong message to the European aviation manufacturing companies to transform their structures. The four European aviation companies, U.K.'s British Aerospace (currently BAe Systems), French Aerospatiale, German DaimlerChrysler Aerospace (DASA) and Spanish Construcciones Aeronauticas SA (CASA) agreed to establish an Airbus Single Corporate Entity (SCE) as a stock company at the end of 1997. However, the Boeing and McDonnell merger seems not to have achieved the enhanced efficiency and cost savings that were expected, and the establishment of the SCE have been repeatedly delayed by discords between the participating companies. Furthermore, various domestic and cross-border mergers have occurred between the European aviation companies.

What is the background to these consolidations in the world aviation industry? What implications of the phenomena can be drawn from them by latecomer countries to the aviation industry? This chapter aims to examine the background to these questions, in order to propose some policy options for the development of Korean aviation technology. The chapter consists of four sections: (1) Overview of the aviation industry, (2) Mergers and Acquisitions (M&As), (3) The aviation technology development strategy, and (4) the conclusion.

3.1 Overview of the Aviation Industry

The power of a huge aeroplane which flies over the sea carrying hundreds of passengers impresses us as a synthetic device at the top of the high technology tree. Moreover, the landing of a human on the moon in 1969 and the development of supersonic, stealth and tilt-rotor technologies seem to be miracles achieved by endless human efforts in a scientific and technological world. Aviation technologies have developed amazingly since the first controlled flight of an aircraft by the Wright Brothers in 1903, and this development has considerably influenced the quality of human life and the development of other industries.

This section is divided into three sub-sections. The first relates to the characteristics of the aviation industry. The second relates to the current aviation industry, presenting international comparison of the aviation industry and major aviation companies. Finally, the third sub-section relates to the future prospects for the aviation market.

3.1.1 Characteristics of the Aviation Industry

The aviation industry has various characteristics, which can be divided into the four categories of economic, technological, market and political aspects.

First, regarding economic characteristics, the aviation industry can provide many jobs. In fact, the European aerospace industry employed about 420,000 persons at the end of 1998 (*Aviation Week & Space Technology,* (hereinafter *AW & ST*), August 2, 1999, p. 38). In addition, it is said to have high value-added effects compared to other industries. According to the Korea Institute of Engineering and Technology (KIET, 1994, p. 5), the added value of the aviation industry in Japan in 1990 was 38.1 per cent, while that of electronic goods, shipbuilding and automobile was 36.0 per cent, 35.5 per cent and 25.5 per cent respectively. The aviation industry requires a huge scale of facilities and funds in achieving the economies of scale. In fact, the development cost of the A3XX, a 555-seat transport to be developed by Airbus Industrie[4], is estimated to be $10-12 billion (*AW & ST*, March 29, 1999, p. 41). Boeing reaches break-even point only when it sells 300 B-709s, for which the unit price is an estimated $25 million (KIET, 1990, p. 13). The aviation industry has a

[4] Airbus Industrie is a group consisting of the four European aviation companies, the UK's British BAe Systems, German Deutsche Airbus, French Aerospatiale and Spanish Construcciones Aeronauticas SA (CASA). It was established in 1970 in order to produce commercial aircraft.

high level of risk and uncertainty in securing markets and gaining profits when developing new aircraft. For example, in the case of Concorde, the first supersonic commercial transport aeroplane, only 16 aircraft were produced due to noise pollution problems and economic concerns (KIET, 1990, p. 46). Hence, many aviation companies have conducted joint projects through domestic and cross-border consolidation and international collaboration, in order to share development costs and risks.

Second, regarding technological characteristics, the aviation industry needs a high level of accuracy and safety in developing aircraft, which means that the aviation manufacturing companies need to have a high level of technologies and highly skilled staffs. According to *Flight International* (13-19 January 1999, p. 27), 27 per cent of total aircraft related accidents in 1998 resulted from the failure of aircraft themselves. That is, 13 of the total 48 accidents happened through technical errors in aircraft, and resulted in 344 fatalities.

Third, regarding market characteristics, both the demanders and suppliers of aircraft each represent an oligopoly (Bluestone *at al.*, 1981, p. 7). In fact, long-range transports with over 150-seats have been supplied by only two large companies, Airbus Industrie and Boeing. On the other hand, major demand for aircraft comes from governments and a few large transport businesses, including 227 major airlines and 132 additional cargo companies world wide (www.airbus.com/gmf99, November 15, 1999).

Finally, regarding political characteristics of the aviation industry, the development of aviation technology seems to have had a close relation with national purposes, such as national security. Many military aircraft were developed for the purpose of national defence. The Joint Strike Fighter (JSF), currently under development, seems to be an example of this. The JSF project, worth 15-18 billion, was contracted between the US Air Force and Boeing, and between the US Air Force and Lockheed Martin respectively in 1995, for the purpose of the development of the JSF demonstrator. It is projected that about 3,000 aircraft will be produced for the US Air

Force, the US Navy, the US Marines and the UK Navy (*Flight International* 23-29 June 1999, p. 29).

Latecomer countries seem to have difficulties in achieving competitiveness in producing aircraft in the world aviation market, because the aviation industry needs huge funds and high technologies in developing aircraft with a high level of safety and marketability.

The definition and classification of the aviation industry and the classification of aircraft will now be examined. The term 'the aviation industry' seems to be varyingly understood, because it can include various industries, such as airframe and aero-engine manufacturing businesses, passenger and cargo transportation businesses, and repair and pilot training businesses. According to the Korean Aerospace Industry Development and Promotion Act, the aviation industry can be defined as the business of manufacturing the structure, parts and materials of aircraft, and aircraft related business. Hence, the aviation industry can include the three areas of manufacturing, including assembly and part supply, aircraft repair and airliner industries. In addition, according to Gyungsang University, Korea (1995, p. 11), the aviation manufacturing industry consists of the airframe, engine, electronics, bogie and material areas.

Aircraft can be divided variously according to the purpose of classification.[5] They can be divided into commercial and military aircraft depending on their use. Commercial aircraft can be divided into airliners and cargo planes. In addition, airliners can be divided by the number of seats into super large-range transports, which are passenger carriers of over 500-seats, large-range transports of 100-500 seats, medium-range transports of 40-100 seats (called regional or

[5] See more details in Todd and Simpson (1986) p. 48 and p. 78.

commuter aircraft)[6], and small-range transports of under 40 seats (called business or corporate aircraft). Military aircraft can be divided into transport, combat aircraft, fighters, reconnaissance aircraft and trainers according to their use. In addition, aircraft can be divided into fixed wing, rotary wing (helicopter) and tiltrotor aircraft (which has the two functions of fixed and rotary wings) according to shape of their wings.

This research will focus on the aircraft manufacturing industry, so the aviation industry will include airframe, engine and material manufacturing businesses in this thesis. This is because most aviation R&D activities seem to be conducted by those businesses, and because this thesis has a high interest in efficient aviation R&D activity in aviation technology policy.

3.1.2 The Current Aviation Industry

This sub-section aims to examine the aviation industry worldwide in order to identify the current position of the Korean aviation industry. It includes an international comparison of the aviation industry capability and of major aircraft manufacturing companies.

The United States has dominated the aerospace industry worldwide, with 61 per cent of its total sales and had 47 among the world top 100 aviation companies in terms of sales in 1997. Furthermore, sales of Boeing, the largest aerospace company, stood at $45,054 million in 1997. The second largest country was the United Kingdom with

[6] The definition of commuter aircraft has been changed. The Commuter Flight Business Regulation which was established by Civil Aeronautics Board of the United States in 1969 defined it as having the following characteristics:

(i) It needed to make over five return flights between two areas.
(ii) A flight schedule had to be announced.
(iii) A mail transportation service had to be carried out.
(iv) The maximum freight weight had to be under 12,000 pounds and the number of its seat less than 19. However, the 1978 Airline Regulation Relaxation law of the United States changed the fourth requirement to the following.
(v) The maximum freight weight had to be under 18,000 pound and the number of seat under 60. Commuter aircraft have been used for supplementary flight on short haul routes, on which large aircraft earn low profits, and for the purpose of improving flight links between hub airports and small branch airports.

12 percent of world sales at $31,850 million and with 12 among the top 100 aviation companies worldwide. The third was France. European countries had 33 per cent of world sales, with $85,840 million, and 38 of the top 100 aviation companies. However, European countries' total sales and number of companies were less than those of the United States. Korea had only 0.2 per cent of world sales with $454 million and only one company, Samsung Aerospace. The world top 100 aviation companies came from 17 countries and only 8 countries' sales represented more than one per cent of world sales (*Flight International* 2-8 September 1998, pp. 48-61). Table 3.1 shows the number of the world's top 100 aviation companies by sales in 1997 in each country.

Table 3.1 International Comparison of the Aerospace Industry by the Sales of Aerospace Companies within the World Top 100 in 1997

Country	USA	UK	France	Germany	Japan	Italy
Sales ($m)	156,940	31,850	31,090	10,300	7,253	6,336
Sales (%)	61.1	12.4	12.1	4.0	2.8	2.5
Number	46	12	13	4	6	2
Country	Canada	Sweden	Israel	Spain	Switzerland	Brazil
Sales ($m)	3,998	2,842	2,063	1,252	1,054	794
Sales (%)	1.6	1.1	0.8	0.5	0.4	0.3
Number	3	3	2	1	2	1
Country	India	Korea	Singapore	S. Africa	Belgium	**Total**
Sales ($m)	493	480	454	335	201	256,670
Sales (%)	0.2	0.2	0.2	0.1	0.1	100
Number	1	1	1	1	1	100

Source: *Flight International* 2-8 September 1998, pp. 48-61.

The aerospace industry, in the table above, includes the commercial aircraft, engine, defence and space industries. In addition, the defence industry includes military aircraft, defence electronics and missile manufacturing companies. In the commercial aircraft industry, the largest company was Boeing with $26,900 million sales, the second largest was Airbus Industrie with $11,600 million and the third was Bombardier, a Canadian company, with $3,300 million. In the aero-engine manufacturing industry, the largest company was General Electric, a US company, with $8,500 million sales, the second was Pratt & Whitney, a company belonging to United Technologies group in the U.S., with $7,400 million sales and the third was

Rolls-Royce, a United Kingdom company, with $5,030 million. In addition, the largest defence company was Lockheed Martin with $18,000 million sales, the second was Boeing with $15,000 million and the third was Raytheon with $14,800 million.

The United States has five companies, namely, Boeing, Raytheon, Textron, Gulfstream and Fairchild, among the world top 12 commercial aircraft companies, and has two engine companies, namely General Electric and Pratt & Whitney among the top five aero-engine manufacturing companies (*Flight International* 2-8 September 1998, p. 64), as shown in Table 3.2.

Table 3.2 Major Aerospace Companies within the World Top 100 Companies by 1997 Sales

Classification	Ranking	Name of Company	Sales ($m)
Commercial Aircraft	1	Boeing	26,900
	2	Airbus Industrie	11,600
	3	Bombardier	3,300
	4	Raytheon	2,450
	5	Textron	2,200
	6	Gulfstream	1,900
	7	Dassault Aviation	1,400
	8	ATR (Aerospatiale/Alenia)	800
	9	British Aerospace	750
	10	Embraer	650
	11	Fairchild Dornier	500
	12	Saab	400
Aero-engine	1	General Electric	8,500
	2	Pratt & Whitney	7,400
	3	Rolls-Royce	5,030
	4	Snecma	2,450
	5	DaimlerChrysler Aerospace	1,700
Defence (military Aircraft, Electronics and Missiles)	1	Lockheed Martin	18,000
	2	Boeing	15,000
	3	Raytheon	14,800
	4	British Aerospace	10,800
	5	Northrop Grumman	7,700
	6	GEC	6,500
	7	Thomson-CSF	6,100

Source: *Flight International* 2-8 September 1998, pp. 48-61.

The world industry seems to be dominated by the US and several European countries, such as the UK, Germany and France. However, the US companies made larger sales than European companies in 1997. In fact, their sales represented 61 per cent of the world top 100 aerospace companies by 1997 sales. Moreover, Boeing, as a single company, accounted for 17.8 per cent of the total sales. Korea has only one company among the top 100 companies, and this company's sales were much smaller than those of the larger companies in the US and European countries.

3.1.3 The Prospect for the Aviation Market

The future of the world aviation industry can be examined under the two categories of aircraft and passengers. Airbus Industrie's Global Market Forecast predicted over the twenty years 1999-2018 that commercial transport would remain one of the world's great growth industries. According to their forecast, passenger traffic will grow at an average annual rate of 5 per cent, while cargo traffic will average 5-7 per cent growth per year. Commercial transport will grow from some 10,000 aircraft at the end of 1998 to 19,106 aircraft at the end of 2018. 14,678 aircraft are expected to be newly produced to replace retired ones and to meet new additional demand. Cargo planes will grow from some 1,450 aircraft at the end of 1998 to 3,400 aircraft by the end of 2018, and 750 aircraft will be newly produced to replace old passenger aircraft and meet new demand (www.airbus.com/gmf99, 15/11/99).

Boeing predicted future aircraft demand, by seat capacity, over the two decades 1997-2017. It expects that aircraft with 121-170 seats will represent the largest portion of demand with 34.7 per cent of total aircraft in 1997, decreasing to about 32.2 in 2017. The proportion of demand for aircraft with 171-240 seats was predicted to increase more than that for any other size of aircraft (www.boeing.com/commercial/cmo, 25/02/99), as shown in Table 3.3.

In addition, according to Airbus Industrie's 20-year forecast by region, airlines of the Asia-Pacific region will lead the world in the purchase of new transports. The Asia-Pacific region will need 4,300 aircraft, worth $450 billion, by 2018, representing a quarter of world demand. Average annual growth of aircraft demand in the case of the Asia-Pacific region will be 6-10 per cent during 1999-2018, while that of world demand was predicted to be 5 per cent in the same period (*AW & ST*, July 26, p. 59).

Table 3.3 Forecast on World Aircraft

Seat	1997		2017		Demand (1997-2017)	
	Aircraft	%	Aircraft	%	Aircraft	Model
50-90	615	5.0	1,941	7.4	1,578	BAe 146, RJ70/85, Canadair RJ
91-120	2,97	23.6	3,608	13.8	2,148	B737-500/600, B717-200, MD-87, RJ100
121-170	4,258	34.7	8,446	32.2	5,299	B737-300/400/700/ 800, MD-80/81/82/ 83 /88, A319/320
171-240	1,213	9.9	4,042	15.4	3,234	B757, A321
230-310	1,273	10.4	3,277	12.5	2,031	B767, A300/310/ 330-200
311-399	1,007	8.2	3,172	12.1	2,332	A330/340, MD-11, B777-200/300
400-plus	1,016	8.3	1,712	6.5	1,029	B747, B747X, A3XX
	12,279	100	26,198	100	17,651	

Source: www.boeing.com/commercial/cmo, February 25, 1999.

The changes of economic situation seem to influence the forecast considerably. According to the International Air Transport Association (IATA) forecast, which took into account the Asian economic crisis, international air traffic was expected to grow 5.5% annually over the next 4 years, down 1.1 percentage points from the prediction a year earlier before the full brunt of Asia's recession had hit. The increase in the rate of air traffic in Asian countries is predicted to be higher than that for other regional zone (*AW & ST*, February 2, 1999, pp. 70-73), as shown in Table 3.4 on the next page.

The world aviation industry seems to have a prosperous future according to the previously mentioned forecasts. Moreover, demand for aircraft by the Asian-Pacific region was predicted to increase faster than in any other regions. Thus, Korea seems to be located in the place where a larger demand for aircraft is predicted. However, a latecomer country may find difficulty in achieving competitiveness in the world aviation industry, because the aviation industry has the characteristics mentioned before which cannot be easily acquired by a weak country with lower technological and economic capabilities. In addition, the world aviation industry is dominated by several huge companies, so Korea with several small scale companies may have great difficulty in attaining competitiveness in producing a complete aircraft. Korea seems to need an appropriate aviation development strategy to cope with its technological and economic situation.

Table 3.4 IATA Forecast on Air Traffic (1998-2002)

Classification by region		1998-2002	1997-2001
Average annual growth in total passengers	Worldwide	5.5%	6.6%
	U.S.-Canada	5.5%	6.1%
	Western Europe	5.9%	6.1%
	Central Europe	6.9%	7.9%
	North-East Asia	4.5%	8.1%
	South-East Asia	4.4%	8.0%
	Middle Asia	5.1%	5.1%
	South Africa	6.2%	7.5%
Selected turnaround Countries	South Korea	2.7%	8.1%
	Taiwan	4.3%	11.2%
	China	8.8%	14.0%

Remarks: Figures in the 1997-2001column come from the IATA forecast made before the Asian economic crisis at the end of 1997.
Source: *AW & ST*, February 1, 1999, p. 71.

3.2 Mergers and Acquisitions (M&As)

In the 1990s, many large-scale domestic mergers were conducted in the world aerospace industry. In addition, currently several large-scale cross-border consolidation are planned, such as the planned European Aeronautic, Defence and Space Company (EADS). Those trends may positively and negatively influence the world aviation industry including the Korean aviation industry. This section will examine the characteristics of merger and acquisition and the major cases of it.

3.2.1 Characteristics of M&As in the Aviation Industry

Most merger deals seem to be driven by the lure of cost savings, synergies and economies of scale (*Flight International* 27 October-2 November 1999, p. 28), but a more fundamental driving force behind merger in the aviation industry may be the dramatic reduction in defence procurement budgets. The resulting over-capacity has sparked a frenzy of mergers and acquisitions (*Flight International* 1-7 September 1999, p. 37). James (1998, pp. 5-6) mentions the background to mergers and acquisitions in the US defence industry on both the demand side and supply side. On the demand side, the US defence equipment budget has decreased considerably since its Cold War peak in 1985. This has resulted in a reduction in overhead costs. On the supply side, the scale of R&D funding to develop the new high technologies needed for future defence weapons has become larger, while the defence budget has decreased. This has driven companies to recognise the need to integrate businesses.

The strategic linkups have the advantage of making companies secure more market share, and greater organisational efficiency and pricing power (*AW & ST*, August 10, 1998, p. 45). In addition, newly consolidated companies may have the opportunity to recruit the highly qualified persons they want. In fact in 1999, Boeing planned to hire 3,000-4,000 people, despite its initial job losses (*AW & ST*, February 8, 1999, pp. 3-4). In addition, newly consolidated companies can take advantage of larger company size, as well as eliminating costly duplications (*AW & ST*, March 17, 1999, p. 47).

However, the positive effects of mergers and acquisitions seem not to appear in the short term. It is said that Boeing and McDonnell Douglas merger has still not achieved the enhanced efficiency and cost savings that were expected, and Lockheed Martin also has the same difficulties. After tens of billions of dollars worth of acquisitions, they seem to be finding that it is difficult to manage huge asset bases in order to achieve the superior operation that they claimed before the acquisition. "Bigger is better" can only be achieved when size can be translated into increased operating margins and an enhanced return on investment (*AW & ST*, May 31, 1999, pp. 44-55).

It may be too soon to tell whether the mergers and acquisitions concluded in the US aerospace industry will be successful in increasing profits and organisational efficiency, but if that happens, the consequences will be mirrored for other companies in planning their merger strategy. The lesson may be that not all large-scale acquisitions achieve the higher economies of scale they expected. Size may not be a prerequisite for success.

3.2.2 Major Cases of Mergers and Acquisitions

This sub-section focuses on recent domestic and cross border mergers in the US and the European aerospace industry, while the consolidations in the US and UK will be presented in more detail in the next chapters.

There were 11 large consolidations in the US aviation industry during the years 1993-1997. The largest merger in terms of price paid was the consolidation between Boeing and McDonnell Douglas at $14 billion in 1997, and the second was that between Lockheed and Martin Marietta at $10 billion in 1995. The price paid in each of the 11 mergers was over $1 billion (James, 1998, p. 7), as shown in Table 3.5.

Table 3.5 The Major M&As of US Aerospace Companies during 1993-1997

Acquirer	Acquired company	Price paid for M&A		Year
		$ billion	Ranking	
Boeing	Rockwell International	3.2	6	12/96
"	McDonnell Douglas	14.0	1	08/97
Lockheed	General Dynamics/ Fort Worth Division	1.5	11	03/93
"	Martin Marietta	10.0	2	03/95
Martin Marietta	General Electric/ Aerospace Division	3.0	7	04/93
Lockheed Martin	Loral	9.0	4	04/96
Raytheon	E-System	2.3	9	05/95
"	Texas Instruments	2.9	8	07/97
"	Hughes	9.5	3	12/97
Northrop	Grumman Corp.	2.1	10	04/94
Northrop Grumman	WestingHouse	3.5	5	03/96

Source: Based on Andrew D. James (1998), Post-merger strategies of the leading US defence aerospace companies, p. 7.

Several domestic and cross-border consolidations have been concluded in European aerospace industries, which had 422,484 employees with sales of $63.5 billion in 1998 (*Flight International* 4-10 August 1999, p. 24).

BAe and Marconi plc (the parent group of Marconi Electronic Systems) announced in January 1999 that they would create a monolithic defence entity, and this was completed in November 11, 1999. The new company, called BAe Systems, will take third place in the aviation industry following Boeing and Lockheed Martin. Marconi plc owns 36.6 per cent and BAe 63.3 per cent of the shares of the new company, which has about 100,000 workers across 60 sites in the UK and 39 sites in seven other countries including France, Germany, Italy, Saudi Arabia, Sweden, Australia and the USA (www.baesystems.com/dynamic, December 2, 1999). Many opinions about the BAe/ Marconi merger were expressed. For example, French industry observers said that "the merger sows the seeds of confusion in the European defence industry's integration." Thomson-CSF, which had twice planned a merger with Marconi, in 1995 and 1997, said that they would pursue an independent global development strategy. In addition, the UK Prime Minister, Tony Blair, criticised the deal for being too British (*Flight International* 27 January - 2 February 1999, p. 30).

The two French aerospace companies, Aerospatiale and Lagardere (the parent group of Matra Hautes Technologies) agreed in February 1999 on the final terms for the Aerospatiale and Matra Hautes Technologies merger. The unified industrial group, called Aerospatiale Matra, will have 56,500 employees and an estimated $14 billion revenues based on 1998 figure (*AW & ST*, February 22, 1999, p. 33). The French aerospace industry welcomed the planned merger, but French labour unions argued fiercely that state-owned Aerospatiale was deliberately undervalued during the negotiations, that Lagardere's company debt would be paid by taxpayers, and that Thomson-CSF's plan to cut 4,000 jobs presaged what could happen soon at Aerospatiale Matra (*AW & ST*, February 22, 1999, p. 33).

Two cross-border mergers have been conducted. First, CASA agreed to merge with DASA in June 1999. DASA will have 86.5-88.5 percent, and SEPI (the Spanish national holding company) 11.5-13.5 per cent of the shares in the new entity. The two companies' merger agreement involved increasing CASA's activity in Airbus by exploiting its design and production capacities, lending momentum to CASA's business by combining the capacities of the two companies, increasing activities in missiles, space and helicopters and generating new business opportunities (*Flight*

International 23-29 June 1999, p. 51). Few opinions were found on the CASA/DASA merger except for surprise that CASA, a 75-year old national aerospace company, was on the verge of being sold.

Second, DASA, Aerospatiale Matra and CASA agreed to merge in October 1999. The merged entity, called the European Aeronautic, Defence and Space Company (EADS), will create the world's fourth largest aerospace with $21 billion estimate been on 1998 figure. The EADS will have an 80 per cent holding in Airbus Industrie, with the other 20 per cent remaining with BAe Systems (*Defence News*, December 20, 1999). In addition, the EADS will have a 58 per cent holding in the Typhoon project (the Eurofighter produced jointly by BAe, DASA, CASA and Alenia), and a 45.7 per cent holding in the Rafale project (a fighter produced by Aerospatiale Matra and Dassault Industries) (*Flight International* 27 October - 2 November 1999, p. 26).

The planned EADS seems to be a competitor with BAe Systems in the European aerospace industry. In fact, their turnover was estimated to be on a similar scale. Their development strategies may influence the establishment of an Airbus Single Corporate Entity. BAe Systems' stance on Airbus Industrie seems to be important in establishing the SCE. Since BAe Systems has only a 20 per cent stake in Airbus Industrie, while EADS has 80 per cent, its position has been weakened by the establishment of EADS. However, BAe Systems seems to need a new strategy towards its role in Airbus Industrie, because it has a similar capability with EADS as shown in Table 3.6.

In the 1990s, many large scale mergers were concluded in the US aerospace industry. However, it seems to be unclear whether the merger have achieved the purposes they expected. European aviation companies also concluded several domestic mergers and have been proceeding with mergers, which may be influenced by US aviation companies' mergers. However, planned mergers in the European countries seem to be delayed by each company's different situation. In fact, the development strategy of the aviation industry in a country may not be decided by consideration of the economic aspect alone. It may also include such other aspects as employment and national prestige.

Table 3.6 Emerging World Top 9 Aerospace Companies

Ranking	Name of Company	Sales ($billion)	Country
1	Boeing	55.4	USA
2	Lockheed Martin	24.4	USA
3	EADS/CASA	21.8	France/Germany/Spain
4	BAe/ Marconi	20.5	UK
5	Raytheon	17.5	USA
6	United Technologies	10.7	USA
7	Northrop Grumman	8.3	USA
8	Thomson-CSF	8.0	France
9	General Electric	7.8	USA

Remark: Sales were estimated on the basis of 1998 sales.
Source: *Flight International* 27 January – 2 February 1999, p. 31., *Flight International* 20-26 October 1999, p. 4., and *Defence News,* December 20, 1999.

3.3 Aviation Technology Development Strategy

This section aims to examine aviation development strategies adopted in the world aviation industry, in order to understand the background of aviation industry development. The section is divided into the three sub-sections of R&D activity, management strategy and international collaboration, which are the principal research focus of this thesis.

3.3.1 Research and Development Activity

This sub-section is divided into two parts. One deals with the development of aviation technology and includes an account of the development trajectory of aviation technology and national aviation technology level. The other is to explain the R&D cost saving strategy, and includes an account of government supported R&D projects, joint R&D projects and the cases of R&D cost saving strategy.

Aviation technology rapidly developed through the two World Wars. The high-powered reciprocation engine, wireless communication, the all-weather aircraft and the helicopter had developed during the period from the end of World War I to the beginning of World War II. In the 1950s, aviation technology developed strongly. Jet-engine transport and supersonic fighters (F-4 and F-101) were developed. In the 1960s, the period of mass-transportation was opened by the development of large-scale turbo engine and wide body aircraft (B-747, DC-10 and L-1101), and the production of the Harrier, Vertical Short Take-Off and Landing (VSTOL) aircraft. In addition, humans first voyaged to the lunar surface in 1969. In the 1970s, supersonic commercial transportation came about with Concorde's first flight in 1976, and noise and environmental pollution from aircraft flight were recognised as important social problems. In the 1980s, tilt-rotor technology, which enabled aircraft to have both helicopter and fixed wing aircraft functions, and stealth technology, such as the F-117A, were developed. In the 1990s, the second-generation supersonic transport,[7] the civil tilt-rotor and unmanned combat aircraft have been developed (Korean Aerospace Industries Association, KAIA, 1997, p. 30).

Currently the aviation industry has oriented towards developing supersonic, hydrocarbon-fuelled and human-crewed aircraft and tilt-rotor aircraft as the future commercial aircraft (*Flight International* 1-7 September 1999, pp. 74-75).

According to MOST(1995), the development of aviation technology can be divided into the five levels of: repair → licensed manufacture → joint production → the development of medium-level technology aircraft → the development of technologically highly advanced aircraft. On this basis, the US, the UK France, Germany, Russia, Italy and Canada belong to the highest level of aviation technology development but Korea belongs to the middle level, as shown in Table 3.7.

Table 3.7 Classification of Aviation Technological Level

Repair	Licensed manufacture	Joint production with technology acquisition	Development of medium technology aircraft	Development of high technology aircraft
Philippines Malaysia	Thailand Singapore Greece	Korea Austria Argentina New Zealand Turkey	China, Taiwan, Brazil, Israel India, Switzerland Spain, Indonesia, Australia	United States United Kingdom Russia, Germany France, Japan, Italy, Canada,

Source: MOST (1995), A Long-Term Vision of The Aviation Industry, p. 5.

[7] The first-generation supersonic transport is said to be Concorde, produced in 1976.

Regarding R&D cost saving strategy, a country and companies may have various aviation R&D cost saving strategies, because the development of an advanced technology aircraft requires huge R&D funds. R&D cost saving strategies are of three broad types as follows.

First, many countries have supported the aviation industry through R&D projects. The United States government has provided the aerospace companies with 43 R&D projects, called X-series, for developing new aircraft or new technologies during the period 1946-1998. For example, X-32 is an R&D project to develop the Joint Strike Fighter (JSF) demonstrator that was contracted between the US Air Force and Boeing in 1996 (*Flight International* 6-12 January 1999, p. 34), and X-37 is a four-year R&D project contracted between NASA and Boeing in July 1999 to develop a reusable vehicle in orbit (*AW & ST*, August 9, 1999, p. 72). In addition, the project for the Nimrod MRA4, a maritime, reconnaissance and attack aircraft, has been contracted between the Royal Air Force and BAe Systems for £2 billion (www.bae.co.uk/dynamic, December 2, 1999).

Second, aviation companies have jointly conducted R&D projects. Thus, Gulfstream has teamed up with Lockheed Martin to investigate the feasibility of a Supersonic Business Jet (SSBJ). Airbus Industrie had an exclusive agreement with Raytheon to market the Airbus Multirole Tanker/Transports (MRTTs). Lockheed Martin and Aerospatiale Matra also agreed to market an MRTT (*Flight International* 4-10 August 1999, pp. 45-46). In addition, the state-owned Aviation Industries of China (AVIC) released details in 1998 of a planned regional jet family and was seeking foreign risk-sharing partners. It hoped to deliver the first models in 2004 and has approached Taiwan Aerospace Industrial Development to discuss a link-up (*Flight International* 25-31 August 1999, pp. 44-57).

Third, aviation companies have made efforts to save R&D funds. Since 1996, Fairchild Aerospace has been adopting a minimum change philosophy to create the 328 Jet, which is a 30-seat aircraft produced by re-engineering the Dornier 328 turboprop with turbofans in order to supply a cheap aircraft to customers. There was no change in the overall structure, for the major changes were introduced in the high pressure turbine to improve reliability and durability (*Flight International* 22-28 September 1999, pp. 56-57). The Brazilian aircraft manufacturer, Embraer, planned to deliver the first ERJ-140, a 44-seat twinjet, as early as March 2001. It planned to invest $45 million to develop the new aircraft, a minimum-change derivative of the ERJ-135 that is scheduled to make its first flight in June 2000. Embraer's goal is to retain a 96 per cent commonality with the ERJ-135, a 37-50-seat twinjet (*AW & ST*, October 11, 1999, p.41). Furthermore, Dassault Aviation shelved the Supersonic Business Jet (SSBJ) project indefinitely although it has the market skill and technologies to introduce an SSBJ. The company forecast that there was at least a 50 per cent chance that an SSBJ project would be successfully launched in the next 15 years, with a potential market for as many as 400 aircraft over a 20-year period (*AW & ST*, July 19, 1999, p. 59).

In addition, currently several large competitive companies have highly advanced technologies with which companies in latecomer countries may not catch up. Stealth, supersonic and tilt-rotor technologies seem to be such technologies. Moreover, developed countries have provided the aviation industry with large scale R&D projects. Latecomer countries may need to provide their aviation industry with more R&D projects in order to reduce technological gaps with the large competitive companies.

3.3.2 Management Strategy

An efficient management strategy seems to be very important in improving the productivity of aviation R&D activity, in particular, to latecomer countries which have smaller resources compared to developed countries. This sub-section is divided into two parts, the first relating to government support systems and the second to the aviation companies' organisational efficiency improvement programmes.

The government support systems can include funding and sales supports, the provision of nation-owned facilities, and the established competitive condition through international negotiations. These systems are presented with the three categories of the European countries, the US and other countries.

Firstly, the European countries have supported the aviation industry through funding and sales supports. The UK, Germany, France and Spain have supported Airbus Industrie with the provision of development funds and sales supports (www.airbus.com/aboutoverview, September 4, 1999). In addition, the Eurofighter (Typhoon) project has been supported by the four governments of the UK, Germany, Italy and Spain, who have ordered 620 Eurofighters. In addition, the UK and Swedish governments have also supported the Gripen AB fighter project, which has been developed as a joint venture by Saab and BAe Systems (www.bae.co.uk/dynamic, December 2, 1999).

Secondly, the US has supported the industry with various ways. It has loaned federal land, building and facilities. In fact, 20 percent of Boeing's land and building is loaned from the government. It has supported the industry through a 'buy America' policy, and has made efforts to make its aviation industry competitive through the establishment of international agreements. For example, the United States made a bilateral agreement with European countries in 1992. The agreement regulates the support to be given for manufacturing civil aircraft with seating capacity of over 100. It prohibits the subsidy of over 33 percent of the total R&D cost. It also regulates that subsidy support must be refunded within 17 years of its receipt (KIET, 1994, pp. 44-47).

In addition, The United States has placed many trade sanctions on the aviation industry, in order to restrict technology transfer to other countries. For example, it prohibited the sale of fighter aircraft to Indonesia and Peru for political reasons, and prohibited the export of missile technology to China in August 1993, but lost a contract for a satellite project worth $100 million. Accordingly the US aviation industry was concerned about government involvement and has been researching the effect of economic sanctions on the aviation industry (*Bimonthly Aerospace Industry*, 1998, 7/8, p. 12).

Finally, regarding other countries' support systems, several governments have also sought to protect their own industries by accusing other of violation of the World Trade Organisation's subsidy regulation.[8] In fact, Canada accused the government of Brazil of making an unfair subsidy to Embraer, a Brazilian aircraft company, and Brazil also accused the Canadian government of making an unfair subsidy to Bombardier, a Canada aviation company in 1998 (*Bimonthly Aerospace Industry*, 1999, 3/4, pp. 10-11). Brazil and Indonesia have a 'buy aircraft domestically produced' policy.

Many countries have supported their aviation industries to have competitiveness through various support systems including the restriction of transferring core technologies and the establishment of international agreements. However, such support systems can possibly become barriers to developing countries in achieving competitiveness of their industries and in acquiring overseas technologies they need. Various governments' support systems for aviation industry development are shown in Table 3.8.

[8] According to the WTO regulation, a subsidy is allowed to the extent of 75% of total R&D funds in the case of pre-competitive R&D projects, but the rate of subsidy to development R&D projects is restricted to 50%. There can be disagreement over whether particular kinds of R&D projects are basic or development (KAIA, 1999, 3/4, p. 13).

Table 3.8 Government' Support Activity for the Aviation Industry

Countries	Financial support	Non-financial support
USA	Supply of R&D projects, Investment for R&D, Establishing demand on aircraft.	Loan of federal land and building to aviation companies, Buy American.
France	R&D funding support: - 45.3% of R&D funding - Subsidy to projects (33% to Airbus project) Loan guarantee for production.	Support for sales of aircraft.
UK	Subsidy to private projects (33% to Airbus project).	Support for sales of aircraft.
Germany	Subsidy to private projects (33% to Airbus), Non-interest loan for production.	Support for sales of aircraft.
Japan	Funding support to R&D project, Subsidy and long-term loan.	International lobby activity.
Brazil		Buy Brazilian, Obliged off-set for buying foreign aircraft.
Taiwan	Funding support to international joint project and R&D project.	Establishment of stable demand on aircraft.
Indonesia	Funding to the development of aircraft.	Buy Indonesian, 50% of tariff to aircraft imported.

Source: Based on Project and Strategy for the Development of the Korean Aerospace Industry, 1993, Bain InterConsulting, p.18.

Regarding aviation companies' organisational efficiency improvement programmes, an organisational efficiency in the aviation industry was evaluated by asset utilisation, productivity and financial stability according to the best managed aerospace company (*AW & ST*, May 31, 1999, pp. 46-49). Several aviation companies' programmes for improving organisational efficiency or productivity will be mentioned.

The US Air Force and the US military aircraft industry joined with the Massachusetts Institute of Technology to launch the Lean Aircraft Initiative (LAI) in 1993. The project gave practitioners a way to drastically cut costs, reduce production cycle times and improve quality. The LAI was aimed at getting lean manufacturing principles [9] and practices adopted throughout the industry. Lean manufacturing is intended to attack waste and give customers exactly what they want. Lockheed

[9] Lean manufacturing is a philosophy pioneered by Toyota executive Taiichi Ohno and codified in the Toyota Production System. It employs five basic principles: (1) specifying the value from the

Martin's Joint Strike Fight team has been focusing on its lean manufacturing techniques for reducing JSF production costs and slashing build time per aircraft (*AW & ST*, August 30, 1999, p. 23).

In addition, the "six sigma" [10] initiative has also been introduced by the aviation companies. Lockheed Martin has had 115 people go through "six sigma" training since August 1998 (*AW & ST*, July 12, 1999, p. 57). Raytheon Aircraft's top 200 managers and Bombardier Aircraft's entire management teams were trained in six sigma techniques which aim to reduce mistakes or defects in producing goods. In addition, Cessna Aircraft, a US company, had a plan to introduce a six sigma initiative in early 2000 (*AW & ST*, October 11, 1999, p. 57).

Through the examination of management strategy, it was confirmed that developed aviation countries have supported their aviation industry strongly. Many countries' governments have support systems, such as subsidies, the establishment of demand for aircraft, loan of nation owned facilities, tariff relief on imported facilities, the exemption of taxes, support for aircraft sales and a buy domestic aircraft policy. In addition, several countries' governments have been involved in removing unfair subsidies given to aviation companies. At the same time, many aviation companies have adopted productivity improvement techniques such as lean and six sigma initiatives. In this circumstance, latecomer aviation countries seem to need strong government support and an efficient management strategy, in order to develop their aviation industry.

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perspective of the end customer, (2) identifying the value stream for each product, (3) creating a continuous flow in manufacturing and assembly, (4) making product flow only at the pull the customer, and (5) striving for perfection. The strategy is called "lean" because it provides a way to do more with less, often much less (AW & ST, October 11, 1999, p. 57).

[10] Six sigma is a method of statistically measuring products and services to achieve world-class performance. The sigma scale of measurement can be applied to anything and typically is, just a common denominator in the number of defects per unit. Six typographical errors in a passage that contains 100 words would represent a three sigma level of quality. Four sigma is typically representative of an average product (*AW & ST*, July 12, 1999, p. 57).

3.3.3 International Collaboration

A lot of international collaboration projects have been conducted in the world aviation industry in order to share R&D costs and secure markets. This sub-section will review some major joint development projects. It is divided into the European joint projects conducted between European aviation companies and other joint projects conducted between aviation companies in countries outside Europe.

The European joint projects worthy of mention will include Airbus Industrie (civil transport joint productions), the Eurofighter and Tornado (military aircraft), the Eurocopter (helicopter) and several aero-engine projects.

Airbus Industrie has produced various types of civil aircraft with over 100-seats, such as the A300 series. It is a consortium created in 1970 by the two companies of Sud Aviation (later Aerospatiale) of France and Deutsche Airbus[11] (later DASA) of Germany, and then two companies, CASA and Hawker Siddeley (later part of BAe Systems) of the UK, joined it later, the former in 1971 and the latter in 1979 (KAIA, 1997, pp. 117-121). Airbus Industrie seems to be a successful case of achieving competitiveness in the large-range civil transport market through international collaboration (*AW & ST*, January 18, 1999, p. 39). It had received orders for 3,586 aircraft and delivered 2,130 aircraft from the date of its establishment up till October 31, 1999. In 1998, it delivered 229 aircraft worth $13.3 billion and reached a 46 per cent share of the world air transport market (www.dasa.com/dasa, December 2, 1999).

Eurofighter (later Typhoon) has been designed to meet the requirements of four European partner nations, the UK, Germany, Italy and Spain. It is a single-seater, high performance agile combat aircraft. Its first flight as a demonstrator was in 1994, and is still three years away from customer delivery. Eurofighter is the product of an international joint venture called Eurofighter GmbH established in 1979 between

[11] Deutsche Airbus was established by the merger of Messerschmitt-Bolkow-Blohm (MBB) and VFW-Fokker (*The World Aerospace Industry*, 1997, KAIA, p. 117).

BAe, Daimler-Benz (currently DASA), CASA and Alenia (an Italian aviation comany).

The other military wing case of note is Tornado, a two-seat multi-role all-weather NATO combat aircraft. This was developed and built by Panavia Aircraft GmbH created in 1969 as a joint venture between BAe, Daimler Benz and Alenia. Over 950 Tornados have been produced and the aircraft are in service with the Royal Air Force, the German Air Force and the Italian Air Force (www.bae.co.uk/static/eurofighter.htm, April 5, 1999).

Eurocopter was established in 1961 between Aerospatiale and Daimler Benz to produce civil and military helicopters and it had sold about 1,500 helicopters up till November 1999. The Eurocopter project produces a civil range, including the Dauphin and the Super Puma, and a military one, including the Panther, the Cougar and the Tiger (www.eurocopter.com December 1, 1999).

Finally, International Aero Engines AG (IAE) was established in 1983 between Rolls-Royce, Japanese Aero Engine Corporation (JAEC), Pratt & Whitney of the US, Motoren Und Turbinen Union (MTU) of Germany and Fiat of Italy. It has produce V 2500 engines. Rolls-Royce began to produce the Adour RB-172 jointly with Turbomecca of France in 1972, and the Olympus engine with Snecma in 1975. Rolls-Royce, BMW-RR, Ishikawajima-Harima and Kawasaki have produce the Trent 800 since 1995 (KAIA, 1997, p. 185).

Regarding other joint projects, the S-92 Helibus, a commercial helicopter, was developed by the Sikorsky Aircraft Corporation of the US, the Jingdezhen Helicopter Group of China, Mitsubishi Heavy Industrie of Japan, the Aerospace Industrie Development Corporation (AIDC) of Taiwan, Embraer of Brazil and Gamesa of Spain. Its first flight was in 1998. The C-27 JIS, tactical transport, has been developed by Lockheed Martin and Alenia. BAe Systems has participated in the JSF programme conducted by Lockheed Martin since 1997. In addition, Bell and Agusta have been developing the BA609 tilt-rotor aircraft since 1998 and plan to complete the first prototype in late 2000 (*Flight International* 4-10 August, 1999, pp. 48-68).

International collaboration seems to have occurred side by side with competition and co-operation, because the European aviation industry is oriented to compete with the US industry but also co-operates with it. However, major international joint projects seem to have been conducted between large aviation companies in developed countries, as shown in Annex 3. Latecomer countries seem to need to strengthen their international collaboration with developed countries for the purpose of reducing technological gaps.

3.4 Conclusion

The world aviation industry is continuously developing because many developed and developing countries have emphasised the development of the aviation industry for the purpose of economic and technological development and national security. In addition, the industry has been predicted to have a higher level of development.

However, the scale of aviation industries in a number of developed countries is very large compared to those of latecomer countries. The US and several European countries dominate the world aviation industry. The scale of several very large aviation companies seems to be a big barrier to small companies of latecomer countries achieving competitiveness.

The aviation industry needs substantial R&D funds to develop advanced aircraft. Moreover, the major companies have conducted international collaboration mainly between themselves due to high R&D costs. In addition, they have applied various management strategies for improving organisational productivity, such as the adoption of the lean manufacturing initiatives, six sigma initiatives, a minimum change strategy and customer management programmes.

Korea has only one company, Samsung Aerospace, in the world's top 100 aviation companies, with sales of $480 million in 1997. Korea's R&D investment was $0.4 billion including private business investment for the aerospace industry, while Boeing's R&D investment was 1.9 billion in 1997. Korean aerospace industry's sales were $1.3 billion in 1998 (KAIA, 1999, 1/2, pp. 10-12), while those of Boeing were $56.2 billion and those of Airbus Industrie were $13.3 billion.

With the Korean aviation industry in such a weak position, the efficient management of R&D funds, facilities and researchers has to be regarded as one of the important goals of Korean aviation technology policy, so that it can overcome its low level of technological capability and small scale of R&D funds compared with developed countries. Accordingly, the aim of this thesis is to propose policy options for the efficient implementation of Korean aviation technology policy. Before moving a more complete analysis of the Korean situation, however, we shall first consider the evolution of aviation technology policy in the previously identified cases of the UK, the US and Japan.

Chapter 4
United Kingdom Aviation Technology Policy

This chapter aims to identify some lessons for the efficient implementation of Korean aviation technology policy from aviation development systems found in the development trajectory of the UK aviation industry and UK aviation technology policy.

The United Kingdom has a technological superiority in, and has made a great contribution to, the world aviation industry. It developed many kinds of new aircraft, notably, the Viscount (the first turbo-prop aircraft), the Comet (the first jet airliner), the Harrier (the first VSTOL aircraft), Trident (the first adaptation of an auto landing system) and Concorde (the first supersonic airliner). In addition, the UK aviation industry was said to have the most competitive companies in each of the three categories of large, middle and small size companies in the world aerospace industry by the 1999 Aviation Week Competitive Survey (*AW & ST*, May 31, 1999, pp. 44-49).

What technology policies have made the UK aviation industry achieve such a performance? This chapter consists of three sections: (1) the UK aviation industry (2) UK aviation development policy and (3) conclusion.

4.1 The UK Aviation Industry

This section is divided into the three sub-sections of the development trajectory of the UK aviation industry, discussions on the development trajectory, and the current UK aviation industry.

4.1.1 The Development Trajectory of the UK Aviation Industry

Understanding various UK aviation development policies conducted in the past seems to be helpful in proposing policy options for the efficient implementation of Korea aviation technology policy. For the purpose of learning lessons from those UK aviation technology policies, this sub-section aims to examine the development trajectory of the UK aviation industry. The development trajectory may be divided into the six stages of generation, first growth, first modulation, second growth, second modulation and current stages, as shown in Table 4.1

Table 4.1 The Development Stages of the British Aviation Industry

Stages	Period	Characteristics of Stage
Generation	Early 19th century – 1913 *(Before World War I)*	Theoretical research on aviation technology. First flight in Britain (1908). Establishment of aviation companies.
1st Growth	1914 – 1918 *(During World War I)*	Establishment of the large aviation industry. A large number of aircraft production.
1st Modulation	1919 – 1938 *(After World War I – before World War II)*	Decrease in demand for of military aircraft. Neglect of civil aviation. Rationalisation of the industry.
2nd Growth	1939 – 1954 *(During World War II and the Korean War)*	Mass production of aircraft again. Neglect in the face of US competitiveness. Rearmament.
2nd Modulation	1955 – 1986 *(After the Korean War- before the completion of privatisation)*	Fragmentation of the companies. Failure of Comet ('54),Bankruptcy of RR ('71) Rationalisation ('59-'60). Nationalisation ('71, '79).
Current	1987 – Present *(Since the completion of privatisation)*	Privatisation of BAe ('85) Privatisation of Rolls-Royce ('87). Large scale consolidations ('99).

The three stages of first and second modulation and second growth may involve many aviation development policies, because in those stages various changes seem to have occurred. Policies undertaken in each stage will be briefly described.

The first stage was the generation of the British aviation industry during the period from the early nineteenth century to 1914, the outbreak of the First World War. This stage may be characterised by the initial theoretical and practical efforts to develop aircraft, the establishment of aviation companies and the UK government's recognition of the importance of aircraft development in national security. In fact, in the nineteenth century, George Cayley, the English natural philosopher, had done theoretical work on mechanical flight, and the Aeronautical Society was formed in

1866. In Britain, the first powered flight was made by Samuel Cody in 1908, while the first flight of the Wright brothers' aircraft in France in 1908 further influenced the UK government to recognise that aircraft were important for national security. The years from 1908 to 1914 were years of rapid advance in English aviation, in which many aviation companies were established. Frederick Handley Page was established in 1908, Robert Blackburn and A.V. Roe in 1910, T.O.M Sopwith in 1911, and Noel Pemberton Billing in 1923 (Edgerton, 1991, pp. 1-9). In addition, the Army Aircraft Factory established in 1911 (renamed the Royal Aircraft Factory in 1912), played a major role in early British aircraft design and production (Hayward, 1989, p. 9).

The United Kingdom seems to have begun its aviation industry at a good time although the government's support for the aviation industry was not seen in this stage. It is possible that this lack of aviation policy left the UK aviation industry behind those of Germany and France in the generation stage.

The second stage was first growth period of 1914-1918, during World War I. This stage was characterised by the creation of a large UK aviation industry through mass production to meet wartime demand. Production of aircraft increased rapidly in this period. Monthly output increased from 10 aircraft in 1914 to 1,229 aircraft in 1917 and 2,688 aircraft in 1918. The labour force employed on manufacture of aircraft, engines and parts, but excluding materials, rose from nearly 49,000 persons in 1916 to 154,000 persons in 1917 and to 268,000 persons in 1918. In addition, several aviation companies were established including Fairey and Westland which were established in 1915 (Edgerton, p. 14). The British aviation industry was the largest and technically one of the most capable in the world, comprising 122 firms by 1918. However, the government seemed not to prepare for the over-capacity in production, because the decrease in demand for military aircraft appeared immediately in the post-war period. Hayward (1989, pp. 10-11) also argued that the government ignored a committee's recommendation to support civil aircraft production and to prepare for the post-war period and that it was not willing to subsidise commercial aircraft. The government seemed to neglect the establishment of an aviation policy for the post-war period.

The third stage was first modulation during the period 1919-1938, between World War I and World War II. In this stage, there were several mergers in the UK aviation industry and initial government support for selected civil aviation companies. The mergers were conducted by the industry itself in order to solve the difficulties of production overcapacity resulting from the abrupt decrease of military aircraft demand, and in the absence of any long term government aviation industry policy. However, by 1924, the government had begun to realise that it needed to support the aviation industry for strategic and political reasons, so it introduced a series of measures designed to encourage that industry. In 1934, the government began to provide the industry with subsidies and aviation development projects, but their support was allocated only to a selected number of large companies called "the Air Ministry ring". This consisted of 18 companies, as shown in Table 4.2.

Table 4.2 The Air Ministry 'Ring' in 1934

Products	Number	Firms
Airframe	13	Armstrong-Whitworth, Blackburn, Boulton Paul, Fairey, Gloster, Hawker, Handley Page, Avro, Short Bros, Supermarine, Vickers, Westland, Saunders Roe
Engine	3	Armstrong Siddeley, Napier, Rolls-Royce
Airframe and engine	2	Bristol, De Havilland

Source: David Edgerton (1991), *England and the Aeroplane*, p. 24.

This selective support ensured the viability of the favoured companies. However, the companies' dependence on government seemed to have a negative side, including the fact that most of them did little R&D to improve aviation technology and cut development costs. This technological gap was mainly filled by the research of the Royal Aircraft Establishment (RAE) and the National Physical Laboratory. However, as argued by Hayward (1989), those research organisations feared competition from private industry and did not encourage the companies to improve their production technology. Furthermore, the government seemed not to provide a concrete policy for the future aviation industry and focused its support only on the financial side.

Accordingly, rationalisation occurred in the UK aviation industry. Vickers bought Supermarine in 1928 and Hawker acquired Armstrong Siddeley, A.V. Roe and

Gloster to form the Hawker Siddeley Group in 1935 (Hayward, 1989, pp. 12-21). For Edgerton (1991, pp. 18-36), the Air Ministry's cardinal error was to place so much emphasis on military aircraft at a time when there was no money and no demand for war machines. There was no long term national direction for the aviation industry and no viable internal market. However he argued that the industry had made many efforts to improve technological capability. For example, by the mid-1920s, aircraft tended to be made of steel rather than wood, the shape of the wings was changed and the capacity of engine was increased considerably. In addition, an English monoplane won the world speed record with a speed of more than 400 mph in 1931. In fact, in 1935/36, the industry itself spent £2.7 million, while the Air Ministry spent £1.25 million on R&D.

The government made several efforts to support the aviation industry, but its aviation technology strategy was still to provide financial support to selected companies. In addition, the government seemed to neglect the preparation of a future aviation development strategy, because the rationalisation of the industry had been conducted by the aviation companies themselves in this stage.

The fourth stage was second growth from 1939-1954, during World War II and the Korean War. This stage was characterised by the growth of the industry again, government intervention, the preparation for civil aircraft development, the increase of government R&D investment and a decrease of market share due to neglect of the rapid growth of the US aviation industry.

The UK aviation industry grew again through mass aircraft production to meet demand caused by war. A large number of aircraft were produced in this period. 26,263 aircraft were produced in 1943, against 2,827 aircraft in 1938. In addition, Ministry of Aircraft Production (MAP) purchases reached nearly £900 million in 1943/44. In 1940, the UK was the largest aircraft producer in the world, making 50 per cent more than Germany.

At the same time, the government produced an aviation policy in preparation for future civil aircraft development after the war. In 1942, it began to turn its attention to post-war reconstruction and asked Lord Brabazon to consider possible post-war requirement for civil aircraft development. His first report, submitted to the Cabinet in 1943, confirmed that the UK civil aviation industry would face a serious situation if there was not support for an adequate civil programme (Hayward, 1989, pp. 27-53). The nine civil aircraft projects recommended by the Brabazon Report are shown in Table 4.3, and the projects were launched before the end of the war.

Table 4.3 The Brabazon Types

Types	Name of Aircraft (characteristics)	Manufacturer
Type 1	Brabazon (long range piston engined airliner)	Bristol
Type 2A	Ambassador (short range piston airliner)	Airspeed
Type 2B	Viscount (short range turboprob airliner)	Vicker
Type 2B	Apollo (short range turboprob airliner)	Armstrong Whitworth
Type 3A	Avro 693 (medium range turboprob airliner)	Avro
Type 3B	Avro Tudor II (development of Avro 693)	Avro
Type 4	Comet (trans-Atlantic mail carrier)	De Havilland
Type 5A	Marathon (piston engined liner)	Miles
Type 5B	Dove (piston engined feeder liner)	De Havilland

Source: Hayward (1989), *The British Aircraft Industry*, p. 40.

R&D investment had also increased during the war. The government spent £114 million in 1950 and £196 million in 1955 on aviation technology R&D, while R&D spending by the industry was £24 million in 1950 and £77 million in 1955 (Edgerton, 1991, pp. 72-92). In addition, a wide range of both formal and informal contacts linked industry and its customers, including the RAF, the Air Ministry and the Ministry of Aircraft Production (MAP). However, Hayward (1989) argued that the UK aviation industry's working environment was inferior to that in the US, and the level of co-operation between companies was low.

While the government had much emphasised rearmament during World War II, the UK aviation industry's competitive position had gradually worsened due to the failure to prepare against the rapid growth of the US aviation industry. Furthermore, the Air Ministry ordered two hundred military aircraft from Lockheed Electra for the Royal Air Force (RAF), despite the fact that the UK aviation industry needed more support in its efforts to compete against the US aviation industry.

The launch of government-supported civil aircraft projects was seen to be a strong initiative for future civil aviation development in this stage, but the government did not provide a determined overall policy for the development of the industry. Moreover, while a close link seemed to be established between the government and the industry in producing aircraft during the war, policies to improve the low level of co-operation between the aviation companies were not implemented.

The fifth stage was second modulation from 1955-1986, during the period from the end of the Korean War to before the completion of privatisation. In this stage, rationalisation, international collaboration and nationalisation were undertaken in the UK aviation industry. This is because there was a decrease in demand for aircraft, a decrease in export markets due to severe competition from the US, an escalation of aviation development costs, industrial fragmentation and, in particular, a change in aviation industry policy.

The Conservatives, who were in power from 1951-1964, changed their aviation industry policy during that period. They had kept a private venture policy during the period 1954-1959.[12] However, most of the Brabazon projects had disappointing outcomes and some were quite disastrous commercially and technologically, due to the rising costs of development attendant on the increasing technological complexity of aircraft (Hayward, 1983, pp. 16-20).[13] Moreover, in 1959, the poor sales of the larger turbo-prob airliners and the costs of developing the new jets placed the industry in difficulty, due to losses and financial instability. Those failures influenced the Conservative government to change its view, so that it began to support the aviation industry with the reintroduction of launch aid for civil aircraft (Hayward, 1983, pp. 38-41).

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[12] The Conservatives had maintained a private venture policy, during the period 1954-1959, according to which private industry should, in all but the most exceptional circumstances, finance its own civil, commercially oriented development. The government believed that a private venture policy would also lead to less overt interference and involvement on its part in the selection and development of individual projects (Hayward, 1983, pp. 18-19). The Conservatives changed their policy in order to support the industry with launch aid after their general election victory in 1959 (Hayward, 1989, p. 74).

[13] However, three projects of the Brabazon types were outstanding, namely, the Viscount (the world's first turbo-prob airliner), the Comet (the world's first prob jet airliners) and the Dove (Hayward, 1983, pp. 16-20).

By 1959, the Conservative government, although it was an advocate of the free market system, had determined to play an active role in expediting the reorganisation of the industry, in contrast to its previous policy. The government's main lever for rationalisation was the OR339 project, aimed at producing an advanced navigation and attack aircraft, which was proceeded with on the basis of consortia in order that it might lead to the merger of the participating companies. The merger had been discussed with industrialists at this time. Merger and acquisition negotiations led to the creation of three main airframe and two engine groups during the period 1959-1960 (Hayward, 1989, pp. 71-76). [14]

However, as Hayward (1989) argues, rationalisation seemed to be only a partial solution to the problems facing the UK industry. In fact, the merged companies, although stronger than the fragmented industry of the 1940s and 1950s, still faced difficulties caused by various factors. Gummett (1992, p. 203) points out that considerable instability in government policy at the level of individual projects, resulting in a stream of cancellations, became a barrier to the development of the aviation industry. Hayward (1989, pp. 80-83) also mentions such impeding factors as the following:

(i) The rationalisation was concluded without an overall concept of an optimal shape of an industry capable of taking on the American or staying in front of its European competitors. In addition, the government did not suggest a clear vision for the future development of the UK aviation industry after rationalisation.

(ii) The rise of development costs and the obvious limitation of the UK domestic market continued to undermine the industry's financial position.

(iii) The UK aviation industry did not actively look for overseas partners in order to cope with the rising costs and risks of development.

In 1964, UK aviation technology policy was changed by the Labour party which came to power in that year. It carefully scrutinised aviation projects including Concorde and the TSR2 (the centrepiece of the military aircraft programme), taking a critical view of the former government's strategy towards the development of the aviation industry. The government was overtly interventionist, encouraging the

[14] Eight of the airframe companies merged into two, the Hawker Siddeley Group and the British Aircraft Corporation. Three of the helicopter companies merged into one company, Westland Aircraft, and Bristol Aero-Engines and Amstrong Siddeley Motors merged into one company, Bristol Siddeley. However, 10 companies were unaffected by the mergers (Hayward, 1989, pp. 71-76).

formation of large groups in key manufacturing sectors in order to increase their competitive position. In 1964, a Committee of Inquiry was established under the chairmanship of Lord Plowden to consider the future place and organisation of the aircraft industry, with the support of Roy Jenkin, the Minister of Aviation. The Committee published the Plowden Report in December 1965. This provided a diagnosis of past failings and suggested possible remedies, including nationalisation, economies of scale and international collaboration (Hayward, 1989, pp. 96-100).

The government accepted the recommendations of the Plowden Report in principle, and further sought to rationalise the industry and to negotiate some form of public participation in the airframe sector. It not only urged outright nationalisation but also international collaboration with European countries. In 1966, the Ministry of Technology (Mintech) was expanded to include the Ministry of Aviation, and thus to co-ordinate aviation industry policy, and the Industrial Reorganisation Corporation was formed to support merger processes. On the other hand, the bankruptcy of Rolls-Royce in 1971[15] and the failure of the commercialisation of Concorde in 1973 gave rise to a deeper concern about civil aeroplane production and the relation between the nation and a high cost and high risk industry. Accordingly, Rolls-Royce was nationalised in 1971 and British Aerospace, a nationalised airframe company, was established with the merger of Hawker Siddeley and British Aircraft in 1979 (Hayward, 1983, pp.73-77). As Hayward (1983, pp. 130-131) described, nationalised companies were given substantial managerial autonomy and independent commercial judgement, but decision making under nationalisation would be slow and cumbersome, due to political and official interference.

At the same time, the UK aviation industry began international collaboration with European countries, assisted by the government's strong support. The first major international collaboration was concluded with France to produce Concorde, a supersonic transport, in 1962. This was in line with Britain's application to join the

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[15] The bankruptcy of Rolls Royce resulted from potent competition from American aero-engine firms, Pratt and Whitney and General Electric, and from the inappropriate contract for the RB211 engine with Lockheed. The contract amount was too low. In addition Rolls Royce failed to manufacture the engine within the contract term due to the unexpected escalation of development costs and technological problems. Finally the Cabinet decided to allow Rolls to go into receivership in 1971 (Hayward, 1989, p. 139).

EEC. Subsequently, the UK government concluded collaboration agreements for the Jaguar, an advanced attack/trainer, with France in 1965, and for the Tornado, a multi-role combat aircraft, with Germany and Italy in 1968. In 1979, BAe became a full member of Airbus Industrie (Hayward, 1989, pp. 101-106).

This was an important stage in the development of the UK aviation industry. The rationalisation of the industry and international collaboration undertaken with strong government support might make the UK aviation industry enter into a competitive position world wide. The forming of a single airframe company, BAe, seemed to create a basis to enable the UK aviation industry to become competitive. In addition, in the UK aviation industry secure stable demand for aircraft production and share development costs through international collaboration with the European aviation industry.

Finally, the current stage represents from 1987 till today and is characterised by the completion of the privatisation of the aviation industry. The privatisation of BAe was begun in 1981 and completed in 1985, and Rolls-Royce was finally privatised in 1987. A primary cause of the privatisation seemed to be Rolls-Royce's large scale losses of £93 million and £115 million in 1982 and 1984 respectively. The Thatcher government's solution was to return Rolls Royce to the private sector. The government believed that a private company would be more competitive than a publicly owned one, and that government financial support and intervention should be reduced. The government's view of its new relations with industry was that it should become more like a public bank than an industrial planner (Hayward, 1989, pp. 158-161).

Recently BAe Systems has been established with the merger of BAe and Marconi Electronic Systems (MES) in November 1999 (*Defence News*, December 20, 1999). Through this establishment, the UK aviation industry seems to have become more strong in competing with the other European aviation companies. The current situation of the UK aviation industry will be discussed in next sub-section.

The UK aviation industry thus appears to have enjoyed effective government support. However, there had been problematic issues in UK aviation technology policies in the past, which Edgerton (1991) argued to be as follows:

(i) The flexibility of labour (hire and fire) was lower than in the US, because the UK emphasised greater stability of labour.
(ii) The shortage of scientists and engineers was a fundamental issue of developing the aviation industry, although appropriate personnel seemed to be of greater importance than its costs, marketability and profitability.
(iii) France and the US seemed to have made better use of their defence/aerospace R&D to stimulate wider industrial use of new technology than the UK.
(iv) The UK's policy for the aviation industry was less consistent than that of France, since changes of minister cause mood changes, but projects do not change.

Hayward (1983), pointed out that remedies for past problems emerged as follows:

(i) The government had to look at not only the economic side but also other aspects of the national interest, such as employment and technological development.
(ii) In some respects, to have a military capability did not require an elaborate and expensive civil sector, but an ambitious civil programme would be difficult without some military activity.
(iii) International collaboration, diplomacy and political support were inevitable.
(iv) The existence of technological, international, environmental and institutional constraints were not entirely absent in choosing projects.
(v) Government would find it difficult to deny help and further assistance. Projects can acquire a life of their own and were out of control once they had been conducted. Therefore, government officials require a massive improvement in their capability and professionalism. In addition, an open and more accountable approach to policy-making might also help to resolve the dilemma of control and autonomy.
(vi) The balance between intervention and autonomy should be regarded as an important factor in the relation of the government and the industry.
(vii) Government must be vigilant against the over-optimism of technological enthusiasts and be aware of the dangers of over-commitment and unnecessary risk taken by its agent.

The above discussions may imply that the working capabilities of government officials and political culture are fundamental factors to be considered in establishing and implementing national aviation development policy.

The foundation of the UK aviation industry seemed to have been timely, being in line with the generation of the world aviation industry in the early twentieth century. Moreover, the UK industry developed considerably through the two world wars with its technological capability and strong government involvement. As the UK aviation industry has developed, it seems to have generally kept a good co-operative relationship with the government. The government has also assisted the industry in its effort to be competitive, with launch aid, R&D projects and the creation of aircraft demand. In particular, it has deliberately established aviation technology programmes, leaving itself open to new ideas by establishing specific committees and listening to the experts appointed to them.

However, several problematic aspects can be pointed out from the past policy. The government, during World War I when aviation production capacity had largely enlarged, seemed not to suggest a proper policy preparing against the over-capacity occurred after World War I. It also appeared not to co-ordinate the industry properly when mergers were concluded in the 1920s-1930s. In addition, during World War II, it is said to neglect to prepare for the decrease in its market share against the rapid growth of the US aviation industry's market share.

On the basis of the examination of the development trajectory, the strengths and weaknesses of UK aviation development policy in each development stage can be summarised as shown in Table 4.4. Lessons from the strengths and the weakness will be mentioned in the conclusion.

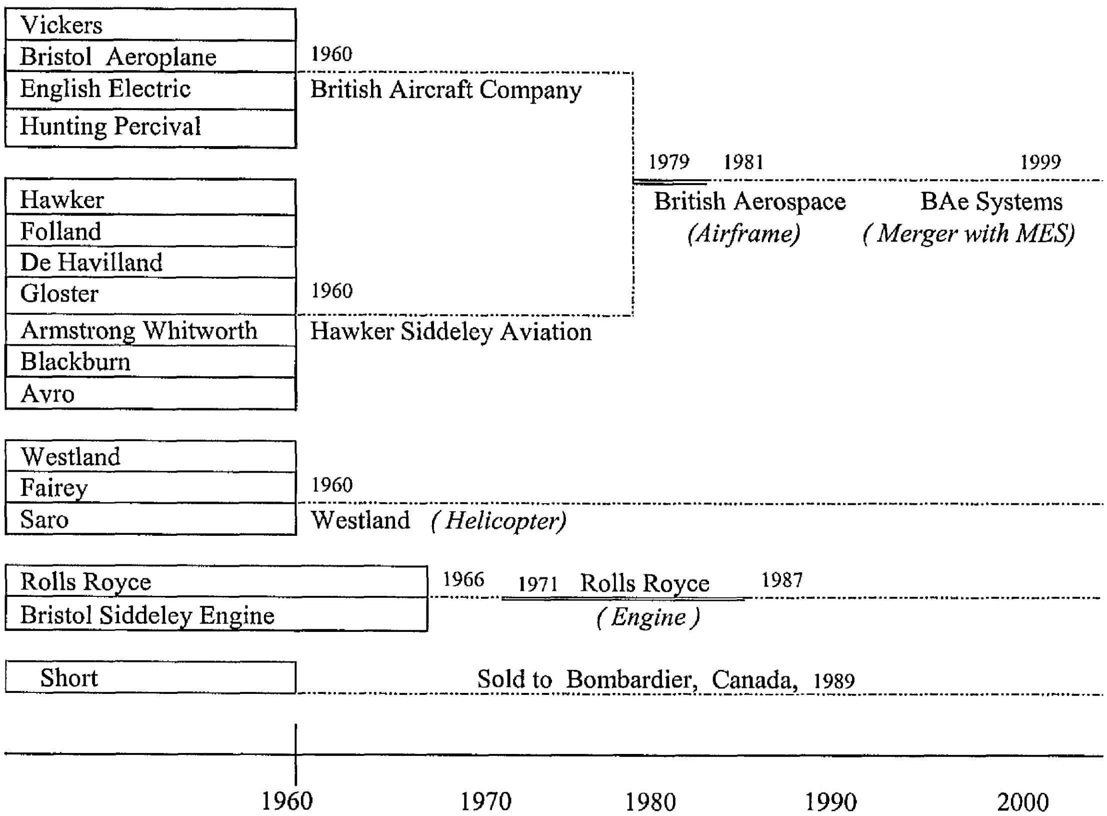
Table 4.4 Strengths and Weaknesses of UK Aviation Technology Policy

Stages	Strengths	Weaknesses
Generation (- 1913)	1.Timely entering the aviation industry. 2.Continuous R&D activity by scientists. - The establishment of the Aeronautical Society in 1866 - The recognition of the necessity of aviation development in 1908	1.Government's lower support. - The UK industry remained behind France and Germany in this stage
1st Growth (1914 – 1918)	1.Higher level of co-operation between the government and the industry for the mass production of aircraft	1.Neglect of post-war policy. 2.Neglect of support for civil aircraft production
1st Modulation (1919 – 1938)	1.Beginning of the support of civil aircraft development. 2.Continuous R&D activity in academia. 3.Hawker, Armstrong Siddeley, A.V.Roe, Gloster were merged into the Hawker Siddeley Group	1.Selected support of civil projects (non-commercial criteria for selected projects). 2.Little R&D activity in the industry which was dependent on government funding support 3.Neglect of providing merger policy.
2nd Growth (1939 – 1954)	1.Beginning of support for civil aircraft projects. 2.Open approach in establishing policy. (The establishment of the Brabazon Committee in 1942) 3.A high level of co-operation between the government and the industry. - Increase of R&D investment - Support of industrial rationalisation	1.Neglect of competitive policy against the rapidly growing US aviation industry, focusing on rearmament. (Decrease of market share) 2.The purchase of 200 US military aircraft.
2nd Modulation (1955 – 1984)	1.Government's strong invention - Large number of mergers in 1959-60. - Active support of international collaboration projects - Nationalisation of bankrupt RR in 1971 2.The strengthening of co-ordination by establishing the Mintech in 1966.	1.Instability of policy - The change of the private venture policy to interventionism in 1959. 2.Lack of a concrete policy for mergers conducted in the stage.
Current (1987 – Present)	1.Continuous support of privatised companies, BAe and RR. 2.Government's co-ordination of large scale merger of BAe Systems	1.Lack of international collaboration with latecomer countries having potentiality.

4.1.2 The Current UK Aviation Industry

In the pursuit of competitiveness in the world market, the UK aviation industry has gone through a long process of the consolidation of its companies. Currently it has only one airframe company (BAe Sytems), one aero-engine company (Rolls-Royce) and one helicopter company (GKN Westland Helicopter) through mergers and acquisitions, as shown in Figure 4.1. This sub-section will present the current situation of the UK aviation industry and the three major UK aviation companies.

Figure 4.1 Restructuring of the UK Aviation Industry



Source: Based on Gummett (1992), Civil and Military Aircraft in the UK, in *History and Technology*, Volume 9, p. 207.
Note: Not all producers are included. Double line: Nationalised, Dotted line: Privatised.

According to in the world's top 100 aerospace companies by 1997 sales, the British share was second only to the US. It accounted for 12 per cent of world total sales, with $31, 850 million, while the US's share was 61%, France 12% and Germany 4%.

The UK aviation industry had the third largest aerospace company in British Aerospace, the third largest aero-engine company in Rolls Royce and the fifth largest defence company in GEC. 12 UK aerospace companies were included in those companies (*Flight International* 2-8 September 1998, pp.50-61), as shown in Table 4.5.

Table 4.5 UK Aerospace Companies in the World Top 100 Aerospace Companies by 1997 Sales

WR	Company	1997 Sales ($ mil)		Employee
3	British Aerospace		13,995	43,000
		Commercial	4,037	
		Defence	10,410	
11	GEC	Marconi Electronics System	6,048	45,000
14	Rolls Royce	Aerospace	5,029	26,900
32	GKN	Westland	1,480	32,678
40	Hunting		1,076	12,579
		Aviation	353	
		Defence	723	
41	Lucas Varity	Aerospace	1,064	-
53	TI Group	Aerospace	779	25,500
59	Smiths Industries	Aerospace	675	13,300
62	Racal		591	-
		Defence Radar & Avionics	371	
		Radio communication	220	
67	Cobham	Manufacturing & Avionics	529	4,260
81	EIS Group	Aircraft & Precision eng.	394	8,058
99	Meggit	Aerospace	190	3,767
Total	12 companies		31,850	

Source: *Flight International* 2-8 September 1998, pp.50-61.
Remarks: WR stands for World Ranking.

The British aviation industry is currently very competitive globally. In 1998, it had a total turnover of £17.3 billion, of which 67% was exported, making a large contribution to the UK economy, and its employees numbered about 155,000 people. In addition, it had the top competitive companies in each of the large, medium sized and small company categories in the world aviation industry, according to the Aviation Week Competitiveness Survey in 1999. BAe was the leading company in the large aerospace company category, Smiths Industries plc the leader in the mid-size category and Umeco plc the leader in the small category (*AW & ST*, May 31, 1999, pp. 44-49).

The situation of the three major aviation companies, BAe Systems, Rolls Royce and GKN Westland, are examined briefly. The establishment of BAe Systems as a result of a merger worth about £7.7 billion may make the UK aviation industry more competitive in the world market. In fact, with more than 100,000 employees in nine countries and an annual turnover of £12.3 billion, it became the second largest defence contractor, behind Lockheed Martin. BAe Systems activities cover the six business areas of military aircraft (Tornado, Typhoon), defence systems, commercial aircraft, land systems, naval systems and avionics (*Defense News*, December 20, 1999). It has several joint venture partners, including Matra BAe Dynamics, Alenia Marconi Systems, SAAB and Matra Marconi Space (http//baesystems.com/ dynamic/d779546.htm, November 30, 1999).

Rolls Royce seems to have been healthy in its business recently. In September 1999, it bought National Airmotive, a California-based US company (a subsidiary of First Aviation Service), enabling it to become stronger in the maintenance, repair and overhaul (MRO) sector. In addition, it also purchased Vickers, the UK marine systems engineering group for £576 million. After the acquisition of the two companies, 46% of Rolls-Royce's total sales were in civil aerospace, 21 % in defence aerospace, 15% in marine power system, 12 % in energy and 6% in Vicker defence systems (*AW & ST*, September 27, 1999, pp. 27-28). In addition, GKN Westland Helicopter appears to be competitive, expecting to see its turnover rise by about 80 per cent in 1999 to nearly £1 billion through the production of the EH-101 (multi-lift helicopter) and the AH-56 (Apache helicopter). It has joint venture partners, including Boeing and Italy's Agusta (*Flight International* 24-30 March 1999, p. 4).

4.2 UK Aviation Development Policy

As previously mentioned, the UK aviation industry seems to have a strong competitive position globally. This superiority may have been achieved with feasible aviation development policies established by the government. What policies have resulted in this performance? This section aims to examine co-operation, co-ordination and motivation systems adopted in the implementation of UK aviation development policy, in order to learn lessons from those systems. It is divided into the three sub-sections of co-operation, co-ordination and motivation systems.

4.2.1 The Co-operation System

This sub-section examines the co-operation systems adopted for the development of the UK aviation industry. The co-operation system is presented into three categories: (1) co-operation organisations in the government and their programmes, (2) co-operation organisations in the industry and their programmes, and (3) international collaboration programmes.

The Department for Trade and Industry (DTI) is responsible for improving the co-operation activities. Branch 2 of its the Engineering Industries Directorate (EID 2) is responsible for co-operation affairs, and, in particular, a range of technology partnerships in the aviation industry. It currently carries out several co-operation programmes and supports the SBAC's co-operation programmes.

The DTI has supported the Foresight Defence, Aerospace and System Panel (DASP). The DASP was launched following the government's Foresight Initiatives in 1998. The panel is the UK's primary forum for aerospace research and technology demonstration, and it formed eight Technology Working Parties (TWPs), including these relating to human factors and aerospace manufacturing, which are composed of industrialists, academics and government. Its work has focused on prioritising technologies (http://www.dti.gov.uk/eid, January 10, 2000).

The DTI has also conducted the two co-operation programmes of the Civil Aircraft Research and Demonstration Programme (CARAD) initiated in 1990 and the Defence and Aerospace Research Partnerships (DARPs) initiated in 1998. The CARAD programme plays a central role in civil aviation research and technology demonstration in the UK. One of its purposes is to encourage co-operation activities, which include the following:

- To encourage industry to work on collaborative projects with higher education institutes.
- To promote the participation of small and medium sized enterprises in collaborative ventures.
- To help the UK industry to improve competitiveness.
- To encourage industry to maintain a long term perspective with investment in innovative work which has no immediate prospect of commercial return.
- To help to maximise the spin-off to civil aircraft from military research and demonstration support, and
- to encourage UK participation in European and international collaboration (http://www.dti.gov.uk/support/carad.htm, March 26, 1999).

The DARPs aim to promote the further success of the UK defence and aerospace industries through close links with universities, and to set up university based, industry-led centres focused on specific research themes (http://www.dti.gov .uk/eid, January 10, 2000).

Regarding co-operation system adopted in the aviation industry, the industry has operated the major three co-operation organisations of the Society of British Aerospace Companies (SBAC), the National Aerospace Forum (NAeF) and the Defence Manufacturers Association (DMA).

The SBAC was established as the national trade association of the UK aerospace industry in 1916, and it has over 400 member companies currently. It has conducted various domestic and international co-operation programmes. It seems to have made many efforts in formulating a high level of co-operation within the industry and between the government and the industry. It invited politicians and visited the party conferences in order to inform politicians of the major contribution of the UK aerospace industry to the community. For example, it held the meeting entitled Aerospace in Your Constituency in the House of Commons on January 13, 1999, for the purpose of establishing more co-operative relations between Parliament and the aviation industry. The event was successfully held, with 40 MPs and over 40 member companies in attendance, and it will continue to be held every six months in the House of Commons. In addition, the SBAC has published the UK Aerospace

Industry Statistics and various reports on the aerospace industry, and offered information through Internet site (http://www.sbac.co.uk/mar99a.htm). In addition, the SBAC has actively involved in international collaboration. Its delegation visited Aviation Industries of China (AVIC) and the Chinese aerospace industry in January 1998, in order to facilitate joint venture partnerships (http://www.sbac.co.uk, January 17, 1999).

The National Aerospace Forum (NAeF), established in 1998, is the first formal grouping of the UK aerospace industry's representative bodies, consisting of the SBAC and other consortia and forums related to the aerospace industry. The NAeF aims to promote and develop strategies relevant to the UK aerospace industry and is a main channel of dialogue between the SBAC and the regional consortia (http://www.sbac.co.uk, January 17, 1999). In addition, the Defence Manufacturers Association (DMA) aims to provide useful information to the UK defence companies. With support from the DTI, it has launched an Export Opportunities for Defence and Security (EODS) project in order to provide information on export opportunities in the defence and security sectors (http://www.dti.gov.uk/support, January 17, 1999).

The industry's co-operation programmes are divided into those conducted by the SBAC, the General Aviation Manufacturers and Trade Association (GAMTA) and BAe Systems.

The SBAC's co-operation programmes include the Supply Chain Relationships in Aerospace (SCRIA), the Foresight Action for Avionics and the Foresight Action for Helicopter. The SCRIA is one part of the Competitive Challenge programme sponsored by the DTI. Its function is to provide a framework for constructive co-operation between all companies involved in the aerospace supply chain, and it offers support services to the participating companies, with training, seminars and networks. The Foresight Action for Avionics programme has provided a focus for UK collaborative demonstration of cockpit technology and avionics systems, and the Foresight Action for Helicopter programme has aimed to develop collaborative helicopter technology demonstrator projects (Cunningham and Boden, 1995).

The GAMTA has conducted the General Aviation Best Practice Programme, in order to enhance the competitiveness of the UK general aviation sector, in partnership with the DTI. The programme supports the general aviation industry with advice and information concerning the industry (http://www.dti.gov.uk/support/ gabpp.htm, January 17, 1999).

BAe Systems has operated the Knowledge Based Engineering (KBE) team. The KBE aims to achieve successful partnerships within internal teams and with external partners including academia and companies (http://www.dti.gov.uk/eid, and the 98/99 SBAC Annual Report, January 10, 2000). It has major roles, such as (1) the establishment of successful partnerships between employees and between BAe engineers, academia and other companies, (2) the training of engineers in order to maximise their capability, and (3) the delivery of new technologies into engineers' everyday engineering activity in order to encourage their innovative activities (http://www.bae.co.uk/sttic/ engistor.htm/ April 5, 1999).

Finally, regarding international collaboration, the UK government and the aviation industry have also conducted international collaboration in order to secure a stable market and to share the development costs of aircraft. The government has supported the establishment of an international collaboration base. In fact, most of the large scale international joint projects conducted by the UK aviation industry were initiated with the UK government's support. Theses include Airbus Industrie (commercial transport joint production project), Eurofighter (military aircraft joint production project), Eurofar (helicopter joint production project), International Aero Engines AG (IAE), the Tornado, the Jaguar and the Gripen (military aircraft projects with European partners).

The UK aviation companies have also conducted international joint R&D activities. BAe Systems has participated in US projects such as the Stealth Reconnaissance Vehicle and Joint Striker Fighter (JSF) programme, and participated in European projects such as the Future Large Aircraft (FLA) project. GKN Westland Helicopter has conducted joint projects with Italy's Agusta. Rolls Royce has also co-operated with Italy's engine company, Turbomeca and the US's Pratt & Whitney, German Motoren Und Turbinen Union and the Japanese Engine Corporation (JAEC). In addition, the UK industry has also participated in the European Association of Aerospace Industries (AECMA) which is a European aerospace trade association aiming to promote competitiveness, collaboration and synergy in the European aviation industry.

Currently the UK government and the aviation industry seem to have maintained a higher level of co-operation through the many co-operation organisations and programmes as mentioned above. In particular, the SBAC seems to have actively conducted a bridging role between the government, the aviation industry and the universities. Moreover the UK aviation industry has actively participated in international joint projects. Latecomer countries may need to consider establishing exclusive divisions in their governments like the UK, in order to achieve a high level of co-operation between the government and the industry or between their aviation companies. In addition, they also may need to review the need for concrete programmes like the UK, for the purpose of improving co-operation activity. The UK, even though it is a developed country, has emphasised and implemented co-operation activity through co-operation organisations and programmes. This may imply that latecomer countries also need to behave similarly.

4.2.2 The Co-ordination System

The co-ordination system, which is conducted for the development of UK aviation industry, seems to have been mainly operated by the government. There seem to be no co-ordination organisations and programmes undertaken by the industry.

The DTI is responsible for co-ordinating different opinions related to aviation development policy. Co-ordination programmes have mainly been supported by two branches of the DTI. EID 3 is responsible for overall aerospace industry policy including aerospace strategy and trade policy, restructuring of the aerospace and defence industries, DTI/MoD relations, the DTI's interest in defence procurement issues and the sponsorship (including launch investment) of fixed wing, helicopter and aero-engine and aerostructure sectors. In addition, EID 1 is responsible for providing project assessments, market and technical advice and aerospace statistics for civil and military programmes. The DTI has also conducted the Study of the Value of the Defence Industry to the UK Economy (VODE) with the participation of the MoD, in order to carry out a study on the value of the defence industry to the UK economy (http://www.dti.gov.uk/eid., January 10, 2000).

In addition, the DTI has supported the National Research Advisory Committees. The NACs act as the national forum for developing defence and aerospace technology, with full representation from industry, government and academics. The Committees were established in 1997, and aim to minimise the overlap between research programmes conducted by the aviation industry by promoting collaboration. Accordingly they also aim to develop communication of information, to develop priorities for research and technology development and to maintain an overview of UK competitiveness in the relevant technology. Four NACs have been established such as aerodynamics, material and structures, flight systems and avionics, and human factors. The establishment of three further NACs is planned in early 2000, in relation to (1) aerospace manufacturing, (2) simulation, modelling and synthetic environments and (3) system engineering (http://www.dti.gov.uk/eid., January 10, 2000).

A high level of co-ordination activity seems to have been conducted in the UK, in order to enhance productivity and to remove duplication in the aviation industry. However, those actual co-ordination programmes have been conducted only by the DTI. The UK have established many co-ordination organisations and programmes. The DTI seems to have actively conducted co-ordination activities through the establishing a co-ordination organisation, the NACs, and a co-ordination programme, the VODE. This may imply that latecomer countries need to involve actively in co-ordination activities for their aviation industry development like the UK case.

4.2.3 The Motivation System

This sub-section will examine the motivation system adopted in the UK government and the aviation industry. The UK government has strongly supported the aviation industry with the provision of launch aids and grants. The DTI is responsible for motivating the industry. In fact, EID 1 is responsible for sponsorships, including launch investment, of fixed wing aircraft including Airbus, helicopter, aero-engine and aero-structure sectors. EID 2 is responsible for the sponsorship of the aerospace and defence equipment sector. And, of course (see previous page) this involves co-operation and co-ordination.

The DTI has afforded launch aid, which is available only to the aerospace sector and stems from the provisions of the Civil Aviation Act, 1982 (http//www.dti.gov.uk/eid, January 10, 2000). It aims to remedy the market deficiency in the availability of development funds for aerospace companies to undertake large development projects.[16] During the period 1948–68, the UK airframe companies received launch aid of £741.2 million (input price) for 22 projects, including the Comet, Viscount, Jetstream, Concorde and other projects. The engine companies also received £764.2 million for 14 projects, including the Spey, Trent, Olympus and other engine projects.[17] In addition, it has provided the aviation industry with grants, such as £2.45 million for the SBAC's Competitive Challenge in January 2000.

The UK aviation industry has also conducted motivation programmes. The SBAC has undertaken the Competitive Challenge, the UK Lean Aerospace Initiative, the

[16] Launch aid has been afforded to the projects which have high costs and pose a high level of risk and generate a return in the long-term. Each launch investment application is considered on its merits against a range of established criteria including public expenditure constraints, and the wider benefits of the project to the economy beyond the company itself, such as the spin-off of new technologies and the wider application of new production methods. The provision of launch investment is entirely discretionary. There is no formal scheme or budget for launch investment. In addition, the government provides the minimum support required for projects that are is technically and commercially viable. On the other hand, most Western countries including France, Germany, the Netherlands and Italy have some form of launch investment, although the US supports the aviation industry by indirect measures, such as the very large R&D programmes run by NASA and the DoD (http://www.dti.uk. gov/eid., January 10, 2000).

[17] See more detail Gummett (1992), Civil and Military Aircraft in the UK, in *History and Technology*, 1992, Vol, 9, p. 211, Table 2.

Business Winning, People Management and the Leadership for Competitive Advantage programmes. (http//www.dti. gov.uk/eid, January 10, 2000).

The Competitive Challenge, established in 1994, has been carried out under the DTI-supported Sector Challenge programme, with about £500,000 of government funding per year over three years. It aims to improve competitiveness by improving the supply chain relationship and people and knowledge management, and supports competitiveness improvement measures such as the UK LAI and the Business Winning programmes. The UK LAI was established in 1998. A UK LAI multi-disciplinary Steering Group was formed by representatives of industry, university, the DTI, the MoD and the EPSRC. The UK LAI provides a mechanism through which international collaboration, particularly with the US, can take place in order to enhance the capability of the UK aerospace industry (http://www.sbac.co.uk, February 1999). In addition, the Business Winning was also established in 1998, as an element of the Competitive Challenge, in order to provide information relevant to the development and marketing of the aerospace industry through the internet, such as through the JSF database (http://www.dti.gov.uk/eid, January 10, 2000).

In addition, the People Management initiative aims to assist the aviation industry in enhancing its management capability. It has held seminars and undertaken the People Management Survey on management capability, reward strategies, training and personnel management. The aims of the survey report are to map the diffusion of high performance work practices and assess the business performance impact of people management. The Leadership for Competitive Advantage programme aims to increase the advantages of organisations through effective leadership. It has also held workshops for effective leadership (The 98/99 SBAC Annual Review).

At the same time, BAe Systems has also conducted the three co-ordination programmes of Engineering Excellence programme, Systems and Service (SS) programme, and Aviation & Construction Consultancy (A&CC).

Engineering Excellence aims to support engineering within the company in order to maintain industrial excellence, by making best use of the company's engineering skills and experience and the teamwork with partners and suppliers (http://www.bae.co.uk/static/maaa.htm, April 5, 1999). SS aims to support customers in the area of airports, airbases, military installations and aerospace manufacture, from project inception to completion, by deploying specialists in master planning, project management and engineering experts. A&CC aims to develop a flexible and integrated design service in order to provide the complete solution to customer's infrastructure requirements, by increasing BAe's specialist resources, encouraging innovation and investing in technology and training (http://www.bae.co.uk/dynamic/d906815.htm, February 8, 1999).

The UK government seems to have recognised the importance of people management in order to improve the competitiveness the aviation industry. For example, the 18 Generic Infrastructural Priorities which were recommended by the 1993 Foresight Programme included various motivation factors, such as incentives, training, communication and the public understanding of science, as shown in Table 4.6.

Table 4.6 The Generic Infrastructural Priorities

Area	Generic Infrastructural Priorities
The Skill Base (4)	Better training of teachers in the area of science, engineering and technology, Communication skills, Information technology competence, Public understanding of science, Business awareness
Research in the Science Base (3)	Support for truly excellent basic research, New incentives for multidisciplinary research, Incentives for universities and Research Councils
Communications (2)	Superhighway, Science-watch function
Finance (4)	Development and encouragement of long-term finance for R&D and innovation, Special incentives for the SMEs, Enterprise architecture
Policy and Regulation (4)	Intellectual property right, Procurement by government, Regulations on the environment, finance and communications. A continuously updated scientific basis standards, Demonstrator projects (applications oriented)
Total (18)	

Source: Cunningham and Boden, (1995), International Network of Correspondents on: Industrial Innovation, Diffusion and Technology Transfer Policy Development, Annex, pp. iii-iv.

The UK aviation industry seems to have been strong on motivation both internally and from the government in order to enhance its competitiveness. The government has motivated the industry through grants and launch aids, and the industry has also conducted various motivation programmes. In addition, the UK government seems to have emphasised the importance of people management in achieving the UK aviation industry's competitiveness.

4.3 Conclusion

The UK government and the aviation industry seem to have made continuous efforts to improve aviation technology capability. Various lessons for the efficient implementation of Korean aviation technology policy can be learnt from the successful and failed policies in the development trajectory of the UK aviation industry and CCM systems adopted in developing the UK aviation industry.

Firstly, the lessons from the development trajectory of the UK aviation industry in relation to co-operation, co-ordination and motivation activities are as follows:

(i) Policy studies seem to be an important factor in establishing a feasible aviation development policy. The establishment of a specific aviation committee may be needed in order to gather expertise from various sources. The UK government decided on civil aircraft projects following the recommendations of the Brabazon Committee Report submitted in 1943.

(ii) Government should establish aviation development programmes taking into account the aviation companies. Aviation companies should also put forward requirements which they think should be reflected in national aviation policy. The UK aviation industry has continuously requested funding support from the government, such as launch aid for Airbus.

(iii) A strong co-ordination activity of government is an important factor for aviation industry development. The UK government has actively conducted co-ordination activity for the development of the UK aviation industry. In fact, a large number of mergers were undertaken in 1959-1960 under the UK government's strong co-ordination activity.

(iv) Government should create aviation policy and development projects in a timely fashion, predicting future market development. The UK government initiated civil aircraft projects during World War II in order to prepare for the decrease in aircraft demand in the post-war period.

(v) It should motivate the aviation industry by providing R&D projects and launch aids. The UK government has continuously provided the civil aviation industry with R&D projects, launch aids and an appropriate procurement policy. In addition, the industry should also motivate its employees to do their best for developing the aviation industry.

Secondly, various organisations and programmes previously mentioned in UK aviation development systems can be summarised, as shown in Table 4.7.

Table 4.7 UK Aviation Development Systems

Systems	**Organisation**	**Classification**	**Name of System**	**Managing Organisation**
Co-operation System	**Government**	**Organisation**	Engineering Industries Directorate (DTI)	DTI
			The Foresight Defence, Aerospace and System Panel (DASP)	"
		Programme	The Civil Aircraft Research and Demonstration (CARAD)	"
			The Defence and Aerospace Research Partnerships (DARPs)	"
	Industry	**Organisation**	The National Aerospace Forum (NAeF)	DTI
			The Defence Manufacturers Association (DMA)	"
			Society of British Aerospace Companies (SBAC)	SBAC
			General Aviation Manufacturers and Trade Association (GAMTA)	GAMTA
		Programme	The Supply Chain Relationships in Aerospace (SCRIA)	SBAC
			Foresight Action for Avionics	"
			Foresight Action for Helicopter	"
			The Knowledge Based Engineering (KBE)	BAe Systems
Co-ordination System	**Government**	**Organisation**	The National Research Advisory Committee (NACs)	DTI
		Programme	The study of the Value Of the Defence Industry to the UK Economy (VODE)	"
Motivation System	**Government**	**Programme**	Government grants	DTI
			Launch Investment	"
	Industry	**Programme**	Competitive Challenge	SBAC
			The UK Lean Aerospace Initiative (UK LAI)	"
			Business Winning	"
			People Management	"
			Leadership for Competitive Advantage	"
			General Aviation Best Practice	GAMTA
			Aviation & Construction Consultancy (A&CC)	BAe Systems
			System and Service (S&S)	"
			Engineering Excellence	"

Accordingly, lessons from the CCM systems adopted in the UK aviation industry will be summarised with the three categories of co-operation, co-ordination and motivation systems.

The lessons from the co-operation system conducted for UK aviation industry development are as follows:

(i) Co-operation programmes in which the government, research institute, university and the aviation industry participate together should be undertaken. In the UK aviation industry, various motivation programmes have been undertaken, namely, the CARAD, the DARPs, the SCRIA, and others.

(ii) Workshops, seminars and forums should be regularly held in order to exchange technological and managerial information. One of the aims of the DARP and the NAeF is to maintain information networks by using databases, the Internet and publications.

(iii) The conduct of joint research programmes studying common interests, such as foresight for future technology, should be strengthened, in order to share R&D costs and exchange technological information. The Foresight Action for Avionics and the Foresight Action for Helicopter programmes have been conducted by the SBAC for those purposes.

(iv) An information network should be operated by establishing a specific programme. The SCRIA programme supported by the SBAC has provided the aviation industry with useful information through information network.

(v) A bridge role connecting the government with industry should be enlarged. In fact, the SBAC has actively played an active bridging role, establishing co-operation relation the aviation industry and the parliament.

The lessons from the UK aviation co-ordination system are as follows:

(i) Organisations and programmes co-ordinating different opinions between civil and military aviation policies should be created, in order to improve the effectiveness of the aviation industry. The DTI has played co-ordination roles between the DTI and MoD through the VODE programme.

(ii) Duplication of R&D activities should be reduced. The DTI has operated the NACs in order to avoid duplicated R&D by providing R&D information.

(iii) A programme linking academic performances with the aviation industry needs to be conducted. The RAeS has promoted the input of academic R&D results to the UK aviation industry.

(iv) Competitiveness improvement programmes should be undertaken. The UK LAI, Business Winning and the General Aviation Best Practice programmes have been conducted for the purpose of improving the aviation industry's competitiveness.

The lessons from the UK aviation motivation system are as follows:

(i) Government funding support including launch aids and grants should be provided to the aviation industry in order to motivate aviation technology development. In fact, the UK, even though it is a developed country, has continuously supported the aviation industry with the provision of launch investment, aircraft procurement policies and aviation R&D projects.

(ii) The aviation industry should also conduct its motivation programmes. BAe Systems has carried out several motivation programmes, namely, Engineering Excellence programme and System and Service (SS) in order to create an innovative environment.

(iii) Personnel management and top manager's leadership need to be strengthened in order to improve productivity. The SBAC has undertaken People Management and Leadership for Competitive Advantage programmes, in order to support the improvement of the personnel management capability.

Chapter 5
United States Aviation Technology Policy

The US aviation industry has dominated the world market since World War II. This superiority seems to be achieved by having a large scale domestic market, huge R&D projects provided by the federal government and the active R&D activities of the US aviation industry. However, it has been said that the US government has not provided the aviation industry with direct funding supports such as launch aids. So what is the tool that has enabled the US aviation industry to maintain its aviation technology superiority, government support policy or the R&D efforts of the industry? This chapter aims to gain several lessons for the efficient implementation of Korean aviation technology policy through the examination of the US aviation technology policy. It consists of the three sections. The first relates to the US aviation industry, the second to US aviation development policy and the third is a conclusion.

5.1 The US Aviation industry

This section aims to examine the US aviation industry in order to assist an understanding of the context of US aviation technology policy. It will present the development trajectory, the current situation and the characteristics of the US aviation industry.

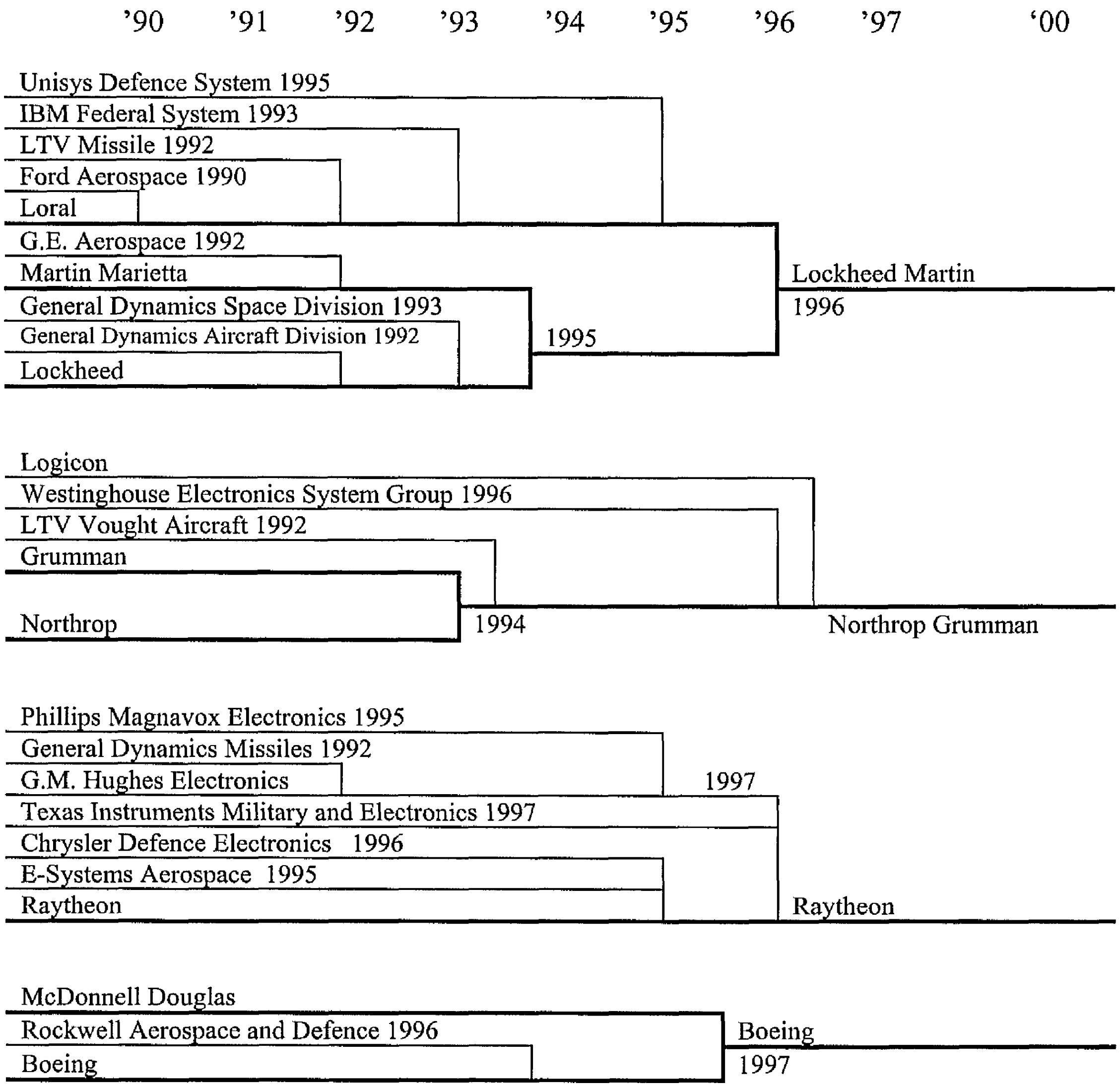
The US aviation industry did not have a strong position before World War II, although the first flight of a powered and human-controlled aircraft was made in the US by the Wright brothers in 1903. In fact, during World War I, the US aviation industry produced about 1,400 aircraft (mostly trainers) per year with approximately 17,500 employees, and was far from being one of the world's leading aviation countries. However, it had superiority globally throughout World War II and the Korean War. The US aviation industry produced over 280 thousand aircraft during World War II, and the Korean War gave another similar opportunity for mass production. A number of the aircraft used in the wars were converted to commercial use, and that stimulated the rapid development of civil passenger and the civil aviation manufacturing industries. The US aviation industry has had a real leading position world wide as a result of the beginning of the operation of the Boeing 707 jet transport in 1958. Moreover, its superior position was settled through the bringing into operation of the Boeing 747 jumbo-jet in 1970 (*Monthly Aerospace Industry*, 1997, pp. 130-131).

However, the decrease in the defence budget since the Cold War influenced the US aviation industry to deal with production overcapacity. In addition, the government pushed the industry strongly to conduct mergers to enhance industrial competitiveness from the early 1990s. Therefore, a number of large-scale mergers were concluded. As mentioned in chapter 3, Northrop took over Grumman in 1994, Lockheed and Martin Marietta were merged with Lockheed Martin in 1995, and McDonnell Douglas was merged with Boeing in August 1997. As a result, the US aerospace industry consists of the four major aviation companies of Boeing, Lockheed Martin, Northrop Grumman and Raytheon, as shown in Figure 5.1 on the next page.

Currently the US aviation industry has a dominant position internationally. In fact, in 1997, the US aviation companies accounted for 63 per cent ($156.9 billion) of total sales ($256.6 billion) of the world's top 100 aerospace companies.

In addition, US aviation companies stood at the top of each category. Boeing was top in the commercial aircraft (all civil fixed wing aircraft production) area. Lockheed Martin was top in the defence (military aircraft, defence electronics and missiles) and space (satellites, launchers and systems) areas, and General Electric was top in the civil and military engine areas. The US aviation industry had 25 companies among the world top 50 aerospace companies in terms of 1997 sales (*Flight International* 2-8 September 1998, pp. 48-61).

Figure 5.1 The Consolidation Process of the US Aviation Industry



Source: *Aviation Week & Space Technology*, March 16, 1998, p.25., http://www.nsf.gov. February 23, 1999.

Note: The above does not include all aircraft companies, and specifically excludes mergers undertaken before the 1990s.

The US aviation industry had gained such a superior position as a result of certain advantageous factors. For Seitz (1985, p. 26), the success of the US aviation industry was partly due to the following powerful factors.

(i) A productive relationship between the government, the major airlines and aircraft manufactures in the context of a free market economy.

(ii) The size, diversity and rapid growth of the US air transport industry that provided a major domestic market, and

(iii) An aggressive and effective programme of technology development combined with an advanced and productive aircraft manufacture capability.

In addition, Hayward (1989, p. 16) pointed out that the development of the US aviation industry was supported by an ideal geographical context with huge continental distances between population centres. Competition between US air transport companies put a premium on sound and efficient equipment and formed a sufficiently broad base to support a number of aircraft manufacturers. Moreover, the US government has encouraged the growth of civil aviation through its procurement of military aircraft.

It seems that the US aviation industry has several characteristics. Firstly, the scale of US aerospace companies is much larger than that of other countries' companies. In fact, Boeing[18] ($45.8 billion), just a company, was larger than all UK aviation companies ($31.8 billion), all French aviation companies ($31.0 billion) and all German aviation companies ($10.3 billion), in terms of 1997 sales. In addition, the sales of other major three companies, namely Lockheed ($27.9 billion), Raytheon ($10.6 billion) and Northrop Grumman ($9.1 billion) were also larger or at similar level with those of Germany. The sales of 25 US aerospace companies included in the world top 50 aerospace companies by 1997 sales are shown in Table 5.1 on the next page.

Secondly, the sales of commercial aircraft are much larger than those of military aircraft. According to the price of shipment in 1999 estimated by the Department of Commerce, civil aircraft sales were estimated to be over 60 per cent of total sales. Moreover, large transport civil aircraft accounted for 37 per cent of total sales, while military aircraft accounted for 15 per cent, as shown in Table 5.2.

Thirdly, sales of several major aviation companies, namely Boeing and Raytheon, increased between 1997-98. However, those of other major companies including

[18] Boeing was set up in 1915, and by 1929 it had grown from a small west coast aircraft manufacturing company to the huge United Aircraft and Transport Corp., which owned aircraft, propeller and engine makers including Pratt & Whitney as well as several airlines. In the early 1930s, Boeing focused on transport aircraft, which led to the development of the Boeing 247 airliner and B-29 Superfortress, the outstanding four-engine US bomber of World War II (*AW & ST*, December 20/27, 1999, p. S4)

Lockheed Martin and Northrop Grumman decreased in the same period. The sales of Raytheon and Boeing increased by 42 per cent and 22.6 per cent respectively, but those of Lockheed Martin and Northrop Grumman decreased by 6.4 percent and 2.7 percent respectively (*Flight International*, 17-23 February 1999, p. 23), as shown in Table 5.3.

Table 5.1 US Aerospace Companies in the World top 50 Aerospace Companies by 1997 Sales

WR	Company	Sales ($ mil)	Production areas	Personnel (persons)
1	Boeing	45,800	Commercial aircraft: 26,929 Information/Space/Defence: 18,125	-
2	Lockheed Martin	27,885	Space/Missile: 8,303 Aeronautics: 6,045 Information/Service: 6,468 Electronics: 7,069	173,000
4	Raytheon	10,640	Electronics (Hughes Aircraft): 8,194 Aircraft (Beech, Hawker): 2,446	119,200
5	United Technologies	10,264	Pratt & Whitney: 7,402 Sikorsky, Hamilton Standard: 2,862	180,000
7	Northrop Grumman	9,153	Aircraft: 4,405 Electronics: 4,101	52,000
9	General Electric	7,799	Aircraft	276,000
10	AlliedSignal	6,412	Aerospace	70,500
20	Textron	3,135	Cessna/Bell	64,000
21	TRW	3,100	Space, Defence	79,726
23	Litton Industries	2,617	Advanced electronics	31,500
24	Hughes Electronics	2,469	Satellite manufacturing	14,000
25	Goodrich	2,468	Aerospace	16,838
26	Honeywell	1,957	Space, Aviation control	57,500
27	Gulfstream	1,903		5,800
30	Rockwell International	1,689	Collins Avionics Communication	45,000
31	ITT Industries	1,668	Defence, Electronics	58,479
34	Loral	1,313	Loral Space & Communications	-
35	Tracor	1,266	Information and Space	10,740
42	Alliant Techsystem	1,058	Space, Defence systems	6,550
43	Sundstrand	1,001	Aerospace	10,400
44	Harries	998	Electronics systems	29,000
46	Allegheny Teledyne	927	Aerospace & Electronics	22,000
47	Sequa	905	Aerospace	11,000
49	Thiokol	890	Propulsion, Fastening systems	5,300
50	Howmet Corporation	864	Aerospace	10,352

Source: *Flight International* 2-8 September 1998, pp. 50-57.
Note: WR stands for World ranking.

Table 5.2 Estimated Shipments of US Aerospace Products in 1999

Classification of products	Price of Shipment		Number of Shipment	
	$ billion	%	Aircraft	%
Large transport civil aircraft	39.0	37	600	11
Military aircraft	15.4	15	560	10
Business aircraft	22.0	21	1,850	35
General aircraft	4.8	4	1,975	37
Rotor aircraft	0.2	0.1	350	7
Aircraft engine and parts	2.6	2	-	-
Guide missile and space vehicle	22.0	21	-	-
Total	106	100	5,335	100

Source: Based on *Aviation Week & Space Technology*, February 1, 1999, p. 69.

Table 5.3 Change of Sales in US major Aerospace Companies during 1997-98

($ Million)

Company	Aerospace '98 Sales	'98 Group Sales	'97 Group Sales	Change (%)	Others
Boeing	55,424	56,154	45,800	22.6	
Lockheed Martin	26,011	26,266	28,069	-6.4	
Raytheon	17,456	19,530	13,673	42.8	
United Technologies	10,767	25,715	24,222	6.2	Pratt &Whitney
General Electric	10,010	100,469	90,840	10.6	
Northrop Grumman	8,802	8,902	9,163	-2.7	
AlliedSignal	7,500	15,130	14,472	4.5	
TRW	4,685	11,887	10,831	9.7	
Textron	3,189	9,683	8,683	11.5	Bell, Cessna
Litton Industries	2,826	4,400	4,176	5.4	

Source: *Flight International* 17-23 February 1999, p. 23.

The US aviation industry has been competitive in the world aviation market. In addition, Boeing, Lockheed Martin and Raytheon are very huge companies globally. Small companies in latecomer countries seem to have great difficulty in competing with those companies. This competitive position may be achieved due to the US aviation development systems including strong government supports and the aviation industry's efficient production systems. The aviation development systems of the government and the industry will be examined in the next section.

5.2 US Aviation Development Policy

This section aims to identify some lessons from the US aviation development systems adopted by the government and the industry. It is divided into the three sub-sections of co-operation, co-ordination and motivation systems, and each sub-section will present the organisations and programmes related to each system.

5.2.1 The Co-operation System

This sub-section presents the co-operation system adopted by the US government and those adopted in the aviation industry. The US government has operated two co-operation organisations for aviation technology development, namely, the National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA).

NASA, established in 1958, has co-operated with the aviation industry in developing new aerospace technologies. It has four strategic enterprises: Human Exploration and Development of Space, Space Science, Earth Science, and Aero-Space Technology, and aims to help the US aerospace industry to have competitive technologies by conducting R&D projects in co-operation with the industry and universities. The Aero-Space Technology Enterprise [19] has the goal of achieving a revolutionary leap in civil aviation technology (http://www.nasa/gov.tto/spinoff1999, January 19, 2000). The FAA has supported co-operation activities by establishing two organisations, namely, the Aviation Research Section in the Division of Research and Acquisition and the Office of Information Services in Headquarters Staff Office (http://www.faa.gov/hqinfo, January 19, 2000).

In addition, government has conducted various co-operation programmes in order to improve co-operation between the government, universities, research institutes and

[19] It consists of five NASA centres: the Ames Research Centre, the Dryden Flight Research Centre, the Glenn Research Centre, the Langley Research Centre, and the Marshall Space Flight Centre (http://www.nasa/gov. tto/spinoff1999, January 19, 2000)

industry. NASA has undertaken the NASA Technology and Commercialisation (NTTC) Programme, the Small Business Technology Transfer (STTR), The NASA Institute for Advanced Concepts (NIAC) Programme, the NASA Tech Brief, the NASA Spinoff and the NASA Commercial Technology Network (RTTC).

The NTTC programme was designed to disseminate technologies developed by itself, according to the mandate of Congress in 1958. The STTR programme aims to transfer technologies developed by universities and federal laboratories to the market place through small business enterprises (http://www.stipo.lar.nasa.gov, January 19, 2000). The NASA Tech Briefs, a monthly engineering publication, has issued since 1962, and has a readership of over 450,000. Its mission is to share information on engineering innovations in order to bolster US competitiveness (http://www.leadnet.com/pubs/xdnb.html, January 19, 2000). The NIAC Programme was awarded to the Universities Space Research Association (USRA), in order to seek revolutionary advanced concepts in the aerospace area from the science and engineering community (http://www.niac.usra.edu, January 19, 2000). The NASA Spinoff is an annual publication to provide the user of aerospace technology with information on technologies developed in NASA (http://www.sti.nasa.gov/tto, January 19, 2000). The NASA Commercial Technology Network, along with each NASA field centre's commercial technology office, is extending the research of NASA technology into the everyday lives of the American public.[20]

The US aviation industry has also operated co-operation organisation and programmes. It has established a professional aerospace society, the American Institute of Aeronautics and Astronautics (AIAA) in 1963 as the principal society of aerospace engineers and scientists. Currently, AIAA has more than 31,000 professional members in its 65 sections and 5,500 student members in 145 student branches. It has undertaken various co-operation roles as follows:

- Acting as a catalyst for information flow by providing forums;

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[20] The RTTC is designed to assist US businesses in accessing and utilising NASA-funded research and technology, and it is a key player in the transfer of NASA technology, and provides a direct link to many resources, report, technologies and facilities at NASA and other federal laboratories. The network of RTTC is divided into several centres, including the Far West Regional Technology Transfer Centre (FWRTTC), the Great Lake Industrial Technology Transfer Centre (GLITTC), and others (http://www.sti.nasa/tto/spinoff, January 19, 2000).

- The conduct of a strong international collaboration activity with the holding of international forum and the initiation of joint activities; and
- The provision of a world-class technical information and publications (http://www.aiaa.com/information, January 19, 2000).

The AIAA has held Congress Days every year to establish co-operative relation with the Congress. In addition, it has issued various publications, including Aerospace America, the AIAA Student Journal and the AIAA Bulletin, in order to provide the public with information on aerospace technology (http://www.aiaa.com/policy, January 19, 2000).

The US aviation industry has jointly conducted aviation development projects domestically and internationally, in order to share costs and risks in developing new advanced aviation technologies. Boeing has conducted the Boeing Business Jet (BBJ) project with General Electric and the CV-22 Osprey (a tilt-rotor development project) with Bell Helicopter Textron. Boeing has developed the BA 609 with Italy's Agusta, and it has over 30,000 suppliers in 37 countries with purchases of $37 billion in 1998. In addition, Raytheon has jointly developing UK's Airborne Stand-Off Radar (ASTOR) programme with BAe Systems, the Multi-Role Tanker/Transport (MRTT) with Airbus Industrie, and the Hawker Horizon with Japanese Fuji Heavy Industries.

Co-operation activity seems to have been emphasised by NASA, the FAA, the AIAA and the US aviation industry, in order to develop aviation technology effectively. NASA has made efforts to transfer the technology it developed. The AIAA have actively conducted co-operation activity including the holding of Congress Days. Even though the US aviation industry has technological superiority, it seems to have highly emphasised the importance of co-operation activities including technology transfer for the development of the aviation industry.

5.2.2 The Co-ordination System

The US government and the aviation industry have operated co-ordination organisations and programmes for the efficient implementation of aviation development policy. This sub-section is divided into parts relating to co-ordination systems adopted in the government and to those adopted in the industry. The government has four co-ordination organisations, namely, the Aerospace Safety Advisory Panel (ASAP) in NASA, the Office of Aviation Policy and Plan, and the Regulation and Certification (AVR) Division in the FAA, and Air and Space Commercialisation Section in the Department of Commerce.

The ASAP's role is to review and evaluate current and future NASA programmes and activities and to report its findings to the NASA administrator. Priority is given to programmes that involve safety and human flight (ftp://ftp.hp.nasa.gov/pub/pao, February 4, 1999). The Office of Aviation Policy and Plans aims to co-ordinate aviation affairs between the government and industry, and the AVR Division also aims to co-ordinate the manufacturing direction that needs to be observed by the aviation industry (http://www.faa.gov/hqinfo.htm, January 19, 2000). In addition, the Air & Space Commercialisation Section in the Technology Administration Division of the Department of Commerce is responsible for the co-ordination of aviation-related issues in the government, research institutes, universities and the industry. However, overall co-ordination of aviation development policy is effected by the National Science and Technology Council (NSTC) and the Office of Science and Technology Policy (OSTP).[21]

At the same time, the government has conducted co-operation activities for aviation industry development. It is involved in several aspects related to the aerospace industry, such as the approval of and objection to mergers proposed by US aerospace companies, the conclusion of international agreements to remove unfair subsidy

[21] The NSTC consists of 26 members including the President (Chairman), the DOC, NSF, NASA and others. One of the most important tasks is to prepare co-ordinated R&D strategies and budget recommendations in order to achieve national goals in the science and technology area. The OSTP was created in 1976 to provide the President with timely policy advice and to co-ordinate S&T investment (http://www.whithehouse.gov/wh/eop/ostp/htm, January 19, 2000).

provision and the restriction of technology transfer in order to maintain aviation technological competitiveness.

Firstly, the government's involvement in the mergers will be examined with reference to mergers occurring in the US aviation industry and the cases of successful and failed mergers. The collapse of the former communist countries in 1989 and of the former Soviet Union in 1992 seems to have provided the context for mergers and acquisitions (M&As) concluded in the aviation industry. Most large aviation companies faced difficulties from the sharp reduction in military budgets, so they began to conduct mergers among themselves in order to overcome problematic situations and maintain their viability through competitiveness. These circumstances also led to mergers in the US aviation industry. Accordingly, eleven large mergers were concluded within it with the approval of the US government during the period 1993-1997, as indicated in Chapter 3. The largest merger in terms of merger price was concluded between Boeing and McDonnell Douglas in August 1997. The merger seems to have been a large and shocking event to the world aviation industry, in particular to the European aviation industry. This seemed to make the European large aviation companies speed up consolidation.

The merger between Boeing and McDonnell Douglas (MD) was announced in December 1996, and completed in August 1997 consequent upon its acceptance by the US government and the European Union (EU). The two companies of Boeing and MD had different reasons for the merger. Boeing aimed to secure a military aircraft manufacturing capability, but McDonnell Douglas required a new strategy to survive from the failure of participating in the Joint Strike Fighter (JSF) Project. The merger was anticipated to have positive effects in both profit and cost. Profit was expected from the missile and commercial helicopter businesses, and cost reduction was expected from facility rationalisation, R&D, a new operational structure and resource purchase aspects (*Monthly Aerospace Industry*, January 1997, pp. 24-25).

There had been strong opposition to Boeing's merger from the EU. European aviation companies asserted that the merger had the specific purpose of seriously reducing the market share of Airbus Industrie, giving Boeing over 70 per cent of market share in the commercial transport industry, and would resulted in the loss of the free competitive market system. The EU had negotiating power with Boeing, in the form of a regulation that can impose a fine of 10 per cent of total turnover, when a large company is established by merger without the acceptance of the EU. The EU placed various conditions on Boeing' merger. For example, the EU demanded that Boeing withdrew from monopolised supply contracts with Delta, Continental, and American Airline for the next 20 years (*Monthly Aerospace Industry*, July 1997, p. 11). The EU approved the merger in July 1997 after agreement with Boeing. The agreement imposed five conditions:

(i) Boeing must cancel its monopoly supply contract with the three U.S airline companies.
(ii) It must not conclude any monopoly supply contract before 2007.
(iii) It should open up patent contents gained from US government projects at reasonable prices.
(iv) It must not stop Boeing's parts suppliers making contracts with other aviation companies including Airbus Industrie.
(v) It should operate its commercial business separately from McDonnell Douglas for the next 10 years (*Monthly Aerospace Industry*, July 1997, p. 7).

In spite of the successful conclusion of the merger, it seems to some extent to have had negative results. Boeing's revenue from the commercial aircraft business was $26.9 billion in 1997, 1.3 times more than the $19.9 billion achieved in 1996. However, there was an operational loss of $1.8 billion in 1997, the first for 50 years, while the profit was $0.9 billion in 1996 before merger (http://www.reportgallery.com, February 19, 1999). Moreover, Boeing Commercial Aeroplane Group announced sweeping plans to sharply reduce aircraft production rates across the board, and to fire or lay off 20,000 more employees in 1998 (*Monthly Aerospace Industry*, December 7, 1998, p. 28).

Velocci and Proctor (1998) indicated that Boeing's plight resulted from its mismanagement of the increase in commercial aircraft production in 1996 and 1997, and from conflicting priorities stemming partly from the major acquisition in 1997. In addition, Sellsby (1999) mentioned that "Boeing had been distracted by the task of integrating MD. The problems were big enough to push the company into the red in 1997, and profits for the next two years are expected to be relatively small."

Both the positive and negative aspects seem to have been carefully considered before the merger and acquisition was embarked upon. This is because the change of the organisational culture, the restructuring of organisation and facilities and the firing of employees are not easy tasks in a newly merged company.

There is a case of failure in concluding merger. Lockheed Martin announced its plan to acquire Northrop Grumman in June 1997, and approval was expected by the end of March 1998. However, the US government rejected the $12 billion merger plan. The Department of Justice and the Department of Defence put the following conditions to Lockheed Martin in March 1998:

(i) It must divest itself of a large portion of its electronics operations; and
(ii) It must agree to a number of discrete divestitures at Lockheed Martin and Northrop Grumman involved primarily in producing radar and electronic countermeasures (*Monthly Aerospace Industry*, March 16, 1998, p.24).

Lockheed Martin gave up the merger in June 1998 due to the unacceptable requirements of the government. It stated that the merger aimed to blunt future competition from Boeing and Raytheon, and to prepare for the world market in the 21st century, through the enhancement of production effectiveness and the integration of the sales network. The failure of the merger negatively influenced Raytheon's employees, making them confused and damaging the company's image (*Monthly Aerospace Industry*, August, 1997, pp. 16-24).

The criteria that have been used by the US government in approving mergers concluded in the US aerospace industry seem to have been decided on the basis of maintaining competitiveness and avoiding monopoly situations in the aviation industry. However, the criteria relating to monopoly could be altered by any change in the government's industrial policy and the environment of the industry.

Merger mania may continue to happen in the aviation industry in the future, in particular, in small aviation companies and suppliers. This is because M&As in the aviation industry may be an attractive option for small companies preparing to ensure their future viability against super-powered large aviation companies. In fact, BFGoodrich and Coltec Industries merged in July 1999 (*AW & ST*, July 19, 1999, p.33), and Honeywell and AlliedSignal merged into an avionics giant in December 1999 (*Flight International*, 8-14 December 1999, p. 32).

Regarding government support for removing unfair subsidy provisions, the US government concluded the US/EC Agreement on support for large civil aircraft with the European countries in July 1992, in the context of the US government's complaint about the European governments' funding support for Airbus Industrie.

The agreement covers all Airbus aircraft and aircraft with a capacity of 100 or more seats manufactured in the US. It states the two main types of support as direct funding and indirect support (such as the R&D programmes run in the US). Its main terms are:

(i) direct government support is limited to 33% of the total development cost of a project;
(ii) direct support to be repaid to the government within 17 years at a rate of return at least marginally above the cost of government borrowing; and
(iii) indirect support limited to 3% of the civil aircraft industry's annual commercial turnover (http://www.dti.gov.uk/eid, January 10, 2000).

The agreement seems to be disadvantageous to the European countries participating in Airbus Industrie. This is because the US government is not affected by the above articles (i) and (ii). The US government has not directly funded US civil aircraft manufacturers, although it has supported the aviation industry by providing huge R&D projects and transferring highly advanced technologies developed by NASA to the civil aircraft industry. In addition, article (iii) also does not relate the US, because most US aviation R&D projects are provided by the DoD and NASA for the purpose of developing military and civil aircraft technology. In fact, according to the KAIA (*Bimonthly Aerospace Industry*, July/August 1998, p. 13), the European countries denied the US's request to place the civil aviation issue in the WTO system in 1997. This may imply that the US's activity in relation to the agreement is unfair.

Regarding the US government's restriction of technology transfer, the US government has protected its core technologies from transfer to foreign countries in order to maintain the competitiveness of the industry. It has requested that US companies seek approval from the DoD when they want to export aerospace products on the military product lists. Moreover, the sales of more critical military products and services to foreign countries need to be approved by Congress through the DoD. In addition, the US government supplied 34,800 tons of stockpiled titanium to the aviation industry in 1998 in order to restabilise the price of the material after it had risen sharply *(Bimonthly Aerospace Industry*, July/August 1998, pp. 15-16).

The US aviation industry has also operated co-ordination organisations. The AIAA has regularly examined and actively commented on the aviation policy issues of NASA and the FAA. It has also contributed technical expertise and policy guidance to the Congress and the executive branches through regularly testifying on aerospace-related issues. It has the Public Policy Committee to distribute information on aviation technology policy to its members and to comment on aviation policy issues. In addition, the Committee intends to identify issues of commonality between the NASA and FAA in order to help them carry out the proper roles in the policy making and implementation areas (http://www.aiaa.com/policy/index, January 19, 2000)

It seems that the US government has emphasised co-ordination activities for aviation industry development. NASA and the FAA have actively played co-ordinating roles through establishing departments responsible for co-ordination activity. In addition, the US government seems to have been actively involved in co-ordinating aviation industry development strategy, for instance, through involvement in companies' merger plans, international negotiation and technology barriers. In fact, one of the major roles of government may include co-ordination activity for national industry development. The US government's active co-ordination system may imply that latecomer countries should strengthen co-ordination activities through establishing a feasible co-ordination strategy for the efficient formulation and implementation of aviation development policy.

5.2.3 The Motivation System

This sub-section is divided into the motivation system adopted in the US government and that adopted in the aviation industry. The US government's motivation system involves government support activities, including the procurement of aircraft, provision of R&D projects and motivation programmes. The industry's motivation system includes managerial programmes aiming to improve organisational efficiency.

The US government seems to have strongly supported its aviation industry through its procurement and R&D strategies, although it is said that the US is an indirect support country in providing funding supports to the aviation industry. The Pentagon budget for procurement was $49.5 billion in FY 1999 (http://www.aiaa.com/policy, January 19, 2000).

According to the Pentagon's FY 1999 budget request, $8.0 billion was to be used for the procurement of major tactical and rotor-wing aircraft, including the F/A-18E/F, F-16, F-22, JSF, MV-22, CV-22 and H-60, in 2000. In addition, during 1999-2005, it is planned to procure 776 tactical and rotary wing aircraft worth $80.9 billion (*AW & ST*, February 8, 1999, p. 28), as shown in Table 5.4.

Table 5.4 R&D and Procurement Plan for Major Tactical Aircraft, 1999-2005

(Funding: $billion, Quantities: aircraft)

Classification		Total	'99	'00	'01	'02	'03	'04	'05
F/A-18F/F	Funding	23.4	3.3	3.2	3.3	3.4	3.3	3.4	3.5
	Quantities	*234*	*30*	*36*	*42*	*48*	*48*	*48*	*48*
F-16	Funding	1.4	0.1	0.4	0.1	0.3	0.3	0.1	0.1
	Quantities	*31*	*1*	*10*	*0*	*10*	*10*	*0*	*0*
F-22	Funding	24.1	1.9	2.4	3.5	3.7	4.6	4.4	3.6
	Quantities	*130*	*2*	*6*	*10*	*16*	*24*	*36*	*36*
JSF	Funding	15.8	0.9	0.5	1.1	2.7	3.6	3.7	3.3
MV-22	Funding	11.0	1.1	1.1	1.5	1.7	1.9	1.9	1.8
	Quantities	*123*	*7*	*10*	*16*	*20*	*30*	*30*	*30*
CV-22	Funding	2.1	0	0	0.4	0.4	0.5	0.5	0.3
	Quantities	*37*	*0*	*0*	*4*	*6*	*9*	*9*	*9*
H-60	Funding	3.1	0.4	0.4	0.4	0.5	0.5	0.4	0.5
	Quantities	*221*	*34*	*21*	*27*	*35*	*40*	*24*	*40*
Total	Funding	80.9	7.7	8.0	10.3	12.7	14.7	14.4	13.1

Source: Based on *Aviation Week & Space Technology*, February 8, 1999, p. 28.

In addition, 10 major US aerospace companies concluded contracts worth $43.5 billion with the DOD in 1998. In particular, two large companies, Lockheed Martin and Boeing, accounted for about half of them, as shown in Table 5.5.

Table 5.5 Contract Amount of Top 10 Contractors with the US DOD in 1998

Company	Contract amount ($billion)	Remarks
Lockheed Martin	12.3	Aircraft
Boeing	10.9	Aircraft
Raytheon	5.7	Missile
General Dynamics	3.7	Submarine
Northrop Grumman	2.7	Electronics, aircraft
United Technologies	2.0	Pratt & Whitney, Sikorsky
Textron	1.8	Bell Helicopter
Litton Industries	1.6	Avionics, warship
Newport News	1.5	Warship
TRW	1.3	Military satellite

Source: *Flight International* 17-23 February 1999, p. 22.

At the same time, the DOD and NASA have provided the US aerospace industry with many R&D projects, and have undertaken R&D projects by themselves. NASA has provided $13.67 billion for the development of aerospace technologies in FY 1999 ($13.88 billion in 1998), of which $5.32 billion is for human space flight, $5.64 billion for science, aeronautics and technology and $2.51 billion for mission support (http://www.aiaa.com.policy, January 19, 2000). Large US aerospace companies have been provided with many R&D projects by the DOD and NASA, including the F-22 Raptor, the CV-22 Osprey and the JSF project. In addition, the US military and NASA have conducted the VTOL UAV, ERAST and HSRA projects, as shown in Table 5.6.

The DOD and NASA have continuously initiated R&D projects called X-series in order to develop advance aerospace technologies. The X-projects, X is for experimental, have played a key role in advancing aerospace technologies over more than 50 years since the Bell X-1 first flew. The nature of the X-series is changing. There is greater emphasis on the rapid prototyping of a small scale unmanned vehicle, and on government/industry cost sharing, in an effort to reduce the cost of demonstrating technology. X-1 to X-29 are finished, and X-31 toX-43 are under way.[22] The series has scored some major successes, from the X-1 breaking the sound barrier in 1947, to X-15 reaching Mach 6.7 flight 20 years later. There have also been

[22] See more details in *Flight International* 6-7 January 1999, pp.28-36.

disappointments, from the underpowered X-3 supersonic jet to the cancelled X-30 hypersonic aerospace-plane (*Flight International* 6-12 January 1999, pp. 28-34). A summary of the X-series is attached in Annex 4. Several ongoing X-projects worth $32 million to $15 billion are as shown in Table 5.7.

Table 5.6 Government-Supported Aerospace R&D Projects

Projects	Sponsor	Manufacturer	Characteristics of Programme
F-22 Raptor	NASA	Lockheed Martin/ Boeing	F-15 alternative, air-fighter, First flight in 1997
CV-22 Osprey	NASA	Bell/Boeing	Tilt-rotor, in researching since 1992
F/A-18E/F Hornet	US Army	Boeing	F-16 alternative, in producing
JSF	DoD	Lockheed Martin (X-35), Boeing (X-32)	F-16 and F/A-18C/D alternative, in developing demonstrator
VTOL UAV	US Navy	US Navy	Vertical Take-Off and Landing Unmanned Air Vehicle, In processing by the US Navy
ERAST	NASA	NASA	Environmental Research Aircraft and Sensor Technology Programme, for using solar-powered aircraft, in researching since 1994
HSRP	NASA	NASA	High Speed Research Project, in researching since 1990, planned first flight in 2007.
VATE	USAF	USAF Research Laboratory	Versatile Affordable Turbo Engine
IHPTET	USAF	USAF Research Laboratory	Integrated High Performance Turbine Engine Technology initiative,
JTR	US Army	Searching for a partner company	Future Joint Transport Rotorcraft, alternative of CH-47F of US Army.
QSAT	In searching sponsor	Lockheed Martin/Gulfstream	Quiet Supersonic Aircraft Technology Project, in processing by LM/Gulfstream

Remarks: Does not contain all government-supported aerospace R&D projects.

Table 5.7 Funding Scale of Several X-Projects

X-series	R&D funds	Remarks
X-32, X-35 (JSF)	$15-$17 bil. (NASA/ Boeing, LM)	5,000 aircraft are planned to produce for the USAF, US Marine Corps, US Navy and UK Royal Navy, estimated to be worth $500-700 billion (*Flight International* 10-16 March, 1999, p. 46).
X-33	$32 mil. (NASA/LM)	Single-Stage-to-Orbit Technology Demonstrator, rocket (*AW & ST*, June 7, 1999, P. 57).
X-37	$173 mil. (NASA/ Boeing)	Reusable Vehicle in Orbit Technology, a four year project, roughly 50/50 basis co-funding (*AW & ST*, August 9, 1999, p. 72).

Regarding government's motivation programmes, NASA has conducted four Base Research Programmes, the Small Business Information Research (SBIR) Programme, the Science and Technology Information (STI) Programme and the NASA Incubator Programmes.

NASA's four Base Research Programmes include the Airframe Programme, the Propulsion Programme, the Rotorcraft System Base Research Programme and the Information Technology Research Programme. They aim to support the industry's technological capability. The NASA Small Business Information Research (SBIR) Programme provides seed money to small companies which develop innovation concepts that meet NASA mission requirements.[23] The Science and Technology Information (STI) Programme has promoted training, education, communication and integration for scientists and engineers in the aerospace industry. In addition, the NASA Incubator Programmes have been undertaken by nine NASA incubators, and aim to support small and medium-sized businesses in commercialising space technology (http://www.stipo.lar.nasa.gov, January 19, 2000).

The industry's managerial programmes include organisational efficiency improvement and market security strategies.

To enhance organisational efficiency, the US aviation industry has made efforts to cut production costs by eliminating wasteful production processes and employees' actions since the Lean Aircraft Initiative (LAI) was launched in 1993. As mentioned in chapter 3, Boeing and Lockheed Martin have adopted the lean manufacturing initiatives and six sigma initiatives in their production lines. They have transformed the old production line, and use single-piece flow which eliminates unnecessary steps on the manufacturing line and eliminate unnecessary actions of employees, and trained employees on the lean principle (*AW & ST*, July 12, 1999, p. 59). At the same

[23] NASA's SBIR Programme is implemented in three phases. Phase I is the opportunity to establish the feasibility and technical merit of innovation. Phase II is the major research and development effort, and Phase III is the process of completing the development of a product to market (http://www.sti.nasa/tto/spinoff, January 19, 2000).

time, Boeing has applied the Define and Control of Aeroplane Configuration/ Manufacturing Resource Management (DCAC/MRM) programme since 1994, in order to improve the production process and reduce costs, cycle time and defects (http://www.boeing.com/commecial, January 19, 2000). Lockheed Martin has undertaken an ambitious productivity initiative, LM 21, to yield verifiable cost savings while bolstering quality. LM 21 represents top management's vision of Lockheed Martin in the 21st century (*AW & ST*, September 27, 1999, p.55).

To secure more customers, Boeing has operated the Boeing Rapid Response Centre, which aims to provide quick access to an unprecedented level of support at night, at the weekend and during holidays (http://www.boeing.com/news, November 15, 1999). In addition, the Boeing Commercial Aeroplane Group launched the Boeing Express in 1998 in order to deliver parts to world wide Boeing Spare Centres and the customer's maintenance facilities quickly, economically and conveniently (http://www.boeing, February 8, 1999).

The US government has emphasised motivation activity for the development of the aviation industry. In particular, it has procured aircraft on a large scale from the industry and provided it with aviation R&D projects including X-projects. At the same time, NASA has strongly supported the US aviation industry with the transfer of technologies they developed. The US aviation industry seems to have also emphasised motivation activities. It has adopted organisational efficiency and market security strategies.

The strong competitive position of the US aviation industry may have resulted partly from the US government's strong support. The funds for aircraft procurement and R&D projects supported by the US government do seem to be larger than the launch investment and R&D funds provided by any European countries. It seems that latecomer countries have great difficulty in achieving competitiveness against the US aviation industry supported strongly by the government. Latecomer countries may need to provide stronger support for aviation industry development.

5.3 Conclusion

The US aviation industry has a superior position globally, through strong government support, active industrial R&D and geographical advantages. Various organisations and programmes seem to have played roles to improve co-operation, co-ordination and motivation activities for US aviation development. US aviation development systems already mentioned are summarised in Table 5.8.

Table 5.8 US Aviation Technology Development Systems

Systems	Organisation	Classification	Name of System	Managing Organisation
Co-operation System	Government	Organisation	The National Aeronautics and Space Administration (NASA)	
			The Federal Aviation Administration (FAA)	
		Programme	The NASA Technology and Communication (NTTC).	NASA
			NASA Small Business Technology Transfer Programme (STTR).	“
			NASA Tech Brief	“
			NASA Spinoff	“
	Industry	Organisation	The American Institute of Aeronautics and Astronautics (AIAA)	
		Programme	The Congress Days	AIAA
			BBJ (Boeing/GE), CV-22 (Boeing/Bell) (Domestic joint R&D projects)	
			BA 609 (Boeing /Agusta), MRTT (Raytheon/Airbus), ASTRA (Raytheon/BAe Systems) (International joint R&D projects)	
Co-ordination System	Government	Organisation	Aerospace safety Advisory Panel	NASA
			The Office of Aviation Policy	FAA
			Air & Space Administration	MOC
		Activity	Involvement in company mergers	
			1992 US/EC Agreement on Supports	
			Technology barrier	
	Industry	Organisation	Public Policy Committee	AIAA
Motivation System	Government	Programme	Aircraft procurement strategy	DOD
			X-series	DOD, NASA
			NASA Small Business Information Research programme (SBIR)	NASA
			The Science and Technology Information Programme (STI).	“
			NASA Incubator	“
	Industry	Programme	Lean manufacturing, Six sigma initiatives	
			The Define and Control of Aeroplane Configuration/ Manufacturing Resource Management.	Boeing
			Boeing Express	“
			LM 21	Lockheed Martin

The US aviation development system can provide several lessons for the efficient implementation of Korean aviation technology policy.

Firstly, the lessons derived from the US co-operation system can be summarised as follows:

(i) Government needs to support the aviation industry to conduct the high level of co-operation activity for aviation industry development. NASA has made many efforts in establishing high level of co-operation with the industry.

(ii) Technology transfer needs to be supported by government. NASA has emphasised technology transfer through the establishment of programme and the publication of information for technology transfer.

(iii) Joint R&D needs to be actively conducted domestically and internationally in order to share the huge costs required in developing new advanced aviation technologies.

(iv) The bridge organisation's role needs to be strengthened in order to link government and the aviation industry. The AIAA has conducted co-operation activities between the government and the aerospace scientist society.

(v) Partnership between organisations concerned. The AIAA has held Congress Days every year to establish co-operative relations with Congress.

Secondly, the lessons from the US co-ordination system can be summarised as follows:

(i) Government needs to involve itself in the development strategy of the aviation industry in order to establish a productive and integrated industrial structure. The US government has been involved in mergers concluded the aviation industry.

(ii) Both the positive and negative results of merger need to be evaluated very carefully in processing merger. Boeing and Lockheed Martin have met several difficulties in managing large organisations established through mergers.

(iii) Government has to establish a competitive environment for the aviation industry. The US government has supported the industry with various activities, including the establishment of technology barriers, the release of stockpiled resource for material price stability and the conclusion of international agreements on aircraft company support.

Finally, the lessons from the US motivation system can be summarised as follows:

(i) The Korean Ministry of Defence should support the *civil* aviation industry development through the procurement of aircraft and the provision of aviation

R&D projects. The US DOD has procured a lot of aircraft from the US aviation companies and provided a large number of aviation R&D projects.

(ii) Government has to establish motivation programmes for the development of small companies.

(iii) The aviation industry needs to conduct organisation efficiency improvement strategies, in order to reduce unnecessary activities of employees and reduce production costs. The US aviation industry has adopted the Lean Aerospace Initiative and six sigma initiatives in order to increase productivity.

The US aviation industry has larger aviation companies such as Boeing, Lockheed Martin and Raytheon, which are competitive in the world aviation industry, and it seems that they have maintained competitiveness through strong government supports including the large scale of aircraft procurement and the X-series. This fact may imply that latecomer countries need more emphasis on the efficient implementation of aviation development policy such as the conduct of high level of co-operation, co-ordination and motivation activities. This will be one of the best ways to develop the aviation industry and overcoming the disadvantage of having smaller R&D funds and lower technological resources than the US.

Chapter 6
Japanese Aviation Technology Policy

The Japanese aviation industry has achieved competitiveness in some areas of aviation technology world wide, despite beginning from a disadvantageous position. It was prohibited from undertaking aircraft production and R&D activities for seven years after defeat in World War II, and technology transfer from the developed countries has been restricted. This chapter aims to identify lessons through the examination of Japanese aviation development policy, focusing on co-operation, co-ordination and motivation systems. It consists of three sections, the first relating to the Japanese aviation industry, the second to aviation development policy and the third being a conclusion.

6.1 The Japanese Aviation Industry

This section aims to provide an understanding of the context of the co-operation, co-ordination and motivation systems that have underpinned the development of the Japanese aviation industry. It consists of two sub-sections, the first relating to the characteristics of the Japanese aviation industry and the second to its development trajectory and its current status.

6.1.1 Characteristics of the Japanese Aviation Industry

The Japanese aviation industry has grown sufficiently for it to be able to collaboratively produce large transports and advanced fighters. However, it cannot be as competitive as other developed countries in securing world aviation market. The Japan aviation industry seems to have the following characteristics:

(i) It has potential to become competitive globally in the design and manufacture of aircraft, through the strength of Japanese technology in engineering and electronics (Anderson, 1984, p. 217). Mowery and Rosenberg (1984, p. 1) also mentioned that many US government and industry representatives believed that Japan could and eventually would become a serious competitor in the world civil aircraft market; the remaining questions were when and how much Japan's share would be.

(ii) It has been indirectly restricted in developing itself since the defeat in World War II. It cannot invest over 1 per cent of GNP on defence and cannot export weapons (North *at al.*, 1992, p. 228., KARI, 1991, p. 8).

(iii) Its development level is lower than that of other Japanese advanced industries. Its scale is smaller and its growth level is lower than the other advanced Japanese industries (KAIA, 1995, P. 1).

(iv) The Japanese aviation industry's dependence on military demand is higher than that of other developed countries, being 74 per cent in 1992, while it was 46 per cent in the US, 47 per cent in France, 51 per cent Germany and 55 per cent in the UK. However, the degree of dependence on the military has gradually decreased since 1988. It was 88 per cent in 1977 and 83 per cent in 1985 (KAIA, 1995, p. 10). [24]

(v) Exports as a percentage of the total products of the Japanese aviation industry are much lower than in other developed countries. In fact, they were 14 per cent in 1992, while they were 76 per cent in the UK, 54 per cent in France and 33 per cent in the US. In addition, exports are much smaller than imports in the Japanese aviation industry (KAIA, 1995, p. 49), as shown in Table 6.1.

Table 6.1 Export and Import of the Japanese Aviation Industry, 1960-1992

Year	1960	1970	1980	1990	1992
Export (¥ billion)	1.6	13.0	20.6	85.5	96.2
Import (¥ billion)	63.9	116.8	292.0	610.6	526.6

Source: KAIA (1995), *Japanese Aerospace Aviation Industry*, p. 55.

[24] The production of aircraft based on defence demand is characterised by production to order, so it can maintain operational stability as long as existing orders last. However, it is limited to gaining profits from production and to producing a large number of aircraft. Furthermore, it may become difficult to maintain established production capability when the demand for defence decreases (KAIA, 1995, p. 59).

(vi) The Japanese aviation companies have emphasised international collaboration in developing aircraft. It has participated in Boeing's projects, such as the B767 and B777 (Ryozoo, 1997).

The Japanese aviation industry is smaller in size than that of other developed aviation countries and it seems to have difficulties in competing with other developed countries due to the restriction placed on the export of and investment in military aircraft after the defeat in World War II. However, it seems to have potential to become competitive in some areas, through the use of advanced technologies developed in other industries.

6.1.2 The Development Trajectory of the Japanese Aviation Industry

The Japanese aviation industry has developed in a different situation to that of other developed countries. It was one of the leading aviation countries before World War II, but it had been devastated in the seven years after World War II, after which aviation R&D and production activities were prohibited. Nevertheless, currently it is again becoming one of the advanced aviation countries. The development trajectory of the Japanese aviation industry may have some implications for the developing countries in overcoming the handicaps to their aviation industries. The development trajectory can be divided into five periods: an advanced past, devastation, licensed production, independent production, and international collaboration periods, as shown in Table 6.2.

In the advanced past period, before the end of World War II, the Japanese aviation industry stayed at the top level of the world aviation industry. It produced about 100 thousand aircraft and 40,000 aero-engines during World War II. In particular, 25,000 aircraft were produced with about one million employees in 1944. In addition, it developed the world's longest flying aircraft in 1937, and had rocket fighter and turbo-jet aircraft production technologies during the War. However, the defeat in the War fatally damaged the aviation industry due to the prohibition on R&D and the production of aircraft (Mowery and Rosenberg, 1984, p. 13).

Table 6.2 Development Trajectory of the Japanese Aviation Industry

Period	Characteristics of Period	Others
Advanced past (Before the end of World War II)	One of leading aviation countries through strong support by military.	25,000 aircraft, mainly for military purposes, were produced in 1944
Devastation (7 years after the War, 1945-1951)	R&D and production activities were prohibited and their facilities were destroyed.	
Licensed production (1952-1964)	Rebuilding of the aviation industry by production licensed from US companies.	Fighters: F 86F, F 104F Trainers: T 33, T 34 Helicopters: S-55, S-62.
Independent production (1965-1973)	The development of the civil aviation industry through independent production.	Civil transport: YS-11 Business aircraft: MU-2 Light aircraft: FA-200
International collaboration (1974-Present)	Initial stage ('74-'84)	Business aircraft: MU-300 Light aircraft: FA-300 Helicopter: BK117 Civil transport B 767
	Active Stage ('85-)	Large civil transport: B777 Jet engine: V2500

Source: Based on the Economy Research Institute (1992, April), The Policy Direction for the Aerospace Industry, p. 19.

The licensed production period was characterised by the reconstruction of the Japanese aviation industry. It began with the repair of US military aircraft stationed in Japan. The Japanese government supported the aviation industry by passing the Aircraft Manufacture Law in 1952 and the Aviation Industry Promotion Law in 1958. 1,740 aircraft were manufactured under licence, mainly from US companies, during the period 1953-1963, as shown in Table 6.3 (KAIA, 1995, p. 23).

Table 6.3 Licensed Production of Aircraft, 1953-1963

Aircraft				Production		
Year	Model	Type	Purpose	Producer	License	No
1953	Bell 47	Small helicopter	Civil	Kawasaki	Bell	236
1954	B-45	Propeller aircraft	Trainer	Fuji	Beech Aircraft	162
1955	F-86F	Jet aircraft	Fighter	Mitsubishi	North American	300
1955	T-33A	"	Trainer	Kawasaki	Lockheed	210
1957	L-19	Propeller aircraft	Military	Fuji	Cessna	22
1958	S-55	Large helicopter	Civil	Mitsubishi	Sikorsky	71
1959	P2V-7	Piston aircraft	Military	Kawasaki	Lockheed	48
1961	F-104J	Jet aircraft	Fighter	Mitsubishi	Lockheed	210
1962	V-107	Large helicopter	Civil	Kawasaki	Boeing	160
1962	S-62	Large helicopter	Civil	Mitsubishi	Sikorsky	27
1963	Bell204B	Middle helicopter	Civil	Fuji	Bell	127
1963	S-61	Large helicopter	Civil	Mitsubishi	Sikorsky	167

Source: KAIA (1995), *The Japanese Aerospace Industry*, p. 23.

The Japanese aviation industry had an unexpected opportunity to develop due to the Korean War, which released Japan from the prohibition on aviation R&D and production. Furthermore, aircraft demand in the War gave the Japanese aviation industry a chance to rebuild (Pempel, 1998, p. 179). Through production licensed from the US, the Japanese aviation industry gained advanced aviation technologies and thus established a basis to develop aircraft independently.

In the independent production period, 1964-74, 1,482 aircraft were produced independently. In 1962, the YS-11, Japan's first civil transport, was developed by the Japanese Aircraft Manufacture Company which was established by the joint capital investment of the government and industry in 1958. The T-1A and the T-1B military trainer aircraft were also produced independently with the support of the Air Self-Defence Force in 1978, as shown in Table 6.4.

Table 6.4 Independent Production of Aircraft, 1964-74

Year	Type	Model	Purpose	Manufacturers	No
1964	Y-11	Turbo-prop	First civil transport	Japan Aviation Manuf. Co.	182
1965	MU-2	Turbo-prop	Business aircraft	Mitsubishi Heavy Industries	757
1965	P-2J	Piston	Military	Kawasaki Heavy Industries	83
1966	FA-200	Turbo-prop	Light aircraft	Fuji Heavy Industries	299
1968	PS-1	Jet	Military	ShinMaywa Industries	23
1971	C-1	Jet	Transport	Fuji Heavy Industries	31
1973	T-2	Turbo-prop	Trainer	Mitsubishi Heavy Industries	96
1974	US-1	Jet	Military	ShinMaywa Industries	11

Source: KAIA (1995), *The Japanese Aerospace Industry*, p. 39.

The Japanese aviation industry made efforts to develop an independent production capability. It undertook two strategies in developing aviation technology in this period. It produced middle and low technology aircraft independently, but high technology aircraft under licence. In fact, about 1,400 aircraft were produced independently and 1,200 aircraft under licensed production (KARI, 1991, p. 11). Independent production involves risks in development and securing a market. In fact, the YS-11 was a technological success, but a failure in commercial terms. However, it provided an opportunity to inform the world of the Japanese aviation production capability. Such a development of advanced new aircraft may have enabled the aviation industry to enhance its technological and production capability.

The Japanese aviation industry began to find an overseas aircraft market after establishing its technological and production capability through licensed and independent productions. The international collaboration period, from 1975 to date, can be divided into initial and active stages. During the initial stage, 1974-1984, the Japanese aviation industry began to produce jointly with foreign partners. For example, the FA-300 light aircraft was jointly produced with the US's Rockwell International, the BK117 helicopter with the German Messershmitt-Bolkow-Blohm (MBB) and the XJB turbo-fan experimental jet-engine with Rolls-Royce.

In the active stage, from 1985 to now, the industry began to participate in a large scale civil transport project, namely, the B-777 project,[25] and a multi-country engine project, the V2500 project. In addition, Fuji, Kawasaki and Mitsubishi Heavy Industries have also conducted international collaboration (KAIA, 1995, pp. 41-42).

From a difficult situation, Japan has currently become one of the countries with a developed aviation industry. Its current situation will now be mentioned.

According to *Flight International* (2-8 September, pp. 54-60), Japan had 6 aerospace companies in the world top 100 aviation companies by 1997 sales. The number of Japanese aviation companies was the fourth world-wide after the US (46 companies), France (13 companies) and the UK (12 companies), although their sales were 4.6 per cent of those of US companies and 22.9 per cent of those of UK companies. The six Japanese aviation companies are shown in Table 6.5. The six companies accounted for 58 per cent of the Japanese aviation industry's total sales in 1997.

[25] The Japanese and US governments concluded an agreement to develop the B-767 in 1978. Mitsubishi Heavy Industries, Fuji Heavy Industries and Kawasaki Heavy Industries in Japan and Boeing participated in the project. The B767-200, a 216-seat transport, made its first flight in 1981, and 724 aircraft had been ordered by 1996. The B-767-400 ERX has been developed and is expected to be delivered in 2000. In addition, the B-777, a 350-seat transport, has been produced jointly since 1994, and 303 were ordered by 1996. The B-777-300, a 550-seat transport, has also been developed since 1995. The three Japanese companies have a 20 per cent total working share in (KAIA, April 1997, pp. 38-39).

Table 6.5 Japanese Aerospace Companies in World's 100 Companies by 1997 Sales

World Ranking	Name of Company	Sales in 1997 ($million)	Employees by a group total
19	Mitsubishi Heavy Industries	3,166	40,685
28	Kawasaki Heavy Industries	1,732	24,211
38	Ishikawajima-Harima Industries	1,135	14,073
64	Fuji Heavy Industries	566	90,889
82	Nissan	391	135,331
92	Japan Aircraft Manufacturing	262	-

Source: *Flight International* 2-8 September 1998, pp. 54-60.

The industry's sales, with overhauls excluded, were $5.4 billion in 1997, of which defence demand was largest representing 56 per cent of the total and exports represented 34 per cent. However civil demand was only 10 per cent, as shown in Table 6.6.

Table 6.6 Sales of the Japan Aerospace Industry in 1997 ($million)

Classification	Total	Civil Demand	Defence Demand	Export
Airframes	930.7	11.5	919.2	-
Airframe parts, equipment	2,765.9	344.6	1,145.6	1,275.7
Engines	1,249.4	108.7	615.8	524.9
Instruments	201.8	53.9	146.1	1.8
Radar, Others	273.9	20.1	210.9	42.9
Total	5,421.7	538.3	3,037.6	1,845.3

Source: *Aviation Week & Space Technology*, April 20, 1998, p. 55.

The Japanese aviation industry seems to have developed to a similar level as other advanced countries in several areas, through overcoming its difficult situation resulting from defeat in the Second World War. It has done so through the process of licensed production, independent development and production, and international joint development. In the end, it has achieved competitiveness in several areas. This development has benefited from government support and industrial development strategy, which will be discussed in the next section.

6.2 Japanese Aviation Development Policy

This section aims to identify lessons through examining Japanese aviation development policy. It is divided into the three sub-sections relating to co-operation, co-ordination and motivation systems.

6.2.1.The Co-operation System

This subsection presents government co-operation organisations, the industry's co-operation organisations and their activities and international collaboration.

The Japanese government has operated organisation and programmes for improving co-operation activities between organisations concerned with aviation industry development. The national organisation responsible for co-operation activities is the National Aircraft Laboratory (NAL) under the Science and Technology Agency. The NAL has transferred technologies and used its research facilities togerther with the industry since 1987 (G.S, Park, 1995, p. 249). However, a high level of co-operation relations seems not to have been established between the ministries concerned. This is because, the level of co-operation is lower due to the fact that responsibility for the aviation R&D systems has been divided between various ministries, including the Ministry of International Trade and Industry (MITI), the Science and Technology Agency and the Ministry of Transport (MOT). In addition, few co-operation programmes seem to have been conducted by the government. Only the Large Industrial Technology Research Project has been conducted in order to establish close relations between universities, research institutes and the industry through the provision of R&D projects (KAIA, 1995, pp. 81-83). On the contrary, it is said that a high level of co-operation has been conducted between the ministry and the industry, and this is a motive to develop the Japanese industry (T.H, Kim, 1996, p. 35).

Regarding the Japanese aviation industry's co-operation organisations, the Society of Japanese Aerospace Companies (SJAC) has conducted co-operation activities, including comments on national aviation policy, the operation of an aviation data base, the collection and distribution of aviation information, the survey of aviation technology, public relation and the conduct of international collaboration activities. In addition, it plays the bridging role of connecting the government and the aviation industry (*Monthly Aerospace Industry*, July 1997, pp. 70-73).

In addition, the industry has co-operated through the establishment of joint development corporations. Several organisations were set up in the past for the conduct of joint aviation development projects. The Japanese Jet Engine Limited Company was formed with the participation of 5 companies in 1953. The Transport Design Research Corporation was established in 1957 in order to conduct basic research and design for the YS-11, the first Japanese civil transport. In 1964, the Japanese Aviation Manufacture Company was established with capital investment from 200 companies, including financial, manufacturing and sales companies and the government, in order to develop the YS-11. In addition, the Engine Research Union was established between Ishikawajima-Harima, Kawasaki and Mitsubishi Heavy Industries in order to develop the FJR 710 Turbo-fan engine in the early 1970s (KAIA, 1995, pp. 70-79).

Currently the Japanese Aviation Development Corporation (JADC) has been established with the participation of aviation manufacturing companies, in order to conduct a survey of new aircraft technologies and manage aviation joint projects. It has administered national and international aviation joint projects such as the B777, B747-X, YXX, YSX and SST projects.[26] The Japanese Aero Engine Corporation (JAEC) was also established through the participation of engine companies, and has participated in the V2500 international engine joint project. In addition, the Hyper Sonic Transport Propulsion Device Research Union (HYDR) has conducted R&D activities in the areas of propulsion systems, turbo-jets and measurement and control systems (*Monthly Aerospace Industry*, July 1997, pp. 73-74).

Japanese aviation companies have jointly produced many aircraft through co-

[26] The B777 project is the development project for the large next-generation civil transports. The B777 project is for a very large civil transport, the YXX project is for a next-generation civil transport, the YSX is a for small civil transport and the SST is for a supersonic transport (*Monthly Aerospace Industry* KAIA, July 1997, p. 73).

operation projects. For example, Mitsubishi Heavy Industries, Fuji Heavy Industries, Kawasaki Heavy Industries and Ishikawajima-Harima Heavy Industries have produced aircraft collaboratively, as shown in Table 6.7.

Table 6.7 Japanese Domestic Joint Aviation Production

Year	Model	Utilisation	Co-operation Companies	Others
1971	C-1	Transport	Basic Design: The Japan Aircraft Manufacture Corporation. Manufacturers: Kawasaki, Mitsubishi, Fuji, ShinMaywa	
1971	FJR 710	Turbo-jet engine	Ishikawajima-Harima, Kawasaki, Mitsubishi	
1973	T-2	Supersonic trainer	Kawasaki, Mitsubishi, Fuji, ShinMaywa	
1980	YX/767	Civil transport	The Japan Aircraft Manufacture Company. Kawasaki, Mitsubishi, Fuji	
1980	XJB	Turbo-fan engine	Ishikawajima-Harima, Kawasaki, Mitsubishi	Rolls-Royce
1985	V2500	Turbo-fan engine	Ishikawajima-Harima, Kawasaki, Mitsubishi	5countries' participation
1995	F-2	Fighter	Kawasaki, Mitsubishi, Fuji	Lockheed Martin
1996	OH-1	Military helicopter	Kawasaki, Mitsubishi, Fuji	

Source: KAIA (1995), *The Japanese Aerospace Industry,* p. 3.
Note: All co-operation projects are not included, Year indicates when aircraft began to be produced.

The Japanese aviation companies have also conducted various international collaboration projects mainly with the US, as shown in Table 6.8. Such projects have been supported by the International Aviation Joint Development Fund (The Economy Research Institute, 1992, p. 19).[27] However, the Japanese aviation industry has neglected to conduct international collaboration with the Asian countries due to its emphasis on international collaboration with the US and European countries. However, the Japanese government has begun to have an interest in co-operation with the Asian countries relatively recently. The MITI

[27] The International Aviation Joint Development Fund, established in 1986, has provided subsidies to the aviation companies which conduct international collaboration projects, such as the B767, B777 and V2500. It supports 50% of development costs. Refund is required if a project achieves a profit but not in the case of the failure of projects. In addition, the companies can borrow 70% of development costs if they cannot receive subsidies. In addition the interest on the loan is paid by the International Aviation Joint Development Fund (KARI, 1991, p. 14).

wanted to survey the possibility of co-operation with Asian countries in 1997 (Ryozoo, 1997).

Table 6.8 International Joint Production

International joint projects			Manufactures	
Beginning	Model	Utilisation	Japan	Foreign partners
1974	FA-300	Business aircraft	Fuji	Rockwell International
1977	BK117	Helicopter	Kawasaki	MBB
1978	B767	Civil transport	JADC	Boeing
1980	XJB	Experimented turbofan engine		
1984	V2500	Middle-rage civil transport engine	JAEC	RR, UTC, MTU, Fiat
1984	YXX/7J7	Civil transport	JADC	Boeing
1988	FS-X	F-2 fighter	Kawasaki, Mitsubishi, Fuji	General Dynamic (currently Lockheed Martin)
1993	Global Express	Jet Business	Mitsubishi	Bombardier
1994	B777	Civil transport	JADC	Boeing
1995	Bell 205	Helicopter	Fuji	Bell
1995	S-92	19-seat helicopter	Mitsubishi	Sikorsky
1996	Hawker Horizon	Jet Business	Fiji	Raytheon

Source: Based on *Monthly Aerospace Industry,* April 1997, pp. 38-44., KAIA (1995), The Japanese Aerospace Industry, pp. 40-41.

A high level of co-operation relations seems not to have been established between ministries concerned for aviation industry development. However, Japanese aviation companies have actively conducted co-operation activities. They have established co-operative organisations including the JADC, the JAEC and the HYDR, and conducted various domestic and international joint programmes. In addition, the SJAC has undertaken a bridging role connecting government and industry.

6.2.2 The Co-ordination System

This sub-section presents co-ordination organisations, regulation and programmes operated by the Japanese government, and those by the industry.

Japanese aviation technology policy is separately conducted by several ministries, including the Science and Technology Agency (STA), the Ministry of International Trade and Industry (MITI) and the Japanese Defence Agency (JDA). The Science STA[28] has responsibility for co-ordinating national aviation technology policy focusing on basic research areas. The concrete activities related to aviation technology policy have been conducted by the National Aerospace Laboratory (NAL) under the STA. In addition, the MITI[29] is responsible for aviation industry policy focusing on the aviation development area, and the JDA is in charge of military aircraft policy in principle. The overall co-ordination of aviation technology policy is in the charge of the Council for Science and Technology (CST),[30] which comes under the Prime Minister's Office (KARI, 1991, pp.15-16). Organisations relevant to Japanese aviation technology policy are shown in Figure 6.1.

The government has several regulations on co-ordination for Japanese aviation industry development. The Aviation Industry Promotion Law was replaced by the Aircraft Manufacture Law, which came into force in 1952, in order to avoid the overlap of and over-investment in R&D in the aviation industry.

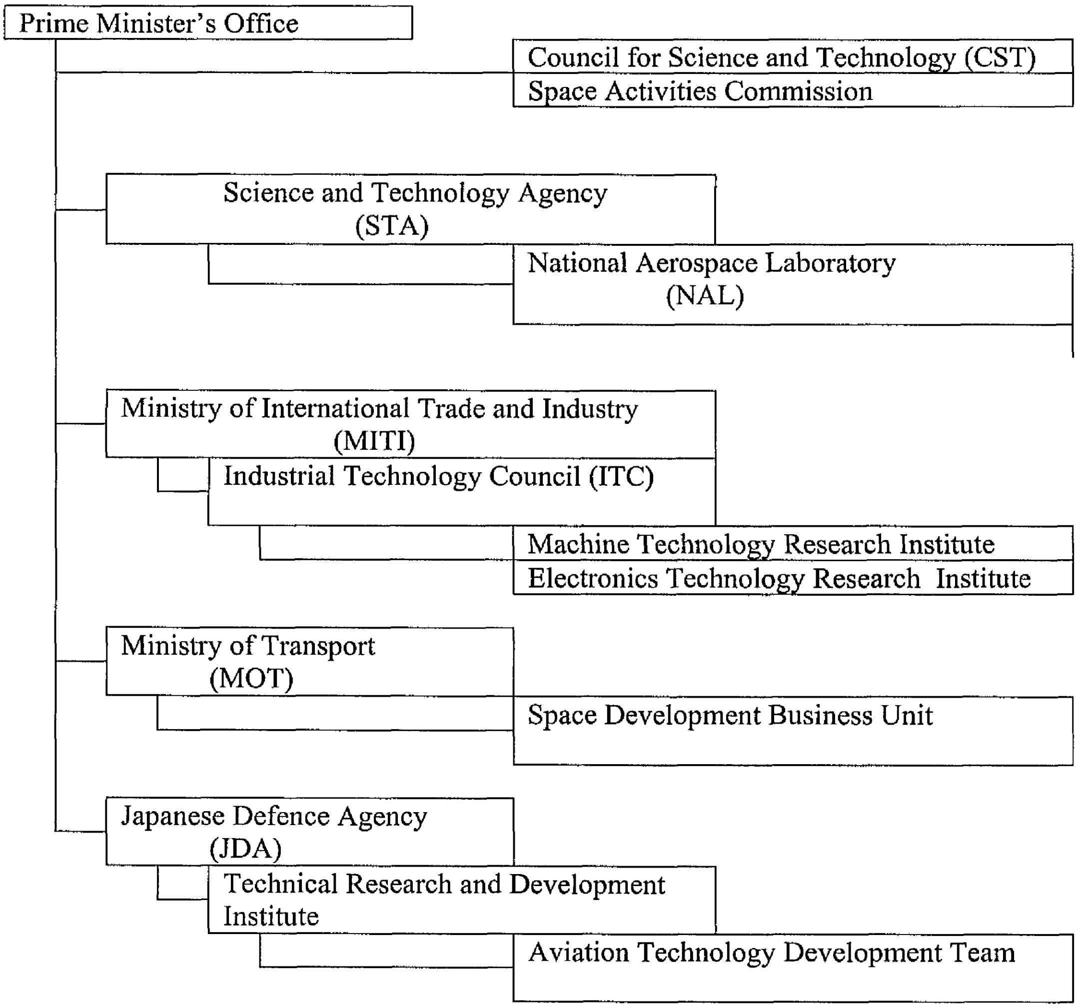
The government has conducted co-ordination programmes for efficient R&D and aviation development domestically and internationally. In fact, the MITI established the Industrial Science Development Programme in 1993 through the integration of four institutes, including the Next-Generation Industrial Technology R&D Institute and the Large Scale Industrial R&D Institute (G.S, Park, 1995, p. 348).

[28] The STA has as its primary duty the general promotion of science and technology policy. It frames science policy and co-ordinate the activities of the other ministries and agencies concerned with science and technology policy. However, its co-ordination roles hampered by competition between the various ministries (Anderson, 1984, p. 56).

[29] The MITI has gained something of an awesome reputation in the western world because its policies are seen to have brought about Japanese economic success. MITI's major roles include: promoting the continuous reorganisation of industry to achieve maximum efficiency, overseeing industrial patent rights, promoting and guiding small and medium-sized businesses, and encouraging research in the whole spectrum of industrial science and technology (Anderson, 1984, pp. 61-62).

[30] The CST is responsible for integrating and co-ordinating research in all government organisations. It was established in 1959 and consists of a chairman (Prime Minister), the ministers concerned and experts from academia and industry (G.S, Park, 1995, p. 201).

Figure 6.1 Japanese Government Organisations Relevant to Aviation Development Policy



Source: Based G.S, Park, (1995), The 1995 *Japanese White Paper on Science and Technology*, pp. 213-214.

The Japanese government has been involved in international collaboration for aviation technology development. It has the case that the achievement of purpose of international collaboration with the US, a developed aviation industry country, is not easy. In particular, related to the F-2 project. These will now be considered.

The Japanese Defence Agency decided to develop the F-2, an advanced fighter, independently in 1985, but its independent development plan was changed to international joint development, due to the combined pressure of the US executive, congress, industry and mass-media. The F-2 project took 10 years to develop, due to the delay resulting from discords between the Japan and the US governments on the development plan, including the refusal of transferring core technologies by the US industry. In fact, the first flight of the F-2 project was in 1995. Moreover, Japan paid a big fee for learning technologies from the project (*Monthly Aerospace Industry,* January 1997, pp. 56-59, and February 1997, pp. 66-69). The process of development of the F-2 project is summarised in Table 6.9.

Table 6.9 The Process of developing the F-2 Project

July 1982: The JDA decided to develop 24 next-generation fighters in seven years to replace the aged F-15 fighter.

January 1985: Identification of the possibility of developing a fighter independently Through its Technology Research Headquarter.

October 1985: Notification of the requirement of the fighter to the US and European Aviation manufacturers. In this stage, Japan believed that it could overcome the US's opposition to its independent development plan.

November 1985: The US industry and Administration began to press Japan to buy a US Fighter.

March 1986: The US Defence Secretary continued to press Japan to buy a US fighter or Conduct a Joint development not an dependent production.

June 1987: The Japanese government tried to postpone the development plan, intending to develop a fighter independently, during the postponement. However, the US continued to insist that the fighter should be made on the basis of the US model.

June 1987: The Japan government and the US government concluded the basic agreement on the joint development of the FS-X project. However, opposition to technology transfer arose again from US executives and the industry.

June 1988: Two governments agreed a Memorandum of Understanding for the FS-X project. The major contents of the MOU are:

(1) The JDA undertakes the plan and management of the project.
(2) The prime contractor is a Japanese aviation manufacturer.
(3) All of the development costs are provided by the JDA.
(4) Technology information developed by the project belongs to the JDA.
(5) Work-share is 55-65% to Japan and 35-45% to the US.

October 1995: First flight of the F-2.

Sources: Based on *Monthly Aerospace Industry,* January 1997, pp. 56-59., February 1997, pp. 66-69.

This case may imply that many difficulties can occur to a country with low technological capability in conducting international collaboration with the developed countries and that latecomer countries need to observe and co-ordinate international collaboration activities in cases where there is a restriction on technology transfer from the developed countries.

Regarding co-ordination activities conducted by the Japanese industry, the Society of Japanese Aerospace Companies (SJAC) has commented on national aviation development policy including budget security in the course of a survey on management improvement and an examination of government policy. The Japanese Aerospace Development Corporation (JADC) and the Japanese Aero Engine Corporation (JAEC) have also co-ordinated different opinions on joint production programmes between participating companies (*Monthly Aerospace Industry*, July 1997, pp. 70-74).

The co-ordination activities by the government seem not have been actively conducted. An exclusive co-ordination projects for aviation technology development is not seen currently. However, the aviation companies seem to have co-ordinated their activities by themselves through the establishment of several organisations, such as JADC, JAEC and HYDE. This may imply that co-ordination activity conducted by the industry itself is necessary to latecomer countries.

6.2.3 The Motivation System

This sub-section presents the government motivation systems which have been put in place for the development of the Japanese aviation industry. It deals with two aspects: (1) Funding support including subsidies and the procurement of aircraft, and (2) aviation R&D projects.

The Japanese government has provided the aviation industry with various funding support for a long time. It provided ¥4.2 billion (54% of capital) for the development of the YS-11, a civil transport development project, in 1964, by establishing the Japanese Aviation Manufacture Limited Company, and provided ¥16 billion for the

YX-B767 project, the first subsidy provided to a project in 1980. In addition, it has provided 75 per cent of the development costs (currently 50%) for the V2500 project, and 50 per cent of development costs of the YXX/7J7 project (KAIA, 1995, pp. 80-81). This shows that the Japanese aviation industry has largely been supported by the government in conducting aviation development projects, including international joint projects.

The government has also supported the aviation industry through its procurement strategy. The JDA procured 1,341 aircraft domestically produced during the period 1952-1993. About 32 aircraft have been purchased every year for 42 years. The number of fighters procured accounted for 62 per cent of total procured aircraft, with trainers next at 25 per cent and transports at 13 per cent, as shown in Table 6.10.

Table 6.10 Aircraft Procured by the JDA, 1952-93

	Model	Number of aircraft	Year
Trainers	T-33	210	1955-57 (3 years)
	T-1	66	1956-62 (6 years)
	T-2	50	1970-85 (10 years)
Fighters	F-86F	300	1955-57 (3years)
	F-104J	210	1960, 66 (2 years)
	F-4EJ	160	1969-77 (6 years)
	F-15J	164	1978-93
Transports	PS-1	23	1965-77 (11 years)
	P-3C	105	1978-1993
	Y-11	23	1963-72 (9 years)
	C-1	30	1971-79 (5 years)
Total		1,341	

Source: KAIA (1995), *The Japanese Aerospace Industry*, p. 45.
Remarks: Year in the round bracket shows the period of the procurement.

In addition, during the four years, 1996-99, the JDA procured 215 aircraft (average 54 aircraft per year) for $8.8 billion. The Air Force accounted for 66 per cent of the total procurement budget, the Navy 19 per cent and the Army 15 per cent, as shown in Table 6.11.

Table 6.11 Procurement of Aircraft by the JDA, 1996-99

Year	Demander	Procurement of aircraft			
		Budget ($mil)	Number	Model	Others
1996	Army	317.01	14		
	Navy	482.33	12		
	Air Force	1,843.86	29		
	Total	2,643.20	55		* Approved Budget
1997	Army	353.60	15		
	Navy	434.04	12		
	Air Force	1,348.13	29		
	Total	2,136.27	56		* Approved Budget
1998	Army	300.07	13		
	Navy	342.07	10		
	Air Force	1,291.15	25		
	Total	1,933.29	48		* Approved budget
1999	Army		4	OH-1	Helicopter (Kawasaki)
			3	UH-60JA	" (Mitsubishi/Sikorsky)
			5	UH-1J	" (Fuji/Bell)
			2	CH-47J	" (Kawasaki/Boeing)
			2	Beech LR-2	Liaison aircraft
	Sub-total	315,55	16		
	Navy		10	UH-60J	Helicopter (Mitsubishi/Sikorsky)
			1	US-1A	Rescuer (Shinmaywa)
			3	Beech TC-90	Trainer
	Sub-total	469.63	14		
	Air Force		8	F-2	Fighter (Mitsubishi/LM)
			2	U-125A	(BAe 125) SAR aircraft
			12	T-14	Trainer (Kawasaki)
			2	CH-47J	(Kawasaki/Boeing)
			2	UH-60J	(Mitsubishi/Sikorsky)
	Sub-total	1,320.79	26		
	Total	2,105.97	56		* 51 aircraft approved
Grand total		8,818.73	215		

Sources: *Aviation Week & Space Technology,* March 10, 1997, p. 69., February 23, 1998, p. 81., September 28, 1998, p. 25., February 1, 1999, p. 87.

The government has supported aviation R&D activity. It established the Infrastructure Technology Promotion Centre in 1985, the Next-Generation Aviation Infrastructure Technology Research Institute in 1986, and the Commuter and Helicopter Advanced Technology Research Institute in 1992, for the support of aviation technology development. In addition, the government has provided the aviation industry with many R&D projects. In particular, the MITI and the JDA have established many R&D projects, as shown in Table 6.12.

Table 6.12 Aviation Projects Provided by the Japanese Government

Organisation	Support Means	Supported Project	Year of Production	Others
MITI	Capital	YS-11	1964	¥4.2 billion invested.
	Subsidies	YX-B767	1981	¥16 billion funded.
		B767-400RRX	2000	Planned year to deliver
		V2500	1988	Beginning in 1984.
		B-777	1994	Conclusion of MOU in 1990.
		B-777-300	1995	Beginning of development.
JDA	Project	J3-3	1953	First Japanese jet engine.
		C-1	1971	Jet military transport. ¥9.4 billion invested.
		T-2	1973	Supersonic trainer (¥8.5 billion)
		XT-4	1981	Beginning of development Trainer.
		SH-60J	1989	Military helicopter.
		FS-X	1995	F-2 development project.
		OH-X	1997	Light helicopter.
STA	Project	STOL	1985	First flight by the NAL
SJAC	Project	YSX	1989	Small sized civil transport development project began. Conducted by the JADC.
ITC	Project	SST	1997	Supersonic transport development project was planned in 1997. Managed by the Propulsion System Research Union.

Sources: KAIA (1995), *the Japanese Aerospace Industry*., KAIA, *Aerospace Industry*, April 1997 p. 39-44, and July 1997, p. 73., *Aviation Week & Space Technology*, March 10, 1997, p.10.
Remarks: STA stands for the Science and Technology Agency, which belongs to the Ministry of Education. ITC is Industrial Technology Council.

The Japanese government has provided considerable support to the aviation industry. It has established several research institutes in order to promote aviation R&D activities, including the Next-Generation Aviation Infrastructure Technology Research Institute and the Commuter and Helicopter Advanced Technology Research Institute. In addition, it has provided the industry with many R&D projects and subsidies. The JDA has recently purchased about 54 aircraft every year from the Japanese aviation companies.

Such government supports may imply that strong government support is indispensable to latecomer countries in developing aviation technology. In particular, the procurement of aircraft by the military authorities seems to be very important for the development of the aviation industry.

6.3 Conclusion

Japan has become one of the developed aviation industry countries through government's strong support, although it is not yet sufficiently competitive to secure a global aviation market. Japanese aviation development systems are summarised in Table 6.13.

Table 6.13 Japanese Aviation Technology Development Systems

Factors	Systems	Name of systems	Major functions
Co-operation	Research Institute	NAL (STA)	Transfer of technology developed to the industry
		Aviation Technology Development Team (JDA)	
	Society	SJAC	A bridge role
	Joint Development Corporation	JADC	Joint production between aviation companies
		JAEC	
		HYDE	"
	Joint project	YS-11, YX/767, V2500, …	Joint development projects
	International collaboration	International Aviation Joint Development Fund	Support of subsidies and loan
Co-ordination	Government	MITI	Co-ordination of aviation Policy
		STA	
		JDA	
	Research Society	NAL	Co-ordination of aviation technology policy
		SJAC	Comment on aviation policy
	Joint Development Corporation	JADC	Co-ordination of companies' Aviation development plan
		JAEC	
		HYDE	
	Law	Aviation Industry Promotion Act	Suggestion of rules for the aviation industry
Motivation	Funding Support	Subsidy	50% of the development cost
		Loan	70% of the development cost
		Payment of interest	Interest of loan
	Procurement	Procurement of aircraft	40-50 aircraft/year
	R&D project	Y-11, YX-B767, OH-X, FS-X, C-I, T-2, J3-3, …..	Provision from the MITI and the JDA
	Research Institute	Next-Generation Aviation Infrastructure Technology Research Institute	Technology promotion
		Commuter and Helicopter Advanced Technology Research Institute	

The lessons from Japanese aviation development systems are follows.

Firstly, lessons from the co-operation system are that:

(i) National research institutes need to transfer technologies they developed. The NAL and the Aviation Technology Development Team have co-operated with the industry in developing aviation technologies and in transferring its technologies.

(ii) Aviation companies should co-operate in developing new aircraft. Japanese aviation companies have co-operated with each other by establishing joint production corporations and the Society of Japanese Aerospace Companies.

(iii) An active bridge role is needed for formulating co-operative relations between government, research institutes, universities and the aviation industry. The SJAC has played a bridging role in order to support the information flow between them.

Secondly, lessons from the co-ordination system are that:

(i) The government needs to make efforts to provide integral R&D and funding support in order to establish effective support systems. The Japanese government has conducted co-ordination activities through the establishment of the Council for Science and Technology in order to co-ordinate different development strategies related to national science and technology policy.

(ii) Aviation companies need to co-ordinate their activity related to aviation technology development through the establishment of co-ordination organisations. Japanese aviation companies have established the JADC, JAEC and HYDE, in order to co-ordinate joint development projects.

(iii) Several organisations to give government independent advice on aviation development policy should be activated. The SJAC and the NAL have commented on aviation development policy.

Lessons from the motivation system are:

(i) The Korean Ministry of Defence should support civil aviation industry development through the procurement of aircraft, in order to establish a defence capability in the long term. The JDA has procured an average 54 aircraft every year during the period 1996-99.

(ii) The government needs to continue to provide the industry with many aviation development projects. The Japanese aviation industry seems to have developed through many aviation development projects provided by the government.

(iii) The government needs to provide aviation companies with funding support for aviation industry development. The Japanese government provides aviation companies with subsidies at 50 per cent of the development cost or with loans at 70 per cent of the development costs in conducting aviation development projects.

Chapter 7
Korean Aviation Technology Policy

This chapter aims to examine the co-operation, co-ordination and motivation systems adopted in conducting Korean aviation development policy. It consists of four sections, dealing with (1) the Korean aviation industry, including the development trajectory and the current Korean aviation industry, (2) Korean aviation development policy, including co-operation, co-ordination and motivation systems, (3) the views of policy experts on that policy, and (4) a conclusion.

The Korean economy has developed rapidly over thirty years since 1962 when the first five-year economy development plan was launched. The Korean government and the industry had closely co-operated under the government's strong leadership from the 1960s to the 1980s. However, they seem not to have undertaken such a high level of co-operative activity since the 1990s, partly due to industry's several activities including the neglect of co-operation with the government in conducting national industrial development strategy, and partly due to the establishment of infeasible policies by the government through the imitation of developed countries' policies without reflection of the Korean social system and culture. Hence, currently the Korean government and the industry seem to need a higher level co-operation activity in order to achieve competitiveness in the world market.

7.1 The Korean Aviation Industry

The Korean aviation industry has the capability to develop lower technological level and small sized aircraft through 20 years engagement in aircraft manufacturing. However, it has difficulties in developing continuously due to the lack of sufficient aviation development projects supported by the government and the fragmentation of the aviation industry into many companies. To provide an understanding of the context of the Korean aviation development policy, this section discusses the development trajectory and the current state of the Korean aviation industry.

7.1.1 Development Trajectory of the Korean Aviation Industry

The Korean aviation manufacturing industry began in 1976 with the assembly of 500MD light helicopters under licence (S.B, Kim, 1991). Its development trajectory can be divided into the three stages of generation, technological capability formulation, and production capability formulation, as shown in Table 7.1.

Table 7.1 Development Trajectory of the Korean Aviation Industry

Stages	Period	Programmes	Others
Generation Stage	1976-1988	The MD500 project, a light helicopter licence production (KAL/Hughes, 1976-88).	The first step in aircraft manufacture in Korea, provided by the KMOD.
		The establishment of the Aerospace Industry Promotion Act (MOER, 1978).	The first act to support the aviation industry.
		The F-5. licensed production of a fighter (KAL/Raytheon, 1980-86).	The first licensed manufacture of a fighter in Korea, provided by the KMOD
Technological Capability Formulation Stage	1989-1998	The announcement of the aviation industry development strategy (MOIR, 1989).	New projects were begun in order to produce aircraft by the 1990s.
		The UH-60 project, the Black Hawk helicopter licence production (KAL/Sikorsky, 1991-99).	Middle scale helicopter project provided by the KMOD
		The KFP project, the F-16 licence production (Samsung/Lockheed 1992-99)	The largest production project Provided by the KMOD
		The Changong 91 project, a 5-seat light aircraft independent development.	Civil aircraft development project provided by the MOST (1988-91).
		The 8-seat Composite Material Twin Engine Aircraft project.	" (KARI, Samsung, 1993-97).
		The KTX-1 project, a basic trainer and lead-fighter production (ADD/Daewoo)	Military trainer development project provided by the KMOD (1988-98).
Production Capability Formulation Stage	1999-Present	The basic plan for the aviation industry began to be established (MOIR, 1999).	Consolidation of aviation companies and funding support are included.
		The KT-1 began to be produceed (Daewoo, 1999)	Production followed the success of the KTX-1 project.
		The BK-117 project, a helicopter production (Hyundai/Kawasaki, 1999)	International joint production by an aviation company
		The SB427 project, a helicopter production (Samsung/Bell, 1999).	"
		The additional KFP project	Planned to begin in 2000
		The F-X project	Planned to begin in 2001

Remarks:

KAL: Korean Air
MOIR: Ministry of Industry and Resources.
ADD: Agency for Defence Development.
KARI: Korea Aerospace Research Institute.
KMOD: Korean Ministry of Defence.
KTX: Korea Trainer Experiment.

The Korean aviation industry was developed through government support from 1976 onwards. The government announced in the 1978 President's Annual Message that Korea would produce aircraft by the mid-1980s, and the Aerospace Industry Promotion Act was passed in 1978. In addition, the government provided the industry with the two licensed assembly projects for the 500MD and the F-5. The 500MD project for a 5-6 seat light helicopter project was the first for aircraft production in Korea and resulted in the assembly of 200 military helicopters and 22 civil helicopter by Korean Air under licence from Hughes during the period 1976-88. The F-5 project was also conducted by Korean Air under licence from Raytheon during the period 1980-86 (S.B, Kim, 1991, pp. 47-50). This stage was characterised by the establishment of the Korean aviation industry through the government's willingness to develop it and through the licensed assembly of aircraft.

The stage of technological capability development begun with another two licensed production projects and four independent development projects. The intention was to maintain the production of aircraft after the 500MD and the F-5 projects finished in 1988. In 1989, the government announced an aviation development strategy, by which Korea would become a developed aviation industry country by 2005. In addition, the Korean Ministry of Defence (KMOD) provided two licensed production projects and two independent trainer development projects. The UH-60, 18-seat middle size helicopters (Black Hawk), were produced by Korean Air under license from Sikorsky during 1991-99. F-16 fighters were also produced by Samsung under licence from Lockheed during the period 1992-99 as the Korean Fighter Project (KFP). In addition, the KTX-1, a basic trainer and lead-fighter, was independently developed by Daewoo during the period 1988-1998, and the KTX-2, a supersonic advanced trainer, began to be developed by Samsung in 1997.

At the same time, the MOST provided the aviation research institute and the industry with two independent aviation development projects. One was the Changong 91, a 5-seat light aircraft. This was developed by the Aerospace Research Consortium, which consisted of Korean Air, the Samseon Industry Company and the Korea Fibre Company during the period 1988-91. The other was the Composite Material Twin Engine Aircraft Project for an 8-seat R&D aircraft developed by the Korea Aerospace Research Institute and Samsung (G.H, Jang, 1999, pp. 25-29).

In this stage, the Korean aviation industry seemed to have an opportunity to develop production technology by conducting large scale projects. However, those projects seemed to be provided to maintain the production of aircraft without a long-term development strategy when the existing programmes finished.

The stage of production capability development also seems to have been initiated in order to continue the production of aircraft, because the KFP project and UH-60 project were going to finish in 1999. In late 1999, the MOIR began to establish the Basic Plan for Aviation Industry Development, which would aim that Korea become a developed aviation industry country by 2015 through the independent development of small and middle sized civil aircraft, fighters and next-generation helicopters. Daewoo started to produce the KT-1, a basic trainer, in late 1999 after the success of developing the KTX-1 project. In addition, the KMOD decided to produce additional F-16s and begin the F-X project, relating to the production of a next-generation fighter for which an international collaboration partner will be selected by late 2001 (*Flight International* 31 March - 6 April 1999, p. 19).

In addition, aviation companies had plans to produce aircraft through international collaboration. Samsung began to produce the SB427, an 8-seat twin-engine light helicopter, with Bell in 1999 (*Monthly Aerospace Industry*, November 1997, p. 30), and Hyundai agreed to produce helicopters jointly with Kawasaki Heavy Industries (Hyundai, 1998). Currently three aviation companies, Samsung Aerospace, Daewoo Heavy Industries and Hyundai Space & Aircraft have merged into Korea Aerospace Industries Ltd (KAI) on October 1999, in order to achieve greater synergy from the consolidation (*Korea Herald*, February 23, 2000).[31]

The Korean aviation industry has been generated through government support and has developed in a short period to the extent that it can produce a light civil aircraft and military trainer. However, only a small number of aircraft development projects were provided by the government during over twenty years. Moreover, the projects were not provided consistently. New projects began to be prepared only when previous projects were about to finish. Hence, there was a four-year break in

[31] The KAI is presented detailed in the subsection of the Co-ordination System of this Chapter.

producing aircraft from 1988-1991, from the finish of the 500MD and the F-5 projects to the beginning of the F-16 and the UH-60 projects.

The government may need to provide aviation development projects consistently in order to avoid the ceasing of production activity, and to steadily implement a settled aviation development strategy. The Korean government announced aviation development strategies on two occasions, but they were not put into effect.

7.1.2 The Current Korean Aviation Industry

This sub-section presents the scale of turnover and trade, and the characteristics of the Korean aviation industry. The turnover and trade of the industry have shown a considerable increase, growing over 20 per cent per annum during the period 1985-96, although imports were much greater than exports (S.R, Lee, 1998, p. 173), as shown in Table 7.2.

Table 7.2 Trends in Turnover of the Korean Aviation Industry, 1985-1996

($ million)

	1985	1990	1996	Average annual increase
Turnover	86	212	971	24.1 %
Export	30	136	224	20.1%
Import	369	1,221	3,092	21.3%

Source: Seung-Ri, Lee, "IMF Era and Korea's Aerospace Industry", in *The Aerospace Article Edition*, 1998, Volume 26th, p. 173, the Korean Society for Aeronautical and Space Sciences.

In 1997, the production of completed aircraft represented a large percentage of the total turnover of the aerospace industry. Of a total turnover of $1,306 million, $587 million (45%) came from completed aircraft manufacture, $389 million (30%) from the manufacture of fuselage and avionics parts and material, $306 million (23%) from engine parts and $24 million from space related manufacture.

There were about 13,000 employees in four major aviation manufacturing companies and 39 small companies in 1997. Four major companies, namely, Korean Air, Samsung Aerospace, Daewoo Heavy Industries and Hyundai Space & Aircraft, dominate the Korean aviation industry. They accounted for 89 per cent of the investment and 91 per cent of the employees of all aviation companies (MOIR, 1999, pp. 21-22), as shown in Table 7.3.

Table 7.3 The Investments and Employees of Korean Aviation Companies in 1997

Companies	Employees (person)	Investment (Korean Won billion)
Samsung Aerospace	3,600	1,370
Korean Air	6,070	627
Daewoo Heavy Industries	1,420	605
Hyundai Space & Aircraft	765	325
Other 39 small companies	1,145	356
Total	13,000	3,283

Source: The Ministry of Industry and Resources (1999), *The Basic Plan for Aerospace Industry Development*, P. 22.

The Korean aviation industry seems to have a prosperous environment. It has various co-operative organisations. There are two aviation research institutes established by the government, and several research institutes established by the four major aviation companies, and aviation universities. The Korea Aerospace Research Institute (KARI) was established under the MOST in 1989 and the Agency for Defence Development (ADD) under the KMOD in 1970. Each major aviation manufacturing company has its own research institute. The KAL Aviation Technology Research Institute was established in 1978, the Samsung Aerospace Research Institute in 1987 and the Daewoo Space & Aviation Research Institute in 1988 (MOST, 1992, pp. 30-31). In addition, there are 15 departments relevant to aviation engineering in 11 universities (the Korean Society for Aeronautical & Space Sciences (KSASS), 1999, p. 20).

In addition, during the next two decades, the Asian region is predicted to have a larger demand for aircraft than any other region. Passengers will increase two fold with an annual growth rate of 6.6 per cent, which will be the highest in the world. The Asian region will also have the largest number of aircraft in the world, with 33 per cent of the total world aircraft, while the US will have 29 per cent and the

European countries 27 per cent (*Bimonthly Aerospace Industry*, May/June 1998, p. 33).

However, the aviation industry is much smaller than other manufacturing sectors in Korea. In 1999, it accounted for only 0.27 per cent of total turnover, 0.21 per cent of total export and 0.5 per cent of total employees of all manufacturing industries (MOIR, 1999, p. 20). It is much smaller than those of developed countries both in scale and technological capability. In fact, only one company, Samsung Aerospace, in 74th place with $480 million, was in the world's top 100 companies by turnover in 1997 (*Flight International* 2-8 September 1998, p. 60).

The Korean aviation industry's market share was also very small with 0.5 per cent of the world aviation industry's turnover in 1997, while the Korean shipbuilding industry accounted for about 30 per cent and the electronics industry for 9 per cent of the world market in their particular areas (MOIR, 1999, p. 23). Furthermore, in 1995, the manufacturing technological level for materials was only 10 per cent of that of developed countries, and that for avionics and bogie, design and test areas was 30 per cent. However, the manufacturing technology for fuselage and assembly areas was higher than for other areas (Gyeongsang University, 1995, p. 22), as shown in Table 7.4.

Table 7.4 Technological Capability of the Korean Aviation Industry

Area	Design	Test	Manufacturing Technology Area					Assembly
			Fuselages	Engines	Avionics	Bogies	Materials	
%	30	30	80	40	30	30	10	90

Source: Korea's Gyeongsang University (1995), *The Current Situation and Development Strategy of the Korean Aviation Industry*, p. 22.
Remarks: Percentage represents the technological level of the Korean aviation industry compared with that of developed countries.

The Korean aviation industry's production and technological capability is very low compared with that of the developed aviation industry countries, although it has a prosperous environment and capable organisations including research institutes, companies and universities.

The characteristics of the Korean aviation industry can be summarised as follows.

(i) It has the technological capability to produce at least small size aircraft, through independent aircraft developments and licensed aircraft productions. In addition, the development of the automobile, electronics and steel manufacturing industries can support the development of the aviation industry (G.D, Lee, 1997, pp. 54-55).

(ii) It can produce aircraft and gain profit from demand from domestic military and industry sectors (J.H, Lee, 1997, pp. 47-51).

(iii) However, the industry is not competitive in the world aviation market. Its production capability is lower than those of other developing countries including Brazil, Indonesia and Taiwan (KIET, 1994, p.104). In addition, it has a large deficit on trade (MOIR, 1999, p. 21)

(iv) Korea intents to develop the aviation industry, in order to establish a high technology industry and to maintain national security (C.S, Hong, 1997, pp. 13-14).

The Korean aviation industry seems to have the ability to produce small sized aircraft, although its development level is low globally, and the government has recognised the necessity of developing the aviation industry. It seems to develop highly in the future if more efforts are given in improving technological capability.

7.2 Korean Aviation Development Policy

This section aims to present co-operation, co-ordination and motivation systems adopted in implementing Korean aviation development policy. It is divided into the three sub-sections of co-operation, co-ordination and motivation systems.

7.2.1 The Co-operation System

The co-operation system is presented under two categories: one is the co-operation system adopted in the Korean government including co-operation programmes and organisations. The other is the co-operation system adopted in the Korean aviation industry including co-operation organisations, joint aviation development projects and international joint projects.

There are several co-operation programmes and organisations supported by the government. The Ministry of Science and Technology has established the Dual-Use Technology Programme, which aims to promote co-operation research between the civil and military organisations. This programme was initiated by an agreement between the MOST and the KMOD in 1995. To promote the programme, the Civil-Military Dual-Use Technology Project Promotion Act was passed in 1998, and forty dual-use technology R&D projects, including the Multi-Purpose Helicopter Development and Dual-Use Transport Aircraft Development projects, were selected in early 1999. Four ministries including the MOST the KMOD, the MOIR and the Ministry of Information and Communication (MOIC) have participated in this programme (MOST, 1999, pp. 3-14).

The MOST has also supported co-operation activity between research institutes and the aviation industry through the Specific R&D Project Management Regulation, which regulates the transfer of research performances and joint R&D in conducting the government-supported R&D Project. In addition, it established the Aerospace Component and Material Research Centre at the Changwon Branch of the Korea Institute of Machinery and Metals (KIMM) in 1997, in order to promote co-operation activity between the aviation industry, universities and aviation research institutes (*Bimonthly Aerospace Industry,* May/June 1998, p. 26). The KARI has conducted co-operation activities, such as the co-utilisation of R&D facilities and the provision of technological assistance for the aviation industry and advice on aviation technology development to the government (KARI, 1998, p. 8).

The MOIR has also supported co-operation activity for the development of the aviation industry. It established the Aerospace Component Development Research Centre at Hankuk Aviation University[32] in 1997, with the participation of the Small

[32] Hankuk Aviation University is a university dedicated to aviation engineering in Korea, and was established in 1965 as a four-year education college. It has nine departments relevant to aviation engineering including Aerospace Engineering, Air Transport, Materials Engineering and others (Hankuk Aviation University, 1997, p. 10, p. 24).

and Middle Sized Business Office and the Gyeonggido Provincial Office. The centre has conducted aviation R&D projects and transferred technologies it has developed (*Bimonthly Aerospace Industry*, May/June 1998, p. 34). In addition, the MOIR has co-operated with the Korea Aerospace Industries Association (KAIA) in establishing aviation industrial policy and selecting development projects. It provided the KAIA with projects, namely, the Survey on the Development of Low Pressure Turbine for a Small Size Jet-Engine in 1997 and the Survey on the Development of an Oil Pressure System for a Twin Light Helicopter in 1998 (*Bimonthly Aerospace Industry*, January/February 1999, p. 47).

The KMOD has co-operated with the aviation industry in developing aviation technology through the establishment of the Agency for Defence Development (ADD). The ADD has co-operated with Daewoo Heavy Industries and Samsung Aerospace in developing the KTX-1 and the KTX-2 projects (MOIR, 1999).

Regarding the co-operation system adopted the Korean aviation industry, several associations have been established between aviation companies and between aviation engineers. The Korea Aerospace Industries Association (KAIA) and The Korea Society for Aeronautical & Space Sciences (KSASS) have actively conducted co-operation activities for the development of the Korean aviation industry. The KAIA has held symposiums and workshops in order to effect the exchange of useful information between aviation manufacturing companies. It has held five meetings, including the Workshop for Component Supply Companies and the Offset Symposium in 1998, and has conducted a bridging role between government and industry.[33]

The KSASS has also held seminars and published papers in order to increase information exchange between member researchers and scholars. It held the Aerospace Technology and Industrial Policy Forum in 1997.[34] The Korea Aviation

[33] The KAIA was established in 1992, and had 40 regular member companies related to the manufacture of aircraft by the end of 1998 (*Bimonthly Aerospace Industry*, January/February 1999, pp. 47-51).

[34] The KSASS was established in 1967, and had about 1000 members including researchers and scholars in 1997, Aerospace Technology and Industrial Policy Forum, the KSASS, 1997, p.1.

Promotion Association (KAPA) was established in 1993 in order to promote co-operation between air transport companies. It has published the monthly 'Aviation News Line' and quarterly 'Aviation Promotion' (KAPA, 1998, pp, 103-105). The Korea Aeronautical Engineers' Association (KAEA) has also been in operation since 1992 in order to enhance co-operation activities between aeronautical engineers. Its roles are to provide the government with advice on aviation development policy and to increase co-operative relations between the government, industry and universities. In addition, it has published the monthly 'Aeronautical Engineering & Information' (KAEA, 1998, pp. 3-4).

In addition, several aviation development projects were collaboratively conducted with the participation of the industry, universities and research institutes. Two light aircraft projects were conducted with the participation of universities and aviation manufacturing companies. The Nare, a two-seater light aircraft, was jointly developed by the Geonkuk University and the Dongin Aviation Company in early 1994 (*Monthly Aerospace Industry*, August 1997, pp. 15-18). The Comet 21, a two-seater light aircraft, was also jointly developed by the Gyeongsang University and the Korea Light Aircraft Company in 1998 (*Bimonthly Aerospace Industry*, January/February 1999, p. 49).

The Changong 91 Project was conducted by the Aerospace Research Consortium consisting of the KARI, the KAL, the Samseon Industry Company and the Korea Fibre Company. The Composite Material Twin-Engine Aircraft Project was conducted by the KARI and Samsung. The KTX-1, the KTX-2 and the KFP projects were also jointly conducted with the participation of domestic aviation companies. Eight companies were participated in the KTX-1 project. Aviation development projects conducted by the participation with domestic aviation companies are shown in Table 7.5.

Table 7.5 Co-operative Aviation Development Projects

Joint Projects	Co-operation Companies		Order organisation (development period)
	Prime contractor	Co-operative companies	
Changong 91 (5-seat aircraft)	KARI	KAL, Samsun Industry, Korea Fiber	MOST ('88-'91)
The Composite Material Aircraft (8-seat aircraft)	KARI	Samsung	MOST ('93-97),
KTX-1 (Basic trainer)	Daewoo	Samsung, KAL, Hyundai, KIA, Korea Fiber, others.	KMOD ('88-'98)
KFP (F-16)	Samsung	KAL, Daewoo	KMOD ('84-'99),
KTX-2 (Advanced trainer)	Samsung	KAL, Daewoo, Lockheed Martin	KMOD ('97-'05),

Regarding international collaboration conducted by the aviation industry, Samsung Aerospace has jointly conducted the KTX-2 project with Lockheed Martin since 1997, and the SB427 helicopter project with Bell since 1996. Hyundai Space & Aircraft has also conducted the BK117 helicopter project with Kawasaki Heavy Industries since 1996, the MAKO project [35] with DASA since 1998 and Gas Turbine Engine Project with AlliedSignal since 1996.[36] Daewoo Heavy Industries established the Daewoo Institute of Science and Technology (DIST) in Moscow in 1994, in order to learn high aviation technologies from the Russian aviation industry (*Bimonthly Aerospace Industry*, January/February 1999, pp. 48-51).

In addition, the Korean aviation industry has supplied various aviation components to the US and European aviation companies including Airbus, BAe Systems, Boeing, Lockheed Martin and others. The major four Korean aviation companies' component supplies to overseas companies are shown in Table 7.6.

[35] An agreement for the development of the MAKO, a multi-purpose light fighter, was made between Hyundai and DASA in 1998, it was planed to begin the project in 1998, to have the first flight in 2003 and for production to begin in 2005 (*Bimonthly Aerospace Industry,* January/February 1999, p. 50).

[36] This information was gained from each company's information brochures published in 1998.

Table 7.6 Aviation Component Supply to Overseas Companies

Co-operation companies		Components for supplying to Overseas aviation companies	Contract	
Korea	Overseas		Year	Quantity
KAL	MD	Part of MD-95 fuselage	1994	50 parts
	Boeing	Wing Part of B737-300	1995	
	Airbus	Upper middle fuselage of A340	1998	$160 million
Daewoo Heavy Industries	Boeing	Wing rib of B747		
		Stretched upper deck frame of B747		
		Component of B777's tail wing	1998	500 parts
	BAe Systems	Wing of Hawk 100		
		Pylons and drop tanks of Hawk trainer	1991	72 parts
	Westland	Nose module for Lynx	1990	36 parts
		Lower structure of Lynx	1990	30 parts
	Airbus	Component of A340-600 wing	1998	$20 million
		Thrust reverser of A319/321		
	Lockheed	Outer wing P-3C Orion	1992	14 parts
Hyundai	MD	Main wing of MD-95	1994	
	Boeing	Main wing of B717-200	1996	
Samsung	Boeing	Wing component of B767-400ER	1998	
	Bell	SB 427 fuselage	1998	$300 million

Sources: Based on Korean aviation companies' Information Brochures and several Monthly Aerospace Industry.

The Korean government has made efforts to promote co-operation activities between the civil and military organisations through the Dual-Use Technology Development Programme. It has also supported co-operation activities through the establishment of regulations and organisations. The Specific R&D Management Regulation promotes technology transfer and joint R&D. The Aerospace Component and Materials Research Centre and the Aerospace Component Development Research Centre aim to support information exchange for the development of the aviation industry. At the same time, the industry has established several associations, such as the KAIA, the KSASS, KAPA and the KAEA, and conducted joint R&D domestically and internationally. However, few co-operation programmes seem to have been conducted between aviation companies and even less between the ministries concerned. Co-operation activities across the aviation industry's associations seem not to have been undertaken. In addition, international collaboration has been carried out in the limited range of joint development and of supplying aircraft components.

7.2.2 The Co-ordination System

This sub-section presents the co-ordination organisation and regulations put in place by the government, and consolidation conducted in the aviation industry. The Korean government has established the Aerospace Industry Development Policy Committee chaired by the Prime Minister, in order to co-ordinate a national aviation development strategy. The committee was established by the Aerospace Industry Development Promotion Act and consists of the ministers of the MOIR, the MOST, the KMOD, the MOIC and the Ministry of Finance and Economy (MOFE), as shown in Figure 7.1.

Figure 7.1 Co-ordination System for Korean Aviation Industry Development

- Aerospace Industry Development Promotion Act
  - Aerospace Industry Development Policy Committee
    - Prime Minister (chairman)
      * Overall co-ordination for aerospace development policy
      - Minister for Industry and Resources (MOIR)
        * Co-ordination of aviation development policy
        * Operation of the Policy Committee
        * Establishment and implementation of the Basic Plan
      - Minister for Defence (KMOD)
        * Procurement of military aircraft
        * Development of strategic weapons
        - Agency for Defence Development (ADD)
          * Technology development and co-operation
        - Korea Institute for Defence Analyses (KIDA)
          * Policy research on aircraft procurement and the defence industry development strategy
      - Minister for Science and Technology (MOST)
        * Space R&D policy co-ordination
        * Aerospace technology R&D support
        * Dual-Use Technology Programme
        * International collaboration
        - Korea Aerospace Research Institute (KARI)
          * Aviation technology R&D and co-operation
          * Policy research on technology development
      - Minister for Transport (MOT)
        * Air transport industry support policy
      - Minister for Information and Communication (MOIC)
        * Satellite technology development policy
      - Minister for Finance and Economy (MOFE)
        * Budget allocation for the aerospace industry development

Source: KARI (1996), *Study on Mid & Long Term Development Scheme of KARI*, p. 93.
Remarks: '*' indicates an organisation's major roles related to the aerospace industry.

Responsibility for co-ordinating the different opinions of ministries concerned to the aerospace industry was given to the MOIR by the Aerospace Industry Development Promotion Act. However, in the MOIR, the Aerospace Industry Division was combined with the Transport Machinery Industry Division in 1999. Currently affairs related to national aviation development policy are the exclusive responsibility of three officials in the MOIR, and national space policy is the exclusive responsibility of one official in the MOST. A total of only four government officials seems to be a very small number to be responsible for establishing and implementing national aerospace development policy through a proper co-ordination activity with other ministries and industry. There was a significant case of delay in formulating aviation development policy. The first Policy Committee met in 1997 and decided to establish the Basic Plan for Aviation Industry Development.[37] However, the plan was not established until the end of 1999 (MOIR, 1999). The second Policy Committee met in April 1999 and again discussed the establishment of the Basic Plan.

There seem to have been difficulties in establishing the Basic Plan, because its implementation requires huge funds, which is separately funded by different ministries, and because the changed Korean economic situation resulting from the economic crisis at the end of 1997 also influenced the aviation industry. It seems that the MOIR needs to undertake a high standard of co-ordination activity in order to establish a feasible policy.

The MOIR is charged with establishing the Ordinance[38] for the development of the aviation industry by the Aerospace Industry Development Promotion Act, which states that the MOIR should establish and implement the Ordinance every year through discussion with the ministries concerned. However, the establishment of the Ordinance has been delayed by the disagreement between ministries. In fact, the MOIR wanted the KMOD to invest as much as possible for the development of the

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[37] The 3rd article of the Aerospace Industry Development Promotion Act gives the MOIR an obligation to establish the Basic Plan for the Aerospace Industry Development.

[38] In the regulation system, Korean aviation development policy is represented by the Aerospace Industry Development Promotion Act, the Basic Plan, the Ordinance and the aviation development strategy. The MOIR is required to establish the Basic Plan by the Promotion Act, and it should establish and implement the Ordinance every year on the basis of the Basic Plan. The aviation development strategy is proposed in the Basic plan (MOIR, 1999).

industry through the procurement of domestically produced aircraft. In contrast, the KMOD might need to keep national security by purchasing advanced aircraft from overseas.

According to the Aviation Industry Development Strategy (a draft) established by the MOIR in 1999 (MOIR, 1999, pp. 35-42), the Korean aviation industry would have the capability of aircraft design and production by 2005, through the production of major components of aircraft, advanced trainers and multi-purpose helicopters. In addition, the industry would have independent aviation design, production, business management and integral technology capabilities by 2015, through the development of small and middle aircraft, fighters and next-generation helicopters. The strategy can be summarised as follows:

(i) The establishment of infrastructure for the development of aircraft components and materials, through improving information exchange, supplying manpower and reducing transition costs.
(ii) The establishment of an efficient production system through the setting up of a united company.
(iii) The establishment of an efficient R&D system through the link between the KARI, the ADD and other related research institutes.
(iv) The creation of aircraft demand for the development of the aviation industry.
(v) The establishment of an integrated implementation system through the regular holding of the Policy Committee and the Operation Committee, and through task force team which would be established if it is necessary (MOIR, 1999, pp. 53-60).

An effective co-ordination activity seems not to have undertaken between ministries concerned. That might be a reason for the delay in the establishment of the Basic Plan. Co-ordination may be very important for the ministries concerned to develop the Korean aviation industry.

Regarding the consolidation of the industry, in October 1999, the three major aviation companies, Samsung Aerospace, Daewoo Heavy Industries and Hyundai Space & Aircraft merged into a single company called Korea Aerospace Industries Ltd. (KAI). The three companies agreed to merge in September 1998. In addition, the Korean government also agreed to the merger plan and decided to provide the consolidated company with aviation development projects (MOIR, 1999, *Korea Herald*, February

23, 2000). KAI was expected to achieve $700 million of annual sales with 3,200 employees (*AW & ST*, June 21, 1999, p. 31). It aims to enhance efficiency in researching and producing aircraft and to solve the problem of the lack of demand for aircraft, through the avoidance of over-competition between domestic aviation companies. KAI also expects to conduct all projects established by the government, including the KT-1, the KTX-2 and the F-X projects (Consolidation Office, May 1999, pp. 1-2), and said that it would be able to emerge as one of the world's top 10 aircraft makers by 2010 with $3 billion in sales (*Korea Herald*, February 23, 2000).

On the other hand, the attraction of overseas investment up to 30 per cent (about $167 million) of the total stake has been delayed, partly because of the link between KAI and Lockheed Martin in producing the F-16, the KT-1 and the KTX-2 (*Flight International* 15-21, February 2000, p. 59). KAI seems to need to establish business stability in securing orders for aircraft and development funds from the government and overseas. It may also need to make Korean Air Aerospace participate in the new future entity.

There are co-ordination organisations and regulations that have been put in place by the government. In addition, the major aviation companies have been merged. It seems that the Korean aviation industry is establishing a foundation from which to develop for the future. However, the Korean government seems to have conducted the lower level of co-ordination activity, due in part to the unsatisfactory working conditions for the officials exclusively responsible for aviation development policy. Inconsistency in conducting aviation policy may be a barrier to conducting an effective co-ordination activity. The steady implementation of co-ordination programmes once established seems to be very important for the Korean government in order to develop the aviation industry.

7.2.3 The Motivation System

This sub-section discusses present government supports for the Korean aviation industry. It examines aviation projects including aviation production, development and component R&D projects provided by the government.[39]

The government has provided the aviation industry with several aviation projects. The KMOD provided five projects which have already been finished, namely, four production projects relating to the 500MD, the F-5, the UH-60 and the KFP, and one development project for the KTX-1. It has provided two projects being currently conducted, project for the development for the KTX-2 and the project for the production of the KT-1 (*International Flight* 2-8 September 1999, pp. 86-88).

The KMOD decided to provide the industry with two future projects, the project for the production of the KT-2 and the project for the development of the K-X planned to produce about 120 next-generation fighters. The MOST also provided two development projects, namely, the Changong 91 and the Composite Material Twin-Engine Aircraft projects. However, the aviation development projects provided by the government seem to be very small in scale. In fact, in over twenty years, the Korean government has provided the aviation industry with only nine aviation projects, although it plans to provide a further two projects (*Flight International* 15-21 February 2000, p. 66), as shown in Table 7.7.

It seems that the government needs a strong support to the industry through the provision of more aviation development projects. Currently only two projects provided by the KMOD have been conducted. One is KT-1 production project which began to produce in late 1999, and other is KTX-2 development project. Moreover, the MOST and the MOIR do not provide any projects to develop a complete aircraft.

[39] For the purpose of this study, aviation projects provided by the government will include production, development and R&D projects. Here, production project means a project to produce complete aircraft, a development project means a project to develop a complete aircraft, and an R& D project means a project to develop aviation technology.

Table 7.7 Aviation Projects Provided by the Government

Order ministry	Characteristics of project	Name of Project	Scale of project	Period of project
KMOD	Licensed Production	500MD	200 military helicopters 22 civil helicopters	'76-'88
		F-5	70 aircraft	'80-'86
		KFP (F-16)	120 aircraft *($5,200 million)	'84-'99
		UH-60	*($110 million)	'91-'99
	Independent Development	KTX-1		'88-'98
		KTX-2	($1,270 million)	'97-
		K-X	120 aircraft	'01-
	Independent Production	KT-1		'99-
		KT-2	600 aircraft ($20,000 million)	'05-
MOST	Independent Development	Changong 91	($5 million)	'88-'91
		Composite Aircraft	*($43 million)	'93-'97

Remarks: '*' indicated project costs by US$ which exchanged from Korean Won by an exchange rate of 1,000 Won/$.

Regarding aviation R&D projects provided by the government, the R&D projects have mainly been provided by the MOST and the MOIR. In addition, most of the projects have been given to the KARI, which is only one exclusive aviation research institute established by the government. R&D projects conducted by the KARI can be divided into aviation and space technology R&D projects according to their technological area. They are also classified into the Specific R&D Project, the Organisation Essential R&D Project, the Industrial Infrastructure Technology R&D Project and the Trust R&D Project according to the sponsor of R&D projects.

The Specific and the Organisation Essential R&D Projects are funded from the MOST, and comprised 86 per cent of the KARI's total R&D budget in 1998. The Specific R&D Project is a project of which research area has been selected by the MOST according to the government's technology development strategy, but the Organisation Essential R&D Project is a project of which area has been decided by the KARI's technology development strategy (KARI, 1998-1). The Industrial Infrastructure Technology R&D Project has been funded and its R&D area has been decided by the MOIR according to the MOIR's industrial technology development strategy, it was funded KW9,056 million in 1998, comprising 18 per cent of the KARI's total R&D budget. The Trust R&D Projects was funded and their R&D areas have been decided mainly by the non-government organisations including the Korean

Telecommunication Company and the Korea Development Institute, they were funded by KW1,404 million in 1998, with 3 per cent of the KARI's total R&D budget (*Monthly Aerospace Industry*, March 1997, pp. 24-27, KARI, 1998-1).

There was a greater increase in the KARI's R&D funds between 1989 and 1997.[40] The annual rate of increase of R&D budget was 150 per cent during the period 1989-1995. In 1998, however, the budget sharply decreased to 65 per cent of the 1997 R&D budget, as shown in Table 7.8.

Table 7.8 R&D Budget Trend of the KARI, 1989-98 (Korean Million Won)

Year	1989	1992	1995	1997	1998
Specific R&D Projects	1,070	2,964	25,751	47,864	30,348
Organisation Essential R&D Project	-	628	724	8,997	8,089
Industrial Infrastructure Technology R&D Project	10	650	5,585	15,913	9,057
Trust R&D Project	10	2,043	2,604	2,340	1,404
Total	1,090	6,285	34,664	75,114	48,898
Annual rate of change	-	150%	150%	58%	-35%

Source: KARI (1998-1), R&D Project Contract Data.

There two reasons for such R&D budget decrease between 1997-98. One was the decision of the government to stop projects in 1998. In particular, the Middle Sized Aircraft Development Project worth KW 3,700 million was abandoned by the MOIR due to the lack of economic benefit. In addition, the MOST's several projects were also stopped. It was a big disappointment to the aviation industry.[41] The other reason was the influence of the Asian economic crisis, which influenced the Korean government to reduce aviation R&D funds.

A large number of the KARI's R&D projects were one-year projects in 1997, which were only funded for a year. They represented 64 per cent of total aviation projects. The duration of all the multi-year projects was also short lasting two or three years. Such a short research term may imply instability of research activity, because researchers may be in an unstable situation and thus have difficulty in predicting the

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[40] In 1989, the KARI was established following the government decision to support the development of the aviation industry more actively. In 1997, the Asian region economic crisis happened and it strongly influenced the government to reduce the R&D budget.

R&D projects they will be conducting next year, and because the high performance of advanced aviation technology R&D seems to be difficult in the short term in principle. In fact, one-year R&D projects were very unstable, and were considerably reduced in 1998 with the impact of the Asian region economic crisis, while multi-year projects were not reduced, as shown in Table 7.10.

Table 7.9 Research Period of the KARI's Aviation R&D Project, 1997-98

(Number of project)

Classification of project	1997			1998		
	Multi-year	Single-year	Total	Multi-year	Single-year	Total
Specific R&D Projects	3	7	10	3	0	3
Organisation Essential R&D Project	3	6	9	2	3	5
Industrial Infrastructure Technology R&D Project	1	2	3	2	3	5
Trust R&D Project	2	1	3	2	4	6
Total	9	16	25	9	10	19

Source: KARI (1998-1), R&D Project Contract Data.

The Korean government's motivation activities for the development of the Korean aviation industry seem to be very low. In fact, during over twenty years, four independent development projects, four licensed production projects and one independent production project were provided by the government. Currently only two projects have been conducted. Such a small number of projects may not maintain the development of the industry. Furthermore, aviation R&D projects have now been sharply reduced. To improve aviation production capability, the government should motivate the industry through provision of more projects which develop and product complete aircraft.

7.3 The Experts' View of Korean Aviation Development Policy

Korean aviation development systems were previously examined. What then is the view of Korean policy experts about Korean aviation development policy? This section aims to discuss that view through the examination of suggestions in articles

[41] Interviews with officials in the MOIR and the KAL Aerospace Division in May 1999.

and policy research reports written by policy experts. This will be helpful in understanding Korean aviation technology policy.

24 publications were chosen in order to examine the views of experts, which consist of 18 articles and 6 policy research reports, as shown Table 7.12. They include 7 publications written by experts in government, 8 in research institutes, 6 in universities and 3 in the industry. Through analysing these publications, 106 suggestions were identified, consisting of 38 suggestions for co-operation, 42 for co-ordination and 26 for motivation, as shown in Table 7.10.

Table 7.10 The Number of Publications and Suggestions

Category		Total	Government	Research Institute	University	Industry
Sampled Publications	**Articles**	18	3	6	6	3
	Research reports	6	4	2	-	-
	Total	24	7	8	6	3
Number of Suggestions	**Co-operation**	38	13	14	7	4
	Co-ordination	42	12	13	15	2
	Motivation	26	9	11	3	3
	Total	106	34	38	25	9

38 suggestions for co-operation are classified into 6 policy options, 42 suggestion for co-ordination into 10 policy options and 26 suggestions for motivation into 4 policy options, as follows.

❑ Policy options for co-operation

(1) The establishment of an efficient co-operation system.
(2) Co-operation between the ministries concerned and between industry, universities and research institutes.
(3) Management of information.
(4) Links with other industries.
(5) International collaboration.
(6) Improvement of indigenous technology capability.

❑ Policy options for co-ordination

(1) The establishment of an overall co-ordination organisation.
(2) A long term plan and government involvement in the development of the aviation industry.
(3) Strategic promotion of the industry and the utilisation of existing manufacturing facilities.
(4) The co-ordination of the regulations concerned.

(5) The establishment of manufacturing infrastructure and the continuous provision of aviation development projects.
(6) The co-ordination of the role of each ministry concerned and co-ordination between research institutes.
(7) The government's involvement in a consolidated aviation company.
(8) The maintenance of consistency in implementing a concrete aviation development plan.
(9) The improvement of the capability of officials engaged in aviation development.
(10) The establishment o efficient working conditions.

❑ **Policy options for motivation**

(1) Development funding support including tax reductions.
(2) Personnel development including training.
(3) The establishment of an investment environment including deregulation in order to increase the use of aircraft.
(4) Industrial rationalisation including consolidation.

In experts' suggestions for co-operation, the largest proportion of the suggestions is the establishment of an efficient co-operation system. The second largest is co-operation between the ministries concerned and between concerned organisations, and the third is international collaboration. In suggestions for co-ordination, the largest proportion is a long term plan and determined willingness of the government. The second largest is the implementation of a concrete enforcement plan and the maintenance of policy implementation. Finally, suggestions for motivation, the largest proportion is the rationalisation of the industrial structure including the consolidation of aviation companies represents, as shown in Table 7.11.

Table 7.11 Policy Options Suggested by Policy Experts

(the number of policy options suggested)

Options	Policy options for Co-operation							Policy options for Co-ordination											Policy options for Motivation				
Experts	1	2	3	4	5	6	T	1	2	3	4	5	6	7	8	9	10	T	1	2	3	4	T
Govern-ment	4	5			3	1	13		5	3		3			1			12	3	3		3	9
Research Institute	4	2	1	2	2	3	14	1	4	2		3	1	1		1		13	4	3	1	3	11
Univer-sities	3	1			2	1	7	1	4	3	1	1	1		3		1	15		1		2	3
Industry	2	1			1		4		1	1					2			4	1			2	3
Total	13	9	1	2	8	5	38	2	14	9	1	7	2	1	6	1	1	42	8	7	1	10	26

Remarks: 1 ~ 6 in the policy options for co-operation column indicate that the kind of policy options suggested for co-operation which presented above. That is, 1 represents the establishment of an efficient support system in the front page. T stands for total.

The number of suggestions for co-ordination is largest, and those concerning co-operation and motivation followed, with 40 per cent for co-ordination, 36 for co-operation and 24 for motivation. Policy experts seem to have the views that the Korean government need to strengthen co-ordination and co-operation and co-ordination activities than motivation activities in undertaking aviation development policy. By organisations, the number of suggestions for co-operation accounted for largest percentage in the case of policy experts in the government, research institute and the industry, but that for co-ordination accounted for largest percentage in the case of policy experts in universities.

The number of suggestions for co-ordination appeared to be the largest, although the government has the Committee and the Act for an efficient co-ordination as mentioned before. However, the number of suggestions for motivation was smallest in spite of the fact that the government has conducted a lower level of motivation activity. Policy experts seem not have focused on motivation issues. The government may need to strengthen co-operation and co-ordination activities and to focus on motivation activity in order to develop the Korean aviation industry.

Table 7.12 The Composition of Sampled Publications

	Name	**Organisation**	**Classification**	**Title of Publications**
G-1	S.Y, Son	Ministry of Construction	Article	National Affairs for Aviation Technology Development, in Aeronautical Engineering & Information, KAEA (ed.), July 1998, pp. 2-4.
G-2	W.G, Lee	MOIR	"	Development Strategy for the Korean Aviation Industry, in Symposium for the Aviation Industry Development, Gyeongsang University (ed.), 1995, pp. 29-37.
G-3	J.H, Lee	Korean Air Force	"	The Establishment of a Strategic Air Force and the Demand in Aerospace, in Forum Article Edition, KSASS, 1997, pp. 47-51.
G-4	Y.S, Ahan	KIET	Policy Research Report	The Comparison of the Korean and American Aviation Industry, in the 20th industry/ Government Co-operation Meeting for New Industry Development, MOIR (ed.), 1996, pp. 11-22.
G-5	-	MOST	"	A Mid and Long Term Development Plan for the KARI, 1996, pp. 103-106.
G-6	-	MOST	"	The Long Term Vision of the Aviation Industry, 1995, pp. 20-25.
G-7	-	MOST	"	The long Term Plan for Science and Technology Development in the 2010s (Large Scale Composite Technology Part), 1994, p. 30.

R-1	C.S, Hong	KAIST	Article	The Korean Aviation Industry and its Affairs, in Monthly Aerospace Industry, KAIA (ed.), June 1996, pp. 12-18.
R-2	S.B, Kim	KIDA	"	An Offset Strategy for the Korean Aviation Industry, 1998, pp. 24-25.
R-3	S.R, Lee	KARI	"	IMF Era and Korea's Aviation Industry, in Aerospace Article Edition, KSASS (ed.), 1998, pp. 167-177.
R-4	Y.S, Ahan	KIET	"	The Analysis of and Development Strategy for the Spin-Off Effect of the Korean Aviation Industry, in Monthly Aerospace Industry, KAIA (ed.), August 1997, pp 10-14.
R-5	H.M, Kim	KIMM	"	Development Strategy for the Aviation Component Industry, in the Symposium for Aviation Industry Development , Gyeongsang University (ed.), 1995, pp. 67-85.
R-6	D.J. Hwang	ADD	"	Will the F-16 and the UH-60 Projects follow the Same Production Ways of the F-5 and 500MD Projects? in Monthly Aerospace Industry, KAIA (ed.), May 1997, pp. 12-21.
R-7	-	KIET	Policy Report	The Vision and Development Strategy for the 20th Century Korean Aviation Industry, pp500-503.
R-8	-	KARI	"	Overall Mid and Long Term Development Plan for Aviation Technology Development, 1993, pp. 184-187.
U-1	D.H, Lim	Inha University	Article	The Aviation Industry's Structure Development Strategy harmonising with IMF Era, in Aeronautical Engineering & Information, KAEA (ed.), July 1998, pp. 8-12.
U-2	D.H, Lee	Seoul National University	Article	The Korean Aviation Industry Standing on Cliff, in Bimonthly Aerospace Industry, KAIA (ed.), 1998 5/6, pp. 14-16
U-3	H.Y, Her	Hankuk Aviation University	"	The Korean Aviation Industry Standing at a Crossroad, in Monthly Aerospace Industry, KAIA (ed.), July 1997, pp. 12-17.
U-4	M.G, Joo	Sejong University	"	National Strategy against Aerospace Revolution, in Forum Article Edition, KSASS, 1997, pp. 59-63.
U-5	S.J, Lee	Gyeongsang University	"	The Gyeongnam Provincial Region' Specific Industry-the Aviation Industry, in Symposium for Aviation Industry Development, Gyeongsang University (ed.), 1995, pp. 89-107.
U-6	G.D, Lee	Illinois University	"	The Korean and American Co-operation in the Aviation Industry, in Forum Article Edition, KSASS, Spring 1997, pp. 53-57.
I-1	Y.H, Baek	The Society for the Defence Industry	"	National Development and the Aerospace Industry, in Forum Article Edition, KSASS, Spring 1997, pp. 5-15.
I-2	J.G, Lee	Samsung	"	The Korean Aviation Industry Preparing for the 21st Century, in Forum Article Edition, KSASS, Spring 1997, pp. 24-32.
I-3	Michael Cannon	Scotland Investment Office (Asian/Pacific Region)	"	Suggestions for the Future Korean Aviation Industry, in Monthly Aerospace Industry, KAIA (ed.), pp. 26-29.

Remarks: G stands for an expert working in government, R an expert working in research institute, U an expert in university and I an expert in the industry.

7.4 Conclusion

This section falls into two parts: one is to summarise co-operation, co-ordination and motivation systems adopted in Korean aviation technology policy; and the other is to discuss the implications of the Korea CCM systems for Korean aviation industry development.

The Korean government has made efforts to improve co-operative activity between the ministries concerned and between the research institutes, universities and the aviation industry. It established the Aerospace Component and Material Research Centre and the Aerospace Component Development Centre, and has conducted the Dual-Use Technology Programme. It has also required research institutes to conduct R&D projects jointly with the aviation companies. Universities and the industry have co-operated in developing aviation technology, they jointly made two light aircraft. In addition, the industry has established several associations and conducted joint R&D and production projects.

The government has co-ordination organisations and regulations for the purpose of co-ordinating the different opinions of ministries and the industry. In addition, major three aviation companies have been consolidated currently.

It has also made efforts to motivate the research institutes and the aviation industry, by providing them with several aviation R&D, development and production projects. These are the four procurement projects relating to the 500MD, the F-5, the KFP and the UH-60, the three independent development projects relating to the Changong 91, the Composite Material Twin Engine Aircraft and the KTX-1, and the two international joint development projects relating to the KTX-2 and the KT-1. In addition, the government has plans to provide the two aviation projects relating to the K-1 and the KT-2 project. However, the number of the projects seems to be insufficient for the development of the aviation industry.

The CCM systems adopted in conducting Korean aviation development policy can be summarised as Table 7.14.

Table 7.13 Korean Aviation Technology Development Systems

Systems	Organisations	Classification	Name of System	Managing Organisation
Co-operation System	Government	Programme	The Dual-Use Technology Programme	MOST
		Regulation	The Specific R&D Project Management Regulation	MOST
		Organisation	The Aerospace Component and Material Research Centre	MOST
			The Aerospace Component Development Centre	MOIR
		R&D project	Survey projects to the KAIA	"
	Industry (University)	Association	Korea Aerospace Industry Association (KAIA)	
			Korean Society for Aeronautical & Space Sciences (KSASS)	
			Korea Aviation Promotion Association (KAPA)	
			Korean Aeronautical Engineers' Association (KAEA)	
		Joint project (University/ industry)	The Nare, a two-seater aircraft (Geonkuk University/ Dongin Aviation Companiy)	
			The Comet 21, a two-seater aircraft (Gyeonsang University/Korea Light Aircraft Co.)	
		Joint project (between companies)	The Changong 91 (3 Companies' participation)	MOST
			The Composite Material Aircraft (KARI, Samsung)	MOST
			The KTX-I project (7 companies' participation)	KMOD
			The KTX-2 project (14 companies' participation)	KMOD
	International Collaboration	Licensed Production	The 500MD, F-5, KFP, UH-60 projects	KMOD
		Joint project	The KTX-2 project	KMOD
			The BK117 helicopter (Kawasaki)	Hyundai
			The Mako fighter (DASA)	Hyundai
			The SB427 helicopter (Bell)	Samsung
Co-ordination System	Government	Organisation	The Aerospace Industry Development Policy Committee	MOIR
		Regulation	The Aerospace Industry Development Promotion Act	MOIR
			The Basic Plan	MOIR
			The Ordinance	MOIR

	Industry	Merger	Korean Aerospace Industries. Ltd. (KAI)	
Motivation System	Government	Procurement Project	The 500MD, F-5, KFP, UH-60 projects The F-X project	KMOD
		Development Project	The KTX-1, the KTX-2 projects	KMOD
			The Changong 91, The Composite Material Aircraft projects	MOST
		R&D project	The Specific R&D project	MOST
			The Organisation Essential R&D Project	MOST
			The Industrial Infrastructure Technology R&D Project	MOIR
			The Trust R&D Project	Others

The implications of the Korean CCM systems already presented will now be summarised.

Firstly, a low level of co-operation activity has been conducted between the ministries concerned and between the government, research institutes, universities and the industry in undertaking aviation development policy, although several co-operation programmes and organisations have been established. It seems that a high level of co-operation activity is very important for Korea in implementing aviation development policy. For achieving the high level co-operation, the Korean government seems to undertake following activities:

(i) Check and remove barriers in achieving an efficient co-operation system.

(ii) Study and support to establish the high level of co-operation relation between the ministries concerned and between the government, research institute, university and the aviation industry, through the support for an active information flow.

(iii) Support more fruitful international collaboration on the basis of developing indigenous technological capability.

(iv) Encourage the aviation industry to make links with other developed industries including the electronics, steel manufacturing and auto mobile industries, in order to improve itself.

Secondly, the ministries concerned seem not to have undertaken a high level of co-ordination activities, although authority to conduct co-ordination activity for aviation industry development has been given to the MOIR by the Aerospace Industry Development Promotion Act, and although the Aerospace Industry Development Policy Committee has the capability to co-ordinate different situations between ministries concerned. The MOIR may need to establish more concrete programmes to conduct a high level of co-ordination activity, as most of the aviation industry countries have strongly involved in improving co-operation activities between organisations concerned. For the efficient implementation of a co-ordination system, the government may need to undertake following activities:

(i) The MOIR needs to be determined in adopting a long-term development strategy to develop the aviation industry and involve itself with confidence in that development, avoiding *laissez-faire* approach.
(ii) The strategic approach is needed in order to gain competitiveness in the world aviation market, recognising the situation of the Korean aviation industry including its technological level, production capability and existing domestic R&D and production facilities.
(iii) The role of each ministry, research institute and industry should be determined, and unnecessary overlapping and over competition between the ministries concerned, between research institutes and between aviation manufacturing companies should be removed, in order to achieve efficient R&D and production systems.
(iv) The implementation of aviation development policy should have consistency through concrete and feasible development strategy.
(v) The government should study and reduce the barriers to officials achieving a high level of co-ordination for aviation industry development.

Finally, the government seems not have supported the aviation industry to do their best in improving aviation technological capability. It has not provided sufficient projects for developing technology. Currently aviation R&D budget has sharply decreased. To achieve a high level of motivation, the government may need to adopt a determined attitude in conducting aviation development policy in consideration of following aspects.

(i) The KMOD should support the aviation industry to develop through the consistent procurement of aircraft the industry produced.

(ii) The MOST and MOIR should establish several projects to develop complete aircraft, and enlarge the KARI's R&D funding.

(iii) The government needs to find feasible policy achieving a high level of communication between officials working in the ministries concerned and between governmental officials and policy managers in research institutes or in the aviation industry.

(iv) It needs to develop personnel through training.

Chapter 8
Survey of Korean Aviation Technology Policy

Earlier chapters have argued that co-operation, co-ordination and motivation are important factors in and identified several possible lessons for the efficient implementation of Korean aviation technology policy. However, to recommend policy options, it is desirable to have primary data and, to understand the context of policy in Korea. With this purpose in mind, this study included surveys to gather new data about Korean aviation technology policy. This chapter presents this empirical work and consists of three sections: survey design; analysis of survey results; and the recommendation of policy options.

8.1 Survey Design

This section is divided into the two sub-sections: the introduction of survey and the analytical method. The introduction presents the survey's purpose, area, method and sample, followed by the analytical method to analyse the results.

8.1.1. The Survey

The survey has aimed to gain practical data related to the implementation of Korean aviation technology policy and to understand its context, through original fieldwork, using a combination of questionnaires and interviews. It also aimed to underpin recommendations for policy options.

The survey focused on three aspects: Firstly, the three factors of co-operation, co-ordination and motivation were explored. Secondly, the three or four elements of the CCM factors were used in the questionnaires in order to gain concrete data on the degree of the CCM activities. Finally, the priorities for and impediments to the efficient implementation of the policy were explored, in order to help identify policy options.

The research design included a written questionnaire, and face-to-face interview. The written questionnaire was used to gather quantitative data, and the interviews were used to complement the quantitative data by adding qualitative information. The respondents of the survey consisted of researchers and policy managers, for they were closely related to the implementation of aviation technology policy.

The questionnaire, given to a sample of researchers, comprised questions asking the degree of the CCM activities, the performance and contribution of each element of the CCM factors, and the order of priorities for or impediments to the efficient implementation of Korean aviation technology policy. Questions about the CCM activities, and the priorities or impediments, asked about their degree or order from the general point of view of the implementation of the policy. However, questions to the elements asked each respondent to reflect upon their "main projects", that is, the main project that was carried out by each respondent's research team over the last three years (May 1996 to June 1999). The composition of questions in the questionnaire is shown in Table 8.1. The full questionnaire is given in Annex 5.

The interviews, with a sample of policy managers, were conducted through structured questions and open discussions. The structured interview asked about the degree of the CCM factors and the order of impediments to the CCM activity in implementing aviation technology via written questions. It was conducted for the purpose of gathering data on a consistent basis. Open interviews, on the other hand, aimed to understand the background of Korean aviation technology policy, via free discussions.

There were two samples of respondents: one for written questionnaires and one for interviews. Firstly, the sample for questionnaires was selected from researchers working in the five major aviation research institutes in Korea. Those included one government supported research institute, the Korea Aerospace Research Institute, and the four business research institutes which were established by four major aviation manufacturing companies, such as Korea Air, Daewoo Heavy Industries Ltd, Hyundai Space & Aircraft Co, and Samsung Aerospace Industries Ltd. Hence. Those five research institutes cover all the major aviation research institutes in Korea.

The sample for interviews was chosen from policy managers undertaking the planning affairs related to aviation technology development in relevant organisations, such as the ministries concerned, aviation research institutes, aviation companies and a university. The interviews were also carried out with most of relevant organisations.

Table 8.1 Questions of the Questionnaire

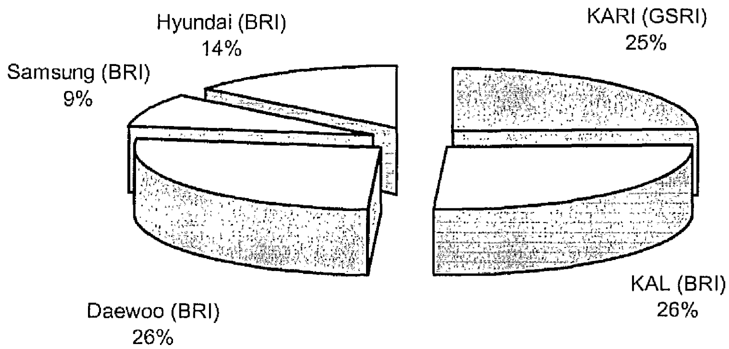
Classification of elements	Contents of elements	Number of questions	Major questions
Elements of Co-operation	Holding of Seminars	4	Performance, contribution
	Dissemination of R&D results	5	"
	Conduct of joint R&D projects	6	"
	International collaboration	13	"
	Total	28	
Elements of Co-ordination	Short-term rotation of officials	4	Frequency, impediment
	Resolution of conflicts	6	Resolution, impediment
	Survey of technology development trends	4	Performance, contribution
	Total	14	
Elements of Motivation	Participation in decision-making processes	2	Degree
	Incentive systems	3	Satisfaction
	R&D evaluation systems	1	"
	Trust relations	7	Performance, contribution
	Total	14	
Other Questions	Degree of the CCM activities	9	R&D results
	Priorities for the CCM activities	3	
	Impediments to the CCM activities	4	
	Total	16	
	Grand total	72	

In terms of the number of respondents, the questionnaires were sent to the five major aviation research institutes, which covers all the major ones in Korea. 15 questionnaires were sent to a policy manager[42] in each of the five research institutes, and each policy manager was requested to distribute 5 questionnaires to each of the three ranks of researchers, namely, high, middle and low rank researchers, in order to

[42] The lists of policy managers, undertaking the planning affairs related to national aviation development policy in organisations concerned, were gained through interviews for the pilot survey on Korean aviation technology policy, with Jin-Young, Hwang, a policy manager in the KARI, on July 1998.

collect data equally from the three ranks. 57 responses were useable,[43] of which 14 respondents came from the KARI, 15 each from Korea Air (KAL) and Daewoo Heavy Industries Ltd, 8 from Hyundai Space & Aircraft Co, and 5 from Samsung Aerospace Industries Ltd. 75 per cent of the respondents for the questionnaires came from 4 Business Research Institutes (BRIs) and 25 per cent from one Government-Support Research Institute (GSRI), as shown in Figure 8.1.

Figure 8.1 Composition of Sample for Questionnaires



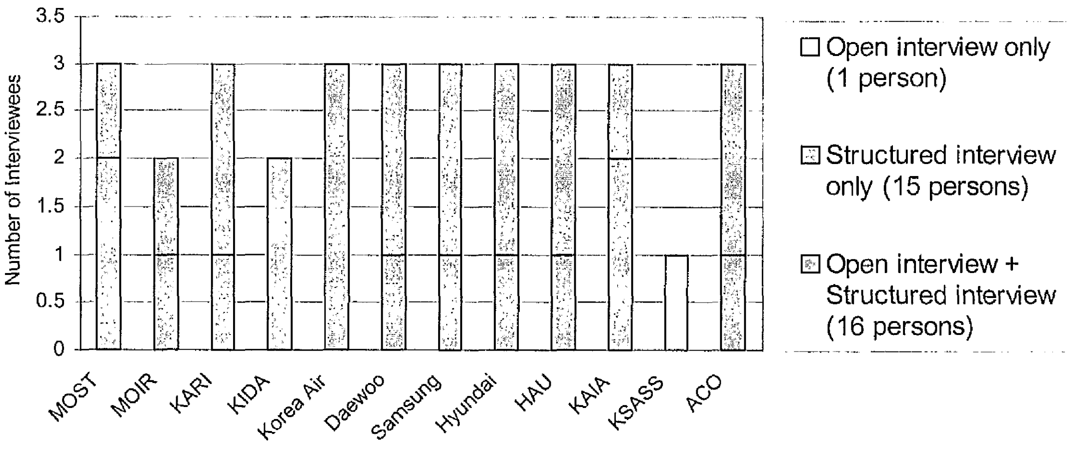
Secondly, with regard to the sample for interviews, 32 interviewees were policy managers working in the 12 major organisations which covered most of organisations concerned with the development of Korean aviation technology. 16 out of them were interviewed together with the structured interview and open discussion, most of them were recommended as open interviewees by J.Y, Hwang, a policy manager in the KARI, who has been involved in the aviation development policy affairs since 1992. In addition, 15 of them with structured interview, and 1 with open discussion. Details of the interviewees for open discussion and its schedule are shown in Annex 7.

Of the 32 interviewees, 3 each were selected from 9 organisations, including the MOST, the KARI, Korea Air, Daewoo, Samsung, Hyundai, Hankuk Aviation University (HAU), the KAIA and the Aerospace Consolidation Office (ACO), 2 each from the MOIR and the Korea Institute for Defence Analyses (KIDA), and 1 from the Korean Society for Aeronautical & Space Sciences (KSASS). In the case of 16

[43] This is 85 % of the total questionnaires of 75 (5 research institutes x 15 questionnaires). 15 % (18 respondents) was not relevant, because they worked in the area of space (not aviation) technology.

interviewees together with the structured interview and open discussion, 3 chosen from Korea Air, each 2 from the MOST, the KIDA and the KAIA, and each 1 from 7 organisations, as shown in Figure 8.2.

Figure 8.2 Composition of Sample for Interviews



8.1.2 Analytical Method

This sub-section presents the analytical approach. As mentioned before, this survey covered three aspects: (1) co-operation, co-ordination and motivation activities, (2) the elements of the CCM factors, and (3) the priorities for or the impediments to the efficient implementation of Korean aviation technology policy. The degree of the CCM activities, the elements and the priorities and impediments were measured by using 'weighted mean value'. The distribution of responses to the questions asking about the CCM activities and their elements were analysed by using 'percentage of response'. The distribution of the priorities or impediments were analysed by using 'weighted percentage'. The three statistical terms will now be explained.

First, the weighted mean value (hereinafter, the mean value) was used in order to identify the degree of the CCM activities, the elements and the impediments reported by respondents to a certain question in the questionnaire. It is calculated by the formula, total of weighted scores ÷ the total number of respondents,

$(1n_1+2n_2+3n_3+4n_4+5n_5) \div N$. The total of weighted scores is obtained by the formula of $(1n_1+2n_2+3n_3+4n_4+5n_5)$, where 1, 2, 3, 4 and 5 represent the weightings given to particular options, and n_1 refers to the numbers of respondents answering to option 1, n_2 refers to the number of respondents answering to option 2 and so on. Thus, for example, 1 in $1n_1$ is the weighting given to the number replying to option 1 as weighted score, 2 in $2n_2$ is the weighting given to n_1 the number of respondents answering to option 1 in order to produce a weighted score of $1n_1$ for option 1. In addition, the total number in the sample 'N' is gained by the formula of $(n_1+n_2+n_3+n_4+n_5)$. A lower mean value means that sample has a negative view in relation to a certain question and a higher mean value represents a positive view. The mean value can be compared by reference to respondents.

A measured value over 3.0 implies that the efficiency of a factor or an element is high in conducting Korean aviation technology policy. On the contrary, a measured value below 3.0 implies that the efficiency is low. This is because, responses to questions in the questionnaires were measured on a scale of 5. That is, 5 options are given to a question; for example, option 1 indicates that the degree of efficiency of an element is very low, 2 that it is low, 3 that it is middle, 4 that it is high, and 5 that it is very high.

Second, the percentage of response to each option can be calculated by the formula: n_1/N in the case of option 1, n_2/N in the case of option 2, and n_3/N, n_4/N and n_5/N in the case of options 3, 4 and 5 respectively. This statistical method is used to identify the distribution of responses to the options of a certain question. Thus, if the percentage is high it means that a particular option among the five optional answers to a certain question has been important.

Finally, the weighted percentage of response is used to identify the distribution of the responses to the questions asking about the order of impediments to the CCM activities in implementing Korean aviation technology policy. The weighted percentage to option 1 of the six optional answers to a question about the degree of impediments is measured by the formula of $1n_1 \div (1n_1+2n_2+3n_3+4n_4+5n_5+6n_6)$. A high weighted percentage means that the degree of the impediments to an option is high.

8.2 Analysis of Survey Results

We need to recognise that survey results gained from questionnaires and interviews can have bias according to the different recognition patterns formulated through the social culture in which respondents have involved. That is, a Korean respondent can respond differently from an English respondent towards the same question according to the difference in recognition to social matters although they live in the same city currently. However, in this case the respondents were highly educated and of professional status. All respondents, except those from the KARI, are independent of the author's own ministry, MOST. Respondents were assured that their answers would be non-attributable. For, these reasons, the author is confident that the survey results do not reflect a propensity to respond in a particular way.

This section analyses the results of the empirical work. It consists of four sub-sections relating to (1) co-operation, (2) co-ordination, (3) motivation, and (4) implementations and recommendations.

8.2.1 Analysis of Co-operation Activities

This sub-section has two aims. One is to identify what degree of co-operation conducted in implementing Korean aviation technology policy, and what degree of contribution of the four elements of the co-operation factor. The other is to examine impediments to the efficient implementation of the policy. It examines four aspects: (1) the analysis of the degree of co-operation, (2) the degree of contribution of the four elements of the co-operation factor, (3) the impediments to efficient implementation, and (4) a conclusion.

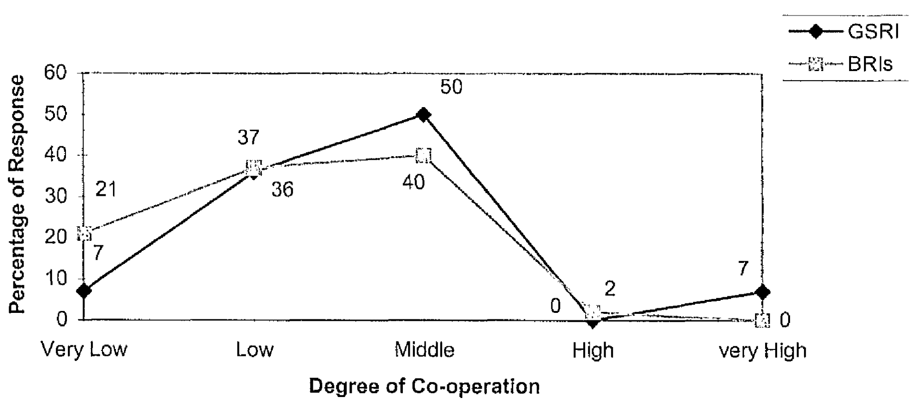
8.2.1.1 Analysis of the Co-operation Factor

The degree of co-operation activity in implementing Korean aviation technology policy is analysed by reference to the two samples of researchers and policy managers.

First, the researchers in the sample replied that the degree of co-operation was low in implementing aviation technology policy. The mean value of the degree of co-operation was reported 2.33,[44] and 55 per cent of them replied to the options of very low and low (low level). 42 per cent of them answered to the option of middle, and only 3.5 per cent replied to the options of very high and high (high level).

In classifying the degree of co-operation by organisation, the respondents from the GSRI replied to be higher than those from BRIs. 43 per cent of from the GSRI replied to the options of very low and low, while 58 per cent of the sample from the BRIs were replied to the same options. In addition, few researchers replied to the options of very high and high, as shown in Figure 8.3. This seems to have been caused by the fact that researchers in the GSRIs generally have been more involved in implementing aviation technology policy. In Korea, the GSRIs have generally received more R&D project funding from the government.[45]

Figure 8.3 Degree of Co-operation Indicated by Researchers



Second, the respondents of policy managers replied that the degree of co-operation activity was low in implementing Korean aviation technology policy. 42 per cent of

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[44] Mean value 1.00 represents very low of degree of co-operation, 2.00 low degree of co-operation, 3.00 middle degree, 4.00 high degree, and 5.00 very high degree of co-operation.

[45] Interview with Nam-Yong, Her, government officer in the Ministry of Industry and Resources, on May 20, 1999.

them answered to the options of very low and low, 58 per cent to the middle option, and nobody to the options of very high and high. Policy managers in the GSRIs and ministries replied to be higher to the degree of co-operation than those in the BRIs. 20 per cent of respondents from the GSRIs answered to the options of very low and low, while 33 per cent of respondents from the BRIs, 67 from the university and KAIA and all from the Aviation Consolidation Office (ACO) replied to the same options. No respondent reported a high degree of co-operation activities, as shown in Table 8.2.

Table 8.2 Degree of Co-operation Reported by Policy Managers

	Total	Ministries	GSRIs	BRIs	University	KAIA	ACO
Respondents (persons)	31	5	5	12	3	3	3
Degree of co-operation (mean value)	2.56	2.80	2.80	2.66	2.00	2.33	1.66
Responses to options of very low and low (%)	42	20	20	33	66	67	100

In comparison of the degree of co-operation reported between researchers and policy managers, policy managers have a more positive view to the degree of co-operation than researchers. 55 per cent of researcher respondents replied to the options of very low and low, while 42 per cent of policy managers replied to the same options. In addition, the mean value reported by policy managers (2.56) is also higher that by researchers (2.33), as shown in Table 8.3.

Table 8.3 Comparison of the Degree of Co-operation Reported by Researchers and Policy Managers

Respondents / Degree of co-operation	Researcher			Policy Manager
	GSRI	BRIs	Total	
1) Number of Respondents	14	43	57	31
2) Degree of Co-operation (mean value) [46]	2.64	2.23	2.33	2.56
3) Percentage of Responses				
to options of very low and low (%)	43	58	55	42
to option of middle (%)	50	39	42	58
to options of high and very high (%)	3	2	3	-

[46] Answers are divided into the five options of (1)very low, (2)low, (3)middle, (4) high and (5) very high. Therefore, the mean value of 2.64 means that the answer is located between the option of low and middle.

The degree of co-operation in implementing Korean aviation technology policy seems to be low, as Kang pointed out.[47] In addition, it appears that policy managers thought more positively about the degree than researchers. The previous reviews on aviation technology policy indicate that Korea could benefit from a high degree of co-operation activity implementation. Thus, a tentative conclusion from the above findings that the government seems to need more emphasis on improving the degree of co-operation activities with the BRIs, university and the industry.

8.2.1.2 Analysis of the Four Elements of the Co-operation Factor

We have just identified a low degree of co-operation existing in implementing Korean aviation technology policy. To understand the degree of co-operation more concretely, the four elements of the co-operation factor will now be analysed. The four elements are: (1) the holding of seminars, which is divided into internal and external seminars. ("Internal" means a seminar held for inside persons of a research institute, and "external" means a seminar held for persons outside a research institute); (2) the dissemination of R&D results; (3) the conduct of joint R&D; and (4) international collaboration.

Regarding the degree of contribution of the four elements, that of the holding of internal and external seminars, and the conducting joint R&D, was reported to be middle, with mean value of 3.00, 2.84 and 2.73 respectively. That of the dissemination of R&D results was low, with 2.10. However, the degree of contribution of two sub-elements of the international collaboration was reported to be high, mean value of 'researcher placement' was 3.76 and that of 'overseas researcher invitation' was 3.38, as shown in Table 8.4.

From the above findings, then, it appears that activities relating to the dissemination of R&D results and the holding of overseas seminars could be strengthened more

[47] Interview with In-Ho, Kang, Senior Researcher in the KIDA, on June 3, 1999. He indicated that the degree of co-operation was low between the KMOD and MOIR in undertaking aviation development policy.

than other elements, if they are really to contribute to the projects. In addition, the government may need to continue the overseas placement of researchers and overseas researcher invitations, as they have both made a high level of contribution in improving co-operation.

The performance of the four elements seems to have been comparatively low during the last year (May 1998 - June 1999). External seminars held averaged 2.7, researchers' technical support to engineers in the aviation manufacturing companies averaged 1.8, and technology transfer and lectures in a university averaged 1.6 per sample reporting.

Table 8.4 Degree of Contribution of the Four Elements of the Co-operation Factor Reported by Researchers

Elements of the co-operation factor	Degree of contribution					
	Mean value			Response to the options (%)		
	GSRI	BRI	Total	Low	Middle	High
1. Holding of seminars						
- Internal seminar	3.00	3.00	3.00	25	49	26
- External seminar	3.21	2.72	2.84	32	52	16
2. Dissemination of R&D results	1.71	2.23	2.10	62	30	8
3. Conduct of joint R&D	2.64	2.76	2,73	37	44	19
4. International collaboration						
- International joint R&D	2.79	3.53	2.92	37	30	34
- Researcher placement	3.16	4.07	3.76	19	23	58
- Researcher invitation	3.08	3.61	3.69	21	26	53
- Overseas periodicals	2.91	2.69	3.38	28	35	37
- Attendance at overseas seminar	2.66	2.07	2.84	49	23	28
- Holding of overseas seminar	2.64	2.06	2.21	68	14	18

Remarks: Mean value 1presents option of very low, 2 low, 3 middle, 4 high, and 5 very high.

The number of joint R&D projects conducted was averaged 0.8 to 2.2. The number of joint R&D projects conducted between research institutes and industry was larger than that between research institutes and universities.

The average number of international joint R&D projects was 1.2 per respondent; the number of researchers dispatched overseas for the periods over three days averaged

4.3 persons per respondent; overseas researchers invited for over three days averaged 3.7 persons per respondent; the subscriptions to overseas periodicals averaged 2.8 per respondent; researchers' attendance at overseas seminars averaged 1.1 per respondent; and the number of seminar held for overseas researchers averaged 0.5 per respondent.

The level of the occurrence of the holding of external seminars and the dissemination of R&D performance in the BRIs was higher than it was in the GSRI. However, the level of the occurrence of international collaboration in the GSRI was higher than in the BRIs except in the case of international joint R&D project, as shown in Table 8.5.

Table 8.5 Occurrence of the Four Elements of the Co-operation Factor

Four Elements of the Co-operation Factor	Occurrence of the Four Elements					
	Unit	GSRI	BRI	-	-	Total
1. Holding of Seminars						
- Internal Seminar	Time	3.5	4.5			4.2
- External Seminar	"	2.5	2.8			2.7
2.Dissemination of R&D Results	Times					
- Technical Support		1.3	2.0			1.8
- Technology Transfer		0.6	2.0			1.6
- Lectures in a University		1.5	1.7			1.6
3.International Collaboration						
- International Joint R&D	Project	0.8	1.3			1.2
- Researcher Dispatch	Person	5.5	4.6			4.3
- Researcher Invitation	"	3.7	3.6			3.7
- Overseas Periodicals	Book	3.5	2.5			2.8
- Attendance at Overseas Seminar	Person	1.5	1.0			1.1
- Holding of Seminars for Overseas Researcher	Time	0.7	0.5			0.5
4.Joint R&D	Unit	RI,B,U	RI,B	RI	B	U
	Project	1.7	2.2	1.7	1.1	0.8

Remarks:
* RI,B,U in the row for Joint R&D means joint R&D between research teams in which a sample works and other research institute (RI), businesses (B), and universities (U).

The occurrence of the four elements of the co-operation factor seems to be small. As mentioned by S.R, Lee, the technical support activities were not conducted actively between the KARI and the aviation industry.[48] It seems that Korea needs to increase the activities related to the four elements of the co-operation factor. In particular, the

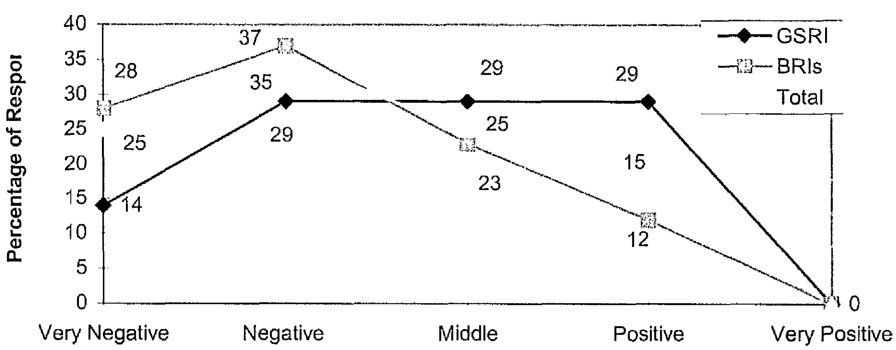
[48] Interview with Seung-Ri, Lee, a principal policy researchers in the KARI, on May 17, 1999.

GSRI needs to strengthen the dissemination of R&D results, and the BRIs need to emphasise international collaboration. In addition, research institutes should conduct more joint R&D with universities.

As described in previous chapters, international collaboration seems to be a very important element for latecomer countries, especially in improving aviation technological capability. The analysis of the international collaboration element is now expanded below in order to identify its degree of efficiency, with reference to the samples of researchers and policy managers, talking about their main projects.

First, researchers replied the degree of efficiency of international collaboration conducted to be low, giving it a mean value of 2.31. The degree of efficiency was seen as higher in the GSRI, where it had a mean value of 2.71, than in the BRIs among whom its mean value was 2.18. In addition, researchers' views on the efficiency of international collaboration were negative, with 60 per cent responding negatively, and only 15 per cent responding positively. Researchers in the GSRI were more positive about the efficiency than those in the BRIs, with 43 per cent of researchers in the GSRI and 65 per cent of researchers in the BRIs answering negatively as illustrated in Figure 8.4.

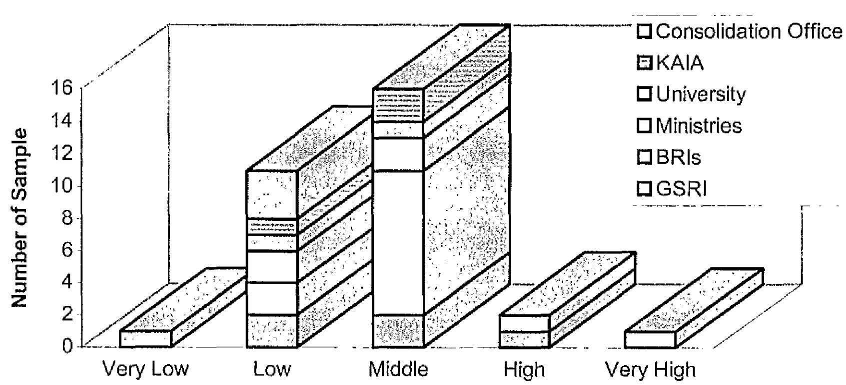
Figure 8.4 Efficiency of International Collaboration
Responded by Researchers



Second, the policy managers replied that the degree of efficiency of international collaboration activity was a little higher than researchers replied. Its mean value was 2.70, but it differed. The mean value of the efficiency was 3.00 reported by government officials, 2.91 by policy managers in the BRIs and 2.80 in the GSRIs. However, the degree reported by policy managers in the KAIA (2.66), university and the aviation Consolidation Office (2.00) were lower than those reported by policy managers in ministries and research institutes.

The policy managers' replies indicated little satisfaction with the degree of efficiency of conducting international collaboration, with 38 percent (12 persons) of them (31 persons) selecting the options of very low and low, while only 9 per cent (3 persons) selected the options of very high and high, as shown in Figure 8.5. This implies that the Korean aviation research institutes should strengthen international collaboration programmes and make them much more efficient.

Figure 8.5 Efficiency of International Collaboration
Responded by Policy Managers



The sample of policy managers reported the degree of efficiency of conducting international collaboration activity more positively than the researchers did. For example, as many as 25 per cent of researchers and only 3 per cent of policy managers responded very negatively.

It seems that the government, research institutes and the aviation industry should make more efforts in enhancing the efficiency of international collaboration, in order to gain advanced aviation technology from the developed countries, although the improvement of in-house technological capability is indispensable as well. [49] In addition, policy managers may need to have a more positive view about the efficiency in conducting international collaboration.

8.2.1.3 Analysis of Impediments to Co-operation Activity

Impediments to co-operation activity are analysed separately in two parts, one relating to impediments to co-operation activity and the other to those to international collaboration activity.

With regard to the impediments of co-operation activities, five options of impediments were given. These were (1) the low level of communication between persons concerned, (2) the orientation of short-term performance, (3) the small number of co-operation programmes, (4) officials' low level of interest in co-operation activity, and (5) the high level of conflicts and low level of trust between persons concerned. The five options are analysed with two categories of respondents: researchers and policy managers.

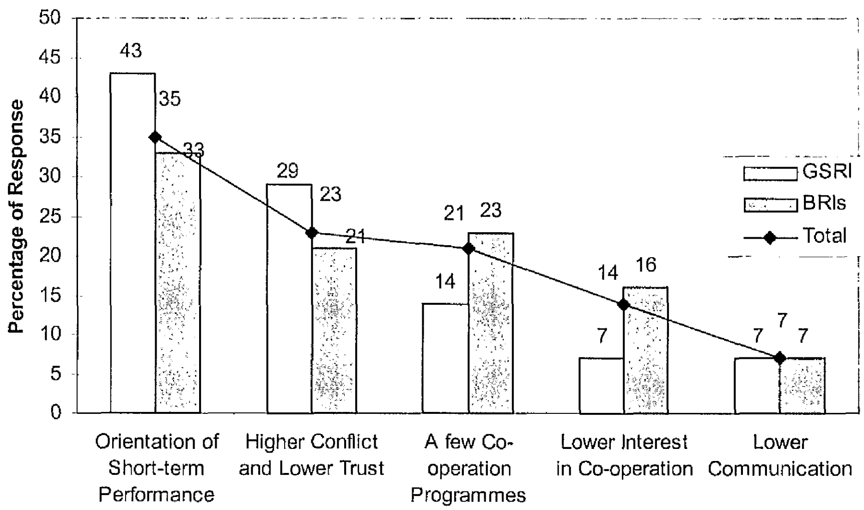
In the case of researchers, the five options were considered as important issues, of which the degree of impediment needs to be decreased, in order to achieve an efficient co-operation activity. The weighted mean value for each of impediments was similar to that of low communication between organisations concerned being 3.35; that of researchers' low interest in co-operation being 3.61; that of higher conflict and lower trust 3.79; that of the orientation of short-term performance 3.92; and that of small number of co-operation programmes being 3.93. Here, 5.00 represents the highest degree of impediment to co-operation activity.

The highest level of impediment to efficient co-operation reported by the researchers was the orientation of short-term performance, the next was higher conflict and lower trust, and then came the small number of co-operation programmes, researchers' low interest in co-operation activity and low communication. The order of the

[49] Interview with Eung-Su, Kim, Director, Defence Business Team, Hyundai Space & Aircraft Co., Ltd, on May 28, 1999.

impediments reported by researcher from the GSRI was similar to that from the BRIs, as shown in Figure 8.6.

Figure 8.6 Degree of Impediments to Co-operation Replied by Researchers



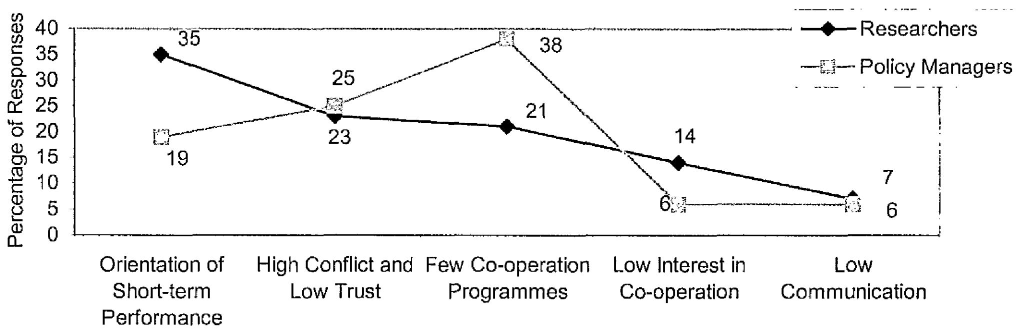
In the case of policy managers, the mean value of the degrees of impediments ranged from 3.38 to 4.16, which was similar to that for researchers. However, the highest level of impediment reported by policy mangers was the small number of co-operation programmes, the second highest was high conflict and lower trust, and the third the orientation of short-term performance.

The highest level of impediment reported by researchers was the orientation of short-term performance and the second was high conflict and low trust. However, the highest level of impediments reported by policy managers was the small number of co-operation programmes and second came high conflict and low trust, as shown in Figure 8.7.

Regarding impediments to international collaboration activity, 10 options were given, and they were analysed in relation to two categories of samples: researchers and policy managers.

The highest weighted mean value represented by researchers was given to the option of low level of domestic technology capability, the second highest to inconsistency of policy and the orientation of short-term strategy, the third to the technology barrier from the developed countries, the fourth to low priority given to international collaboration, and the fifth to low level of international collaboration relations established.

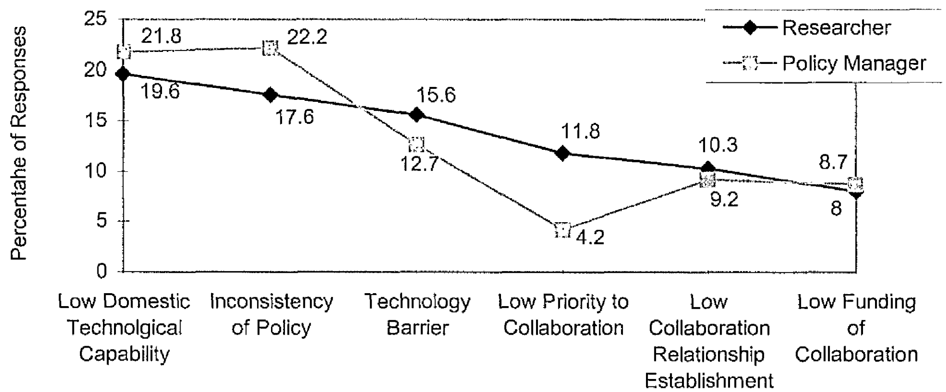
Figure 8.7 Difference of the Degree of Impediments to Co-operation Replied by Researchers and Policy Managers



The highest mean value represented by policy managers was given to the option of the inconsistency of policy and the orientation of short-term strategy, the second highest to the low level of domestic technological capability, and the third highest to technology barriers put up by developed countries.

The mean values of options, with the first to the sixth largest values, are different for each group of samples. The highest weighted mean values of the impediment to international collaboration activity appeared differently between researchers and policy mangers. The highest level of impediment reported by researchers was low domestic technological capability, and that reported by policy managers was the inconsistency of policy. However, the degree of impediments to international collaboration reported by each set of samples was similar, as shown in Figure 8.8.

Figure 8.8 Defference of Impediments to International Collaboration Replied by Researchers and Policy Managers



8.2.1.4 Conclusion

A higher degree of co-operation seems not to have been undertaken implementing Korean aviation technology policy. Korea needs to strengthen several co-operation activities and reduce impediments to the co-operation activity. Several implications can be drawn on the basis of the examination of the degree of co-operation, the degree of contribution of the four elements for the main project, and the impediments to co-operation and international collaboration.

Firstly, implications gained from the examination of the degree of co-operation can be presented for the efficient implementation of Korean aviation technology policy, as follows:

i) The government should improve the degree of co-operation activities in implementing aviation technology policy.

ii) It needs to recognise that the degree of co-operation reported by the researchers was lower than that reported by the policy managers.

iii) It needs to strengthen co-operation activities with business research institutes.

iv) It also needs to emphasise co-operation activities with universities, KAIA and the Consolidation Office.

Secondly, implications from the examination of the degree of contribution of four elements can be discussed, as follows:

i) The degree of contribution of the four elements needs to be strengthened in order to achieve a high level of co-operation in implementing Korean aviation technology policy

ii) The degree of contribution of external seminars and international collaboration needs to be increased more in the BRIs than in the GSRI, but that of the dissemination of R&D results and joint R&D need to be increased more in the GSRI rather than in the BRIs.

iii) The degree of contribution of the dissemination of R&D results and international collaboration needs to be increased more than the options of external seminars and joint R&D.

iv) The performance of the four elements needs to be increased. In particular, the performance of external seminar, joint R&D and the dissemination of R&D performance need to be improved in the GSRI than in the BRIs. However, international collaboration needs to be improved more in the BRIs than in the GSRI.

Finally, implications from the impediments to co-operation and international collaboration can be described, as follows:

i) A long-term strategy is required to maintain consistency in implementing aviation technology policy.

ii) More co-operation programmes need to be established.

iii) Conflicts between researchers and persons concerned with their R&D activities should be eradicated, and a higher level of trust relation between organisations concerned needs to be established.

iv) The improvement of in-house aviation technological capability should be focused in order to conduct effective international collaboration.

v) A strategy to overcome technology barriers arising from developed countries should be more concretely established.

vi) Consistency of international collaboration policy needs to be maintained in implementing international collaboration policy.

8.2.2 Analysis of Co-ordination Activities

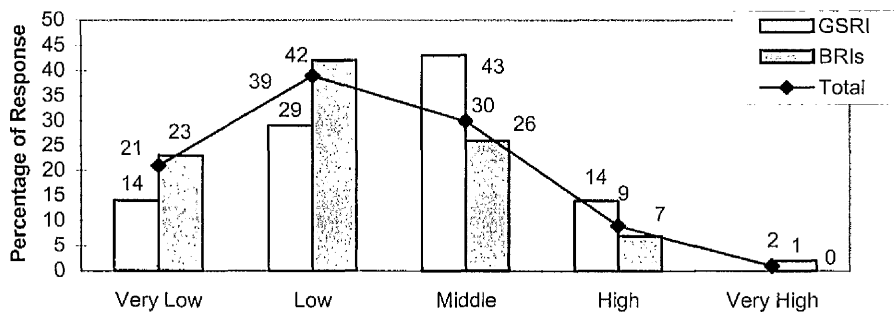
This sub-section aims to identify the co-ordination activities conducted in implementing aviation technology policy. It consists of four parts: (1) the analysis of the degree of co-ordination activity; (2) the analysis of the degree of contribution of the three elements for the main project. The three elements of the co-ordination are the short-term rotation of officials, the existence of conflicts and the survey of technology development trend; (3) the analysis of impediments to co-ordination activities; and (4) a conclusion.

8.2.2.1 Analysis of the Co-ordination Factor

The degree of co-ordination activity in implementing aviation technology policy is discussed by reference to the two samples of researchers and policy managers from the general point of view.

First, the sample of researchers reported the degree of co-ordination activity to be under middle, with a mean value of 2.31. 60 per cent of the researchers responded to the options of very low and low, and only 10 per cent replied to the options of very high and high. In addition, the degree of co-ordination differs according to the organisations. 43 per cent of researchers in the GSRI (mean value 2.57) replied to the options of very low and low, 65 per cent of researchers in the BRIs (mean value 2.23) replied to the same options, as shown in Figure 8.9.

Figure 8.9 Degree of Co-ordination Replied by Researchers



Second, policy managers also replied negatively to the degree of co-ordination in implementing aviation technology policy, with mean value 2.19. In addition, they replied differently according to the organisations they worked for. Policy managers sampled from a university and ministries reported that the degree of co-ordination was lower than those reported by policy managers from other organisations. The mean value of degree of co-ordination reported by policy managers from university was 1.30 and that from ministries was 1.60, while that from GSRIs was 2.40, that from the BRIs 2.25, and those from the KAIA and the Consolidation Office 2.00, as shown in Table 8.6.

Table 8.6 Degree of Co-ordination Reported by Policy Managers

	Total	Ministries	GSRIs	BRIs	University	KAIA	ACO
Respondents (persons)	31	5	5	12	3	3	3
Degree of co-ordination (mean value)	2.19	1.60	2.40	2.25	1.30	2.00	2.00
Responses to options of very low and low (%)	68	100	40	66	100	100	100

Policy managers were slightly more negative than researcher respondents about the degree of co-ordination activity. 68 per cent of the policy managers (mean value 2.19) and 60 per cent of the researchers (mean value 2.31) answered to the options of low and very low. Policy managers sampled from the ministries, university, the KAIA and the Aerospace Consolidation Office (ACO) reported very negatively, all of them replied to the options of very low and low.

An official in the MOST stated that the co-ordination activity needed to be improved between the MOST and the MOIR. Those in charge of matters concerned with aviation technology policy in the MOST had not been given any information about an executive plan for aviation technology development until the MOIR came to final stage in establishing it, although co-ordination between the two ministries is indispensable in making a plan for aviation technology development at a national level.[50] In addition, E-J, Cho also stated that the degree of co-ordination activity in the KAIA was low, although the KAIA has been established to provide co-ordination between the ministry concerned and businesses in implementing aviation technology policy.[51]

8.2.2.2 Analysis of the Three Elements of the Co-ordination Factor

In order to have a more concrete understanding of the degree of co-ordination in implementing Korean aviation technology policy, the three elements of the co-ordination factor will be analysed.

The first element is the short-term rotation of officials including government officials and researchers. This element was chosen to examine the degree of consistency in implementing aviation technology policy, since the short-term rotation of officers may reduce this consistency. Actually, a change of co-ordinator often causes a change in policy direction due to the different styles of identifying a certain policy.[52]

The element of the short-term rotation of officials will be analysed by reference to the responses of the two samples of governmental officials and researchers. The mean value of frequency and impediment of the short-term rotation of officials and percentage of responses to each option can be summarised, as shown in Table 8.7.

[50] Interview with Ho-Il, Kang, Deputy Directer, The Strategic Technology Division, the MOST, on June 8, 1999.
[51] Interview with Ei-Jun, Cho, Assistant General Manager, Project Planning Team, Aerospace Division, Korea Air, on May 26, 1999.
[52] Interview with Jin-Young, Hwang, Senior Researcher in the KARI, in July 1998.

Table 8.7 Frequency and Impediments of the Short Term Rotation of Government Officials and Researchers Reported by Researchers

Short-term rotation of Officials	Mean value			Response to the options (%)		
	GSRI	BRI	Total	Low	Middle	High
* Frequency of rotation of						
- government officials	3.86	3.33	3.46	16	30	54
- researcher	1.64	3.28	2.88	37	33	28
* Impediments of short-term						
- government officials	3.71	3.61	3.64	12	25	63
- researcher	3.00	3.65	3.50	19	21	60

Remarks:

1. Mean value 1presents option of very low, 2 low, 3 middle, 4 high, and 5 very high.
2. The frequency is related to the rotation of officials happened over the last three years (June 1996 – May 1999).

Through the above table, we can see that the *frequency* of rotation of government officials was high (mean value 3.46). 54 per cent of the researchers replied to the options of very high and high, and only 16 per cent replied to those of very low and low. In addition, the degree of *impediment* represented by the short-term rotation of government officials to co-ordination activity was to be high, with 63 per cent of the researchers replying to the options of very high and high and 12 per cent replying to the options of very low and low.

This seems to imply that government officials involved in the development of aviation technology policy have been changed very frequently, and that the degree of impediment of short-term rotation was high. In fact, the interviewees were dissatisfied with the short-term rotation of governmental officials when interviews were conducted.[53]

Regarding the rotation of researchers carrying out research, the frequency of the rotation of researchers was shown to be lower than that of government officials. 38 per cent of researchers replied to the options of very high and high in relation to the question on the frequency of rotation of researchers, and 54 per cent of them replied to the same option in relation to the question on the frequency of rotation of government officials. In particular, the frequency of the rotation of researchers was

[53] Interview with Young-Kap, Kim, general Manager in the KAIA, on May 25, 1999.

shown to be very low in the GSRI (mean value 1.64), since nobody replied to the options of very high and high.

The degree of the impediment represented by the short-term rotation of researchers is similar to that of government officials. 59 per cent of researchers replied to the options of very high and high in relation to the question about the degree of impediment represented by the short-term rotation of researchers, and 63 per cent of them replied to the same options in relation to the question about the degree of impediments by the short-term rotation of government officials. This seems to show that the short-term rotation of researchers and government officials represents a impediment to efficient co-ordination in implementing Korean aviation technology policy.

The second element is the existence of conflicts between persons related to the conduct of R&D activity. The activity of resolving conflicts may be a very important element in undertaking co-ordination activity. The degree of resolution of conflicts and the degree of impediment of conflicts to co-ordination can be summarised, as Table 8.8.

Table 8.8 Degree of Resolution of Conflicts and its Impediment to R&D Activity

The element of the existence of conflicts	Mean value			Response to the options (%)		
	GSRI	BRI	Total	Low	Middle	High
* Resolution of conflicts						
- between researchers in the research team	3.14	2.53	2.68	42	40	18
-between research team and internal support divisions	2.86	2.63	2.68	37	53	10
-between research team and ministries concerned	2.79	2.39	2.49	47	46	7
* Impediment of conflicts	3.29	3.75	3.63	11	30	59

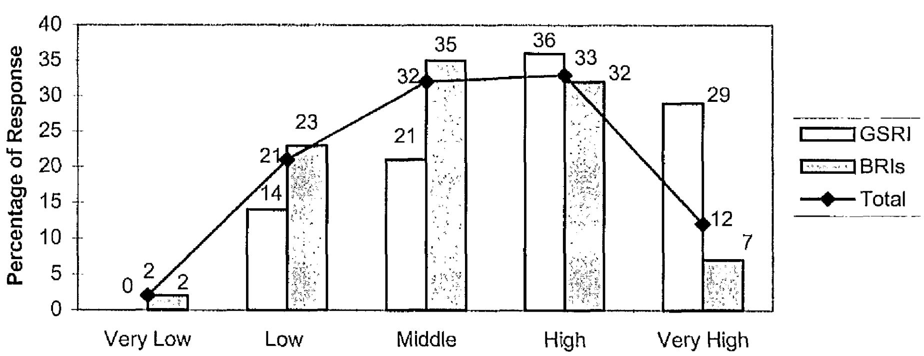
The degree of resolution of conflicts was shown to be under middle. It was higher in the GSRI than in the BRIs. In addition, it was higher between internal organisations than between research team and ministries concerned.

The degree of impediment represented by existing conflicts between the research team and organisations concerned was shown to be high, with a mean value of 3.63, and 59 per cent of the sample replying to the options of very high and high. The degree of impediment represented by existing conflicts in the BRIs (mean value 3.75) was higher than in the GSRI (mean value 3.29).

The third element is the survey of technology development trends. To co-ordinate R&D activity efficiently, an understanding of environments related to R&D activity may be required, and the survey of technology development trends may be a necessary element in understanding the environment.

A positive response was received regarding the degree of contribution of the survey of technology development trends. The mean value of degree of the contribution was reported to 3.22, and 64 per cent of the sample from the GSRI (mean value 3.79) and 39 per cent from the BRIs (mean value 3.18) replied to the options of very high and high, as shown in Figure 8.10.

Figure 8.10 Contribution of the Survey to Technology Development Trend Replied by Researchers



The number of survey of technology development trends conducted for the last three years was an average 3.2 per sample replying. The average number of surveys per sample reporting conducted in the GSRI was 3.6 while it was 3.1 in the BRIs.

63 per cent of the samples reported the best source of information to be the internal survey, 22.8 per cent reported it to be other research institutes, 9 per cent reported it as government and 5 per cent reported as industry. However, strangely, no one reported the university as the best source. This may imply that R&D activities in a university are not helpful to research institutes in developing aviation technology.

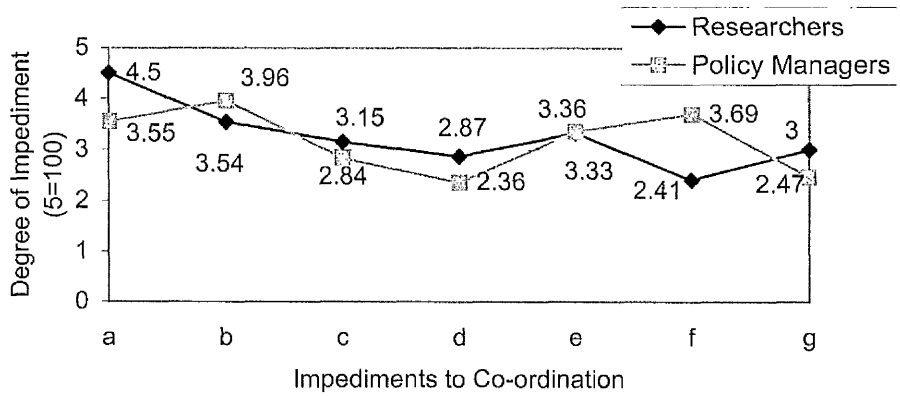
8.2.2.3 Analysis of Impediments to Co-ordination Activity

Seven options were given as possible responses to the question about the degree of impediment to co-ordination activity, and the degree of the impediment was analysed separately by reference to the responses of the researchers and policy managers.

First, the highest level of impediments to co-ordination activity reported by researchers was the selfishness of the organisation in reaping benefits for itself (27%); the second was a tendency to block the flow of information in order to keep knowledge to oneself (18%); the third was the non-existence of a governmental organisation for co-ordination (15%); and the next was the fact there are few co-ordination institutes formulating regulations and programmes (14%); the low level of interest in co-ordination activity (13%); and the short-term rotation of officials (11%).

Second, the highest impediment to co-operation activity reported by policy managers was the non-existence of a governmental organisation for efficient co-ordination (26%), the second highest was the short-term rotation of officials concerned (23%), and the third was organisational selfishness (23%). The different responses by researchers and policy managers are shown in Figure 8.11.

Figure 8.11 Degree of Impediment to Co-ordination
Replied by Researchers and Policy Managers



Remarks:

a: organisational self-interest
b: the non-existence of governmental co-ordination organisation
c: a small number of co-ordination programmes and regulations
d: the low level of interest in co-ordination activity
e: tendency to block flow of information
f: the short-term rotation of officials
g: others

8.2.2.4 Conclusion

From the comparative analysis on aviation technology policy, it can be postulated that the co-ordination factor is likely to be important in implementation for Korea.

The degree of co-ordination was reported to be low. In addition, the degree of conflicts between researchers and related organisations, that of the selfishness of the organisation in reaping benefits for itself and that of a tendency to block the flow of information in order to keep to oneself were high.

Several implications can be drawn for Korea from the survey results relevant to co-operation. In order to achieve a high level of co-ordination, the following should be considered:

i) The government should strengthen co-ordination activity in implementing Korean aviation technology policy. In particular, co-ordination activity between university and the industry should be considered.

ii) The frequency of the rotation of government officials should be reduced. The degree of impediment represented by the short-term rotation of government officials was shown to be high.

iii) There should be more attention given to the resolution of conflicts between researchers, particularly, those in the BRIs.

iv) The survey of technology development trends needs to be strengthened in the BRIs.

v) The selfishness of the organisation in reaping benefits for itself, and the tendency to block the flow of information in order to keep it to oneself should be reduced.

8.2.3 Analysis of Motivation Activities

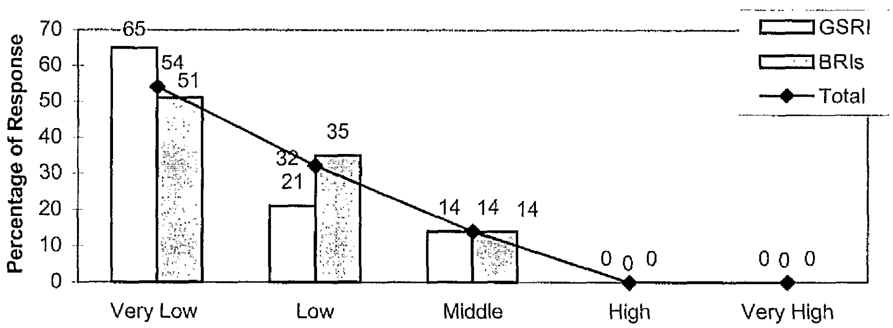
This sub-section aims to examine the degree of motivation activities conducted in implementing Korean aviation technology policy, and to identify the four elements of the motivation factor which are helpful in improving motivation. The four elements comprise researchers' participation in decision-making processes, the incentive system, the R&D evaluation system and trust relations. It therefore consists of four parts: the analysis of the degree of motivation activity; the analysis of the degree of satisfaction with the four elements; the analysis of impediments to motivation activities; and a conclusion.

8.2.3.1 Analysis of the Motivation Factor

The level of researchers' motivation in conducting the main project is analysed by reference to the two categories: researchers and policy managers.

First, from the responses of researchers, the degree of motivation was shown to be very low (mean value 1.59), since 86 per cent of researchers replied to the options of very low and low, and 14 per cent of them to middle. In particular, no one replied to the options of very high and high. The degree of motivation of researchers sampled from the GSRI was similar between researchers in the BRIs (mean value 1.58) and those in the GSRI (mean value 1.62), as shown in Figure 8.12.

Figure 8.12 Degree of Researchers' Motivation Reported by Researchers



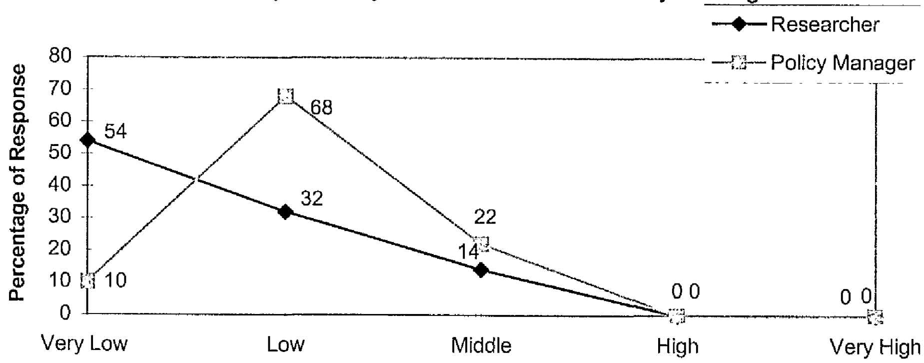
Second, for policy managers, the degree of motivation was reported to be low with a mean value of 2.12. It is particularly noteworthy that all the policy managers sampled from ministries and the Aerospace Consolidation Office selected the options of very low and low regarding the degree of motivation, as shown in Table 8.9.

Table 8.9 Degree of Researchers' Motivation Reported by Policy Managers

	Total	Ministries	GSRIs	BRIs	University	KAIA	ACO
Respondents (persons)	31	5	5	12	3	3	3
Degree of co-ordination (mean value)	2.12	1.80	2.40	2.08	2.33	2.33	2.00
Responses to options of very low and low (%)	78	100	60	75	67	67	100

Researchers and policy managers replied very negatively to the degree of motivation. It appears that policy managers had a slightly more positive view about the degree of satisfaction than researchers, 78 per cent of policy managers replied to the options of very low and low, as shown in Figure 8.13.

Figure 8.13 Difference of the Degree of Researchers' Motivation Reported by Researchers and Policy Managers



Researchers were very disappointed with motivation activity in implementing their R&D activity. Many of the interviewees worried about the cancellation of the important Development of Middle-Range Aircraft project in early 1999 by the MOIR. This cancellation resulted from the difficulty in finding a proper international collaboration partner, and the uncertainty of producing economic benefits from the development of a middle range aircraft.[54]

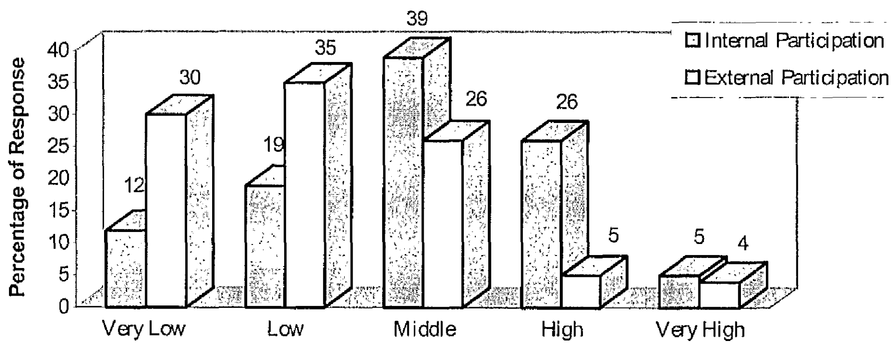
8.2.3.2 Analysis of the Four Elements of the Motivation Factor

To understand the degree of motivation further more concretely, its four elements will be analysed.

First, the degree of researchers' participation in decision-making processes relevant to main projects is explained in two parts: researchers' participation in internal and external decision-making processes. The degree of researchers' participation in internal R&D processes was reported to be middle with a mean value of 2.98. The degree of such participation was higher in the BRIs than the GSRI, for the mean value was 3.02 for the BRIs and 2.07 for the GSRI.

The degree of researchers' participation in external decision-making processes relevant to the main project, was reported to be low with a mean value of 2.08. 70 per cent of the researchers sampled from the GSRI and 63 per cent of the sample from the BRIs replied to the options of very low and low. The degree of participation in internal and external decision-making processes was shown to be higher within the BRIs (3.02 in internal, 2.32 in external) than within the GSRI (2.07 in internal and external). It seems that researchers in the GSRI participated less in the decision-making processes relevant to the main project. The degree of participation in internal and external decision making process is shown in Figure 8.14.

Figure 8.14 Degree of Participation in Internal/External Decision-Making Processes



Second, the incentive systems are analysed by reference to the two categories of grant and merit. Here, grant means a funding award given and merit means a certificate of merit given by internal or external organisations including the government as an award for the high level of R&D performance.

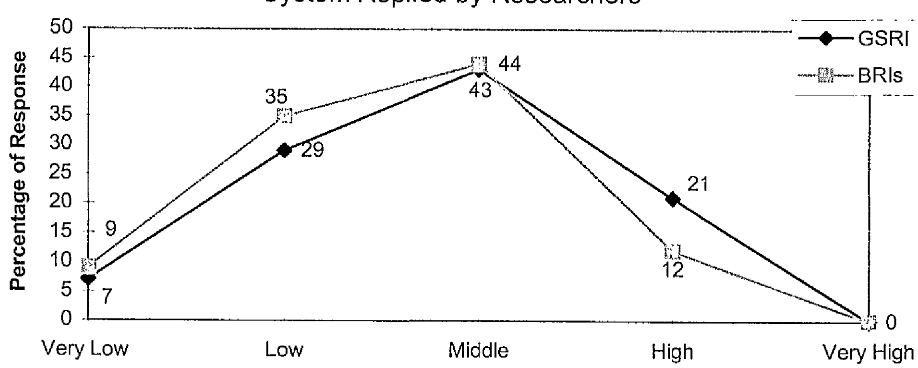
The degree of satisfaction with grants afforded by the government was reported to be low by the respondents of researchers, with a mean value of 1.89 and 77 per cent responding to the options of very low and low. In addition, researchers sampled from the BRIs were less satisfied with grant system than those from the GSRI, for 81 per cent of the researchers in the BRIs, and 64 per cent of the researchers in the GSRI replied to the options of very low and low.

[54] Interview with Seung-Ri, Lee, Principal Researcher, Policy & Planning Section, the KARI, on May 17, 1999.

The degree of satisfaction with the merit system, including the conferring of a certificate of merit, was very similar to the degree of satisfaction with the grant system. The mean value of the degree of satisfaction with merit system was 1.88.

Third, the degree of satisfaction with the R&D evaluation systems undertaken by the government was reported to be low, with a mean value of 2.63. The mean value reported by researchers in the GSRI was a little higher than that reported by researchers in the BRIs, with mean values of 2.79 and 2.58 respectively. In addition, 36 per cent of the researchers sampled from the GSRI and 44 per cent of those from the BRIs chose the options of very low and low, while no one selected the option of very high, as shown in Figure 8.15.

Figure 8.15 Degree of Satisfaction with the R&D Evaluation System Replied by Researchers



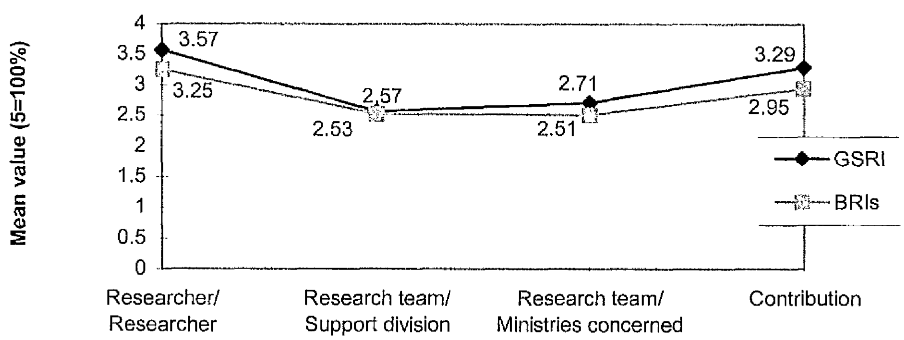
Fourth, the establishment of higher levels of trust relations may be an important element in motivating researchers for achieving a higher level of R&D performance. The degree of establishment of trust relations will be explained in relation to three categories: (1) that between researchers in a research team; (2) that between the research team and support divisions; and (3) that between the research team and ministries concerned.

The degree of the establishment of trust relations between researchers in the research team was shown as middle, but the degree reported by the researchers sampled from the GSRI was higher than those from the BRIs. In fact, 64 per cent of the sample from the GSRI and 49 per cent from the BRIs replied to the options of very high and high.

The degree of trust relations established between researchers in the research team (mean value 3.36) was higher than those between the research team and support divisions (mean value 2.54), and those between the research team and the ministries concerned (mean value 2.56). In particular, the degree of trust relations between the research team and support divisions was slightly lower than that between the research team and the ministries concerned.

The degree of contribution of the establishment of good trust relations to the conduct of the main project was reported to be middle (mean value 3.10). However, the degree of contribution reported by researchers in the GSRI was higher than in the BRIs, for 43 per cent of the researchers in the GSRI and 21 per cent of those in the BRIs chose the options of very high and high, as shown in Figure 8.16.

Figure 8.16 Degree of Trust Relation Establishment and its Degree of Contribution

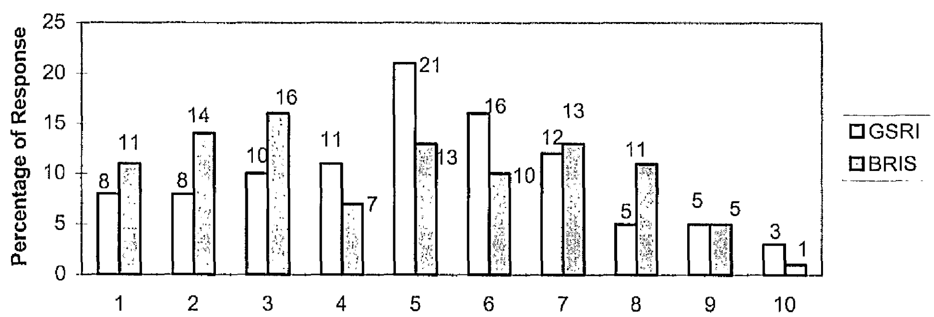


8.2.3.3 Analysis of Impediments to Motivation Activity

Nine options were given as responses to the researchers and policy managers sampled, in order to examine the degree of impediment to motivation activity in conducting aviation technology policy. First, in the researchers, the highest level of impediment was the low level of government support in carrying out R&D activity (response percentage 14.9), the second highest was the low level of autonomy (14.5%) and the third was the low level of wages (12%).

Researchers in the GSRI indicated that the highest impediment was the low level of governmental support (21%), the second was the instability of job (16%), and the third was the lower level of wages (12%). Researchers sampled from the BRIs replied that the highest level of impediment was the low level of autonomy (16%), the second highest was the centralisation of decision making process (14%), and the third highest was the low level of government support (13%), as shown in Figure 8.17.

Figure 8.17 Degree of Impediments to Motivation Replied by Researchers



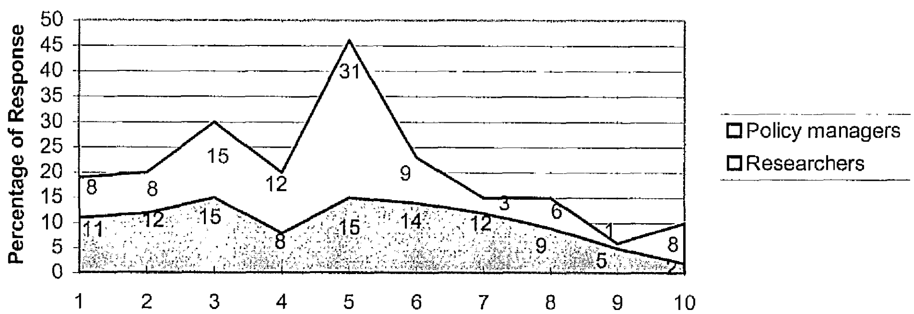
Remarks;

1: Rigid managerial environment in conducting R&D
2: Centralisation of decision-making processes
3: Low level of autonomy
4: High level of governmental involvement
5: Low level of governmental support
6: Job instability
7: Low level of wages
8: Low level of incentives
9: An inactive audit system
10: Others

These results show that there was a low level of autonomy in research institutes where there were higher levels of government involvement and a rigid managerial attitude and where decision-making processes were centralised. In addition, the low level of government support, job instability and the low level of wages also seem to act as impediments to motivation activity.

Second, in the case of policy managers, the highest level of impediment to the motivation activity was the low level of government support (31%), the second highest was the low level of autonomy (15%) and the third highest was the high level of government involvement (12%). The highest level of impediment in the GSRIs was the high level of governmental involvement (25%), the second was the lower level of governmental support (18%), and the third was the low level of autonomy (16%). The highest level of impediment reported by officials in the ministries concerned was the low level government support (29%), the second was the centeralisation of the decision making processes (12%). The highest level of barrier replied by policy managers sampled from a university, the KAIA, and the Aerospace Consolidation Office was the low level of government support. The differences between the highest level of impediment reported by researchers and that reported by policy managers are illustrated in Figure 8.18.

Figure 8.18 Difference of the Impediments to Motivation Reported by Researchers and Policy Managers



Remarks;

1: Rigid managerial environment in conducting R&D
2: Low level of participation in decision-making processes
3: Low level of autonomy
4: High level of governmental involvement
5: Low level of governmental support
6: Job instability
7: Low level of wages
8: Low level of incentives
9: An inactive audit system
10: Others

8.2.3.4 Conclusion

The motivation factor appears to be important for the efficient implementation of Korean aviation technology policy. The degree of the motivation activity in implementing Korean aviation technology was reported to be low. In addition, the degree of satisfaction with participation in external decision making processes, that with the incentive systems, that with the R&D evaluation systems, and that with trust relations between the research team and ministries concerned were indicated to be low, with the mean value of 2.08, 1.89, 2.63 and 2.56 respectively. The above results indicate several implications for the efficient implementation of Korean aviation technology policy, as follows:

(i) Motivation activity should be strengthened in order to implement the Korean aviation technology policy effectively.
(ii) There needs to be more concentration in strengthening the level of participation in external decision making processes than that in internal decision making processes.
(iii) The level of participation in decision making processes should be increased more in the GSRI than in the BRIs.
(iv) The incentive system (grant ad merit system) should be strengthened.
(v) R&D evaluation systems need to be carried out more efficiently.
(vi) The establishment of trust relations should be further emphasised between the research team and internal support divisions, and between the research team and ministries concerned.
(vii) A high level of government support should be given to researchers in order to motivate them to conduct better levels of research in aviation technology. In addition, the researchers should be given a higher level of autonomy in conducting their R&D tasks with a lower level of government involvement, a flexible managerial attitude, and a higher level of participation in the decision making process.

8.2.4 Recommendations

This sub-section concludes the survey results with a summary of the analysis results, and with the recommendations of policy options for the efficient implementation of Korean aviation technology policy. It therefore consists of two parts synthesising the survey results and recommending policy options.

8.2.4.1 Synthesis of the Survey Results

Co-operation, co-ordination and motivation were identified as significant factors through the analysis of survey results, and they need to be strengthened for the efficient implementation of Korean aviation technology policy. This is because the mean value of degree of the CCM factors was shown to be low. The mean values for co-operation, co-ordination and motivation reported by researchers were 2.33, 2.31 and 1.59 respectively. Policy managers replied more positively than researchers in relation to the degree of co-operation and motivation, but they were more negative compared to researchers in relation to the degree of co-ordination, as shown Table 8.10.

Table 8.10 Degree of the CCM Activity

	CCM Factors		
	Co-operation	Co-ordination	Motivation
Degree of the CCM activity (mean value)			
- Replied by researchers	2.33	2.31	1.59
- Replied by policy managers	2.56	2.19	2.12
Percentage of responses to the options of *very low and low* (%)			
- Replied by researchers	55	60	86
- Replied by policy managers	42	68	78
middle (%)			
- Replied by researchers	42	30	14
- Replied by policy managers	58	32	22
very high and high (%)			
- Replied by researchers	3	10	0
- Replied by policy managers	0	0	0

The contribution and performance of the four elements of the co-operation factor need to be increased for achieving a higher degree of co-operation activity. The mean values of the contribution of the four elements for the main project are under 3.00. The mean value of the holding of external seminars was 2.84, it of the dissemination of R&D performance was 2.10, it of joint R&D 2.73 and it of international collaboration 2.31. Accordingly, the four elements need to be strengthened for conducting an efficient co-operation activity.

The two elements of the co-ordination factor, namely, the short-term rotation of officials and the existence of conflicts were shown to be important elements for improving co-ordination activity in implementing aviation technology policy. In addition, the degree of impediment of short-term rotation of government officials was high with a mean value of 3.64, and that of the existence of conflicts was also high with a mean value of 3.63. However, in the case of one element of the survey of technology trends, its contribution was reported to be middle with a mean value 3.22. Accordingly, the frequency of rotation of government officials needs to be extended and conflicts between organisations concerned should be reduced, in order to improve co-ordination activity.

The four elements of the motivation factor were confirmed to be helpful in improving the motivation of researchers through survey results. The degrees of satisfaction with the four elements were indicated to be low. The mean value of satisfaction with the incentive systems was 1.89, that of participation in external decision-making was 2.08, that with trust relation establishment between the research team and the government was 2.56, and that of the R&D evaluation system was 2.63, as shown in Table 8.11.

Table 8.11 Mean Value of the Elements of the CCM Factors

Factors	Elements of the CCM factors	Mean Value	Measures
Co-oper Ation	1. Holding of Seminars		
	- Internal Seminars	3.00	Contribution
	- External Seminars	2.84	"
	2. Dissemination of R&D Performance	2.10	"
	3. Joint R&D	2.73	"
	4. International Collaboration	2.31	Efficiency
Co-ordi Nation	1. Short –Term Rotation of Officers		
	- Researchers	3.50	Impediment
	- Government Officers	3.64	"
	2. Existence of Conflicts	3.63	"
	3. Surveys of Technology Trend	3.22	Contribution
Moti Vation	1. Participation in Decision Making		
	- Internal Decision Making Processes	2.98	Satisfaction
	- External Decision Making Processes	2.08	"
	2. Incentive System		
	- Grant	1.89	"
	- Merit	1.88	"
	3. R&D Evaluation System	2.63	"
	4. Trust Relations between		
	- Researchers in Research Team	3.36	"
	- Research Team/Ministries Concerned	2.54	"
	- Research Team/Internal Support division	2.56	"

Regarding the impediments to the CCM activity, the highest level of impediments to co-operation activity was the orientation of short-term performance, that to international collaboration was lower domestic technological capability, that to co-ordination was organisational selfishness and that to motivation was lower government support, as shown in Table 8.12.

Table 8.12 Order of Impediments to the CCM Activity

Factors	Impediments to the CCM activity reported by researchers			% by policy Managers
	Order	Impediment issues	%	
Co-operation	1	Orientation of short-term performance	35	19
	2	High conflicts and low trust	23	25
	3	Little number of co-operation programme	21	38
	4	Lower interest in co-operation affairs	14	6
	5	Lower communication	7	6
	6	Others	-	6
International collaboration	1	Lower domestic technological capability	20	22
	2	Inconsistency of policy implementation	18	22
	3	Technology barrier from developed countries	16	13
	4	Lower priority given to international collaboration	12	4
	5	Lower establishment of international collaboration base.	10	9
	6	Others	24	30
Co-ordination	1	Organisational selfishness	27	23
	2	Tendency of blocking information flow	18	3
	3	Non-existence of co-ordination organisation	15	26
	4	Lack of co-ordination regulations	14	9
	5	Lower interest in co-ordination affairs	13	6
	6	Short-term rotation of officials	11	23
	7	Others	2	10
Motivation	1	Lower government support	15	31
	2	Lower autonomy in conducting R&D	15	15
	3	Lower wages	13	3
	4	Centralisation of decision-making process	12	8
	5	Inconsistency of job	11	9
	6	Rigid managerial environment	11	8
	7	Lower incentive systems	9	6
	8	Higher government involvement	8	12
	9	Others	6	8

8.2.4.2 Policy Options

Policy options for improving co-operation, co-ordination and motivation activities were recommended and detailed in each conclusion of the co-operation, co-ordination and motivation sub-sections. Policy options will now be summarised shortly on the basis of the survey results, then in the final chapter on this work, the possible policy options which enlarged from the survey and interview will be more fully developed.

Firstly, to achieve a high level co-operation, the Korean government and research institutes, university and the aviation industry need to undertake the following activities:

i) They should recognise that the degree of co-operation activity was reported to be low in implementing aviation technology policy by researchers and policy managers involved in aviation technology development, and that few replied to the options of very high and high in relation to the degree of co-operation.

ii) The degree of contribution of the four elements for the main project should be improved. In particular, the dissemination of R&D results and international collaboration need to be strengthened.

iii) The performances of the three elements of the holding of external seminars, joint R&D,the dissemination of R&D performance and international collaboration need to be further strengthened.

iv) It is required to maintain consistency in implementing aviation technology policy with a long-term strategy, to eliminate conflicts between researchers and persons concerned, and to establish better trust relations between concerned persons.

Second, to achieve a high level of co-ordination several policy options can be mentioned as follows:

(i) The government should recognise the fact that no-one among policy makers from the ministries, university, the KAIA and the Aviation Consolidation Office replied to the options of very high and high in relation to the degree of co-ordination.

(ii) The frequency of the rotation of government officials should be extended, and conflicts occurring in R&D activities should be minimised.

(iii) The selfishness of the organisation in reaping benefits for itself and the tendency to block the flow of information in order to keep it to oneself should be eliminated. In addition, the government's co-ordination role needs to be strengthened.

Finally, to strengthen motivation activity several policy options may be considered as follows:

(i) The government needs also to recognise that the degree of motivation was reported to be lower than that of other factors of co-operation and co-ordination.

(ii) The degree of the participation in external decision making processes needs to be improved, and the incentive systems and R&D evaluation systems should be strengthened.

(iii) The researchers should be given a high level of autonomy in conducting their R&D activity with lower government involvement, a flexible managerial attitude, and a high level of participation in decision-making processes.

Chapter 9: Conclusion

Nowadays, only Boeing and Airbus Industrie are competitive in producing large transport aircraft. They seem to have achieved superiority in terms of production volume and market share through mergers, economies of scale and joint productions. Korea, as a latecomer country, may find it difficult to gain competitiveness in the large transport market in the near future, although Korea has made efforts to develop its aviation industry in order to establish a strong technological industry.

To develop the aviation industry, it appears that the Korean government needs a determined approach in implementing an aviation technology policy, through the provision of more projects for developing and producing completed aircraft. The Korean aviation industry seems to have a prosperous basis for its future development. Korea has highly advanced technologies in the electronics, automobile and shipbuilding industries. In addition, recently three major aviation companies have merged. Therefore, the Korean aviation industry seems to have potential to develop strongly, if the government, research institutes, companies and universities make efforts to establish a high level of co-operation, co-ordination and motivation activities to this end.

This concluding chapter consists of three sections. The first is a summary of the study, which will highlight the main points of the previous chapters. The second relates to policy options for the efficient implementation of Korean aviation development policy, which will be suggested on the basis of the analysis of co-operation, co-ordination and motivation systems used in conducting the UK, the US, Japan and Korean aviation technology policy, and on the basis of the survey results of Korean aviation technology policy. Finally, the third includes suggestions for future research.

9.1 Summary of the Study

This thesis has emphasised the CCM factors of co-operation, co-ordination and motivation. Those were identified to be important factors in the efficient implementation of science and technology policy through a study of the literature on science and technology policy and aviation technology policy. To propose policy options for the efficient implementation of Korean aviation technology policy, the aviation development systems of the UK, the US, Japan and Korea were examined, and the surveys of Korean aviation development system were carried out by a combination of questionnaires and interviews.

This section summarises the research with two parts. One is to explain the importance of the CCM factors in implementing science and technology policy, which was indicated in the literature of science and technology. The other is to summarise the CCM activities adopted in implementing aviation technology policy of the three developed countries and Korea.

The CCM factors are frequently mentioned in the literature on science and technology policy, in policy options suggested by policy experts[55] and in impediments reported by the researchers and policy managers who were sampled for questionnaires and interviews. In addition, it was identified that each element of the CCM factors was also significant in improving the CCM activity. Those elements are frequently mentioned in the literature.

The dissemination and adaptation of new knowledge (The European Commission, 1994), the determination of national goals and priorities (Strasser and Simon, 1973), the allocation of R&D resources, the impact of scientific and technological change (Livingston, 1977) were mentioned in the definition of science and technology policy. In addition, the major issues of science and technology included technology transition, international collaboration (Grayson, 1995), co-ordination, the restructuring of technological institutes, technological development programmes, co-operation between defence and civil sectors, technical training (OECD, 1994),

[55] Policy experts include professors and policy managers in the Korean government, research institutes and the aviation industry.

technological innovation, organisational management, human resources, environment, the encouragement of innovation, spill-over and side-effects, managerial systems, priorities (Tisdell, 1981), co-operation between universities, industry, research institute and government, the condition of the capital market, the attitude of the workforce, economic and technological strength, efficiency in government, technological management, the quality of life (Strasser and Simon, 1973), resistance to change, a short-term outlook, the lack of indigenous skill, institutional control (Petrella, 1994), technological transition efficiency, the balance of power in the decision making process, and the management of public-funded research and information flow (Grayson, 1995).

In addition, the CCM factors and their elements were also indicated to be important in the efficient implementation, by the experts who suggested policy options for aviation industry development found in journals and research reports, and by the results of surveys on Korean aviation development policy. These included the holding of seminars, joint R&D activity the dissemination of R&D results and international collaboration (elements of the co-operation factor), the short-term rotation of officials, the existence of conflict and the survey of technology development trends (elements of the co-ordination factor), participation in decision making process, incentive system, R&D evaluation system and trust relations (elements of the motivation factor).

Hence, we can conclude that the CCM factors are helpful in the efficient implementation of science and technology policy, in general, and of Korean aviation development policy in particular. It also confirms that each element of the CCM factors is important in conducting science and technology policy, and in improving the degree of CCM activities undertaken in implementing Korean aviation development policy.

The CCM activities conducted in implementing aviation technology policy of the three developed countries and Korea will now be summarised on the basis of international comparison, policy options suggested by experts, and survey results.

Co-operation systems can be categorised into those conducted by the government and those conducted by the aviation industries. Regarding each government's co-operation system, the UK government has established one co-operation organisations, the Foresight Defence, Aerospace and System Panel (DASP) and two co-operation programmes including the Civil Aircraft Research and Demonstration (CARAD) and Defence and Aerospace Research Partnerships (DARPs). The US government has underpinned co-operation activities through NASA, and which has operated several co-operation programmes, such as the NASA Incubator, the NASA Brief and the NASA Spin-off. The Korean government has undertaken co-operation activities together with the government-supported aviation research institutes, namely, the KARI and the Agency for Defence Development. They have recently established two co-operation organisations, such as the Aircraft Component and Material Research Centre and the Aircraft Component Development Centre, and one programme, the Dual-Use Technology Programme. The Japan government has also supported co-operation activities through the National Aerospace Laboratory, but few co-operation programmes were found.

Regarding co-operation systems set up by the aviation industry, the UK aviation industry has established the Society of British Aerospace Companies. This has actively conducted various co-operation programmes, including the National Aerospace Forum, the Supply Chain Relationships in Aerospace, the Foresight Action for Aviation and the Foresight Action for Helicopters. The US aviation industry has operated the American Institute of Aeronautical and Astronautics, which has undertaken co-operation programme such as the Congress Days. The Japanese aviation industry has established the Society of Japanese Aerospace Companies, and has conducted joint aviation production projects such as the YS-11, the YX-767 and the V2500 projects, through the establishment of consortiums including the Japanese Aviation Development Corporation (JADC) the Japanese Aero Engine Corporation (JAEC) and the Hyper Sonic Transport Propulsion Device Research Union (HYDE). The Korean aviation industry has also established the Korea Aerospace Industries Association (KAIA) and the Korean Society for Aeronautical and Space Sciences (KSASS) to promote co-operation between aviation companies and between scientists. Korean aviation companies conducted joint aviation development projects with other companies and research institutes and universities, including the Nare, the

Comet 21, the Changong 91, the Composite Material Aircraft and the KTX-1 projects. In addition, the KTX-2 project is currently being jointly developed.

The UK government and the aviation industry seem to have made more efforts than other countries in improving co-operation activities between organisations relevant to aviation industry development. The UK and US governments and their aviation industries have also shown much interest in the active exchange of aviation technological and managerial information in co-operation activities. However, the Japanese government and industry seem to have more focused on joint production. The Japanese aviation industry seems to have highly co-operated in producing aircraft jointly.

The Korean government has shown more interest in technology transfer between the industry, research institutes and universities, as recently it has established two joint research centres and the Dual-Use Technology Programme. However, there seems to be little co-operation between the government, the industry, research institutes and universities. In fact, the degree of co-operation appeared to be low according to survey results. 55 per cent of researchers sampled replied negatively to the degree of co-operation (replied to the options of very low and low about the question asking the degree of co-operation). Only 4 per cent replied positively (replied to the options of high and very high about the question). In addition, the degree of satisfaction with the four elements of the co-operation factor was also reported to be low.

The largest impediment to efficient co-operation was reported by researchers sampled to be the orientation of short-term performance. The second largest was a high level of conflict and low trust between the organisations concerned. The third largest was the relative lack of co-operation programmes, the fourth was low interest in co-operation activity and the fifth was lack of communication. In addition, the largest impediment to efficient international collaboration was reported to be low indigenous technological capability and the second largest was the inconsistency of policy. Furthermore, the highest priority to achieve an efficient co-operation activity was given to the development of efficient co-operation systems by policy experts, followed by the improvement of co-operation activities between organisations concerned, international collaboration and then the development of indigenous technology capability.

The improvement of co-operation activity appears to be an important factor for the development of the Korean aviation industry. To improve co-operation activity, the implementation of a long-term development strategy, the development of indigenous technology capability and the establishment of a co-operation system are identified as critical options for efficient co-operation activity.

Co-ordination systems can be categorised into those established by governments and the aviation industry. Regarding governments' co-operation systems, the UK government has established co-ordination organisation programmes, such as, the Study of the Value of the Defence Industry to the UK Economy (VODE). The US government has supported the aviation industry in order to maintain its competitiveness. It has concluded an agreement with European countries on the restriction of government funding support for the civil aviation industry, and has established technology barriers to prevent high technologies from transferring to foreign countries. In addition, it has released its stockpiled materials in order to maintain the price stability of those materials. The Japanese government has also conducted co-ordination activities. It established the New Energy Industrial Technology Integral Development Institute in order to co-ordinate R&D system and established the Aviation Industry Promotion Act. The Korean government established the Aviation Industry Development Policy Committee, in order to co-ordinate a national aviation development strategy across the ministries concerned, and it has made the Aviation Industry Development Promotion Act.

Regarding the co-ordination activities conducted by the aviation industry, in the UK, the Competitive Challenge and Business Winning Programme are undertaken by the SBAC, the General Aviation Best Practice Programme by the General Aviation Manufacturers and Trade Association (GAMTA), and the Aviation and Construction Consultancy and the System and Service Programme by BAe Systems. However, few co-ordination organisations and programmes conducted by aviation companies were seen in the US, Japanese and Korean aviation industry. Large scale consolidations of aerospace companies occurred in the UK and the US as well as Korea.

The UK government and aviation industry seem to have undertaken a higher level of co-ordination activity than other countries. The US government seems to have indirectly undertaken co-ordination activity for the industry, including the establishment of a competitive environment. However, few concrete co-ordination programmes established by the Japanese and the Korean government were not seen.

The Korean government has made several efforts to achieve a high level of co-ordination activity, by establishing regulations, committees and an aviation development strategy. However, a high level of co-ordination activity seems not to have been conducted. 60 per cent of sampled researchers and 68 per cent of sampled policy managers replied negatively to the degree of co-ordination. Only 11 per cent of sampled researchers replied positively. The largest impediment to efficient co-ordination, replied to by researchers sampled, was organisational egoism within the ministries concerned, research institutes and the industry. The second largest was lower information flow and short-term rotation of officials, and the third was the non-existence of an overall co-ordination organisation. Policy options for efficient co-ordination accounted for the largest percentage of the total options suggested by policy experts with 42 per cent. The policy options show that the most important element for an efficient co-ordination activity is the implementation of a long-term development strategy and the need for a government to be committed to it. The second most important one is a strategic approach in selecting aircraft development projects and strategies, and the third is consistency of policy implementation.

Co-ordination activity seems to be a critical factor for the development of the Korean aviation industry. The Korean government and industry may need more efforts to enhance co-ordination activity while conducting aviation development policy.

Motivation systems are driven by governments. Regarding governments' activities for the motivation of the aviation industry, the UK government has motivated the aviation industry with funding support. In fact, during the period 1948-68, it provided the UK airframe companies with launch aid of £741.2 million for 22 projects. It also provided the engine manufacturing companies with launch aid of £764.2 million for 14 projects (Gummett, 1992). The US government has strongly motivated the aviation industry with funding support. In 1998, the DOD made contracts worth $43.5 billion with 10 major US aerospace companies (*Flight International* 17-23 February 1999, p. 22). The Pentagon's major tactical aircraft procurement budget was $7.7 billion in 1999 and $8.0 billion in 2000 (*AW &ST*, February 8, 1999, p. 28). In addition, NASA and the DOD have motivated the industry through the establishment of many aviation R&D projects. In fact, they have established 43 X-programmes since 1946 (*Flight International* 6-12 January 1999, pp. 28-35).

The Japanese government has motivated its aviation industry through the procurement of aircraft and the provision of aviation development projects. The Japanese Defence Agency procured 215 aircraft worth $8.8 billion during 1996-99 (*AW & ST*, February 1, 1999, p. 87). In addition, the JDA and the Science and Technology Agency have provided many aviation development projects since 1953, and the Ministry of International Trade and Industry has provided aviation companies with subsidies since 1964 (details in Table 6.12). The Korean government has also motivated the aviation industry through the provision of aviation production and development projects, including the three licensed production projects for the 500MD, the F-5 and the KFP, the four development projects for the KTX-1, the KTX-2, Changong 91 and the Composite Material Aircraft and the one independent development project for the KT-1. In addition, the government has provided aviation research institutes, in particular, the KARI, with many R&D projects.

The three developed countries have strongly motivated their aviation industries through the provision of aviation development projects and the procurement of aircraft from their aviation companies. However, the Korean government has provided four licensed production projects and five aviation development projects over the past two decades. Moreover, currently, only one development project, the KTX-2 project, and one production project, the KT-1 project, are working. The Korean government seems not to have motivated its aviation industry so strongly as the governments of other developed counties. In fact, the degree of motivation was reported to be very low by the researchers sampled: 80 per cent of researchers replied to the options of low and very low, and none replied to the options of high and very high.

The largest impediment to motivation reported by the researchers sampled was lower government support and lower autonomy. Next came job instability, following by low wages, and then low participation in the decision-making process. In addition, the most favoured policy option suggested by policy experts was the rationalisation of the industry, following by financial support including provision of development projects, then personnel development and finally the establishment of an efficient working environment.

The Korean government has sought to motivate its aviation industry less than the governments of developed countries, even though its aviation industry's capability is much lower than those of the developed countries. It may need to make more efforts to improve co-operation, co-ordination and motivation activities in carrying on aviation industry development policy.

Nelson (1993) and Amsden (1989) pointed out several positive factors which Korea has rapidly developed: Government's strong intervention with effective industrial strategies, the establishment of large business groups and high qualified labours. The Korean economy had developed the last three decades through government's strong leadership, but it seems to be an effective tool for lest developed country, currently Korea economy became very complicated and difficult to be controlled by the government in general. It may be more important for the Korean government that an effective synthesis and co-ordination of industrial capability rather than non-effective intervention. Korea's large business groups (chaebol), although their size is smaller than that of a large company in the developed countries, also have shown negative result that they make small-sized firms difficult in surviving in Korean market. However, Korea may be possible to compete with overseas giant enterprises through the competitiveness of those chaebol. A number of qualified manpower will be a strong motive in developing technological capability future.

OECD (1996) mentioned the weaknesses of Korea in developing technological capability. Co-ordination has not been conducted between those ministries as pointed out by OECD (1996). Government officials have neglected to co-operate with officials in other ministries concerned due to mistaken over-competition in achieving each ministry's benefit and a busying working environment resulted from the orientation of short-term performance. Korea's technological development can be achieved through synthesising the capability of each ministry. OECD also pointed out weak contribution of the GSRIs and university in developing technological capability, weak social condition for creative and science and technology base, and lower effort in diffusing technology. In fact, the roles of the Korean universities are very weak differently from those of UK ones. Traditionally, the Korean universities have concentrated on only teaching students as a tool which helps students gain job. However recently, the research activity of university has been emphasised by MOST through the establishment of Science Research Centres. On the contrary, it is hard to mention that the contributions of the GRSI are low in general. The development of advanced electronics products produced by the Korea Electronics Telecommunication Research Institute (ETRI) has contributed largely to the Korean economy. In addition, there is a highly creative environment, the government has supported strongly for the improving R&D capability, and most Korean scientists recognise profoundly that the possession of high level technology is critical for continuous economic development of Korea, although technology base is lower than developed countries. The future of Korea seems to very prosperous through a creative environment and qualified scientists and managers.

The future of the Korean aviation industry seems to be very difficult in developing and possessing advanced aviation technology. The government has not given priority to the aviation industry, although the aviation industry needs a strong government support. Many developed countries have strongly involved in the development of the aviation industry. Large-scale consolidations concluded between aviation companies also make Korea difficult in developing technologies, because it may that aviation technologies Korea developed cannot compete with those Boeing developed with huge R&D funds in general. Moreover, researchers in Korean aviation technology research institutes seem to be less motivated resulted from the cancellation of an important national R&D project, the Middle-Size Aircraft Development Project in 1999. The Korean government should decide whether Korea would develop the aviation industry or not. The development of Korean aviation industry cannot be expected without a strong support from the government in procuring aircraft and providing R&D projects.

9.2 Policy Options

Korea has rapidly developed its technological and economic capability, and currently it is well known internationally for developing semiconductor technologies. However, the Korean government seems not to have emphasised the efficient implementation of policies established, due to the social environment in which researchers and policy managers ignore or neglect the importance of co-operation, co-ordination and motivation activities in order to implement given policy effectively. Korean government's role may be very critical in making efforts to remove these weaknesses and achieve the goals of science and technology policy successfully.

As discussed previously, the aviation industry is one which can significantly contribute to country's technological capabilities and economic success, although this global industry is highly competitive. However, the Korean aviation industry has found it very difficult to compete with the developed countries' aviation industries which have been strongly supported by governments.

The aviation technology policy was not given a higher priority, with insufficient provision of aviation technology development projects and the procurement of aircraft, although the government has recognised the need for the development of the aviation industry. The government may strongly support the aviation industry, so that the Korean aviation industry can become more competitive in the world aviation industry.

Policy options will now be recommended in consideration of the literature review of science and technology and aviation technology policy, lessons from CCM systems adopted in the UK, the US and Japan, and the survey result of Korean aviation technology policy. Policy options are recommended with two aspects: the government's strong support; and the achievement of a high level of CCM activities for aviation technology development.

To achieve a higher level of support for the aviation industry, the Korean government need s to consider the following options:

i) MOST and MOIR should consistently provide aviation research institutes with more *R&D projects* to develop complete aircraft, such as the US's X-projects.

ii) KMOD has to *procure* a significant number of aircraft produced by the Korean aviation industry like the US and Japanese procurement policies, in order to support the aviation industry to develop.

iii) The government needs to provide *funds* to the aviation companies, research institutes, universities and other related organisations including the KAIA, so that they can conduct aviation R&D and production projects and management skill development projects, such as the UK's and Japan's launch investment and grant systems.

iv) It should also develop highly qualified researchers and managers, and improved research and information facilities, through the link with *education* systems.

It seems to have had difficulty in establishing the above options within a short term, due to the requirement of huge budgets. Since political support, technological community's consensus and a higher priority given to aviation technology development are needed in establishing aviation technology projects with a large budget. Hence, the following mechanisms need to be established in order to achieve those purposes:

- The government, in particular, MOST, MOIR and KMOD, has to establish strong *determination* in developing aviation technology, with the establishment of a concrete and long-term policy giving aviation technology development a higher priority.
- The three ministries concerned should establish a close *co-operation* relationship in setting up and implementing aviation technology policy.
- MOIR, an overall co-ordinator as stated by the Aviation Industry Development Promotion Act, and the KAIA, as an organisation representing the aviation

companies, need to conduct *public relations* activities in order to formulate society's consensus and gain political support.

A higher level of effectiveness for the above policy options may not be achieved successfully without a continuos funding support every year, efficient policy implementation and the proper establishment of the above mechanisms. New aviation R&D and production projects should be more consistently prepared, and existing projects (the KT-1 and the KTX-2 projects) also need to be supported actively.

Policy options for achieving a higher level of CCM activities will now be recommended within three categories: those for co-operation, co-ordination and motivation. Then, this will be followed by two mechanisms required for achieving the policy goals. These are the replacement of managers and the establishment of an effective working environment.

Firstly, the policy options can be recommended under three categories of CCM activities as follows:

To achieve a higher level of co-operation activity, the following options need to be considered:

i) The government needs to support the holding of regular *seminars* to enable managers and researchers to communicate their affairs.

ii) It needs to support the publication of *periodicals* in order to facilitate dissemination of information concerning management skills and technology developments.

iii) A higher level of *information supply* activity should be achieved in the government, research institutes and universities, through establishment of advanced facilities and the replacement of proper number of managers.

iv) The government should assist the aviation industry closer links with *other industries*, such as the semiconductor and automobile and shipbuilding industry, which may be beneficial for aviation technology development.

v) It has to encourage the co-operation organisations established by the industry, the KAIA and the KSASS, to act as *bridge* between the aviation industry and the government.

vi) It should support universities participation in the co-operation projects conducted between the government, the industry and research institutes.

vii) Policy priority should be given to the development of *indigenous* technological capability for the effective implementation of international collaboration.

To achieve a higher level of co-ordination activity, the following options can be proposed:

i) *A co-ordination meeting* should be held regularly with the participation of managers in ministries concerned, research institutes and universities.

ii) *A regulation* needs to be established so that co-ordination activity is conducted in selecting aviation R&D project provided by the ministries concerned, in order to avoid unnecessary overlap of R&D activities.

iii) The establishment of feasible policies through the consideration of *research reports* conducted by experts or committees.

iv) Many long-term R&D projects, which are conducted several years, should be provided in order to maintain a stability in conducting aviation research.

v) The government's *involvement* in co-ordination for the aviation industry should be strengthened, in order to increase synergy and to avoid over competition between the aviation companies.

To achieve a higher level of motivation activity, the following options can be recommended:

i) The government should improve research autonomy, job stability, communication and participation in decision-making processes.

ii) Several *merit systems* for a higher level of *CCM activity* need to be introduced for managers and researchers.

iii) The frequent overall *structural change of research institutes* needs to be prohibited, including merger with other institutes, so that better job stability is maintained.

iv) The government should support the industry to produce aircraft with lower costs, through the provision of advanced *managerial techniques* in harmony with the Korean culture.

v) It should support the industry to be competitive in the world aviation market. To do this, the government needs to establish *a material price stability strategy* so that the industry has price competition.

vi) It has to make efforts to find and remove unfair economic and technological *sanctions* and regulations from foreign countries which affect the aviation industry.

Secondly, although the above options are actively established, their effectiveness cannot be easily achieved without a proper number of qualified officials effectively managing the policies. However, the emphasis of short-term performance can neglect the importance of management affairs. In the Korean government, such a tendency seems to result in a lack of the number of qualified mangers, and the neglect of management activities including a higher level CCM activities, although higher R&D results cannot be achieved without a sufficient number of managers. To achieve a high level of CCM activities, the government should establish new posts in the these responsibilities, as follows:

i) A single official needs to be posted in MOST. He is responsible for aviation technology information strategy and evaluating the performance of *information flow*, in order to support organisations concerned.

ii) A single official responsible for *public relations* activities on promoting the necessity of aviation technology development and for achieving community's consensus. In addition, the role of the KAIA needs to be strengthened in conducting public relations, through an increase in the number of managers.

iii) A single official responsible for *overall co-ordination* for aviation technology policy in MOIR.

iv) A single official responsible for the *motivation* of researchers in MOST. He can establish and evaluate the motivation systems.

In MOST and MOIR, the appointment of several exclusive officials seems to be very important, in order to enhance the degree of CCM activity, because the degree of CCM activities conducted in implementing its aviation technology policy was identified to be low from the previous chapters.

Finally, although aviation technology projects are provided, their effectiveness cannot be easily achieved without the establishment of a proper working environment in which higher level CCM activities are undertaken. The emphasis on only short-term performance and the neglect of an effective policy implementation should be removed. To achieve an effective working environment, the following mechanisms need to be considered:

i) *Organisational egoism* should be removed in implementing national aviation technology policy.
ii) The *implementation* stage of policy together with CCM activities should be regarded to be important in conducting the affairs related to aviation policy.
iii) The frequency of rotation of government officials should be extended in order to place *experts* in positions to implement aviation technology policy.
iv) Both long-term and short-term strategies should be established in order to maintain *stability of policy*.
v) Conflicts between officials in other ministries, research institutes and the aviation industry should be reduced through the establishment of higher level *communication* systems.

The Korean government needs to analyse the past mistakes in implementing aviation technology policy, in order to implement the current aviation technology policy effectively, and to avoid repeating previous mistakes. It should establish mechanisms to overcome such failures and the current weaknesses in implementing policy through the consideration of analysis report. In addition, it should establish an effective working environment in order to achieve the goals of the mechanisms. The effectiveness of those mechanisms may appear in the short-term or the long-term, and with higher or lower performance according to the working environment. Korea seems to have the funding capability to support the development of advanced aircraft. Hence, if a higher priority will be given to aviation technology development, and if aviation technology policy is implemented effectively, the Korean aviation industry can be highly developed.

In this respect, this thesis is expected to contribute to policy managers working within Korean aviation technology development, through suggestion of several options for the efficient implementation of Korean aviation technology policy. In addition, this thesis is also meant to contribute to the study of science and technology policy field through the postulation of the importance of CCM factors for the efficient implementation of science and technology.

9.3 Future Research

This thesis has emphasised the importance of co-operation, co-ordination and motivation activity in implementing aviation technology policy, and focused on gaining lessons through the examination of the developed countries' aviation development policy. In addition, the survey of Korean aviation development policy was carried out through using a combination of questionnaires and interviews. Finally, the policy options for the efficient implementation of Korean aviation technology policy are recommended, an important aim of the thesis, on the basis of the international examination and the survey results.

It could be argued that the CCM factors would have fewer benefits to efficient implementation of science and technology policy in different technology areas and countries. A more detailed study of the benefits of the CCM factors would include the following three areas.

(i) A study of aviation development policies of other countries which have less developed aviation technology capability compared to the developed countries of the UK, the US and Japan. The less developed countries may include Brazil, Indonesia and Taiwan, whose aviation development policy would provide wider views on the efficient implementation of aviation development policy.

(ii) A study of the stages of policy establishment and evaluation. Those stages influence the stage of policy implementation researched in the thesis.

(iii) A study of cultures involved in the efficient implementation of aviation development policy. Lessons from the examination of the developed countries' aviation development policy may not exactly harmonise with Korean aviation development policy. To recommend feasible science and technology policy options, it would be necessary to understand the culture related to the implementation of the policy, including researcher and policy manager's working attitudes and their working environment.

(iv) A policy study on the role of the Korean government and aviation enterprises and their relations in developing aviation technological capabilities. This is because, the government needs to know and support industrial requirements, and because aviation firms also need to participate in establishing and achieving national aviation technology strategy. It is difficult to separate the role of government and industry in this sector, particularly in the case of Korea, where the industry is not well established in global terms. This study has focussed upon government, and provided part of a large picture, which would also include Korean enterprises and their relationship to other global players.

Annex 1 The Major World Aviation Companies

Classification of aircraft and region		Company	'97 sales ($billion)	Employee	Country
Large-Range Aircraft	Europe	Airbus Industrie	13.3*		Europe
		BAe Systems	20.5*	43,000	UK
		EADS/CASA	21.8*	89,000	Europe
		Dassult Aircraft	3.4*	'9,000	France
		Finmeccanica (Alenia, Agusta)	3.9	-	Italy
	America	Boeing	56.2*	220,000*	US
		Lockheed Martin	22.4*	173,000	"
		Raytheon	13.7	119,200	"
		Northrop Grumman	9.1	52,000	"
Middle Range Aircraft	America	Textron (Cessna, Bell)	3.1	64,000	"
		Gulfstream	1.9	5,800*	"
		Fairchild Dornier	0.5	-	"
		Bombardier	3.3	47,500	Canada
		Embraer	0.8	4,500	Brazil
Helicopter	Europe	Westland	1.5	32,600	UK
		Agusta			Italy
	America	Sikorsky			US
		Bell	-		"
Aero-Engine	Europe	Rolls-Royce	5.0	26,900	UK
		SNECMA	3.9	22,000	France
		TURBOMECA	0.4	-	Italy
		BMW-RR	0.3	2,060	Germany
		Fiat Avio	1.4	6,500	Italy
	America	General Electric	7.8	276,000	US
		Pratt & Whitney	7.4	-	"
Component	Europe	Thomson-CSF	5.9	133,600	France

Remarks
'98 data marked * is from Flight International 20-26 October 1999, pp. 25-27, and an Internet search.
'97 data is from Flight International, 2-8 September 1998, pp. 48- 61.

Annex 2 International Comparison of the Aerospace Industry by World Top 100 Companies by 1997 Sales

Country	Companies in the Top 100			Performance of Major Companies		
	Sales ($m)	Sales (%)	Numbers	Rak-ing	Sales ($)	Name of Company
USA	156,940	61.1	46	1	45,054	Boeing
				2	27,885	Lockheed Martin
				4	10,640	Raytheon
				5	10,264	United Technologies
				7	9,153	Northrop Grumman
UK	31,850	12.4	12	3	13,995	British Aerospace
				11	6,048	Marconi Electronic Systems (GEC)
				14	5,029	Rolls-Royce
				32	1,480	Westland (GKN)
				40	1,076	Hunting
				41	1,064	Lucas Varity
France	31,090	12.1	13	12	5,996	Thomson-CSF
				17	3,607	Dassualt Aviation
				22	2,768	Lagardere
				39	1,125	Arianespace
				51	835	Labinal
Germany	10,300	4.0	4	8	8.818	DASA
				48	894	Siemens
				88	302	BMW- Rolls Royce Aeroengine
Japan	7,253	2.8	6	19	3,166	Mitsubishi Heavy Industries (HI)
				28	1,32	Kawasaki HI
				38	1,135	Ishikawajima-Harima HI
				64	566	Fuji HI
				82	392	Nissan
				92	262	Japan Aircraft Manufacturing
Italy	6,336	2.5	2	16	3,900	Finmeccania
				33	1,436	FiatAvro
Canada	3,998	1.6	3	18	3,303	Bombardier
				68	510	CAE
				100	185	Magellan Aerospace
Sweden	2,842	1.1	3	37	1,136	Saab
				45	979	Volvo
				54	727	Celsis

Israel	2,063	0.8	2	29	1,691	Israel Aircraft Industries (IAI)
				83	372	Elbit System
Spain	1,252	0.5	1	36	1,252	SEPI
Switzerland	1,054	0.4	2	55	715	Oerliken
				84	339	Liebherr
Brazil	794	0.3	1	52	794	Embraer
India	493	0.2	1	71	493	Hindustan Aeronautics
Korea	480	0.2	1	74	480	Samsung Aerospace
Singapore	454	0.2	1	76	454	Singapore Technologies Aerospace
South Africa	335	0.1	1	85	335	Denel
Belgium	201	0.1	1	98	201	SABCA
Total	256,670	100	100	-	-	

Annex 3 Major International Collaboration in the Aviation Industry

Joint Venture (Field)	Joint Partners (Share (%), Nationality)	Year
Airbus Industries (Civil aircraft)	BAe Systems (20, UK) Aerospatiale Matra (37.9, France) DaimlerChrysler Aerosapce (37.9, Germany) Construccions Aeronaticas S.A. (4.2, Spain)	1970
Eurofighter (Fighter)	BAe Systems (37, UK) DaimlerChrysler Aerosapce (Germany) Construccions Aeronaticas S.A. (Spain) Alenia Spazia (19, Italy)	1979
Eurocopter (Helicopter)	Aerosapatiale Matra (60, Fance) DaimlerChrysler Aerosapce (40, Germany)	1961
Gripen (Combat aircraft)	BAe Systems (UK) Saab (Sweden)	1988
Harrier (Combat aircraft)	BAe Systems (UK) Boeing	1981
Concorde (Civil aircraft)	BAe Systems (UK) Aerosapatiale Matra (Fance)	1976
Jaguar (Combat aircraft)	BAe Systems (UK) Dassault (France)	1968
Tornado (Combat aircraft)	Panavia Aircraft Gmbh - BAe Systems (UK) - DaimlerChrysler Aerosapce (Germany) - Alenia Spazia (Italy)	1969
NH 90 (Helicopter)	NH Industries - Aerosapatiale Matra (Fance) - DaimlerChrysler Aerosapce (Germany) - Agusta (Italy) - Fokker (Netherlands)	1999
S-92 Helibus (Helicopter)	- Sikorsky Aerospace Corporation (US) - Jingdezhen Helicopter Group (China) - Mitsubishi Heavy Industries (Japan) - Aerospace Industries Development Corporation (Taiwan) - Embraer (Brazil) - Gamesa (Spain)	1999
C-27JIS (Tactical Transport)	- Lockheed Martin (US) - Alenia Spazia (Italy)	1999
BA 609 (Civil tiltrotor)	- Bell (US) - Agusta (Italy)	1998
Joint Strike Fighter (Demonstrator)	-Lockheed Martin (US) - BAe Systems (UK)	1997
Adour RB-172 (Engine)	Rolls-Royce(UK), Turbomeca(France)	1972

Olympus (Engine)	Rolls-Royce Snecma(France)	1975
RB-199 (Engine)	Rolls-Royce(UK), Turbomeca(France)	1978
V 2500 (Engine)	Pratt &Whitney (US) Rolls-Royce (UK) Motoren Und Turbinen Union (Germany) Fiat(Italy) Japan Engine Corporation (JAEC)	1988
PW 4000 (Engine)	Pratt &Whitney (US) Motoren Und Turbinen Union (Germany) Fiat(Italy) Mitsubishi, Kawasaki(Japan)	1994
GE 90 (Engine)	General Electric (US) Snecma (France)	1995
Trent 800 (Engine)	Rolls-Royce (UK) BMM-RR (Germany) Ishikawajima-Harima, Kawasaki (Japan)	1995

Annex 4: US X-series

1. Experimental Aircraft Conducted: X-1 to X-30

X-Series	Manufacturer	Mission	Flight test period
X-1	Bell Aircraft	Supersonic (3 projects)	1946-58
-2	"	High aerodynamics	1952-56
-3	Douglas Aircraft	High speed phenomena	1954-56
-4	Northrop Aircraft	Semi-tailless configuration	1950-53
-5	Bell Aircraft	Variable-geometry aerodynamics	1952-55
-6	General Dynamics	Nuclear propulsion	1955-57
-7	Lockheed Missile	Hypersonic ramjet	1951-56
-8	Aerojet Engineering	Inexpensive upper-air vehicle	1947-56
-9	Bell Aircraft	Air-to-surface missile	1949-53
-10	North American	Aerodynamic for cruise missile	1955-59
-11	Convair	Single-stage ballistic rocket	1957-58
-12	"	One-and-a-half-stage ballistic rocket	1958
-13	Ryan Aeronautical	VTOL configuration	1955-58
-14	Bell Aircraft	"	1957-81
-15	North American	Hypersonic flight beyond M6	1959-68
-16	Bell Aircraft	Reconnaissance aircraft (cancelled)	1952
-17	Lockheed	Multi-stage rocket	1955-57
-18	Hiller Aircraft	Large-tilt wing V/STOL aircraft	1959-64
-19	Curtiss-Wright	Tilt-prop VTOL hypersonic	1963-65
-20	Boeing	Hypersonic and orbit (cancelled)	1963
-21	Northrop	Full-scale boundary layer control	1963-64
-22	Bell Aerospace	Dual-tandem ducted propeller V/STOL	1966-1986
-23	Martin Marietta	Hypersonic lifting-body re-entry vehicle	1966-67
-24	"	"	1969-1975
-25	Benson Aircraft	"Gyro-chute" crew escape concept	1968
-26	Lockheed/Schweizer	Stealthy, intelligence gathering	1967-68
-27	Lockheed California	Advanced Lightweight fighter	1971
-28	George Pereira	Single-seat seaplane	1971
-29	Grumman Aerospace	High angle-of-attack	1984-92
-30	Never selected	Single-stage-to-orbit demonstrator (cancelled)	1994

Source: *Flight International* 6-12 January 1999, p. 34.

2. Active X-series

X-series	Manufacturer	Mission	Contract period
X-31	Rockwell/MBB	First international X-programme, US-Germany. Enhanced Fighter Manoeuvrability aircraft	1990-99
-32	Boeing	JSF concept demonstrator aircraft	1996-00
-33	Lockheed Martin	A half-scale technology demonstrator for VentureStar, a single-stage-to-obit reusable launch vehicle.	1996-01
-34	Lockheed	Future reusable launch vehicle	ND
-35	Lockheed Martin	JSF concept demonstrator aircraft	1996-00
-36	Boeing	An agile tailless fighter, $20 million	1997-
-37	Boeing	Low-cost access to space ($150 mil, 50:50)	-02
-38	NASA	Crew Return Vehicle for Space Station	1995-00
-39	USAF	Sub-scale unmanned demonstrator	reserved
-40	Boeing	Space Manoeuvre Vehicle	1998-
-41	-	Experimental manoeuvrable re-entry vehicle	reserved
-42	-	Experimental expendable liquid rocket	reserved
-43	Tullahoma	Piloted single-stage-to-orbit demonstrator	1998-

Source: *Flight International* 6-12 January, pp. 28-35.

ANNEX 5: Content of Questionnaire

- Questionnaire *to Survey Korea Aviation Technology Policy*

> The survey aims to analyse a main R&D project carried out or being carried out by your research team over the last three years (May 1996 to June 1999). Pleas select a main R&D project (hereinafter the **main project**), and then reply to questions below based on the main project.
>
> Please tick appropriate answers.

I. General Questions

1. What are the characteristics of the main project?

- o Title of the main project:
- o Purpose of the main project:
- o Content of the main project:

(Q.1) Characteristics of the main project:
1) R&D project ( ) 2) Organisational management project ( ) 3) Others ( )

(Q.2) Pattern of the main project:
1) Basic research ( ) 2) Applied research ( ) 3) Development ( )

(Q.3) Research period of the main project: ( ) year

(Q.4) Research funding of the main project: ( ) Korean million Won

2. What are the characteristics of your research team ?

(Q.5) The number of researchers participating in the main project: ( ) persons
(Q.6) How long has your research team been in existence since its establishment ? ( ) years
(Q.7) How many projects has your research team carried out in the last three years? ( ) projects

II. These are questions on co-operation activities in conducting the main project.

1. In respect of seminars held by your research team in relation to the main project for the last year (June 1998 ~ May 1999):

(Q.8) What is the number of times seminars have been held for inside researchers ?
1) 0 times( ) 2) 1~2 times( ) 3) 3~4 times( ) 4)5~6 times( ) 5) over 7 times( )

(Q.9) What is the number of times seminars have been held for outside persons ?
1) 0 times( ) 2) 1~2 times( ) 3) 3~4 times( ) 4)5~6 times( ) 5) over 7 times( )

(Q.10) What is the degree of contribution of seminars for persons inside organisation to the main project ?

1 2 3 4 5

Very low Middle Very high

(Q.11) What is the degree of contribution of seminars for person outside organisation to the main project ?

1 2 3 4 5

Very low Middle Very high

2. Regarding the dissemination of R&D performance by your research team for the last year:

(Q.12) How many times has advice been given to engineers in business enterprises ?
1) 0 times( ) 2) 1~3 times( ) 3) 4~6 times( ) 4) 7-9 times( ) 5) over 10 times( )

(Q.13) What is the number of technology transfers to business enterprises ?
1) 0 items( ) 2) 1~3 items( ) 3) 4~6 items( ) 4) 7-9 items( ) 5) over 10 items( )

(Q.14) What is the number of university students who have been participated in the research processes of the main project? (   ) persons

(Q.15) How many lectures have been given in universities ?
1) 0 ( ) 2) 1~3 ( ) 3) 4~6 ( ) 4) 7- ( ) 5) over 10 ( )

(Q.16) What is the level of contribution of dissemination activities to the main project ?

1 2 3 4 5

Very low Middle Very high

3. Regarding joint R&D projects relevant to the main project, <u>for the last three years:</u>

(Q.17) What is the number of joint projects conducted with the participation of other research institutes, businesses and universities ?
1) 0 projects( ) 2) 1~3 projects( ) 3) 4~6 projects( ) 4) 7-9 projects( )
5) over 10 projects( )

(Q.18) What is the number of joint projects conducted with the participation of other research institutes and businesses ?
1) 0 projects( ) 2) 1~3 projects( ) 3) 4~6 projects( ) 4) 7-9 projects( )
5) over 10 projects( )

(Q.19) What is the number of joint projects conducted with the participation of other research institutes ?
1) 0 projects( ) 2) 1~3 projects( ) 3) 4~6 projects( ) 4) 7-9 projects( )
5) over 10 projects( )

(Q.20) What is the number of joint projects conducted with the participation of businesses ?
1) 0 projects( ) 2) 1~3 projects( ) 3) 4~6 projects( ) 4) 7-9 projects( )
5) over 10 projects( )

(Q.21) What is the number of joint projects conducted with the participation of universities ?
1) 0 projects( ) 2) 1~3 projects( ) 3) 4~6 projects( ) 4) 7-9 projects( )
5) over 10 projects( )

(Q.22) What is the degree of contribution of joint R&D projects to main project?

1 2 3 4 5

Very low Middle Very high

III. These are questions on co-ordination activities with organisations concerned in the conduct of the main project.

1. With regard to the working rotation of officers (researchers, managers and government officers) who influence the conduct of the main project:

(Q.23) What is the competent ministry and division related to the main project ?
Ministry ( ), Division ( )

(Q.24) How often have <u>government officers</u> concerned with the main project been changed in the last three years ?

1	2	3	4	5
Very high		Middle		Very low

(Q.25) What is the degree of impediment caused by government officers' short-term rotation in conducting the main project ?

1	2	3	4	5
Very high		Middle		Very low

(Q.26) How often have <u>researchers</u> in your research team been changed in the last three years ?

1	2	3	4	5
Very high		Middle		Very low

(Q.27) What is the degree of impediment caused to the conduct of the main project by the short-term rotation of researchers ?

1	2	3	4	5
Very high		Middle		Very low

2. In relation to conflicts with relevant persons in conducting the main project <u>for the last three years:</u>

(Q.28) What is the degree of successful resolution of conflicts between your research team and other research teams in your research institute ?

1 2 3 4 5

Very low Middle Very high

(Q.29) What is the degree of successful resolution of conflicts between your research team and support divisions in your research institute ?

1 2 3 4 5

Very low Middle Very high

(Q.30) What is the degree of successful resolution of conflicts between your research team and concerned ministries ?

1 2 3 4 5

Very low Middle Very high

(Q.31) What is the degree of successful resolution of conflicts between your research team and universities ?

1 2 3 4 5

Very low Middle Very high

(Q.32) What is the degree of successful resolution of conflicts between your research team and businesses ?

1 2 3 4 5

Very low Middle Very high

(Q.33) What is the degree of impediment represented by conflicts with organisations concerned in conducting the main project ?

1 2 3 4 5

Very high Middle Very low

3. Regarding technology development trend analyses through which the research team aims to adapt to a fast changing technological environment <u>for the last three years:</u>

(Q.34) Who has been the best source of information for the purpose of analysing technology development trends relevant to the main project ?

1) Government ( ) 2) Businesses ( ) 3) Universities ( )
4) Other research institutes ( ) 5) Self survey ( )

(Q.35) What has been the number of technology development trend analyses conducted relevant to the main project ?

1) 0 ( ) 2) 1~2 ( ) 3) 3~5 ( ) 4) 6-7 ( ) 5) over 8 ( )

(Q.36) What has been the level of technology development trend analysis activity undertaken in conducting the main project ?

1 2 3 4 5
Very low Middle Very high

(Q.37) What has been the degree of contribution of technology development trend analysis activity in conducting the main project ?

1 2 3 4 5
Very low Middle Very high

IV. The following are questions concerned with researchers' motivation to achieve high level of R&D performance.

1. With regard to researcher's participation in decision-making processes relevant to the main project <u>for the last three years:</u>

(Q.38) What has been the researchers' degree of participation in decision-making processes relevant to the main project in your research team ?

1 2 3 4 5
Very low Middle Very high

(Q.39) What has been the researchers' degree of participation in the concerned ministry's decision-making processes relevant to the main project ?

1 2 3 4 5

Very low Middle Very high

2. In respect to government activities to enhance R&D performance of the main project:

(Q.40) What is the degree of satisfaction with the government funding incentive system relevant to the main project ?

1 2 3 4 5

Very low Middle Very high

(Q.41) What is the degree of satisfaction with the government merit system relevant to the main project ?

1 2 3 4 5

Very low Middle Very high

(Q.42) What is the degree of satisfaction with the government's evaluation of the research performance of the main project ?

1 2 3 4 5

Very low Middle Very high

3. In relation to trust relation establishment activities:

(Q.43) What is the number of entertainment circles in your research institute ?
1) 0 circles ( ) 2) 1~3 circles ( ) 3) 4~6 circles ( ) 4) 7-9 circles ( )
5) Over 10 circles ( )

(Q.44) What is the number of entertainment circles you have joined ?
1) 0 circles ( ) 2) 1~3 circles ( ) 3) 4~6 circles ( ) 4) 7-9 circles ( )
5) Over 10 circles ( )

(Q.45) What is the level of contribution of entertainment circles in formulating trust relations between researchers in your research institute ?

1 2 3 4 5

Very low Middle Very high

(Q.46) What is level of trust established between researchers in your research team in conducting the main project ?

1 2 3 4 5

Very low Middle Very high

(Q.47) What is the level of trust established between your research team and support divisions, such as the research planning division and the information office, in your research institute in conducting the main project ?

1 2 3 4 5

Very low Middle Very high

(Q.48) What is the level of trust established between your research team and ministries concerned in conducting the main project ?

1 2 3 4 5

Very low Middle Very high

(Q.49) What is the level of contribution of the establishment of the trust between your research team and concerned persons in conducting the main project ?

1 2 3 4 5

Very low Middle Very high

V. The following are questions about international collaboration activities related to the conduct of the main project.

1. Regarding international joint research related to the main project in the last years:

(Q.50) What has been is the number of international joint projects relevant to the main project ?

1) 0 projects ( ) 2) 1~3 projects ( ) 3) 4~6 projects ( ) 4) 7-9 projects ( )
5) Over 10 projects ( )

(Q.51) What has been the degree of contribution of international joint projects to the main project ?

1 2 3 4 5

Very low Middle Very high

2. Regarding researcher exchange activities to enhance the research performance of the main project, in the last year:

(Q.53) What has been the number of researchers dispatched to overseas research institutes in conducting the main project ?

1) 0 persons ( ) 2) 1~5 persons ( ) 3) 6~10 persons ( ) 4) 11~15 persons ( )
5) Over 16 persons ( )

(Q.54) What has been the number of researchers invited from foreign countries in the course of the conduct of the main project ?

1) 0 persons ( ) 2) 1~5 persons ( ) 3) 6~10 persons ( ) 4) 11~15 persons ( )
5) Over 16 persons ( )

(Q.55) What has been the degree of contribution to the conduct of the main project represented by dispatching researchers to overseas research institutes ?

1 2 3 4 5

Very low Middle Very high

(Q.56) What has been the degree of contribution of researchers invited from foreign countries in conducting the main project ?

1 2 3 4 5

Very low Middle Very high

3. Concerning the acquisition of overseas advanced information in conducting the main project:

(Q.57) What is the number of overseas periodicals subscribed to relevant to the main project ?
1) 0 ( ) 2) 1~3 ( ) 3) 4~6 ( ) 4) 7~9 ( ) 5) Over 10 ( )

(Q.58) What is the number of attendance of researchers in your research team at overseas conferences related to the main project ?
1) 0 times ( ) 2) 1~5 times ( ) 3) 6~10 times ( ) 4) 11~15 times ( )
5) Over 16 times ( )

(Q.59) What is the number of international conferences organised by your research team in relation to the main project ?
1) 0 times ( ) 2) 1~3 times ( ) 3) 4~6 times ( ) 4) 7~9 times ( )
5) Over 10 times ( )

(Q.60) What is the degree of contribution to the main project represented by subscribing to relevant overseas periodicals ?

1 2 3 4 5
Very low Middle Very high

(Q.61) What is the degree of contribution to the main project represented by attending overseas conferences related to it ?

1 2 3 4 5
Very low Middle Very high

(Q.62) What is the degree of contribution of international conferences organised by your research team in relation to the main project ?

1 2 3 4 5
Very low Middle Very high

VI. The following are questions concerning managerial issues related to aviation technology policy.

(Q.63) What is your degree of satisfaction with the R&D performance of Korean aviation technology research institutes at a national level ?

1 2 3 4 5

Very low Middle Very high

(Q.64) What is your degree of satisfaction with the R&D performance of Korean aviation universities ?

1 2 3 4 5

Very low Middle Very high

(Q.65) What is your degree of satisfaction with government activities to support the development of Korean aviation technology ?

1 2 3 4 5

Very low Middle Very high

(Q.66) Given the current situation of Korean aviation technology policy, please select important factors from the following list which should be supported by the government in order to improve aviation technology, and give the order of priority of the factors you select.

Factors	Priority	
1 ( )	( )	Improvement of the in-house R&D ability of research institutes
2 ( )	( )	Strengthening of international joint R&D activities
3 ( )	( )	Strengthening of purchasing advanced technologies from over overseas
4 ( )	( )	Licensing production from overseas
5 ( )	( )	Strengthening of researcher training overseas
6 ( )	( )	Others ( )

(Q.67) What is the efficiency of organisational management in Korean aviation research institutes ?

1 2 3 4 5

Very low Middle Very high

(Q.68) Please select important factors from the following list that should be supported by the government in terms of organisational management, and give the order of priority of the factors you select.

Factors Priority

1 ( ) ( ) Establishment of research motivation through incentive systems

2 ( ) ( ) Establishment of co-operative relations between organisations concerned with aviation technology development

3 ( ) ( ) Implementation of a high level of co-ordination activity to integrate national aviation technological capability

4 ( ) ( ) Maintenance of policy stability to continue R&D activities with a long-term strategy

5 ( ) ( ) Maintenance of organisational stability without frequent organisational adjustment of the research institute in order to sustain researchers' morale

6 ( ) ( ) Other ( )

(Q.69) What is the degree of satisfaction with research facilities and regulation related to Korean aviation technology development ?

1 2 3 4 5

Very low Middle Very high

(Q.70) Please select factors from the following list that should be supported by the government in terms of regulation, and give the order of priority of the factors you select.

Factors Priority

1 ( ) ( ) Establishment of an integration organisation to co-ordinate the different opinions of ministries

2 ( ) ( ) Integration of aviation technology research institutes in order to concentrate their R&D capabilities

3 ( ) ( ) Revision of regulations to sustain the continuity of R&D activity with a long-range strategy

4 ( ) ( ) Establishment of a system of co-utilisation of R&D facilities

5 ( ) ( ) Recruitment and training of able managers

6 ( ) ( ) Strengthening of government support for aviation technology development with huge funding

7 ( ) ( ) Others ( )

(Q.71) What is the degree of co-operation between research institutes, universities, businesses and government in the development of aviation technology ?

1 2 3 4 5

Very low Middle Very high

(Q.72) Please select factors from the following list that negatively influence the formulation of co-operative relation between organisations concerned in aviation technology development, then give the order of priority of the factors you select.

Factors	Priority	
1 ( )	( )	Low level of communication between concerned organisations
2 ( )	( )	Emphasis on a short-term performance
3 ( )	( )	Small number of co-operative projects and regulations
4 ( )	( )	Manager's low support to co-operative activities in conducting R&D
5 ( )	( )	Low level of trust relations and the high level of conflicts between organisations concerned
6 ( )	( )	Others ( )

(Q.73) What is the degree of co-ordination between organisations related to aviation technology development in integrating aviation technology R&D activities ?

1 2 3 4 5

Very low Middle Very high

(Q.74) Please select factors form the following list that negatively influence the formulation of efficient co-ordination activity, and then give the order of priority of factors you select.

Factors	Priority	
1 ( )	( )	Selfishness of organisation in reaping benefits for itself, rather than contributing towards national development
2 ( )	( )	Tendency to block the flow of information in order to keep knowledge to oneself
3 ( )	( )	Researchers' low level of recognition of the importance of co-ordination activity
4 ( )	( )	Non existence of a co-ordination organisation in government
5 ( )	( )	Few co-ordination institutes with regulations and programmes
6 ( )	( )	Frequent change of project content due to the short-term rotation of officers in concerned organisations
7 ( )	( )	Others ( )

(Q.75) What is the level of research motivation of researchers in research institutes and universities related to aviation technology development ?

1 2 3 4 5

Very low Middle Very high

(Q.76) Please select factors from the following list that negatively influence researchers' motivation, and give the order of priority of factors you select.

Factors Priority

1 ( ) ( ) High managers' rigid managerial attitude
2 ( ) ( ) Low level of participation in decision making procedure
3 ( ) ( ) Low level of autonomy in research activities
4 ( ) ( ) High level of government intervention in research activities
5 ( ) ( ) Low level of government support to R&D activities
6 ( ) ( ) Job instability through frequent change of R&D organisations
7 ( ) ( ) Low level of salary
8 ( ) ( ) Low level of incentives to research performance
9 ( ) ( ) Inefficient audit system
10( ) ( ) Others ( )

(Q.77) What is the degree of efficiency of international collaboration activities in organisations related to the development of Korean aviation technology ?

1 2 3 4 5

Very low Middle Very high

(Q.78) Please select factors from the following list which negatively influence international collaboration activities, then give the order of priority of the factors you select.

Factors Priority

1 ( ) ( ) Low level of domestic technological capability
2 ( ) ( ) Technology barrier from developed countries
3 ( ) ( ) Inactive international collaboration activity
4 ( ) ( ) Low level of formulation of international collaboration relation
5 ( ) ( ) Language barrier
6 ( ) ( ) Discontinuity of international collaboration projects due to the taking of a short-term views
7 ( ) ( ) Low quality of management system of overseas R&D information
8 ( ) ( ) Difficulty in the formulation of trust relation with foreign R&D organisations
9 ( ) ( ) Low scale of budget for international collaboration projects
10( ) ( ) Others ( )

Finally,

** Please answer the following questions relating to your personal careers ? **

(Q.79)Name of research institute you work for (   )

(Q.80) Major field in academia
1) R&D area (   ) 2) Management area (   ) 3) Others (   )

(Q.81) Academic career
1) Bachelor (   ) 2) Master (   ) 3) Doctor (   ) 4) Others (   )

(Q.82) Research experience
1) Under 5 years (   ) 2) 6~10 years (   ) 3) 11~15 years (   )
4) Over 16 years (   )

(Q.83) Period of research in current organisation
1) Under 5 years (   ) 2) 6~10 years (   ) 3) 11~15 years (   )
4) Over 16 years (   )

** Please could you give your advice about my research ? **

Thanks for your co-operation !!!

❑ Content of Questionnaire to Policy Managers

- Structured Interview on Korean Aviation Technology Policy

Division / Organisation:
Position / Name:

The following are questions concerning managerial issues relevant to the efficient implement of Korean aviation technology policy. Would you please answer the following questions ?

(Q.1) What is your degree of satisfaction with the research performance of Korean aviation technology research institutes, businesses, and universities at a national level ?

1 — 2 — 3 — 4 — 5

Very low — Middle — Very high

** Given the current situation of Korean aviation technology policy, please select important factors from the following list that should be supported by the government in order to improve aviation technology, and give the order of priority of the factors you select.

Factors	Priority	
1 ( )	( )	Improvement of the in-house R&D ability of research institutes
2 ( )	( )	Strengthening of international joint research
3 ( )	( )	Increased purchasing advanced technology from overseas
4 ( )	( )	Licensing production from overseas
5 ( )	( )	Strengthening of researcher training from overseas
6 ( )	( )	Others ( )

(Q.2) What is the level of efficiency of organisational management in Korean aviation research institutes ?

1 2 3 4 5

Very low Middle Very high

** Please select important factors from the following list that should be supported by the government in order to improve organisational management, and give the order of priority of the factors you select.

Factors Priority

1 ( ) ( ) Establishment of research motivation through incentive system

2 ( ) ( ) Establishment of co-operative relations between organisations concerned with aviation technology development

3 ( ) ( ) Implementation of a high level of co-ordination activity to integrate a national aviation technological capability

4 ( ) ( ) Maintenance of organisational stability without frequent adjustment to the organisation of the research institute in order to maintain researchers' morale

5 ( ) ( ) Other ( )

(Q.3) What is the degree of satisfaction with research facilities and regulations related to Korean aviation technology development ?

1 2 3 4 5

Very low Middle Very high

** Please select factors from the following list that should be supported by government in terms of regulation, and give the order of priority of the factors you select.

Factors Priority

1 ( ) ( ) Establishment of an integration organisation to co-ordinate the different opinions of ministries

2 ( ) ( ) Integration of aviation technology research institutes in order to integrate their R&D capabilities

3 ( ) ( ) Revision of regulations to in order to maintain the consistency of R&D activity with a long-range strategy

4 ( ) ( ) Formulation of co-utilisation system of modern R&D facilities

5 ( ) ( ) Recruitment and training of able managers

6 ( ) ( ) Strengthening of government support for aviation technology development with large scale funding

7 ( ) ( ) Others ( )

(Q.4) What is the degree of co-operation between research institutes, universities, businesses and government in the development of aviation technology ?

1 2 3 4 5

Very low Middle Very high

** Please select factors from the following that negatively influence establishment of co-operative relation between organisations involved in aviation technology development, then give the order of priority of the factors you select.

Factors	Priority	
1 ( )	( )	Low quality of communication between related organisations
2 ( )	( )	Strengthening of short-term performance
3 ( )	( )	Few co-operative projects and regulations
4 ( )	( )	Managers' low level of support to co-operative activities in conducting R&D
5 ( )	( )	Low quality of trust relation and higher level of conflicts between organisations concerned
6 ( )	( )	Others ( )

(Q.5) What is the degree of co-ordination between organisations related to aviation technology development in integrating aviation technology R&D activities ?

1 2 3 4 5

Very low Middle Very high

** Please select factors from the following list that negatively influence the establishment of efficient co-ordination activity, then give the order of priority of the factors you select.

Factors	Priority	
1 ( )	( )	Selfishness of the organisation in reaping benefits for itself, rather than contributing towards national development
2 ( )	( )	Tendency to block the flow of information in order to keep knowledge to oneself
3 ( )	( )	Researchers' lower level of recognition of the importance of co-ordination activity
4 ( )	( )	Non existence of a co-ordination organisation in government
5 ( )	( )	Few co-ordination institutes with regulations and programmes
6 ( )	( )	Neglect of a long-range strategy
7 ( )	( )	Frequent change of project content due to the short-term rotation of officers in organisations concerned
8 ( )	( )	Others ( )

(Q.6) What is the degree of motivation of researchers in research institutes and universities related to aviation technology development ?

1 2 3 4 5

Very low Middle Very high

** Please select factors from the following list that negatively influence researchers' research motivation, then give the order of priority of the factors you select.

Factors Priority

1 ( ) ( ) High level of the rigid managerial attitude of mangers
2 ( ) ( ) Low level of participation in decision making processes
3 ( ) ( ) Low level of autonomy in the conduct of research activities
4 ( ) ( ) High level of intervention form government in research activities
5 ( ) ( ) Low level of government support to R&D activities
6 ( ) ( ) Job instability due to the frequent change of R&D organisations
7 ( ) ( ) Low level of salary
8 ( ) ( ) Low level of incentives to research performance
9 ( ) ( ) Inefficient audit system
10( ) ( ) Others ( )

(Q.7) What is the degree of efficiency of international collaboration activities in organisations related to the development of Korean aviation technology ?

1 2 3 4 5

Very low Middle Very high

** Please select factors form the following list that negatively influence efficient international collaboration activities, then give the order of priority of the factors you select.

Factors Priority

1 ( ) ( ) Low quality of domestic technological capability
2 ( ) ( ) High level of technology barrier from developed countries

3 ( ) ( ) Low level international collaborative relations
4 ( ) ( ) High level of language barrier
5 ( ) ( ) Inactive international collaboration activity
6 ( ) ( ) Discontinuity of international collaboration projects due to the taking of a short-term views
7 ( ) ( ) Low quality of the management system of overseas R&D information
8 ( ) ( ) Few instances of joint R&D programmes
9 ( ) ( ) Few instances of overseas direct investment such as the establishment of overseas research institutes
10 ( ) ( ) Lack of monitoring system for overseas technology
11 ( ) ( ) Difficulty in the establishment of trust with foreign R&D organisations
12 ( ) ( ) Low scale budget for international collaboration projects
13 ( ) ( ) Others ( )

ANNEX 6: Responses to the Questionnaire

No	Organisation	Responses					Average	Questions
		1	2	3	4	5		
8	KARI (1)	2	4	3	2	3	3.00	Number of internal seminars held
	KAL (2)	-	7	2	1	5	3.27	
	SAMSUNG (3)	-	-	-	1	4	4.80	
	DAEWOO (4)	-	4	3	2	6	3.67	
	HUYNDAI (5)	1	5	-	1	1	2.50	
	(2+3+4+5)	1	16	5	5	16	3.46	
	(1+2+3+4+5)	3	20	8	7	19	3.33	
9	KARI (1)	-	9	5	-	-	2.36	Number of outside seminars held
	KAL (2)	4	6	2	-	3	2.47	
	SAMSUNG (3)	-	1	1	1	2	3.80	
	DAEWOO (4)	3	6	4	1	1	2.40	
	HUYNDAI (5)	3	5	-	-	-	1.62	
	(2+3+4+5)	10	18	7	2	6	2.44	
	(1+2+3+4+5)	10	27	12	2	6	2.42	
10	KARI (1)	2	3	4	3	2	3.00	Contribution of internal seminar to the main project
	KAL (2)	-	5	7	3	-	2.87	
	SAMSUNG (3)	-	-	3	2	-	3.40	
	DAEWOO (4)	1	1	10	2	1	3.07	
	HUYNDAI (5)	1	1	4	2	-	2.87	
	(2+3+4+5)	2	7	24	9	1	3.00	
	(1+2+3+4+5)	4	10	28	12	3	3.00	
11	KARI (1)	-	3	7	2	2	3.21	Contribution of external seminar to the main project
	KAL (2)	1	5	8	1	-	2.60	
	SAMSUNG (3)	-	-	4	-	1	3.40	
	DAEWOO (4)	1	2	9	2	1	3.00	
	HUYNDAI (5)	2	4	2	-	-	2.00	
	(2+3+4+5)	4	11	23	3	2	2.72	
	(1+2+3+4+5)	4	14	30	5	4	2.84	
12	KARI (1)	6	7	1	-	-	1.64	Number of assisting engineers in works
	KAL (2)	9	3	1	-	2	1.87	
	SAMSUNG (3)	-	3	-	-	2	3.20	
	DAEWOO (4)	4	8	1	-	2	2.20	
	HUYNDAI (5)	7	-	1	-	-	1.25	
	(2+3+4+5)	20	14	3	-	6	2.02	
	(1+2+3+4+5)	26	21	4	-	6	1.92	
13	KARI (1)	11	3	-	-	-	1.21	Number of technology transfer to business
	KAL (2)	11	4	-	-	-	1.27	
	SAMSUNG (3)	2	2	1	-	-	1.80	
	DAEWOO (4)	4	7	2	-	2	2.27	
	HUYNDAI (5)	7	-	1	-	-	1.25	
	(2+3+4+5)	24	13	4	-	2	1.67	
	(1+2+3+4+5)	35	16	4	-	2	1.56	
15	KARI (1)	7	7	-	-	-	1.50	Number of lecture in a university by researchers
	KAL (2)	7	6	-	-	2	1.87	
	SAMSUNG (3)	-	5	-	-	-	2.00	
	DAEWOO (4)	10	4	1	-	-	1.40	
	HUYNDAI (5)	8	-	-	-	-	1.00	
	(2+3+4+5)	25	15	1	-	2	1.58	
	(1+2+3+4+5)	32	22	1	-	2	1.56	
16	KARI (1)	7	4	3	-	-	1.71	Contribution of the dissemination of R&D Performances
	KAL (2)	5	4	5	1	-	2.13	
	SAMSUNG (3)	-	-	4	1	-	3.20	
	DAEWOO (4)	4	4	4	2	1	2.47	
	HUYNDAI (5)	6	1	1	-	-	1.37	
	(2+3+4+5)	15	9	14	4	1	2.23	
	(1+2+3+4+5)	22	13	17	4	1	2.10	

17	KARI (1)	3	10	1	-	-	1.86	
	KAL (2)	3	10	-	1	1	2.13	Number of joint researches with business, other research institutes and universities
	SAMSUNG (3)	-	4	1	-	-	2.20	
	DAEWOO (4)	4	7	3	-	1	2.13	
	HUYNDAI (5)	1	7	-	-	-	1.87	
	(2+3+4+5)	8	28	4	1	2	1.97	
	(1+2+3+4+5)	11	38	5	1	2	1.94	
18	KARI (1)	2	11	-	-	1	2.07	
	KAL (2)	3	10	-	1	1	2.13	
	SAMSUNG (3)	-	4	-	1	-	2.40	Number of joint researches with business and other research institutes
	DAEWOO (4)	1	10	1	2	1	2.47	
	HUYNDAI (5)	2	6	-	-	-	1.75	
	(2+3+4+5)	6	30	1	4	2	2.20	
	(1+2+3+4+5)	8	41	1	4	3	2.17	
19	KARI (1)	3	10	1	-	-	1.86	
	KAL (2)	5	8	1	-	1	1.93	Number of joint researches with other research institutes
	SAMSUNG (3)	2	2	1	-	-	1.80	
	DAEWOO (4)	2	10	2	1	-	2.13	
	HUYNDAI (5)	5	3	-	-	-	1.37	
	(2+3+4+5)	14	23	4	1	1	1.88	
	(1+2+3+4+5)	17	33	5	1	1	1.87	
20	KARI (1)	6	8	-	-	-	1.57	
	KAL (2)	5	9	-	-	1	1.87	
	SAMSUNG (3)	2	2	-	-	1	2.20	Number of joint researches with business
	DAEWOO (4)	4	9	2	-	-	1.87	
	HUYNDAI (5)	7	1	-	-	-	1.12	
	(2+3+4+5)	18	21	2	-	2	1.76	
	(1+2+3+4+5)	24	29	2	-	2	1.87	
21	KARI (1)	8	6	-	-	-	1.43	
	KAL (2)	9	5	1	-	-	1.47	
	SAMSUNG (3)	4	1	-	-	-	1.20	Number of joint researches with universities
	DAEWOO (4)	9	6	-	-	-	1.40	
	HUYNDAI (5)	6	2	-	-	-	1.25	
	(2+3+4+5)	28	14	1	-	-	1.37	
	(1+2+3+4+5)	36	20	1	-	-	1.38	
22	KARI (1)	2	3	7	2	-	2.64	
	KAL (2)	3	4	8	-	-	2.33	
	SAMSUNG (3)	-	-	1	2	2	4.20	Contribution of joint researches
	DAEWOO (4)	1	3	7	3	1	3.00	
	HUYNDAI (5)	2	3	2	1	-	2.25	
	(2+3+4+5)	6	10	18	6	3	2.76	
	(1+2+3+4+5)	8	13	25	8	3	2.73	
24	KARI (1)	2	9	2	1	-	2.14	
	KAL (2)	2	7	6	-	-	2.27	
	SAMSUNG (3)	-	2	1	2	-	3.00	Frequency of the rotation of government officers in the last three years
	DAEWOO (4)	-	2	7	3	3	3.47	
	HUYNDAI (5)	3	4	1	-	-	1.75	
	(2+3+4+5)	5	15	15	5	3	2.67	
	(1+2+3+4+5)	7	24	17	6	3	2.54	
25	KARI (1)	2	9	1	1	1	2.29	
	KAL (2)	1	9	5	-	-	2.27	
	SAMSUNG (3)	1	3	-	1	-	2.20	Impediment represented by the short-term rotation of government officers
	DAEWOO (4)	3	2	6	3	1	2.80	
	HUYNDAI (5)	2	4	2	-	-	2.00	
	(2+3+4+5)	7	18	13	4	1	2.39	
	(1+2+3+4+5)	9	27	14	5	2	2.36	
26	KARI (1)	-	-	2	5	7	4.36	
	KAL (2)	5	2	5	1	2	2.53	
	SAMSUNG (3)	1	1	1	1	1	3.00	Frequency of the rotation of researchers
	DAEWOO (4)	1	1	8	5	-	3.13	
	HUYNDAI (5)	2	3	3	-	-	2.12	
	(2+3+4+5)	9	7	17	7	3	2.72	
	(1+2+3+4+5)	9	7	19	12	10	3.12	

27	KARI (1)	3	3	3	1	4	3.00	Impediment represented by the short-term rotation of Researchers
	KAL (2)	3	8	1	3	-	2.27	
	SAMSUNG (3)	1	2	1	-	1	2.60	
	DAEWOO (4)	1	6	6	1	1	2.67	
	HUYNDAI (5)	3	4	1	-	-	1.75	
	(2+3+4+5)	8	20	9	4	2	2.35	
	(1+2+3+4+5)	11	23	12	5	6	2.50	
28	KARI (1)	-	4	5	4	1	3.14	Degree of co-ordination with research teams in Organisation
	KAL (2)	3	7	5	-	-	2.13	
	SAMSUNG (3)	-	3	2	-	-	2.40	
	DAEWOO (4)	2	1	7	4	1	3.07	
	HUYNDAI (5)	1	3	4	-	-	2.37	
	(2+3+4+5)	6	14	18	4	1	2.53	
	(1+2+3+4+5)	6	18	23	8	2	2.68	
29	KARI (1)	-	4	8	2	-	2.86	Degree of co-ordination with support divisions
	KAL (2)	3	5	5	1	1	2.47	
	SAMSUNG (3)	2	-	3	-	-	2.20	
	DAEWOO (4)	-	3	10	1	1	3.00	
	HUYNDAI (5)	-	4	4	-	-	2.50	
	(2+3+4+5)	5	12	22	2	2	2.63	
	(1+2+3+4+5)	5	16	30	4	2	2.68	
30	KARI (1)	-	4	9	1	-	2.79	Degree of co-ordination with ministry concerned
	KAL (2)	4	7	4	-	-	2.00	
	SAMSUNG (3)	-	2	2	1	-	2.80	
	DAEWOO (4)	3	4	6	1	1	2.53	
	HUYNDAI (5)	-	3	5	-	-	2.50	
	(2+3+4+5)	7	16	17	2	1	2.39	
	(1+2+3+4+5)	7	20	26	3	1	2.49	
31	KARI (1)	1	4	4	5	-	2.93	Degree of co-ordination with university
	KAL (2)	3	4	5	3	-	2.53	
	SAMSUNG (3)	-	1	3	1	-	3.00	
	DAEWOO (4)	2	-	11	1	1	2.93	
	HUYNDAI (5)	1	2	4	1	-	2.62	
	(2+3+4+5)	6	7	23	6	1	2.74	
	(1+2+3+4+5)	7	11	27	11	1	2.61	
32	KARI (1)	-	6	4	4	-	2.86	Degree of co-ordination with business
	KAL (2)	3	8	4	-	-	2.07	
	SAMSUNG (3)	-	1	4	-	-	2.80	
	DAEWOO (4)	1	2	10	1	1	2.93	
	HUYNDAI (5)	1	3	2	2	-	2.62	
	(2+3+4+5)	5	14	20	3	1	2.56	
	(1+2+3+4+5)	5	20	24	7	1	2.63	
33	KARI (1)	-	7	5	1	1	2.71	Degree of disadvantage arising from conflicts With related organisations
	KAL (2)	5	5	4	1	-	2.07	
	SAMSUNG (3)	2	2	1	-	-	1.80	
	DAEWOO (4)	3	6	3	2	1	2.47	
	HUYNDAI (5)	-	4	4	-	-	2.50	
	(2+3+4+5)	10	17	12	3	1	2.25	
	(1+2+3+4+5)	10	24	17	4	2	2.37	
34	KARI (1)	-	1	-	1	12	4.71	Best supplier of information for the surveys of Technology development trends
	KAL (2)	3	-	-	8	4	3.67	
	SAMSUNG (3)	-	-	-	1	4	4.80	
	DAEWOO (4)	2	1	-	1	11	4.20	
	HUYNDAI (5)	-	1	-	2	5	4.37	
	(2+3+4+5)	5	2	-	12	24	4.11	
	(1+2+3+4+5)	5	3	-	13	36	4.26	
35	KARI (1)	-	5	5	1	3	3.14	Number of the surveys of technology Development trends conducted
	KAL (2)	1	5	3	-	6	3.33	
	SAMSUNG (3)	-	2	3	-	-	2.60	
	DAEWOO (4)	-	5	6	1	3	3.13	
	HUYNDAI (5)	-	4	4	-	-	2.50	
	(2+3+4+5)	1	16	16	1	9	3.02	
	(1+2+3+4+5)	1	21	21	2	12	3.05	
36	KARI (1)	-	3	3	5	3	3.57	
	KAL (2)	1	5	4	5	-	2.87	

	SAMSUNG (3)	-	-	4	1	-	3.20	Level of surveys of technology development trends
	DAEWOO (4)	2	2	1	8	2	3.40	
	HUYNDAI (5)	-	2	5	-	1	3.00	
	(2+3+4+5)	3	9	14	14	3	3.11	
	(1+2+3+4+5)	3	12	17	19	6	3.22	
37	KARI (1)	-	2	3	5	4	3.79	
	KAL (2)	-	4	6	5	-	3.07	
	SAMSUNG (3)	-	1	2	2	-	3.20	Level of surveys of technology development trends
	DAEWOO (4)	1	3	2	6	3	3.42	
	HUYNDAI (5)	-	2	5	1	-	2.87	
	(2+3+4+5)	1	10	15	14	3	3.18	
	(1+2+3+4+5)	1	12	18	19	7	3.33	
38	KARI (1)	2	4	3	4	1	2.07	
	KAL (2)	4	1	4	6	-	2.80	
	SAMSUNG (3)	-	4	-	1	-	2.40	Degree of internal communication
	DAEWOO (4)	1	-	11	2	1	3.13	
	HUYNDAI (5)	-	2	4	2	-	3.00	
	(2+3+4+5)	5	7	19	11	2	3.02	
	(1+2+3+4+5)	7	11	22	15	3	2.98	
39	KARI (1)	4	6	3	1	-	2.07	
	KAL (2)	6	3	5	-	1	2.13	
	SAMSUNG (3)	2	2	-	1	-	2.00	Degree of external communication
	DAEWOO (4)	3	6	4	1	1	2.40	
	HUYNDAI (5)	2	3	3	-	-	2.12	
	(2+3+4+5)	13	14	12	2	1	2.32	
	(1+2+3+4+5)	17	20	15	3	1	2.08	
40	KARI (1)	4	5	4	-	1	2.21	
	KAL (2)	10	3	2	-	-	1.47	
	SAMSUNG (3)	-	5	-	-	-	2.00	Degree of satisfaction with grant system
	DAEWOO (4)	5	6	4	-	-	1.93	
	HUYNDAI (5)	2	4	2	-	-	2.00	
	(2+3+4+5)	17	18	8	-	-	1.79	
	(1+2+3+4+5)	21	23	12	-	1	1.89	
41	KARI (1)	4	4	5	1	-	2.21	
	KAL (2)	10	3	2	-	-	1.47	
	SAMSUNG (3)	-	5	-	-	-	2.00	Degree of satisfaction with merit system
	DAEWOO (4)	5	7	3	-	-	1.87	
	HUYNDAI (5)	2	4	2	-	-	2.00	
	(2+3+4+5)	17	19	7	-	-	1.77	
	(1+2+3+4+5)	21	23	12	1	-	1.88	
42	KARI (1)	1	4	6	3	-	2.79	
	KAL (2)	1	5	5	4	-	2.80	
	SAMSUNG (3)	1	4	-	-	-	1.80	Degree of satisfaction with R&D evaluation system
	DAEWOO (4)	1	5	9	-	-	2.53	
	HUYNDAI (5)	1	1	5	1	-	2.75	
	(2+3+4+5)	4	15	19	5	-	2.79	
	(1+2+3+4+5)	5	19	25	8	-	2.63	
43	KARI (1)	-	1	2	6	5	4.07	
	KAL (2)	1	12	2	-	-	2.07	
	SAMSUNG (3)	-	-	-	-	5	5.00	Number of entertainment circles
	DAEWOO (4)	3	8	3	-	1	2.20	
	HUYNDAI (5)	1	4	2	-	2	2.50	
	(2+3+4+5)	5	24	7	-	8	2.65	
	(1+2+3+4+5)	5	25	9	6	13	3.00	
44	KARI (1)	3	6	4	1	-	2.21	
	KAL (2)	10	4	1	-	-	1.40	
	SAMSUNG (3)	-	5	-	-	-	2.00	Number of participants in entertainment circles
	DAEWOO (4)	4	9	2	-	-	1.87	
	HUYNDAI (5)	7	1	-	-	-	1.12	
	(2+3+4+5)	21	19	3	-	-	1.58	
	(1+2+3+4+5)	24	25	7	1	-	1.73	
45	KARI (1)	1	1	5	6	1	3.36	
	KAL (2)	2	4	7	1	1	2.67	
	SAMSUNG (3)	1	-	1	3	-	3.20	Contribution of entertainment circles
	DAEWOO (4)	-	2	3	5	5	3.87	
	HUYNDAI (5)	2	2	4	-	-	2.25	

	(2+3+4+5)	5	8	15	9	6	3.06	
	(1+2+3+4+5)	6	9	20	15	7	3.14	
46	KARI (1)	-	1	4	9	-	3.57	Degree of trust relations between researchers in the research team
	KAL (2)	2	4	5	3	1	2.80	
	SAMSUNG (3)	-	-	-	4	1	4.20	
	DAEWOO (4)	1	2	3	7	2	3.47	
	HUYNDAI (5)	-	-	5	3	-	3.37	
	(2+3+4+5)	3	6	13	17	4	3.25	
	(1+2+3+4+5)	3	7	17	26	4	3.36	
47	KARI (1)	2	3	8	1	-	2.57	Degree of trust relations with support divisions
	KAL (2)	2	8	4	1	-	2.27	
	SAMSUNG (3)	2	1	2	-	-	2.00	
	DAEWOO (4)	1	2	10	2	-	2.87	
	HUYNDAI (5)	1	1	5	1	-	2.75	
	(2+3+4+5)	6	12	21	4	-	2.53	
	(1+2+3+4+5)	8	15	29	5	-	2.54	
48	KARI (1)	1	6	3	4	-	2.71	Degree of trust relations with ministry concerned
	KAL (2)	4	4	5	2	-	2.33	
	SAMSUNG (3)	-	2	2	1	-	2.80	
	DAEWOO (4)	2	4	7	2	-	2.60	
	HUYNDAI (5)	-	4	4	-	-	2.50	
	(2+3+4+5)	6	14	18	5	-	2.51	
	(1+2+3+4+5)	7	20	21	9	-	2.56	
49	KARI (1)	-	3	5	5	1	3.29	Contribution of trust relations
	KAL (2)	2	6	3	2	2	2.73	
	SAMSUNG (3)	-	1	4	-	-	2.80	
	DAEWOO (4)	-	1	10	3	1	3.27	
	HUYNDAI (5)	-	2	5	1	-	2.87	
	(2+3+4+5)	2	10	22	6	3	2.95	
	(1+2+3+4+5)	2	13	27	11	4	3.10	
50	KARI (1)	8	6	-	-	-	1.43	Number of international joint research projects In the last one year
	KAL (2)	5	9	1	-	-	1.73	
	SAMSUNG (3)	2	3	-	-	-	1.60	
	DAEWOO (4)	4	9	2	-	-	1.87	
	HUYNDAI (5)	5	3	-	-	-	1.37	
	(2+3+4+5)	16	24	3	-	-	1.69	
	(1+2+3+4+5)	24	30	3	-	-	1.63	
51	KARI (1)	3	3	4	2	2	2.79	Satisfaction with international collaboration Partners
	KAL (2)	3	4	6	2	-	2.47	
	SAMSUNG (3)	1	1	2	1	-	2.60	
	DAEWOO (4)	1	4	7	3	-	2.80	
	HUYNDAI (5)	3	2	2	1	-	2.12	
	(2+3+4+5)	8	11	17	7	-	2.53	
	(1+2+3+4+5)	11	14	21	9	2	2.59	
52	KARI (1)	3	1	6	1	3	3.00	Contribution of international collaboration to the main project
	KAL (2)	3	3	5	4	-	2.67	
	SAMSUNG (3)	-	1	-	2	2	4.00	
	DAEWOO (4)	-	5	4	5	1	3.13	
	HUYNDAI (5)	3	2	2	1	-	2.12	
	(2+3+4+5)	6	11	11	12	3	2.88	
	(1+2+3+4+5)	9	12	17	13	6	2.91	
53	KARI (1)	1	11	2	-	-	2.07	Number of researchers dispatched for overseas training in the last year
	KAL (2)	4	8	2	-	1	2.07	
	SAMSUNG (3)	1	2	-	-	2	3.00	
	DAEWOO (4)	2	8	3	-	2	2.47	
	HUYNDAI (5)	2	5	-	-	1	2.12	
	(2+3+4+5)	9	23	5	-	6	2.32	
	(1+2+3+4+5)	10	34	7	-	6	2.26	
54	KARI (1)	1	11	1	1	-	2.14	Number of foreign researchers invited in the last year
	KAL (2)	5	9	1	-	-	1.73	
	SAMSUNG (3)	1	1	1	-	2	3.20	
	DAEWOO (4)	1	9	2	2	1	2.53	
	HUYNDAI (5)	5	2	1	-	-	1.50	
	(2+3+4+5)	12	21	5	2	3	2.13	
	(1+2+3+4+5)	13	32	6	3	3	2.14	

55	KARI (1)	-	1	2	5	6	4.14	
	KAL (2)	2	3	4	6	-	2.93	
	SAMSUNG (3)	-	2	1	-	2	3.20	Contribution of dispatching researchers
	DAEWOO (4)	-	1	3	6	5	4.00	Overseas
	HUYNDAI (5)	2	-	3	2	1	3.00	
	(2+3+4+5)	4	6	11	14	8	3.37	
	(1+2+3+4+5)	4	7	13	19	14	3.56	
56	KARI (1)	-	2	2	7	3	3.79	
	KAL (2)	3	2	4	6	-	2.87	
	SAMSUNG (3)	-	1	3	1	-	3.00	Contribution of inviting foreign researchers
	DAEWOO (4)	-	-	4	6	5	4.07	
	HUYNDAI (5)	2	2	2	2	-	2.50	
	(2+3+4+5)	5	5	13	15	5	3.23	
	(1+2+3+4+5)	5	7	15	22	8	3.36	
57	KARI (1)	2	6	4	1	1	2.50	
	KAL (2)	2	9	3	1	-	2.20	
	SAMSUNG (3)	1	3	1	-	-	2.00	Number of subscriptions to overseas
	DAEWOO (4)	3	4	7	1	-	2.40	Publications
	HUYNDAI (5)	1	7	-	-	-	1.87	
	(2+3+4+5)	7	23	11	2	-	2.18	
	(1+2+3+4+5)	9	29	15	3	1	2.26	
58	KARI (1)	4	9	1	-	-	1.79	
	KAL (2)	8	5	2	-	-	1.60	
	SAMSUNG (3)	2	3	-	-	-	1.60	Number attending overseas seminars
	DAEWOO (4)	7	6	2	-	-	1.67	
	HUYNDAI (5)	7	1	-	-	-	1.12	
	(2+3+4+5)	24	15	4	-	-	1.53	
	(1+2+3+4+5)	28	24	5	-	-	1.59	
59	KARI (1)	9	5	-	-	-	1.36	
	KAL (2)	13	2	-	-	-	1.13	
	SAMSUNG (3)	4	1	-	-	-	1.20	Number of seminar held for foreigners
	DAEWOO (4)	11	2	1	1	-	1.47	
	HUYNDAI (5)	8	-	-	-	-	1.00	
	(2+3+4+5)	36	5	1	1	-	1.23	
	(1+2+3+4+5)	45	10	1	1	-	1.26	
60	KARI (1)	1	1	4	5	3	3.57	
	KAL (2)	2	4	7	1	1	2.67	
	SAMSUNG (3)	-	1	2	2	-	3.20	Contribution of subscriptions to overseas
	DAEWOO (4)	3	2	3	5	2	3.07	publications
	HUYNDAI (5)	1	1	4	2	-	2.87	
	(2+3+4+5)	6	8	16	10	3	2.90	
	(1+2+3+4+5)	7	9	20	15	6	3.07	
61	KARI (1)	3	1	3	5	2	3.14	
	KAL (2)	2	5	6	1	1	2.60	
	SAMSUNG (3)	1	2	1	1	-	2.40	Contribution of attending overseas seminars
	DAEWOO (4)	3	5	2	4	1	2.67	
	HUYNDAI (5)	4	2	1	1	-	1.87	
	(2+3+4+5)	10	14	10	7	2	2.46	
	(1+2+3+4+5)	13	15	13	12	4	2.63	
62	KARI (1)	4	3	2	4	1	2.64	
	KAL (2)	5	6	4	-	-	1.93	
	SAMSUNG (3)	1	3	1	-	-	2.00	Contribution of holding seminars for
	DAEWOO (4)	5	5	1	2	2	2.40	foreigners
	HUYNDAI (5)	4	3	-	1	-	1.75	
	(2+3+4+5)	15	17	6	3	2	2.06	
	(1+2+3+4+5)	19	20	8	7	3	2.21	
63	KARI (1)	2	4	3	5	-	2.79	
	KAL (2)	1	4	6	4	-	2.87	
	SAMSUNG (3)	-	-	4	1	-	3.20	Satisfaction with the R&D performance of
	DAEWOO (4)	1	2	1	6	5	3.80	research institutes
	HUYNDAI (5)	-	3	2	3	-	3.00	
	(2+3+4+5)	2	9	13	14	5	3.25	
	(1+2+3+4+5)	4	13	16	19	5	3.14	
64	KARI (1)	2	6	5	1	-	2.36	
	KAL (2)	4	5	5	1	-	2.20	

	SAMSUNG (3)	1	2	2	-	-	2.20	Satisfaction with the R&D performance of universities
	DAEWOO (4)	2	5	3	4	1	2.80	
	HUYNDAI (5)	3	3	2	-	-	1.87	
	(2+3+4+5)	10	15	12	5	1	2.34	
	(1+2+3+4+5)	12	21	17	6	1	2.35	
65	KARI (1)	2	3	6	3	-	2.71	Satisfaction with government efforts for developing aviation technology
	KAL (2)	3	6	5	-	1	2.33	
	SAMSUNG (3)	2	1	1	1	-	2.20	
	DAEWOO (4)	4	2	6	3	-	2.47	
	HUYNDAI (5)	1	3	4	-	-	2.37	
	(2+3+4+5)	10	12	16	4	1	2.39	
	(1+2+3+4+5)	12	15	22	7	1	2.47	
67	KARI (1)	2	3	9	-	-	2.50	Satisfaction with organisational management activities in research institute
	KAL (2)	4	8	2	1	-	2.00	
	SAMSUNG (3)	2	1	1	1	-	2.20	
	DAEWOO (4)	3	1	8	-	3	2.93	
	HUYNDAI (5)	1	3	4	-	-	2.37	
	(2+3+4+5)	10	13	15	2	3	2.41	
	(1+2+3+4+5)	12	16	24	2	3	2.43	
69	KARI (1)	1	4	3	6	-	3.00	Satisfaction with research facilities and institutions
	KAL (2)	4	6	4	1	-	2.13	
	SAMSUNG (3)	1	3	1	-	-	2.00	
	DAEWOO (4)	2	3	8	1	1	2.73	
	HUYNDAI (5)	1	3	4	-	-	2.37	
	(2+3+4+5)	8	15	17	2	1	2.37	
	(1+2+3+4+5)	9	19	20	8	1	2.52	
71	KARI (1)	1	5	7	-	1	2.64	Degree of co-operation in conducting research to develop aviation technology
	KAL (2)	2	6	6	1	-	2.40	
	SAMSUNG (3)	3	2	-	-	-	1.40	
	DAEWOO (4)	2	6	7	-	-	2.33	
	HUYNDAI (5)	2	2	4	-	-	2.25	
	(2+3+4+5)	9	16	17	1	-	2.23	
	(1+2+3+4+5)	10	21	24	1	1	2.33	
73	KARI (1)	2	4	6	2	-	2.57	Degree of co-ordination in conducting research to develop aviation technology
	KAL (2)	1	11	2	1	-	2.20	
	SAMSUNG (3)	2	1	2	-	-	2.00	
	DAEWOO (4)	4	3	6	1	1	2.47	
	HUYNDAI (5)	3	3	1	1	-	2.00	
	(2+3+4+5)	10	18	11	3	1	2.23	
	(1+2+3+4+5)	12	22	17	5	1	2.31	
75	KARI (1)	9	3	2	-	-	1.58	Degree of motivation in conducting research to develop aviation technology
	KAL (2)	10	4	1	-	-	1.40	
	SAMSUNG (3)	3	1	1	-	-	1.60	
	DAEWOO (4)	5	6	4	-	-	1.93	
	HUYNDAI (5)	4	4	-	-	-	1.50	
	(2+3+4+5)	22	15	6	-	-	1.62	
	(1+2+3+4+5)	31	18	8	-	-	1.59	
77	KARI (1)	2	4	4	4	-	2.71	Degree of international collaboration to developing aviation technology
	KAL (2)	5	7	1	2	-	2.00	
	SAMSUNG (3)	-	1	2	2	-	3.20	
	DAEWOO (4)	5	4	5	1	-	2.13	
	HUYNDAI (5)	2	4	2	-	-	2.00	
	(2+3+4+5)	12	16	10	5	-	2.18	
	(1+2+3+4+5)	14	20	14	9	-	2.31	

Annex 7 List of Interviewees

❑ Office Interviews

Korea Aerospace Research Institute (KARI)

Lee, Seung-Ri, Principal Researcher, Policy & Planning Section	17 May 1999

Ministry of Industry & Resource (MOIR)

Rhee, Yun-Su, Deputy Director, Aerospace Industry Division	20 May 1999

Samsung Aerospace Industries, Ltd

Park, Ki Arm, Manager, Planning Department	20 May 1999

Aerospace Consolidation Office

Seo, Won-Cheol, Assistant General Manager, Planning Team	21 May 1999

Korea Aerospace Industries Association (KAIA)

Kim, Young-Kap, General Manager, Planning & Management Division	
Kim, Youn, Assistant General Manager, Planning Division	25 May 1999

Korea Air (KAL) (Head Office)

Cho, Ei-Jun, Assistant General Manager, Project Planning Team, Aerospace Division	
Choi, Woo-Jong, Choi Assistant General Manager, Market & Contracts Team, Aerospace Division	26 May 1999

Hyundai Space & Aircraft Co., LTD.

Kim, Eung-Su, General Manager, Defence Business Team	28 May 1999

The Korean Society for Aeronautical & Space Science (KSASS)

Kang, Won-Gi, Secretary General	28 May 1999

Hankuk Aviation University

Hwang,Myoung-Shin, Professor, Director, Institute of Aircraft and Systems Management	1 June 1999

Korea Institute for Defence Analyses (KIDA)

Seong-Bae Kim (Ph.D.)Research Fellow, Center for Weapon Systems Studies	
Kang, In-Ho, Senior Researcher, Division of Naval & Aero Weapon Systems	3 June 1999

Daewoo Heavy Industries LTD., (ChangWon Plant)

Chun, Ku-Tae, General Manager, Aerospace Division	7 June 1999

Korea Air (Pusan Plant)

Ahan, Kil-Won, Vice President, Plant Operations &Helicopter Plant, Aerospace Division	8 June 1999

Ministry of Science and Technology (MOST)

Kang, Ho-Il, Deputy Director, Strategic Technology Development Division	
Kim, Ju-Han, Director, Research and Development Office (former)	15 June 1999

❑ Interviews for Pilot Survey

Ministry of Industry and Resources (MOIR)

Her, Nam-Yong, Deputy Director, Aerospace Industry Division (former)	May 1997

Korea Aerospace Research Institute (KARI)

Hwang, Jin-Young (KARI), Senior Researchers, Policy Planning Office	November 1997 July 1998

Milyang National University

Hong, Hyung-Deuk, Professor, Major in Science and Technology Policy	March 1999

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