White Paper on Science and Technology

— Visions and Strategies for the Development of Science and Technology

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National Science Council

Republic of China

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Abstract

In the early years of the 21st century, just as the global economy began showing signs of recovering from recession, the events of September 11 in America and the ensuing war in Iraq thwarted all prospects of a global recovery. When the world turned its hopes to Asia for economic revival, the outbreak of Severe Acute Respiratory Syndrome (SARS) caused further economic disarray, spreading its effects around the world. Indeed, similar events are likely to occur as the world grows increasingly intertwined with trade liberalization, transparent monetary systems, rapid developments in technology information, and threats to the ecological environment – significant impacts on one region can spread quickly and affect many other parts of the world.

Confronted by these challenges, nations around the world are recognizing the importance and urgency of promoting science and technology, and Taiwan is no exception. In the late 20th century (1999), the government enacted the “Fundamental Science and Technology Act” to establish fundamental principles and directions for the development of science and technology. Article 9 of this Act calls for the government to present a written statement once every two years describing the visions, strategies, and current status of developments in science and technology; Article 10 stipulates the formulation of a National Science and Technology Development Plan once every four years. Since the promotion of scientific and technological development requires a timetable for the planning of specific measures and actual implementation, the National Science and Technology Development Plan shall operate on a four-year term, but an overall examination shall be conducted once every two years to update visions and strategies to stay current with rapid developments in science and technology.

The first statement of visions, strategies, and status from the “Fundamental Science and Technology Act” appeared in the “National Science and Technology Development Plan (2001~2004),” which was passed by the Executive Yuan following the Sixth National Science and Technology Conference in 2001. The second statement of visions, strategies and status serves as the main framework for this compilation of the “ROC White Paper on Science and Technology (2003~2006).” As science and technology are constantly evolving, future statements of visions, strategies, and status reports shall appear biannually in the “ROC White Paper on Science and Technology” and the “National Science and Technology Development Plan,” which are separately compiled once every four years, and released alternately at two-year intervals.

Faced with the challenges and opportunities of the knowledge-based economy era, and confronting major changes to technology both at home and abroad, the government shall emphasize sci-tech expenditures and manpower utilization, strengthen knowledge creation and technological innovation, put the legal system on a sound basis, enhance flexibility of the sci-tech system, and develop technologies that promote public welfare.

Current Status and Future Visions of Science and Technology Development

Regarding future visions of science and technology, advanced nations recognize the central importance of scientific and technological development to overall competitiveness. In terms of sci-tech resources therefore, nations have established specific goals for levels of expenditures devoted to research and development. The European Union, for instance, has recently set the goal of devoting 3% of GDP to R&D on average by the year 2010. As for Taiwan, the goal is increase ***R&D expenditures to reach 3% of GDP*** as specified in the "Challenge 2008 National Development Plan," and even to meet this target ahead of schedule ***by the year 2006***. Although gross domestic expenditures on R&D reached 2.30% of Gross Domestic Product (GDP) in 2002, this is still a considerable gap from the 3% of GDP goal set in the Challenge 2008 plan, and is slightly lower than that of advanced countries, therefore government and private sectors shall continue investing heavily in technology. In terms of research personnel, the type of researchers that contribute most to R&D are those with university degrees or above, and this group has grown significantly over the past five years. In 2002, the number of researchers reached 28.7 person-years (full-time equivalent) per 10,000 population, and the goal is to ***increase the number of researchers with university degrees or above to 32 person-years (full-time equivalent) per 10,000 population by the year 2007.***

In terms of research performance, the World Economic Forum (WEF) in 2003 ranked Taiwan 5th in the world for growth competitiveness, and 3rd for technology, signifying that it is a very competitive nation that has earned global recognition for its scientific and technological capabilities. Taiwan also ranks highly for the number of papers cited in *Science Citation Index (SCI)* and *Engineering Index (EI)*, placing 17th in *SCI* (10,635 articles) and 10th in *EI* (5,103 articles) for the year 2001, but receding to 18th place in *SCI* (10,831 articles) and 11th place in *EI* (5,350 articles) for 2002. For the number of US patents granted, Taiwan surged to 4th place in 2002. Already achieving high ranks for quantities of paper citations and US patents, future efforts shall focus on enhancing the quality of these works. In terms of academic research, aside from establishing a world-class research environment, Taiwan shall also develop intelligent and innovative academic research and serve as a center of academic research and knowledge innovation in the Asia-Pacific region, with ***at least one university rising to world-class standards by the year 2013.*** In terms of industrial technology, aside from creating an industrial technology environment offering internationally competitive advantages and developing high-tech industrial clusters, the government shall turn Taiwan into a global center for the production and supply of high value-added products. ***By 2007, at least 3.5% of all granted US patents (not including new design patents) will go to applicants from Taiwan.*** In terms of public well-being, the world has become a smaller place with closer-knit connections through advances in technology, the speed of the Internet, and the convenience of telecommunications. In 2002, the number of households with broadband connections climbed to 2.129 million, and the goal is to ***promote broadband connections to reach more than six million households by 2007.*** In the future, the government shall promote sci-tech development that is focused on knowledge, innovations, regulations, and is beneficial for the citizenry of Taiwan. The hope is to build a nation that returns to the benefits of sci-tech results to society, and allows citizens to use science and technology to live more peaceful, secure, and quality lifestyles.

To achieve the goals and visions described above, six strategies have been formulated:

1. Strengthening the cultivation, training, recruitment, and utilization of scientific and technological manpower resources.
2. Maximizing and augmenting funds for R&D and innovation, effectively utilizing existing scientific and technological resources.
3. Emphasizing academic research, developing distinctive fields of world-class research.
4. Stimulating technological innovations, building an environment suitable for industrial development.
5. Fostering the interactive development of science and technology, society, and the environment, improving public welfare and environmental quality.
6. Building a superior defense technology system, promoting the development of military-civilian dual-use technologies.

Specific measures for these strategies shall reflect the overall demands and conditions of the nation's scientific and technological development. After the next (Seventh) National Science and Technology Conference, these measures shall be formulated in detail by incorporating key points from future sci-tech policies at various government agencies, and then integrating with overall national policies on science and technology.

PART ONE

Visions and Strategies for the Development of Science and Technology

CHAPTER ONE – Introduction

1.1 Challenges and Opportunities of the Knowledge-based Economy Era

The challenges of the knowledge-based economy are: an explosion of information and communication technology and the liberalization of world trade. Humanity's ways of living and working have therefore been transformed by science and technology, and as a result, governments and industries can no longer rest behind trade barriers and protective legislation. Taiwan is not exempt from these challenges either; after gaining membership in the World Trade Organization (WTO) in 2002, the nation was required to dismantle restrictions and protection in stages, and observe international standards on intellectual property rights. And faced with an open global market, the nation's future will be met with even stronger international competition.

On the other hand, Taiwan enjoys many opportunities: a strong information and communications technology infrastructure, a highly-educated populace, excellent R&D capabilities and production experience in the academic and industry sectors, a mature capital market, and extensive global trade experience. If the government can seize these opportunities, increase administrative efficiency, spend generously and effectively on innovation and R&D, and construct a comprehensive legal framework, these efforts can help to accumulate knowledge-based assets, generate industrial innovations, enhance the value of traditional industries, promote economic development, bolster national competitiveness, and create new turning points for the nation.

1.2 International Trends in Sci-Tech Development

World nations agree that scientific and technological development is a major driving force behind economic progress. Many countries, therefore, especially technologically advanced nations, are placing considerable emphasis on developing science, technology, and innovation. Nations are also making overall plans that encompass multiple aspects, including the formation of sci-tech legislation, effective use of R&D expenditures, development of human resources, and research directions and priorities. While circumstances and goals differ within each country, several general trends are apparent:

I. Promoting Innovation

In recent years, developed countries are placing particular emphasis on knowledge- and innovation-based industries. Consequently, areas being developed are growing increasingly mature, making use of innovation results to create new business models, and even produce new industries. Examples:

- Recognizing innovative ability as a crucial factor in economic competitiveness, Germany is actively creating environments conducive to innovation activities for small and medium-sized enterprises. The mobility of personnel and knowledge is being increased between enterprises and research institutions to give enterprises better access to advanced technology.
- Japan has previously relied heavily on innovations in the production process, and is presently seeking innovative high value-added products. By using innovation to search for technological advancement, many potential demands are being uncovered.

II. Growing Public Funding for Research and Development

Despite the slowdown in the world economy, with some national economies even receding, many countries still recognize the importance of technological development in national competitiveness. Therefore, nations across the globe have established specific targets for R&D expenditures (Table 1).

Table 1 R&D Expenditure Targets

Country	Year	Target
South Korea	2002	Increase government R&D investment to 5% of total government budget
Spain	2003	Boost R&D spending to 1.29% of GNP
Austria	2005	Increase share of R&D expenditure in GNP to 2.5%
PRC (China)	2005	Raise R&D expenditures as a percentage of GDP to 1.5%
Norway	2005	Improve level of R&D funding to reach at least OECD* average
Canada	2010	Advance ranking to 5th place in OECD community
EU	2010	Devote 3% of GDP to R&D and innovation

Source: OECD *Science, Technology and Industry Outlook 2002*

*OECD, Organisation for Economic Co-operation and Development

III. Boosting the Sci-Tech Workforce and Improving Worker Training

All countries are currently facing shortages of personnel in key and emerging fields, particularly in information and communication technology (ICT), biotechnology, and nanotechnology. Yet the success of scientific and technological research and innovation depends on a nation's supply of talented human resources. Examples:

- The Czech Republic, Germany, the Netherlands, Poland, and Sweden are facing problems of aging and retiring researchers.
- The United States is experiencing a decline in the enrollment of US citizens in graduate-level science and engineering programs, creating a shortage of US citizens among these students.

Many countries are therefore monitoring closely the supply and demand of skilled workers, attracting young people into scientific and technical careers, increasing the number of scientists and engineers, training the workforce, and recruiting international talent. Examples:

- Canada and Singapore are initiating several programs to encourage citizens to enter advanced studies by doubling and extending education tax credit and allowing deductions for childcare expenses. These nations are also proposing immigration and other measures to increase the supply of highly qualified international professionals.
- France is promoting equal opportunity between men and women in the education system.
- Germany is actively increasing the number of women in engineering and life sciences.
- New Zealand has introduced talent visas to make it easier for companies to bring in skilled personnel.

IV. Increasing Targeted Funding to Specific Fields

Most countries are directing ongoing government R&D expenditures into basic sciences, health, national defense, the environment, etc. Certain countries have even identified priorities in particular fields of science and technology, and are facilitating entrepreneurial development; fields such as information and communication technology, nanotechnology, and biotechnology are receiving widespread attention. Table 2 presents key areas of development in technologically advanced nations, small countries similar to Taiwan, neighboring South Korea, and the PRC (China).

Table 2 Key Areas of Development in Various Countries

Country	Key Areas of Development
US	Homeland security and antiterrorism R&D, networking and information technology R&D, National Nanotechnology Initiative (NNI), molecular-level understanding of life processes, climate change science and technology, and education research
France	Life sciences, information and communication technology (ICT), the environment, energy, and aerospace
Germany	Energy research, biotechnology, genetic engineering, and aerospace
Japan	Life sciences, ICT, environmental sciences, nanotechnology, and materials
Netherlands	Life sciences, earth sciences, nanosciences, and emerging technologies
Switzerland	Nanotechnology, the environment, and bioinformatics
Norway	Marine research, ICT, and medical and healthcare research
Austria	Biotechnology, ICT, intelligent transport system and services, aeronautics and space, and sustainable economy
S. Korea	ICT, biotechnology, nanotechnology, environmental technology, and space technology
PRC (China)	Very Large Scale Integration (VLSI) and software, data security, e-Government and e-Banking, functional genetics and biochips, electric vehicles, high-speed magnetic suspension trains, innovative medicine and modern Chinese medicine, major agricultural products processing, dairy industry, food safety, agricultural water conservation, water treatment, and standards of key technologies

V. Restructuring Sci-Tech Organizations

To enhance the efficiency and flexibility of research and development, certain countries have initiated significant reforms to the administrative and funding procedures at public research organizations and universities. Examples:

- Through legal change, a number of OECD nations are adjusting the structures of universities and public research organizations, and changing the criteria and means of funding. These organizations are now required to be more autonomous and transparent with increased flexibility and performance.
- France is encouraging universities and organizations to set up external evaluation committees of senior scientists mostly from abroad. Also, the government is funding universities on a contract basis, where contract renewals are based on performance evaluations of the laboratories concerned.
- Germany has shifted its criteria for funding universities to weigh performance in teaching, research, as well as support for young scientists.
- Japan has overhauled its government research structure to legally change national research institutions into independent administrative institutions. It is evaluating the possibility of similar changes to national universities as well.

A number of countries have even undertaken major restructuring of governmental bodies in charge of science and technology:

- In 2001, Japan merged the Ministry of Education, Science, Sports and Culture with the Science and Technology Agency to form the Ministry of Education, Culture, Sports, Science, and Technology (MEXT). Japan also established the Council for Science and Technology Policy (CSTP) under the Cabinet Office, to centralize the planning of basic and national policies concerning science and technology.
- In Australia, responsibility for science was transferred in 2001 from the Department of Industry, Science and Resources (DISR) to the Department of Education, Science and Training (DEST). This move was intended to reflect the strong links between these sectors.
- Iceland intends to establish a science and technology policy council at the ministerial level headed by the Prime Minister, to replace the Icelandic Research Council, whose members are appointed by the Minister of Education.
- Spain established the Ministry of Science and Technology (MCYT) in 2000.

When evaluating the effectiveness of science and technology policies, government programs must be carefully designed and evaluated periodically to ensure the effectiveness of public policy. Programs that are properly planned and managed are more likely to achieve the desired outcomes, and periodic evaluations are likely to improve policy decision making and accountability. In recent years, the demand for more accountability and transparency in government activities has been growing, and nations are monitoring and evaluating policies and programs more closely. Currently, more countries are introducing new evaluation systems and special institutions:

- Austria formalized the Platform on Research and Technology Evaluation in 2001.
- Australia is requiring clearer objectives and measurable performance when designing government programs. Independent post-implementation evaluations are improving program performance.
- South Korea set up the Institute for S&T Evaluation and Planning in 2001 based on the Science and Technology Framework Law.
- The General Auditor of Canada was established to better evaluate government programs.

1.3 Changes in Taiwan's Scientific and Technological Development

When implementing science and technology policies, Taiwan will first consider its actual technological strengths, evaluate its standing in international communities, consult sci-tech development policies from advanced countries, and then establish appropriate medium and long-term goals and policies. These efforts made in the past are gradually paying off as evidenced by the enormous changes in Taiwan's technological environment, where sci-tech organizations are constantly restructuring within a stronger legal framework. This environment is evolving in response to domestic needs as well as current trends in international development. Changes in domestic scientific and technological development are described as follows:

I. Regulating Technology

Enacted by the President in 1999, the "Fundamental Science and Technology Act" is the first fundamental act in the nation's history. The Act provides legislative standards for the fundamental direction of sci-tech policies, mechanisms for planning and coordinating sci-tech development, the stabilization of sci-tech inputs, research personnel affairs, maintaining fiscal flexibility, and the ownership and utilization of intellectual property rights (IPR). The Act places the planning and implementation of sci-tech policies on a firm legal and systematic basis. Article 9 of this Act calls for the government to present a written statement once every two years describing the visions, strategies and current status of developments in science and technology. Article 10 stipulates the formulation of a "National Science and Technology Development Plan" once every four years, which, apart from presenting visions, strategies, and status report, shall also prescribe specific measures associated with strategies. Moreover, the "White Paper on Science and Technology" shall update the status report, visions, strategies, and scientific and technological development at government agencies. With regards to the specific measures associated with strategies, consensus drawn from the quadrennial National Science and Technology Conferences shall be used to propose comprehensive key measures, which will be incorporated into the "National Science and Technology Development Plan."

After the enactment of the Fundamental Science and Technology Act, the government amended certain articles in May 2003 for several purposes. First, to prevent ineffective, misappropriate, or other unlawful use of research results after intellectual property rights have been granted to research institutions, enterprises, or other third parties. Second, to allow greater flexibility at research institutions by relieving certain types of procurement from being subject to the Government Procurement Act. Third, to create flexible learning environments for children of sci-tech personnel recruited from abroad. Finally, to establish a legal basis for the subsidiary units' budgets created under the National Science and Technology Development Fund.

For regulations governing national defense technology, Article 22 of the National Defense Law contains several basic policies: government agencies shall consolidate efforts of the private sector to develop defense technology industries; acquisition of weapon equipment shall firstly consider those built domestically; when it is necessary to pursue outsourcing channels, the acquisition activities shall realize technology transfer policy so as to establish an autonomous national defense infrastructure; and, consolidation of efforts with the private sector shall be achieved through means of cooperation, mutual entrusting, or entrusting of management. Pursuant to these basic policies, three regulations were enacted in December 2001, namely: "Regulations Governing the Cooperation Between National Defense Technology Institutions and Private Entities for Research, Development, Production, Manufacturing and Maintenance," "Regulations Governing the Sale of Products by National Defense Technology Institutions," and "Regulations Governing the Operation and Management of National Defense Technology Institutions by Private Entities." Future national defense technology production shall shift toward collaborations with the private sector. Through cooperation with domestic or foreign corporate bodies or the mutual commissioning of R&D, production, and maintenance, the nation hopes to achieve the goal of autonomous defense capabilities.

II. Large Increases in Government Sci-Tech Expenditures; Steady Growth in Gross Domestic R&D Expenditures

Regarding the use of scientific and technological resources, the government is making effective integration and appropriate allocations, promoting cooperation among government agencies, and integrating government and private sci-tech resources. Also, in order to raise domestic technological developments to the standards of developed nations within ten years, the long-term goal for gross domestic R&D expenditures has been set to 3% of GDP by the year 2006.

III. Emphasizing the Cultivation, Recruitment, and Utilization of Personnel

To meet the national manpower needs for developing basic and emerging fields, the government is actively promoting the "Science and Technology Manpower Training and Utilization Program" and "Graduate Student Study Abroad Program." Other endeavors include strengthening the training of domestic technology manpower, recruiting foreign high-tech professionals, expanding applications for the reserve duty system for technology and science, and promoting the flow of personnel among industrial, government, academic, and research sectors.

IV. Raising Taiwan's Academic Capabilities and Promoting Excellence

The "Program for Promoting Academic Excellence of Universities" is being promoted to provide special support for research-type universities to build world-class academic environments and to nurture accomplished research personnel capable of making major contributions to certain fields. Apart from fostering superior academic fields, promoting cutting-edge scientific research projects, developing the Centers for Theoretical Sciences and Ocean Research, and maintaining leading positions in various well-performing academic fields native to Taiwan, the government has gone one step further by integrating national resources to promote National Science and Technology Programs. These national programs aim for breakthroughs in important areas including hazards mitigation, telecommunications, agricultural biotechnology, biotechnology and pharmaceuticals, genomic medicine, digital archives, system-on-chip, nanoscience and nanotechnology, and e-learning.

V. Strengthening Technological Innovation, Developing High-Tech Industries

Government undertakings to strengthen high-tech industrial development, expedite the adjustment of industrial infrastructure, build industrial innovation systems, and commercialize R&D results have all proven successful. In fact, developments of science-based industrial parks in northern, central and southern Taiwan have created special high-tech industrial clusters, featuring "integrated circuits in the north, nanotechnology in the center, and optoelectronics in the south." In 1993, the northern science park generated NT$128.96 billion in sales, and in 2002, northern and southern science parks generated a combined total of NT$807.30 billion, making for tremendous contributions to Taiwan's economy. Also, key fields of development are being planned, including computers and software technology, telecommunications systems technology, micro-electromechanical technology and precision machinery technology, energy and environmental technology, advanced materials and chemical technology, and life science and biomedical technology. Other endeavors include developing the "Two Trillion and Twin Stars" industries, R&D service and information application service industries, and upgrading traditional value-added industries.

VI. Promoting the Development of Military-Civilian Dual-Use Technology

The "National Defense Technology Development Steering Committee" is promoting collaborations with academic research to enter into five major areas of research: aerospace, missiles, electronics, chemistry, and materials. In addition, to harness research results and better serve defense R&D agencies and related industries, academic institutions are being commissioned through the National Defense Industrial Development Fund to engage in cutting-edge defense technology research, map out plans for advanced military armament systems, or develop technology for the production of parts, etc. The Chung Shan Institute of Science and Technology (CSIST) is opening its “Chingshan,” “Lungyuan,” and “Taichung” research parks to provide technical service to government and civilian sectors. These research parks are effectively providing the industry with necessary technology and services, and increasing market surveys to aid industries in taking advantage of business opportunities.

VII. Reviewing and Improving the Sci-Tech Organizational Framework; Strengthening Functions

To comply with reorganizations within the Executive Yuan, the government is adjusting the structures of sci-tech agencies and advocating the conversion of national universities and government research institutions into non-profit entities; in 2003, the national laboratories have already been converted into non-profit organizations. Also, following the essence of the Fundamental Science and Technology Act, the government is strengthening the management and distribution of R&D results of academic research institutions, stressing performance reviews, and creating mechanisms to safeguard intellectual property rights and build flexibility into sci-tech personnel affairs.

1.4 Developing Science and Technology Based on Knowledge, Innovations, Regulations, and Taiwan’s Citizenry

Through advances in technology, the speed of the Internet, and the convenience of transportation, the world has become a smaller place with closer-knit connections. And as distances between people shrink, technological diffusion and competition grow increasingly intense, inducing risks, ethical and moral conflicts, and societal problems. Maintaining a balance between technological development and a humanistic society has become a topic of great importance in the knowledge-based society.

In recent years, the environmental problems caused by economic development are gradually beginning to surface. On top of these problems, Taiwan suffered a series of natural disasters including the devastating earthquake of September 21, 1999 and Typhoon Nari, with levels of losses already affecting overall development, and post-disaster reconstruction at enormous costs to society. In addition, recent outbreaks of dengue fever, the enterovirus, avian influenza, and SARS have also posed grave threats to the people of Taiwan and hampered economic development.

Despite technological advances and economic growth, Taiwan is still subject to diseases, calamities, and pollution that may bring damage to the properties and welfare of society and individuals. Citizens therefore hold high expectations for the control of epidemics, the research and monitoring of natural disasters, prevention of environmental pollution, improvement of ecological quality, national security, and preservation of the ecology. In addition to developing technology, pursuing innovations, and establishing regulations, what ordinary citizens desire even more is for the government to apply technology for the improvement of the public's physical and mental well-being, transportation, the environment, public safety, and the quality of living. In so doing, the people of Taiwan can enjoy a secure and comfortable living environment, and a lifestyle that keeps pace with modern trends and public expectations.

In the future, the government shall develop science and technology that is based on knowledge, innovations, regulations, and is beneficial for the citizenry of Taiwan. Technology shall be used to reduce the gap between economic development and the quality of life and environment, to improve living conditions, strengthen the ecology, and allow economic progress to proceed in harmony with a quality living environment. The government shall also emphasize the welfare of citizens and the sustainable development of a culturally-refined technology island, promote technological innovations that revolve around the humanities, and strengthen research in the fields of medical and public health, hazards mitigation, environmental protection, energy, agriculture, transportation, construction, and civilian applications of atomic energy. Through all these efforts, Taiwan can enjoy green production and consumption, boasting a beautiful countryside that coexists with technologically advanced communities.

CHAPTER TWO – The Current State of Science and Technology in Taiwan

2.1 The Mission and Framework of Scientific and Technological Development

I. Evolution of Government's Science and Technology Policies

In 1959, the Executive Yuan approved the "Guideline for the Long-range Development of Science" as guiding principles for Taiwan's early sci-tech policies, and in that same year created the "National Council on Science Development," in charge of promoting scientific development. This council was reorganized in August 1967 as the "National Science Council" and further expanded two years later into the "National Science Council (NSC), Executive Yuan." The NSC convenes council meetings on a regular basis and has now become the agency exclusively responsible for the development of science and technology in Taiwan. The National Science and Technology Conference has convened six times since 1978, meeting once every four years to gather consensus on sci-tech development from industry, government, academia, and research communities, and to form conclusions which serve as the basis for creating domestic sci-tech policies and promoting the development of science and technology. The "Science and Technology Advisory Group, Executive Yuan" was established in 1979 and invites prominent domestic and foreign experts to serve as science and technology advisors to the Premier of the Executive Yuan. This group is responsible for coordinating conferences relating to science and technology, including the Strategy Review Board Meeting on Electronics, Information, and Telecommunications; the Coordination Meeting for Recruitment and Training of Scientists and Technicians; and the National Informational and Communication Security Taskforce. The Science and Technology Meeting of the Executive Yuan convened for the first time in 1998, and has since been held on a regular basis. All of the aforementioned conferences are important events in gathering common consensus and plotting directions for sci-tech policies (see Figure 1). The evolution of major government sci-tech policies is described as follows:

(1) "Guideline for the Long-range Development of Science" (1959)

Sought to create a foundation for scientific development. Key measures included personnel recruitment, encouragement of research, research facilities development, and the provision of dedicated funding for scientific purposes.

(2) "National Science Development Program" (1968)

Broke with previous emphasis on pure academics and basic science research by placing more attention on academic research, raising research standards, and promoting technological research in accordance with national development needs.

(3) “Science and Technology Development Plan” (1978, 1982)

Designated energy, materials, information, and automation as key areas in 1978. Added biotechnology, optoelectronics, food technology, and hepatitis prevention in 1982, to form eight key areas.

(4) “National Science and Technology Ten-year Plan” (1986)

Laid out four major objectives, six major strategies, and the first quantitative indicators to measure R&D expenditures and manpower. In addition to the eight existing key areas, hazards mitigation, synchrotron radiation, marine science and technology, and environmental science and technology were added, for a total of twelve key areas of science and technology.

(5) “National Science and Technology Six-year Plan” and “Twelve-year Plan” (1991)

Announced the nation’s overall long- and mid-term goals for science and technology development: to raise the standards of science and technology, promote economic development, raise the quality of life for citizens, and establish an autonomous defense capability.

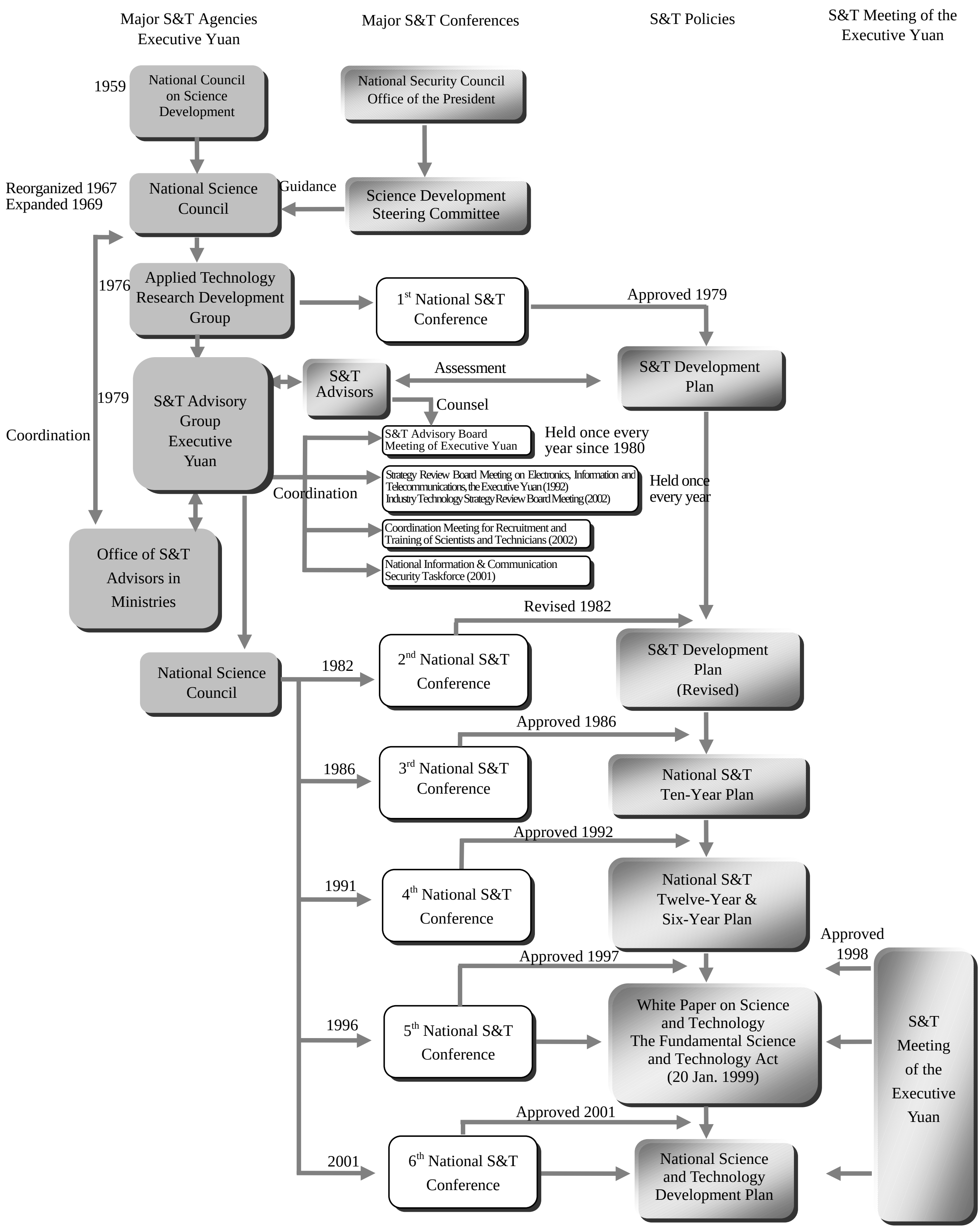
(6) “ROC White Paper on Science and Technology” (1997), “Action Plan for Building a Technologically Advanced Nation” (1998)

Planned science and technology development targets for the years 2000 and 2010, and also proposed the following: first, the government’s science and technology budget should be allowed to grow at a steady rate; second, a legal foundation for the development of science and technology should be established; third, the promotion of National Science and Technology Programs and cutting-edge basic research should be strengthened; fourth, sustained, focused support should be provided for the development of high-tech industries; and fifth, science and technology should be better reconciled with the humanities and social sciences.

(7) “National Science and Technology Development Plan” (2001)

Established six overall goals: to strengthen the knowledge innovation system, boost industry’s competitive advantage, improve citizens’ quality of life, promote sustainable development, improve nationwide technological standards, and reinforce the country’s autonomous defense capability.

Figure 1 Development of Taiwan's Sci-Tech Framework and Evolution of Policies



II. Promotion and Implementation of Sci-Tech Development

The development of science and technology is classified into basic research, applied research, experimental development, and commercialization, and is carried out through a division of labor scheme separating tasks between promotion and implementation (Figure 2). Responsibilities for the promotion of scientific and technological development are delegated among various government agencies: under the Office of the President is the Academia Sinica, and under the Executive Yuan are the Science and Technology Advisory Group, National Science Council, Ministry of Education, Department of Health, Environmental Protection Administration, Ministry of Economic Affairs, Council of Agriculture, Ministry of Transportation and Communications, Atomic Energy Council, Ministry of the Interior, Council of Labor Affairs, Public Construction Commission, Council for Cultural Affairs, and Ministry of National Defense. The government guides and implements policies on scientific and technological development through budget planning and execution at each agency. Responsibilities for actual implementation of scientific and technological development are shared by the research units of universities, research organizations, non-profit organizations and public and private enterprises. Figure 3 displays the organizational framework for scientific and technological development, consisting of government agencies, affiliated research institutions, and non-profit organizations.

Figure 2 Schematic View of the Division of Labor between Promoting and Implementing Organizations

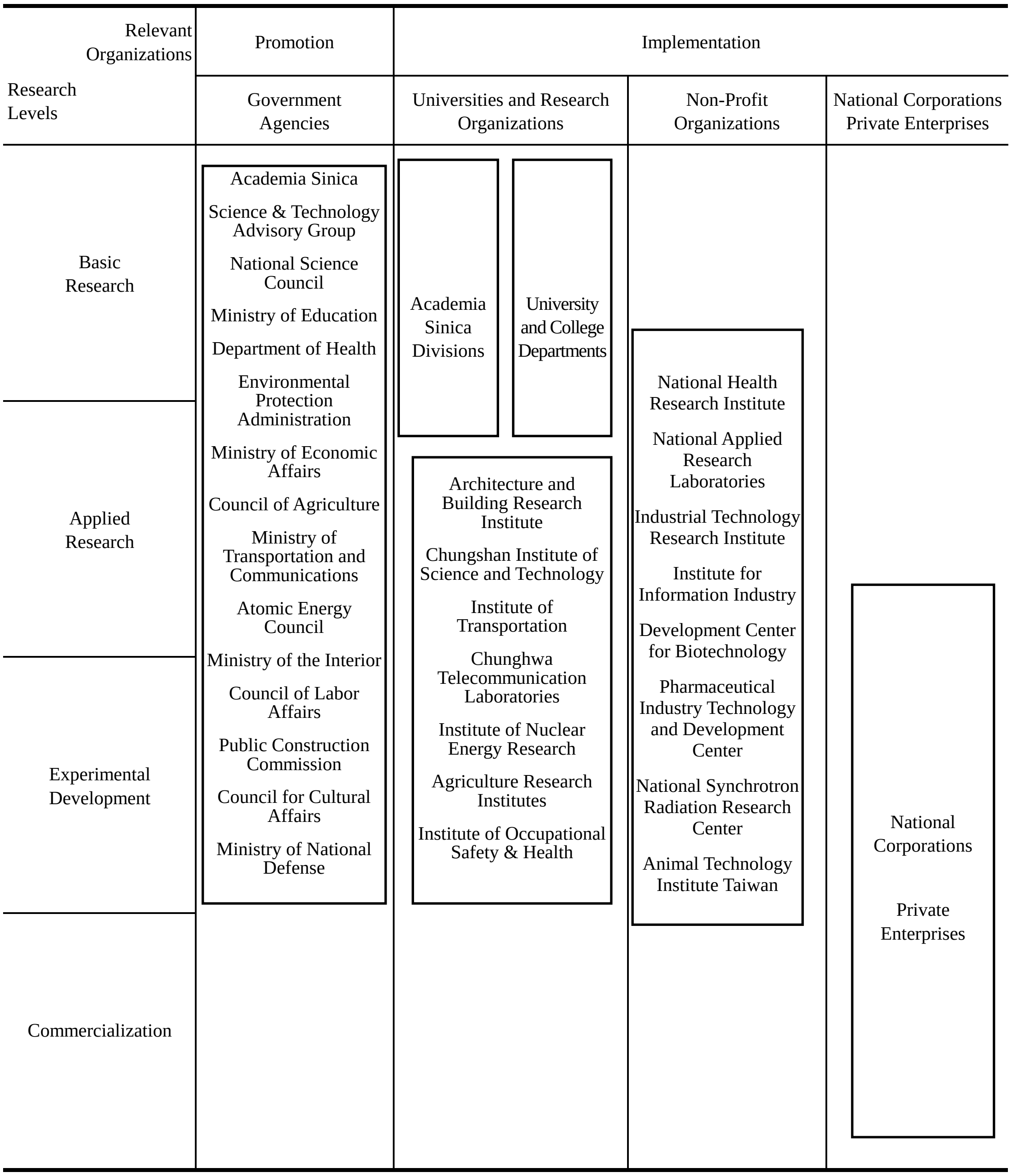
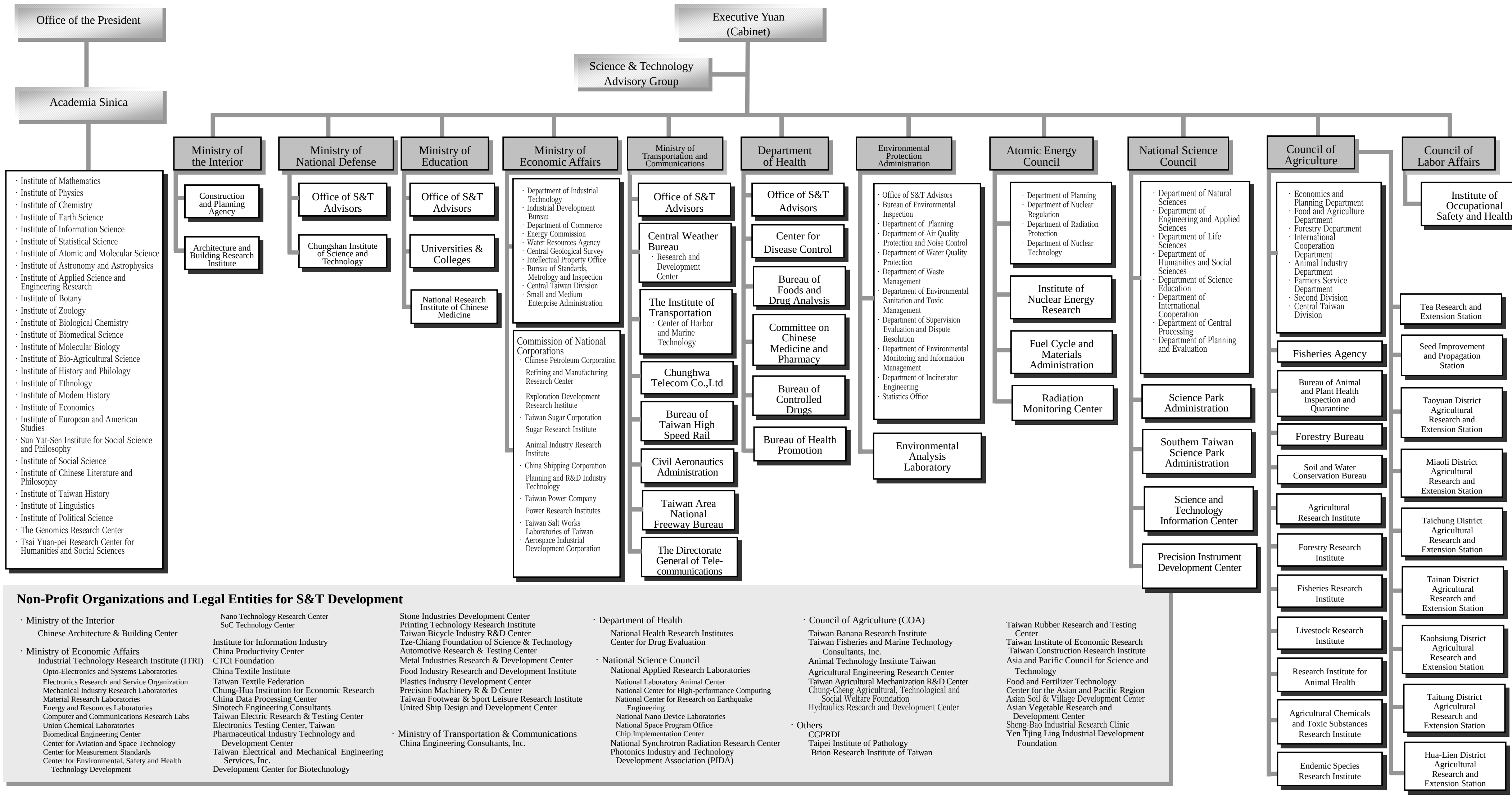


Figure 3 Organizational Framework for S&T Development in the ROC



Source: Government agencies

Notes: 1. Data current as of March 2003.

2. On January 1, 2003, the National Laboratory Animal Center, National Center for High-performance Computing, National Center for Research on Earthquake Engineering, National Nano Device Laboratories, and National Space Program Office were reorganized into the non-profit National Applied Research Laboratories. The National Synchrotron Radiation Research Center was also reorganized into a non-profit organization on January 1, 2003.

2.2 Scientific and Technological Development's Resources and Outputs

I. Research and Development Expenditures

(1) Growth in gross domestic R&D expenditures slowing down

Gross domestic R&D expenditures from public and private sectors totaled NT$176.5 billion in 1998, and NT$224.4 billion in 2002, increasing only 27% over these five years. The growth in gross domestic R&D expenditures showed signs of slowing down from 1998 to 2001, but recovered again in 2002 when gross domestic R&D expenditures rose to 2.30% of GDP, already meeting the National Science and Technology Development Plan's mid-term goal of achieving 2.3% by the year 2004 (Table 3).

Table 3 R&D Expenditure Indicators in Recent Five Years

Item		1998	1999	2000	2001	2002
Gross Domestic R&D Expenditures (NT$ Bil)		176.5	190.5	197.6	205.0	224.4
Growth Rate	(%)	12.9	8.0	3.7	3.7	9.5
As a Percentage of GDP	(%)	1.97	2.05	2.05	2.16	2.30
Public/Private R&D Expenditures	(NT% Bil)	67.6/108.9	72.1/118.4	74.2/123.5	75.8/129.2	85.5/139.0
	Percent of Total (%)	38.3/61.7	37.9/62.1	37.5/62.5	37.0/63.0	38.1/61.9

Source: *Indicators of Science and Technology, Republic of China (2003)*, National Science Council (http://www.nsc.gov.tw/tech/index.asp)

Note: Data for 1998~2001 excludes national defense R&D expenditures; 2002 data includes national defense R&D expenditures.

(2) Ratio of public-to-private sector R&D contributions toward gross domestic R&D expenditures holds steady

Public expenditures on R&D increased from NT$67.6 billion in 1998 to NT$85.5 billion in 2002, while private R&D expenditures increased from NT$ 108.9 billion in 1998 to NT$139.0 billion in 2002. As a percentage of gross domestic R&D expenditures, public contributions declined from 38.3% in 1998 to 37.0% in 2001, and rose again to 38.1% in 2002; private contributions climbed from 61.7% in 1998 to 61.9% in 2002, approaching a steady ratio of public-to-private sector expenditures on R&D (Table 3).

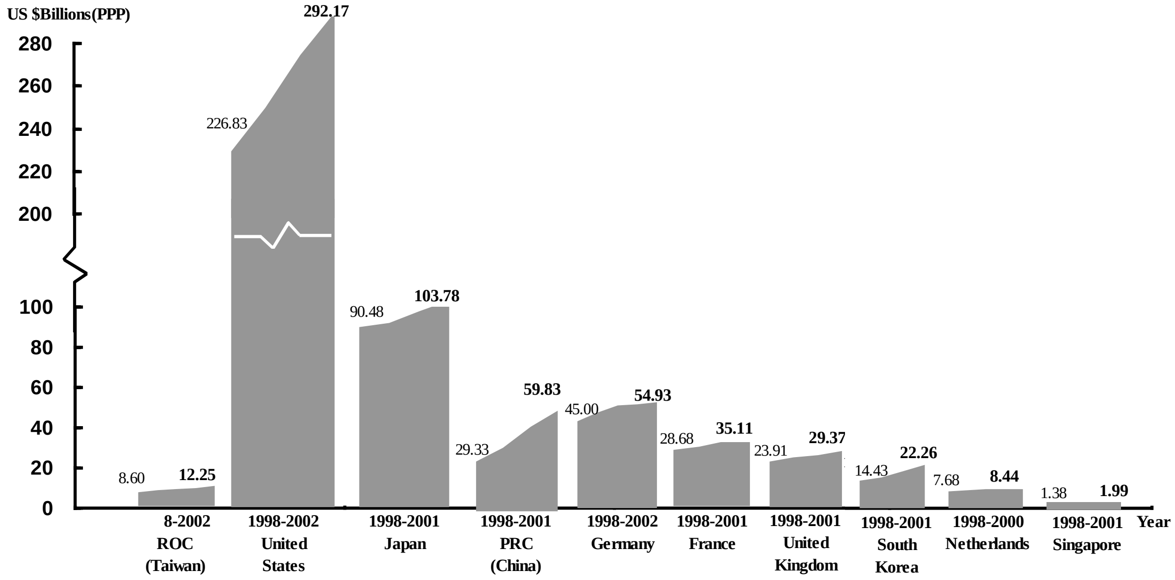
(3) Business enterprise expenditures on R&D account for low percentage of value added in industry

In 2002, Taiwan's business enterprise expenditures on R&D accounted for 1.92% of the value added in industry, rising slightly from 1.83% in 2001, but is still below the levels of Japan (3.1%), the US (2.77%), Germany (2.51%), and Korea (2.42%), indicating that domestic enterprises still need to invest more in R&D.

(4) Gross domestic R&D expenditures still low

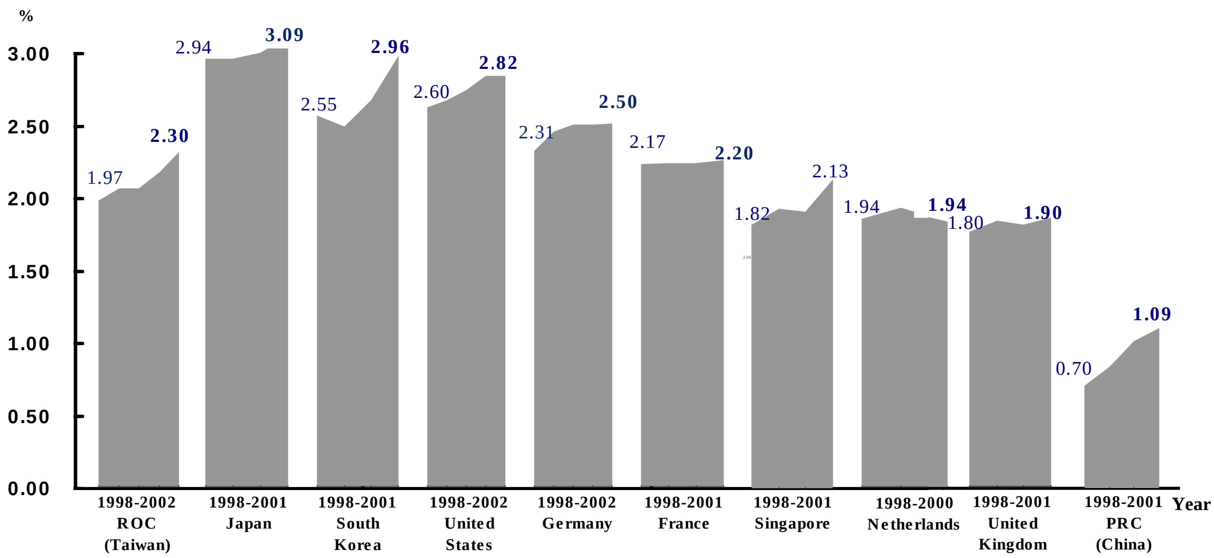
Compared with other nations, Taiwan's gross domestic R&D expenditures in 2002 measured roughly NT$22.44 billion, or US$12.25 billion if calculating with purchasing power parities. This figure is higher than the Netherlands' US$8.44 billion in 2000 but not as high as South Korea's US$22.26 billion in 2001 (Figure 4). Comparing R&D expenditures as a percentage of GDP, Taiwan measured 2.30% in 2002; Japan, 3.09% (2001); South Korea, with an economic scale comparable to Taiwan, a lofty 2.96% (2001); the United States, 2.82% (2001); and Germany, 2.5% (2002). These figures indicate that Taiwan is still lagging behind in R&D expenditures (Figure 5).

Figure 4 R&D Expenditures of Major Countries



Source: *Indicators of Science and Technology, Republic of China (2003)*, National Science Council

Figure 5 R&D Expenditures as a Percentage of GDP for Major Countries

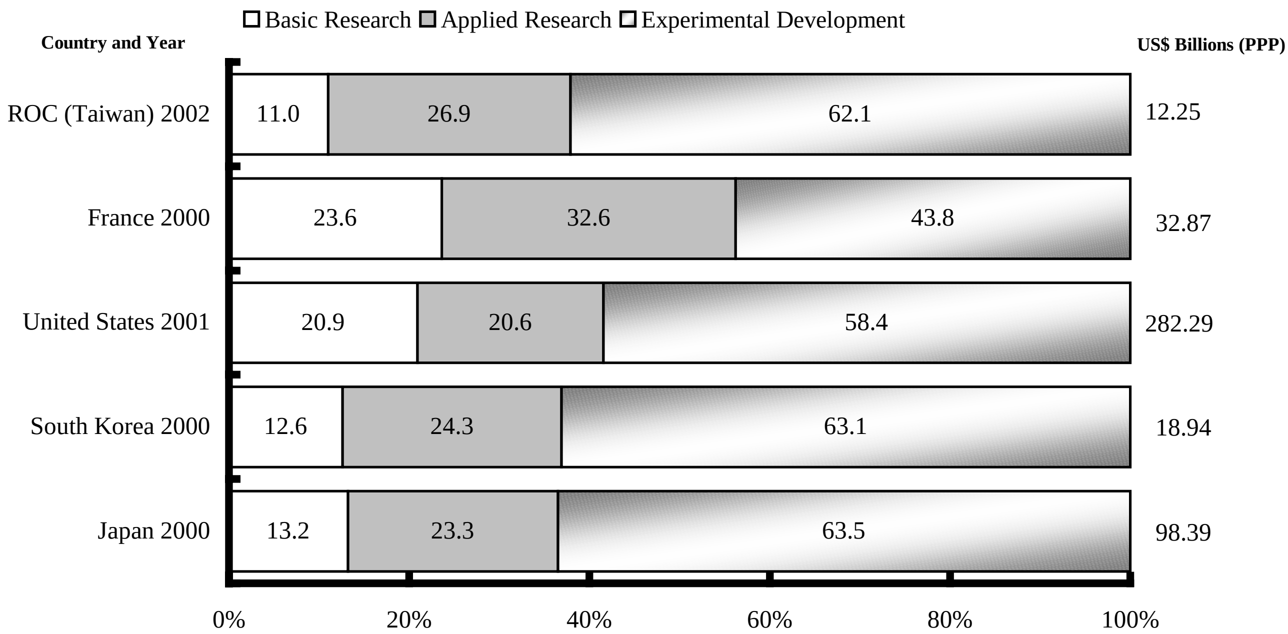


Source: *Indicators of Science and Technology, Republic of China (2003)*, National Science Council

(5) Taiwan’s proportion of basic research still low

Expenditures in research and development are divided among three types of activities: basic research, applied research, and experimental development. For Taiwan in 2002, R&D expenditures were divided among these three activities in the ratio 11:27:62, respectively. Patterns for other nations differ – France’s R&D expenditures were in the ratio 24:33:44 in 2000, the United States in the ratio 21:21:58 (2001), South Korea in the ratio 13:24:63 (2000), and Japan in the ratio 13:23:64. The expenditures devoted to basic research by each of the above countries were all higher than that of Taiwan (Figure 6).

Figure 6 R&D Expenditures by Type of Activity



Source: *Indicators of Science and Technology, Republic of China (2003)*, National Science Council

II. Research and Development Manpower

(1) Marked increase in researchers with university degrees or higher

In 2002, a total of 150,200 persons were engaged in R&D work, or 114,296 person-years if measured on a full-time equivalent basis (FTE, referring to the number of persons engaged in R&D accounted for on a full-time working basis). This figure includes the group that contributes the most to R&D – researchers with university degrees or higher – accounting for 64,385 person-years, or 56.3% in 2002; compared with 53,492 person-years in 1998, this group grew approximately 20.36%. For every 10,000 population, this group has increased steadily each year from 24.5 person-years in

1998 to 28.7 person-years in 2002, for a total growth of 17.1%. Moreover, for every 10,000 employed persons, their numbers increased from 57.6 person-years in 1998 to 68.1 person-years in 2002, increasing 18.3% in the span of five years. It has become apparent in recent years that maintaining steady growth of researchers, whether in quality or quantity, is of vital importance to all areas of Taiwan's research and development (Table 4).

Table 4 R&D Manpower Indicators

Item	1998	1999	2000	2001	2002
Number of researchers (FTE) (university degree or higher, person-years)	53,492	54,844	55,460	59,656	64,385
Number of researchers per 10,000 population (person-years)	24.5	24.9	25.0	26.7	28.7
Number of researchers per 10,000 employed persons (person-years)	57.6	58.4	58.4	63.6	68.1

Sources: 1. *Indicators of Science and Technology, Republic of China (2003),* National Science Council
2. *Monthly Bulletin of Statistics (November 2003),* Directorate-General of Budget, Accounting, and Statistics

Notes: 1. Data for 1998~2001 excludes national defense R&D manpower; 2002 data includes national defense R&D manpower.
2. R&D manpower measures researchers with university degrees or above on a full-time equivalent basis (FTE), in person-years.

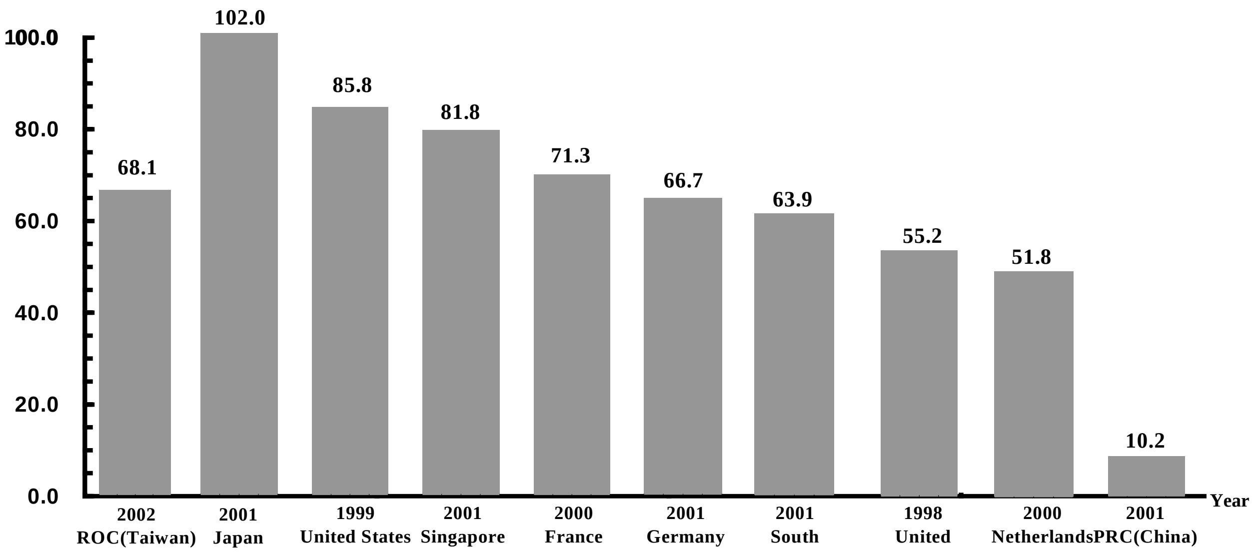
(2) Number of researchers with Ph.D. degrees in industries still low

In 2002, the number of researchers working in the industry sector was 37,527 person-years FTE, which rose 27.8% from 29,361 person-years in 1998, but includes only 2,091 person-years of researchers with Ph.D. degrees, accounting for a mere 15.5% of the 13,453 researchers nationwide that possess doctorate degrees.

(3) Number of researchers among employed population still low

In 2002, the number of researchers for every 10,000 employed persons was 68.1 person-years FTE. In comparison with other countries, this figure is higher than those of the United Kingdom (55.2 person-years), South Korea (63.9 person-years), and the Netherlands (51.8 person-years), but still lower than those of Japan (102.0 person-years), the United States (85.8 person-years), Singapore (81.8 person-years), France (71.3 person-years), and Germany (66.7 person-years); see Figure 7.

Figure 7 Researchers per 10,000 Employed Persons



Source: *Indicators of Science and Technology, Republic of China (2003),* National Science Council

III. Technological Innovation Activities in Enterprises

Apart from engaging in research and development, enterprises can also raise their competitive abilities through different innovation activities, including the use of patents or know-how, inducing new technologies, upgrading manufacturing processes or facilities, and training employees. According to results from the Taiwan Technological Innovation Survey, jointly conducted by the NSC and the Ministry of Economic Affairs, from 1998 to 2000, 43.3% of employees in enterprises with six or more employees had engaged in technological innovation activities; the figure for enterprises with twenty or more employees was 50.2%. In both size groups, the manufacturing sector outperformed the service sector (Table 5).

Enterprises can boost their competitiveness by engaging in technological innovation activities that succeed in introducing new products, new manufacturing processes, or new services to customers. In Taiwan from 1998 to 2000, the technological innovation success rates were 53.5% for enterprises with six or more employees, and 59.4% for enterprises with twenty or more employees.

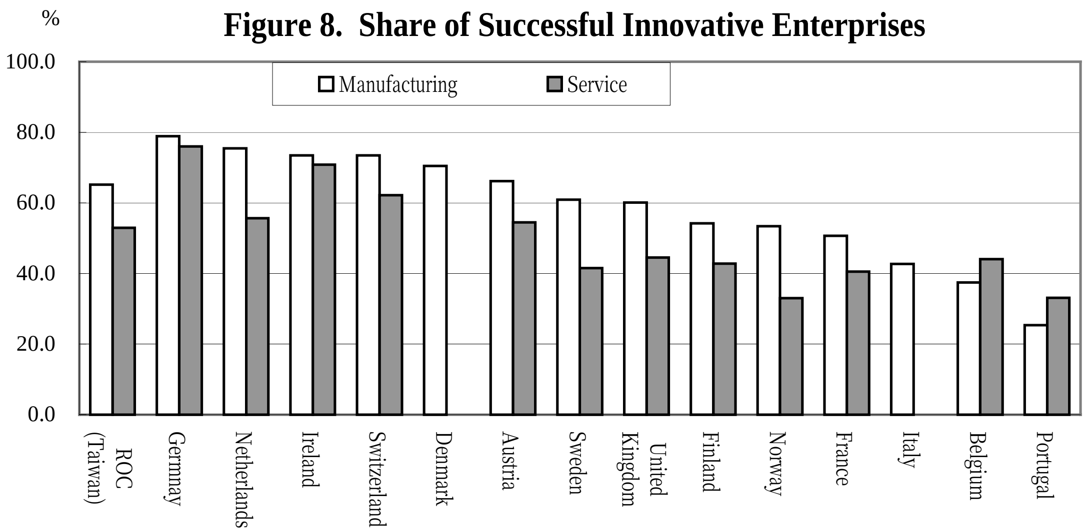
Table 5 Technological Innovation Activities in Enterprises, 1998~2000

Unit: %

Number of Employees	Sector	Proportion of Enterprises Engaged in Technological Innovations (weighted by number of enterprises)	Proportion of Enterprises Successful in Technological Innovations (weighted by number of employees)
6 or more	Manufacturing	47.9	60.4
	Service	40.1	46.8
	Overall	43.3	53.5
20 or more	Manufacturing	51.1	65.2
	Service	49.3	52.9
	Overall	50.2	59.4

The *Science, Technology and Industry Scoreboard (2001)* published by the OECD compiles two indicators relating to technological innovation that are highly regarded by all nations. Figure 8 displays the share of successful innovative enterprises for major nations. In most of these countries, the share of innovative enterprises is higher in manufacturing than in service; in Taiwan, 65.2% of manufacturing enterprises are innovative, compared to 52.9% of service enterprises.

Figure 8. Share of Successful Innovative Enterprises

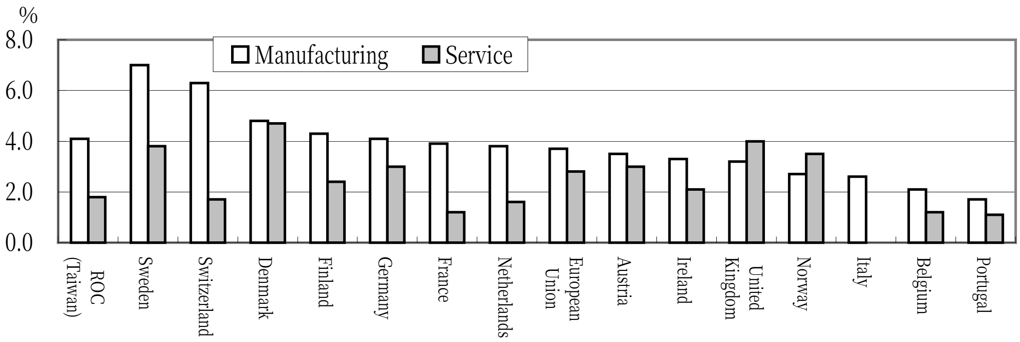


Sources: 1. International data from OECD *Science, Technology and Industry Scoreboard (2001)*, 1994~1996 data.
2. ROC data from Taiwan Technological Innovation Survey, 1998~2000 data.
3. Rates are weighted by number of employees.

Figure 9 shows expenditure on innovation as a share of total sales for various countries. In 2000, enterprises in Taiwan with twenty or more employees spent roughly

NT$564.0 billion on innovation, accounting for an average 2.81% of current year revenues. This figure reflects higher levels of spending by the manufacturing sector, where expenditures on innovation accounted for 4.08% of sales, topping the EU's average of 3.7%. The service sector measured 1.84%, lower than the EU's average of 2.8%.

Figure 9 Expenditure on Innovation as a Share of Total Sales



Sources: 1. International data from OECD *Science, Technology and Industry Scoreboard (2001),* 1996 data.
2. ROC data from Taiwan Technological Innovation Survey, 2000 data.

IV. Scientific and Technological Development Performance

(1) *Science Citation Index (SCI)*

The number of papers written by Taiwanese authors indexed in the *Science Citation Index* has been growing each year. From 8,605 papers in 1998 to 10,831 papers in 2002, the number of citations increased by more than 25.9% in five years. In terms of rank, Taiwan maintained 19th place from 1998 to 2000, advanced to 17th place in 2001, but receded to 18th place in 2002 (Table 6).

(2) *Engineering Index (EI)*

The total number of papers indexed in the *Engineering Index* increased by 32.9% in five years, from 4,026 papers in 1998 to 5,350 papers in 2002. Taiwan ranked 11th in 2002 (Table 7).

Table 6 Annual Papers and Rank in SCI

Country	1998		1999		2000		2001		2002	
	Papers	Rank	Papers	Rank	Papers	Rank	Papers	Rank	Papers	Rank
US	244,889	1	245,679	1	243,269	1	250,128	1	245,578	1
Japan	66,907	2	68,809	2	68,047	3	70,574	2	69,183	2
UK	65,591	3	67,163	3	68,362	2	67,813	3	65,395	3
Germany	62,721	4	63,222	4	62,941	4	64,960	4	63,428	4
France	45,128	5	46,180	5	45,214	5	46,435	5	44,999	5
PRC (China)	19,476	10	22,743	9	24,923	9	29,381	8	33,561	6
Canada	31,687	6	32,704	6	31,985	6	32,192	6	32,533	7
Italy	28,751	7	29,344	7	29,482	7	31,436	7	31,562	8
Russia	24,769	8	24,511	8	25,629	8	23,265	9	23,441	9
Spain	19,433	11	20,661	11	20,847	10	22,220	10	22,901	10
Australia	20,066	9	20,679	10	20,234	11	21,054	11	21,078	11
Netherlands	18,152	12	18,062	12	18,295	12	18,790	12	18,823	12
India	14,936	13	16,067	13	15,161	13	16,623	13	17,325	13
Sweden	14,359	14	14,692	14	14,384	14	15,301	14	14,846	15
S. Korea	9,545	16	11,048	16	12,218	16	14,641	15	15,643	14
Switzerland	13,002	15	13,588	15	13,568	15	13,429	16	13,192	16
Brazil	7,915	21	8,948	18	9,511	17	10,555	18	11,285	17
ROC (Taiwan)	8,605	19	8,944	19	9,203	19	10,635	17	10,831	18

Source: National Science Indicators on Diskette, 2003, ISI Co., USA

Note: Data for PRC (China) includes Hong Kong.

Table 7 Annual Papers and Rank in EI

Country	1998		1999		2000		2001		2002	
	Papers	Rank	Papers	Rank	Papers	Rank	Papers	Rank	Papers	Rank
US	52,369	1	56,075	1	51,394	1	50,340	1	57,754	1
Japan	19,128	2	23,037	2	22,789	2	22,770	2	24,273	2
PRC (China)	12,584	3	11,837	3	13,467	3	19,184	3	24,269	3
Germany	9,856	5	11,409	5	11,909	5	11,561	4	12,942	4
UK	11,280	4	11,671	4	12,086	4	10,231	5	11,516	5
France	7,366	6	8,294	6	8,683	6	8,484	6	9,528	6
S. Korea	3,645	11	5,279	9	848	9	6,536	7	6,990	8
Italy	5,084	8	5,616	8	6,339	7	6,153	8	7,205	7
Canada	6,237	7	6,426	7	6,172	8	5,429	9	6,823	9
India	3,613	12	4,550	12	4,393	11	4,373	11	5,436	10
ROC (Taiwan)	4,026	9	4,690	11	4,878	10	5,103	10	5,350	11

Source: Compendex, Nov. Week 1, 2003, E.I. Inc., USA

(3) Patents

Patents are one of the most important indicators for measuring performance in research and development. In 2002, the top five countries to which US patents were granted are the United States, Japan, Germany, Taiwan, and France. In 2002, a total of 5,431 US patents were granted to Taiwan, representing 2,331 more than the 3,100 patents granted in 1998, an increase of over 75%. In terms of world rank, Taiwan improved from 7th place in 1998 to 4th place in 2002 (Table 8).

Table 8 US Patents Granted (Excluding New Design) and Rank

Country	1998		1999		2000		2001		2002	
	Cases	Rank	Cases	Rank	Cases	Rank	Cases	Rank	Cases	Rank
US	80,291	1	83,905	1	85,072	1	87,607	1	86,977	1
Japan	30,840	2	31,104	2	31,296	2	33,223	2	34,859	2
Germany	9,095	3	9,337	3	10,234	3	11,260	3	11,277	3
ROC (Taiwan)	3,100	7	3,693	5	4,667	4	5,371	4	5,431	4
France	3,674	4	3,820	4	3,819	5	4,041	5	4,035	5
UK	3,464	5	3,572	6	3,667	6	3,965	6	3,838	6
Canada	2,974	8	3,226	8	3,419	7	3,606	7	3,431	8
S. Korea	3,259	6	3,562	7	3,314	8	3,538	8	3,786	7
Italy	1,584	9	1,492	9	1,714	9	1,709	10	1,750	9
Sweden	1,225	12	1,401	10	1,577	10	1,743	9	1,675	10
…….										
Total Granted	147,518		153,485		157,495		166,037		167,334	

Source: US Patent and Trademark Office

(4) National Competitiveness

When measuring the comparative strengths of sci-tech development among world nations, the World Economic Forum (WEF) and the International Institute for Management Development (IMD) issue authoritative reports on these matters. According to the WEF's *Global Competitiveness Report* released November 2003, Taiwan ranked 5th in growth competitiveness, 3rd in technology, 2nd in innovation, and 7th in information and communication technology (Table 9). In the *IMD World Competitiveness Yearbook* released in May 2003, among nations with population over 20 million, Taiwan ranked 6th in overall performance, 11th in economic performance, 6th in government efficiency, 4th in business efficiency, and 7th in infrastructure (Table 10).

Table 9 WEF's Global Competitiveness Ranking 2003

Country	Competitiveness Factor					
	Growth Competitiveness Index					
		1. Technology			2. Public Institutions	3. Macroeconomic Environment
			1a. Innovation	1b. ICT		
Finland	1	2	3	2	2	2
US	2	1	1	5	17	14
Sweden	3	4	4	3	7	8
Denmark	4	8	11	4	1	5
ROC (Taiwan)	5	3	2	7	21	18
Singapore	6	12	15	6	6	1
Japan	11	5	5	18	30	24
South Korea	18	6	7	11	36	23

Source: *The Global Competitiveness Report 2003~2004*, World Economic Forum (http://www.weforum.org)
Note: Growth Competitiveness Index (GCI) measures economic growth potential over the coming five to eight years, and is based on technology, public institutions, and the macroeconomic environment. The Technology Index is based on innovation and ICT.

Table 10 IMD's World Competitiveness Ranking 2003

Country	Competitiveness Factor				
	Overall Performance				
		1. Economic Performance	2. Government Efficiency	3. Business Efficiency	4. Infrastructure
United States	1	1	2	1	1
Australia	2	10	1	2	2
Canada	3	6	4	3	3
Malaysia	4	8	3	5	9
Germany	5	3	12	6	4
ROC (Taiwan)	6	11	6	4	7
Thailand	10	7	5	9	16
Japan	11	14	17	21	5
PRC (China)	12	2	9	24	17
Korea	15	18	18	20	11

Source: *2003 IMD World Competitiveness Yearbook*, International Institute for Management Development (http://www02.imd.ch/wcy/)
Note: Overall Performance Factor is based on economic performance, government efficiency, business efficiency, and infrastructure. Among countries with population greater than 20 million, Taiwan ranked 6th in overall performance.

2.3 Academic Research and Major Sci-tech Activities

To lay the groundwork for scientific and technological development, the NSC takes into consideration the comprehensive plans and reviews made by all disciplines, and maps out focal directions for academic research in accordance with national needs and international trends. As a result of vigorous promotion in these efforts, funding across all categories of academic research has grown steadily in recent years. Apart from each discipline's thorough planning and integration, the government also adopts relevant strategies and measures regarding sci-tech programs, and designates important areas for R&D within each field for mid- and long-term promotional efforts. In addition, the government carefully selects subjects, integrates up-, mid-, and downstream resources, and draws comprehensive plans to promote National Science and Technology Programs.

I. Academic Research

(1) Program for Promoting Academic Excellence of Universities

To pursue academic excellence and promote inter-university collaboration, the Ministry of Education and the NSC have sponsored the "Program for Promoting Academic Excellence of Universities" since 2000, and have processed two batches of projects altogether. In the first batch, sixteen projects totaling NT$4.3882 billion were approved, including four projects in the field of natural sciences, three in engineering and applied sciences, five in life sciences, and four in humanities and social sciences; project period runs from January 2000 through March 2004. In the second batch, twelve projects totaling NT$2.125 billion were approved, including two projects in the field of natural sciences, six in engineering and applied sciences, three in life sciences, and one in humanities and social sciences; project period for this second batch spans April 2002 through March 2006.

Also, the NSC in January 2003 announced the "Guidelines for Funding the Program for Promoting Academic Excellence of Universities" to encourage outstanding research teams from the Excellence projects to continue R&D work beyond project completion, with the hopes of expanding their research into academic fields where Taiwan possesses an advantage. Proposal forms from the first batch of projects were due April 1, 2003. After the review process, proposals that are approved will begin execution in April 2004.

(2) Academic research in various fields

Taiwan's academic research can be generally classified into five major fields: natural sciences, engineering and applied sciences, life sciences, humanities and social sciences, and science education. Relevant research in these fields is primarily conducted by universities and academic research institutions. Each field of research is planned and reviewed, and important directions for development are then established.

Table 11 describes the funding situation of NSC-sponsored research projects.

In recent years, the NSC has been following the plans made by each discipline, gradually increasing not only individual research but also targeted research subjects; this is intended to guide scholars away from free research and more toward mission-oriented research. Also, the NSC since 2002 has aggressively promoted cross-field and interdisciplinary research projects, strengthening their integration to seek significant breakthroughs. In 2002, twenty cross-field and interdisciplinary research projects were approved, with grants totaling NT$234 million.

Table 11 Research Projects Funded by NSC

Unit: NT$ Millions

Field	2000		2001		2002	
	Number of Projects	Funds Approved	Number of Projects	Funds Approved	Number of Projects	Funds Approved
Natural Sciences	1,531	1,673	1,634	1,825	1,577	2,260
Engineering and Applied Sciences	4,691	2,862	5,188	3,205	5,928	3,944
Life Sciences	3,077	2,620	3,157	2,789	3,352	3,427
Humanities and Social Sciences	2,463	959	2,582	1,069	2,985	1,482
Science Education	541	294	630	463	643	457

Source: NSC Research Funding and Awards Statistics Database, data collected May 1, 2003.

The Academia Sinica is also seeking to achieve further advancements in current research by vigorously advocating research topics which are long-term, cutting-edge, integrated, possess competitive potential, and does not exclude meaningful or practical topics. Looking ahead, full efforts will be devoted to these important fields: genomic research (including agricultural and medical), nanotechnology research, biodiversity research, global environmental change research, agricultural biotechnology research, and digital archiving. In the field of natural sciences, fresh developments are ushering in novel methods of experimentation, launching new fields of research and inducing high-tech applications. In the life sciences, much of the research in recent years has already achieved international standards, featuring interdisciplinary projects that further progress and understanding in areas such as gene regulation, biodiversity, genomic research, and bioinformatics. By adhering to predetermined plans, the field of humanities and social sciences has not only made tremendous progress compared to the past, but is also meeting globalization and localization needs. Generally speaking, academic capabilities are clearly improving.

The establishment of the "Center for Theoretical Sciences" and the "Center for Ocean Research" has made great contributions toward improving Taiwan's forefront and basic scientific abilities and drawing scholars to the newest fields of research. The NSC and the Ministry of Education are jointly implementing the "Program for Promoting Academic Excellence of Universities," actively promoting basic scientific research on advanced materials, research on ultra-high polymers and carbon nanotubules, cosmology and particle astrophysics, isotope geology dynamics, new generation magnetic resonance imaging, and geomagnetic indications of earthquakes, etc. In addition, the Synchrotron Radiation Research Center has constructed two world-class beamlines in Japan's SPring-8 facility for Taiwan's exclusive use, paving the way for Taiwan's scholars to conduct cutting-edge experimentation in hard X-ray science. With regards to international cooperation, the National Center for High-Performance Computing is promoting a program for the next generation of high-performance research networks, and has connected with the STAR TAP network of the National Science Foundation in the US to build a high-quality academic environment within a global cooperative network. The National Space Program Office (NSPO) has participated in the design and manufacture of three satellite programs: "ROCSAT-1," which is operating successfully, "ROCSAT-2," resource remote-sensing satellite, and "ROCSAT-3," sub-orbital satellite; all three programs proceeding on schedule. Through international cooperation, the efforts of the space program are upgrading applications and expanding the capabilities of Taiwan's space technology.

In regards to academic research, important future developments will not only rely on the ongoing planning and promotion of every discipline, but also on the strengthened promotion of the Program for Promoting Academic Excellence of Universities and national sci-tech programs to establish world-class research universities. In addition, more flexibility will be built into the academic research funding system and amounts granted, to provide outstanding researchers with ample funding that meets all research needs. Budding young scholars will be encouraged to conduct multiyear research projects. Outstanding researchers or teams will be encouraged to participate in international collaborative projects, major international conferences or organizational activities to enhance research capabilities and widen Taiwan's perspectives. The nation also hopes to leap across the high-tech divide by switching from gradual means of progress to innovative and inventive means of advancement, and guiding the mutual integration of research and industrial R&D.

II. Major Scientific and Technological Activities – Government's Sci-Tech Programs

(1) Projects in various fields of science and technology

The government supports projects in 35 fields of science and technology with each field featuring unique development goals, environmental structures, and distinctive needs for different types of resources and funding policies. In order to achieve the goals of every field while working with limited resources, the government relies on comprehensive and strategic policies for planning and allocation purposes. For this reason, the collective consensus of experts and scholars from each field are gathered and used to form government policies. Furthermore, through the planning and implementation at various agencies, the up-, mid-, and downstream resource needs of each field are being provided for, with academic capabilities improving, and industrial technologies advancing. (Table 12 presents results from the central government's reviews of each field's sci-tech development projects).

The NSC and the Science and Technology Advisory Group (STAG) invite experts from industrial, government, academic, and research communities to convene in the Science and Technology Strategy Planning Sessions. The purposes of these planning sessions are to plan roadmaps for future development and evaluate R&D capabilities and implementation results from the past three years. These planning sessions also assess the latest conditions and trends in sci-tech development to draw roadmaps for R&D work in the coming four years, select important areas of development within fields, and propose subjects and strategies for forefront technology R&D. These results are then used by the government as important reference when allocating sci-tech resources. Before each planning session convenes, several pre-meetings are called beforehand to gather reports from top agencies, to draw blueprints for development of fields, and select topics for discussion; this allows for greater efficiency and focus when the planning sessions officially meet.

In 2001, the Science and Technology Strategy Planning Session convened on 13 fields: electronics, information, machinery, materials, environmental protection, medical health, pharmaceuticals, agriculture, forestry, fishery, livestock, e-culture, and biotechnology. Thirteen more fields were discussed at the planning session held in 2002: automation, aerospace, optoelectronics, chemical engineering, textiles, resources, energy, civil engineering, transport, food products, meteorology, earth sciences, and biodiversity. Altogether, strategic planning reports for 26 fields will serve as references for prioritizing the 2004 annual review of science and technology programs.

Table 12 Approved Funding for Sci-Tech Development Projects in Various Fields

Unit: NT$ Millions

Field \ Year	2001	2002	2003
Electronics	2,227.304	2,321.298	1,763.736
Information	984.407	794.876	749.643
Telecommunications	1,702.358	2,024.891	61.373
Automation	986.911	863.932	359.165
Machinery	1,561.567	1,352.610	801.718
Aerospace	2,718.057	2,192.591	2,670.230
Optoelectronics	918.885	758.039	423.295
Materials	1,269.042	1,101.707	997.579
Chemical Engineering	601.984	503.945	295.185
Environmental Protection	979.827	1,021.513	763.946
Textiles	689.750	654.489	668.654
Resources	187.017	158.417	149.733
Engineering	1,781.800	1,714.385	1,763.405
Atomic Energy	746.326	734.450	611.142
Civil Engineering	360.343	438.008	276.945
Transport	1,081.719	990.895	806.383
Biotechnology	1,267.854	1,425.416	1,421.373
Food Products	364.830	374.166	377.009
Medicine	2,286.747	2,281.800	1,847.353
Pharmaceuticals	1,092.617	1,285.160	1,183.350
Agriculture	1,465.982	1,510.077	1,192.166
Forestry	438.183	415.279	348.224
Fishery	288.891	278.923	257.381
Livestock	303.808	218.837	425.047
Physics	917.258	913.725	882.581
Chemistry	22.298	23.442	27.094
Meteorology	245.126	239.844	253.832
Humanities	67.274	54.158	46.498
Science Education	1,057.464	929.315	747.248
Common Fields	8,105.367	9,805.943	8,244.420
Marine Sciences	82.683	66.345	61.160
Earth Sciences	366.021	347.296	207.893
e-Culture			870.232
Environment Building Technology Program			
Communications and Optoelectronics			413.532
Precision Machinery and MEMS			538.669
Materials and Chemical Engineering			177.164
Biotechnology and Medicine			146.167
Sustainable Development			66.640
Total	37,169.700	37,795.772	32,897.165

Source: Central government's annual review of sci-tech development programs from 2001, 2002, and 2003.

Notes: 1. Approved funding for 2003 does not include National Science and Technology Programs.
2. Two programs were added in 2003: e-Culture and Environment Building Technology Program (including Communications and Optoelectronics, Precision Machinery and Micro-Electromechanical Systems, Materials and Chemical Engineering, Biotechnology and Medicine, and Sustainable Development).

(2) National Science and Technology Programs

a. Conditions for establishing programs

To boost the country's competitive advantages and address major socio-economic problems, the NSC passed the "Guidelines for Promoting National Science and Technology Program" in 1997. The purposes of these guidelines are to integrate R&D resources across up-, mid-, and downstream levels, select subjects, map overall plans for the promotion of National Science and Technology Programs, and to implement R&D results more effectively. Major conditions for establishing National Science and Technology Programs are as follows:

- Should have long-term, clearly defined goals, involve innovative technology, and be capable of significant contributions to industrial development or national welfare.
- Possess interdepartmental or cross-disciplinary properties, require guidance, investment, and long-term support from the government.
- Possess international and forward-looking properties, with depth and width of influence and impact. Require clear division of labor and integration of resources across up-, mid-, and downstream levels, and across industry, government, academic, and research communities.

b. Process of forming programs

To designate topics for national-level programs, the NSC's Council Meeting will consider conclusions drawn from national sci-tech conferences and major issues in Taiwan's socio-economic development. After review and approval, the Minister of the NSC and the Minister without Portfolio in the Executive Yuan in charge of sci-tech affairs call together deputy agency heads of relevant sci-tech agencies, scholars, and experts to form a steering committee on National Science and Technology Programs. This committee is responsible for selecting a program manager for each national program, setting policy directions, ratifying working plans proposed by program managers, approving candidates for advisory committees, and reviewing outline plans submitted by program managers.

c. Control and evaluation of programs

After outline plans are reviewed and approved by the NSC Council Meeting, the funds required by each agency to implement these programs are promptly budgeted in order of priority, in accordance with each agency's sci-tech budgeting procedures. Expenses relating to planning and administrative support are financed in coordination by the NSC, the Science and Technology Advisory Group, or other relevant agencies. Overall responsibilities for monitoring national programs lie with the NSC. During the execution stage, affairs are managed and coordinated by the program manager's central office through periodic reviews, discussion forums, and public announcements of results thereof. After project completion, the NSC will hire additional groups of domestic and foreign experts to assess the performance of the entire program.

d. Current programs underway

As of 2003, the NSC has already planned and implemented nine National Science and Technology Programs: hazards mitigation, telecommunications, agricultural biotechnology, biotechnology and pharmaceuticals, genomic medicine, digital archives, system-on-chip, nanoscience and nanotechnology, and e-learning. Three programs in particular – hazards mitigation, agricultural biotechnology, and biotechnology and pharmaceuticals – are already operating in their second phase. (Table 13 presents the results of national program reviews over the past three years.)

Table 13 Funding for National Science & Technology Programs

Unit: NT$ Millions

Program Title	2001	2002	2003
Hazards Mitigation	338.319	495.242	535.510
Telecommunications	1,955.249	1,965.826	2135.677
Agricultural Biotechnology	189.449	236.040	530.652
Biotechnology and Pharmaceuticals	294.507	359.041	397.619
Genomic Medicine	-	1,977.255	2,285.919
Digital Archives	-	383.020	330.935
System-on-Chip	-	-	1,676.987
Nanoscience and Nanotechnology	-	-	2,562.188
e-Learning	-	-	570.360
Total	2,777.524	5,416.424	11,025.847

Source: Central government's annual review of sci-tech development programs: 2001, 2002, 2003.

1. National Science and Technology Program for Hazards Mitigation

(First phase 1998~2001, NT$1.04 billion / Second phase 2002~2006, NT$3.39 billion. Ministry of Economic Affairs, Council of Agriculture, Ministry of Transportation and Communications, Ministry of the Interior, National Science Council, Ministry of Finance, Department of Health, Ministry of Education, Environmental Protection Administration, Public Construction Commission, Council of Indigenous Peoples, National Disaster Prevention and Protection Commission.)

This program focuses on R&D work relating to the prevention and mitigation of earthquakes, typhoon-generated torrential rainfall, and other disasters posing the highest level of threat to the Taiwan region. Efforts include typhoon mitigation (including meteorology, flood mitigation, and debris flow mitigation), earthquake mitigation, and mitigation management (including information systems), etc. The program's responsibilities include integrating, coordinating, and promoting R&D work relating to hazards mitigation; strengthening research in mitigation technology and applying those results to actual hazards mitigation systems in operation; and assisting in creating effective disaster relief countermeasures to minimize direct and indirect losses caused by disasters. (This program is operating in its second phase.)

2. National Science and Technology Program for Telecommunications

(1998~2003, NT$14.36 billion. Ministry of Education, Ministry of Economic Affairs, National Science Council, Ministry of Transportation and Communications.)

To accommodate future trends in telecommunications, representatives from industrial, government, and academic communities assembled to plan and develop matters of sci-tech research and personnel training relating to telecommunication manufacturing and services. The two major areas of expansion are broadband Internet and wireless communications, separately developing Internet technology and IMT 2000 technology. The program aims to:

- Enhance the research coordination mechanism among government agencies, improve efficiency in telecommunication R&D, train telecommunication technology personnel.
- Research and develop key technologies (broadband Internet and wireless communication), create competitive advantages for the nation.
- Boost competitiveness and productivity in telecommunication services and communications manufacturing.
- Improve Internet bandwidth and quality, achieve targets set by NICI.

3. National Science and Technology Program for Agricultural Biotechnology

(First phase 1998~2001, NT$0.79 billion / Second phase 2002~2004, NT$1.99 billion. Academia Sinica, Department of Health, Council of Agriculture, National Science Council.)

This program seeks to upgrade the capabilities of traditional agricultural technology through the use of biotechnology, and to maintain a leading role in technological R&D and application efficiency. To these ends, seven key fields are being developed through three different types of project schemes. The seven key fields are: flowers and ornamental plants, plant protection, aquaculture, animal vaccines, postharvest technology and utilization, environmental protection, and medicinal plants.

The three different project schemes include: projects in key fields which conform to topics planned by this program; R&D application projects that encourage collaboration between industries and academia (including research communities); and original projects that comply with this program's objectives, possess creative potential, and merit exploratory research. By exploiting technological and biological resources that involve promising native agricultural and biotechnological products, this industry is aiming to take root and flourish in Taiwan. (This program is already operating in its second phase.)

4. National Science and Technology Program for Biotechnology and Pharmaceuticals

(First phase 2000~2002, NT$1.06 billion / Second phase 2003~2006, NT$7.59 billion. Department of Health, Ministry of Economic Affairs, National Science Council.)

This program's predecessor was the "National Science and Technology Program for Pharmaceuticals and Biotechnology," which sought to expedite the commercialization of R&D results by promoting research and development in pharmaceuticals and biotechnology and establishing basic framework and structures. The program began its second phase in 2003 when it was renamed the "National Science and Technology Program for Biotechnology and Pharmaceuticals." By integrating domestic resources, this program aims to develop patented medication through the research and development of Chinese herbal medication, genomics- and protein-based medication. (This program is already operating in its second phase.)

5. National Research Program for Genomic Medicine

(2002~2004, NT$7.48 billion. Academia Sinica, Department of Health, Council of Agriculture, Environmental Protection Administration, National Science Council.)

In recent years, the research and development of genomic medicine has already been firmly established in Taiwan, with increases in relevant personnel, continued investments in biotechnology from the private sector, and developments in key areas of innovation technology and product expansion. Main plans for this program include:

- Upgrading fields that have already produced results in the "Frontier Project on Medical Genomics."
- Linking with the computer information industry to develop bioinformatics.
- Stepping up research in proteomics to understand gene functions and pathogenic mechanisms.
- Strengthening ethical, legal, and social implication studies (ELSI) of genomic technology to explore precautionary measures.
- Accommodating the knowledge-based economy, advocating the expansion of genomics-based medical technology.

6. National Digital Archives Program

(2002~2006, NT$2.81 billion. Academia Sinica, Council for Cultural Affairs, Historica Sinica, National Palace Museum, Ministry of Education.)

This national program focuses on the humanities by integrating culture with technology to digitize the nation's major artifacts. Apart from digitizing the exquisite artifact collections at nine holding institutions, this program also enhances the contents, technological R&D, and applied research of digital archiving. The program aims to gradually expand the base of participation to preserve the country's cultural assets, build a public databank system to popularize refined art, and merge information technology with culture to stimulate the development of Taiwan's humanities, social sciences, industry, and the economy.

7. National Science and Technology Program for System-on-Chip

(2002~2005, NT$7.67 billion. Ministry of Education, Ministry of Economic Affairs, National Science Council.)

Contents of this program include transforming Taiwan into a global system-on-chip (SoC) design center, creating prolific silicon intellectual property (SIP), integrating electronic design automation (EDA) software, fostering an excellent design environment, and providing services for system design manufacturers around the world. The program seeks to continue expanding Taiwan's design platforms, generate new design advantages, achieve vertical integration, and turn the nation into a major player in semiconductor, information, and electronics industries around the world.

8. National Science and Technology Program for Nanoscience and Nanotechnology

(2003~2008, NT$23.19 billion. Ministry of Education, Ministry of Economic Affairs, National Science Council, Department of Health, Environmental Protection Administration, Atomic Energy Council, Department of Transportation and Communications.)

This program's goals are to integrate the nation's nanotechnology manpower and resources, and harness the industry's strength to expedite the commercialization of nanotechnology. Current plans are divided into four components: research in academic excellence, industrial technology, personnel cultivation, and the establishment of common core facilities. The program will also set up "flagship projects" focusing on consumer goods and chemical industries, metal and mechanical industry, electronic information, energy, and biotechnology. By channeling the developments of basic research, technological R&D, and product manufacturing toward a common direction, Taiwan can be transformed into a center for innovative nanotechnology R&D and high value-added manufacturing.

9. National Science and Technology Program for e-Learning

(2003~2007, NT$4.01 billion. Ministry of Economic Affairs, Council of Labor Affairs, Council for Cultural Affairs, Ministry of Education, Ministry of National Defense, Central

Personnel Administration, Tainan County Government, Department of Health, National Science Council, National Palace Museum.)

Under the guidance of government policies, this program seeks to create an advantageous environment, encourage all citizens in e-learning, shrink the digital divide, establish a "learning society," and transform Taiwan into a "premium e-society." By laying new foundations, bringing forth new waves of academic research on "learning technology," creating public demands for e-learning, and stimulating development of the e-learning industry, Taiwan will expand from a "major manufacturer of information hardware" to a "major user of information technology," and become a leading nation in the research of "learning technology."

2.4 National Science and Technology Development Plan (2001－2004)

(http://www.nsc.gov.tw/tc/)

In accordance with the "Fundamental Science and Technology Act" passed in January 1999, the Executive Yuan convened the Sixth National Science and Technology Conference in January 2001, and used the conclusions from this conference to produce the "National Science and Technology Development Plan (2001~2004)," which in turn serves as the basis for formulating technology policies and promoting R&D in Taiwan.

The "National Science and Technology Development Plan" includes six overall goals, eight major strategies, and 247 measures, all of which are implemented by 33 government agencies and relevant organizations, with the NSC assuming responsibility for control tasks. "National Science and Technology Development Plans" are produced once every four years to maintain continuity. The control mechanism includes evaluation by experts, interdepartmental coordination meetings to provide any necessary assistance in the actual implementation of measures, and any measure not completed within the current term will be carried over to the "National Science and Technology Development Plan" of the subsequent term.

The "National Science and Technology Development Plan (2001~2004)" has established six overall goals: strengthening the knowledge innovation system, boosting industry's competitive advantage, improving citizen's quality of life, promoting sustainable development, improving nationwide technological standards, and reinforcing the country's autonomous defense capability. This plan also envisions Taiwan's technological development to reach the standards of developed nations within ten years.

To achieve the aforementioned visions and goals, eight major strategies were established, with 247 key measures divided into specific implementation measures or plans for execution. The implementation results of this plan are as follows:

Strategy 1 Strengthening the training, recruiting, and utilization of technological manpower

In 2001, the sci-tech workforce grew faster than the preceding year as the number of researchers possessing at least a university degree reached 73,239 persons and drew closer to the government's mid-term targets. The number of researchers with master's and Ph.D. degrees as a proportion of all researchers possessing at least a university grew to 64.7% nationwide, and 50.8% in the industry sector, already meeting mid-term goals of achieving 60% and 50% respectively by 2004.

In order to strengthen the training of technological manpower, the Ministry of Education (MOE) announced the "White Paper on Creativity" and will promote preliminary initiatives on training. To encourage mission-oriented research projects on creativity, the NSC and MOE jointly implemented the "High School Basic Science Manpower Training Program." The NSC drafted the "Graduate Student Study Abroad Program" in 2002 to provide greater incentives for young researchers.

The government established a more flexible personnel affairs system and revised the "Nationality Act" to ease certain public service restrictions on persons with dual nationality. To establish a system of personnel exchange among industry, government, universities, and research institutions, various bills and amendments were submitted to the Legislative Yuan for approval, including draft statutes on the hiring of personnel, teachers' salaries, labor retirement, and the retirement of public servants. The NSC National Applied Research Laboratories and the National Synchrotron Radiation Research Center were transformed into non-profit research institutions in 2003 in accordance with the "National Experimental Research Institutes Establishment Statute" and the "National Synchrotron Radiation Research Center Establishment Statutes."

Strategy 2 Making the fullest and most effective use of technological funding

Gross domestic R&D expenditures accounted for 2.30% of GDP in 2002, rising from 2.16% in 2001. The government and private sector respectively accounted for 38.1% and 61.9% of nationwide R&D expenditures, with the proportion of contributions from the private sector increasing over the past few years.

Regarding the government's sci-tech budget, the Executive Yuan formulated mid-term budget plans that were based on a target of 10% growth per year. In 2002, the budget was planned for 10% growth and actually increased by 13% with the addition of extra funding into the National Science and Technology Programs. In 2003, the Executive Yuan continued planning for 10% increase, but an additional income NT$500 million from various agencies raised the actual rate to 11%.

The NSC formulated strategic plans for 26 fields in an effort to ensure that sci-tech spending is rationally allocated. Assessments have been performed on five schools and non-profit institutions, while another 29 government subsidiary research organizations are currently being assessed. The NSC and Ministry of Economic Affairs (MOEA) jointly implemented the "Taiwan Technological Innovation Survey Program" to survey the status of scientific and technological development in Taiwan, and also to measure innovation activities in the knowledge-based economy using statistical indicators.

Strategy 3 Strengthening academic research, pursuing academic excellence

To better integrate resources, the MOE has implemented a research university integration plan, and approved an intramural integration plan for National Taiwan University for 2002. National Tsing Hua University, National Chiao Tung University, National Yang Ming University, and National Central University have submitted the Taiwan United University System Plan, while National Cheng Kung University and National Sun Yat-Sen University have submitted an inter-university integration plan.

In order to foster academic excellence, the NSC and MOE proposed major funding to universities through the "Program for Promoting Academic Excellence of Universities" to enhance academic development and improve the basic infrastructure of universities. After these plans were completed, the government continued to implement this program and has approved a follow-up program.

To stimulate economic growth through knowledge innovation, research institutions are creating technology transfer centers and strengthening the management of research results. The MOEA is implementing academic Technology Development Programs to harness the capabilities of the academic community and to develop advanced innovative technologies. The MOEA is also assisting industries through the "R&D Alliance Preliminary Research Promotion Program" to establish R&D alliances, achieve mutual objectives, build common platforms, and integrate external technologies. Certain articles of the "Fundamental Science and Technology Act" were revised in May 2003 to better manage R&D results, personnel, and funding.

Strategy 4 Strengthening technological innovation, promoting industrial upgrading

Focal areas for industrial development are being formulated in different fields of science and technology. In computer and software technology: establishing A-grade DVD experiment laboratories, defining international standards, establishing new specifications, and cooperating with major international factories to develop multimedia application mobile terminal platforms. In telecommunications system technology:

helping businesses to harness broadband connections and wireless communications key technologies, and establishing testbeds for core telecommunication technology. In micro-electro-mechanical and precision machinery technology: developing micro-nozzle plate technology, micro-cooler technology, reflective light source modules, micro-RF modules, micro-fluidic devices, etc. In energy and environmental technology: developing technologies to reuse and extract resources from difficult wastes, and assisting domestic industries to manage environmental protection issues. In advanced materials and chemical product technology: boosting the competitive abilities of the upstream materials industry and chemical industry in Taiwan. In biological and biomedical technology: developing new medicines, medical devices, and genomic technology, etc.

To foster technological innovation, the government is gradually increasing the percentage of R&D funding of Technology Development Programs going into innovative pioneering projects. This percentage was 23% in 2002 and may surpass 25% in 2003. The government is also encouraging financial institutions to allow the use of intellectual property rights as loan collateral, and is extending loan eligibility for small and medium-sized enterprises to include the purchase of hardware/software for e-business or new technologies. "Technical services involving intellectual property rights" and "R&D services" have been included among strategic business items eligible for five-year tax holidays or stockholder tax abatement privileges.

The government has strengthened the science parks' infrastructure and expanded the Chunan site. Land surveys and drilling have been completed for the proposed Central Taiwan Science Park, along with a development report, environmental impact assessment report, and water/soil conservation plans. The first phase of the Tainan Science Park and public facilities will be completed ahead of schedule by 2005, and the second phase is already being developed.

Strategy 5 Improving public welfare and environmental quality

Regarding environmental protection and global climate change, the Environmental Protection Administration (EPA) and MOEA formed a task force to manage issues of ultimate waste disposal. A center-satellite guidance system for industrial wastes has been implemented, and an "Environmental Technology Park" has been established. To counter the effects of global climate change, the NSC consolidated the relevant policies and research results of all ministries and departments. The "Fundamental Environment Act" was enacted in December 2002 to upgrade environmental quality and promote sustainable development.

Disaster prevention efforts include strengthening the R&D, commercialization, and applications of hazards mitigation. The Ministry of Transportation and

Communications (MOTC) installed an earthquake early warning system, and the MOEA completed a non-contact water flow measurement system that uses remote sensing technology to create a water resource database. The NSC completed a round-the-clock population model, an emergency shelter selection model, and updated the related databases. The Council of Agriculture (COA) designated 77 water/soil conservation areas and surveyed 1,420 rivers and streams for potential debris flow. The MOE completed the "White Paper on Disaster Mitigation Technology and Education" to promote hazards mitigation and relief education.

Regarding water and ocean resources, the MOEA defined data standards for water resources, created a database for southern Taiwan, and updated the northern and central Taiwan databases. The MOEA deployed more base stations in the coastal hydrology network and extracted light metals from seawater. The COA promoted the development of ecologically-friendly and environmentally-balanced resources for aquatic life forms.

Regarding energy resources, the MOEA submitted a draft of the "Statute on the Development of Renewable Energy" to the Legislative Yuan for approval. Regulations on the utilization of renewable energy were implemented to provide system installation subsidies. Small electric-powered vehicles are being developed. To encourage private firms to invest in methane energy generation, the EPA increased financial incentives and extended the validity period to the end of 2006.

To advocate e-government, the nation stepped up efforts to train the public on information use. The Research, Development, and Evaluation Commission (RDEC) established an integrated e-government portal website with online access to 1,500 public services and began monitoring websites for performance, and as a result, Taiwan was named first in the world for e-government performance by Brown University’s 2002 report on global e-governments.

In terms of public health, the Department of Health established the "Genetically-modified Foods Deliberation Committee" and "Genetically Modified Foods Interdepartmental Working Group" to set standards on sampling technology, monitor the entry of these foods into Taiwan’s market, and inspect certifications. National-level genomic research facilities were established, and the National Health Research Institutes (NHRI) completed a high-speed broadband system for bioinformatics.

In agriculture, the Council of Agriculture (COA) revised the "Plant Seedling and Variety Law" to better manage the impact and applications of transgenetic technology, and implemented aerial remote-sensing technology to create a spatial database for drought and flood early warning systems. The COA also strengthened plant and animal disease-prevention technology, established an import quarantine inspection animal health system, and completed the nation's first plant virus diagnostic kits, which also have commercial applications.

In the area of transport and shipping, the Ministry of Transportation and Communications (MOTC) completed plans on a computer and communications platform framework for the intelligent transportation infrastructure, integrated software for standardizing urban traffic signs, and drafted necessary procedural guidelines. The government also increased applications of intelligent transportation systems and created an interdepartmental promotion task force.

In terms of construction technology, the Ministry of the Interior computerized the industry's infrastructure, drafted a performance and incentive system for green building design, and created an architectural materials basic database. An interdepartmental "Ecological Construction Method Promotion Committee" was established to advocate sound ecological practices for public construction projects.

Regarding civilian applications of atomic energy technology, the Atomic Energy Council established the "Nuclear Medicine Application Promotion Committee" to strengthen nuclear technology R&D for use in medical diagnosis and treatments. Several pharmaceutical products have already been developed and are being distributed routinely to major hospitals around the nation.

Strategy 6 Promoting the mutual development of technology and a humane society

To establish a high-quality humanities research environment, the government utilized computer technology to digitize the first collection of Betacam newsreels from the National Central Library. Standards were defined for the annotated recording of music, drama, dance, and movies, and for the digitization of script, image, and audiovisual information. The National Digital Archives Program completed a database approximately 16.7 terabytes in size.

The Department of Health established a "Medical Ethics Committee" to study the impact of emerging technologies on ethical, legal, and social implications (ELSI) and to formulate relevant policies and legislation. The NSC promoted research on the impact of genetic technology on ELSI issues through the "National Research Program for Genomic Medicine: ELSI Team."

Strategy 7 Implementing nationwide technology education and improving citizens' technical knowledge

To boost the public's knowledge of science and technology, the NSC organized "Citizens' Technological Innovation Contests" and "Citizens' Science Education Activities." The MOEA publishes the monthly *Technology Project Bulletin – Sci-Tech*

Pioneer and announces results of technology projects through designated websites. The Academia Sinica opened its facilities to visitors and held popular science lectures.

To disseminate technology news, the NSC implemented the “Public Science Education Research and Promotion” plan and held weekly press conferences on appropriate topics of interest. The aim is to inform the public through media reports of news on science and technology, R&D results, and social impacts of science and technology. To create statistical indicators measuring citizens’ sci-tech knowledge, the NSC implemented a plan to survey junior high school students and the general public to investigate their scientific and technological capacities in six key fields, including biotechnology, biomedical technology, and other hot topics of development in Taiwan.

Strategy 8 Establishing an autonomous defense technology industry and R&D system

In December 2001, the Ministry of National Defense (MND) enacted the "Regulations Governing the Cooperation Between National Defense Technology Institutions and Private Entities for Research, Development, Production, Manufacturing and Maintenance," "Regulations Governing the Sale of Products by National Defense Technology Institutions," and "Regulations Governing the Operation and Management of National Defense Technology Institutions by Private Entities." These three regulations promote the development of the defense industry.

The Chung Shan Institute of Science and Technology's Chingshan, Lungyuan, and Taichung research parks will be developed as "intelligent research parks" respectively specializing in the areas of chemistry, electronics and electrical machinery, and aerospace machinery. The Wireless Communication Engineering Center (WiCE) is being developed at Lungyuan, and plans of converting into a non-profit institution are being considered.

CHAPTER THREE – Visions and Strategies for the Development of Science and Technology

Since science and technology policies hold important bearings on national development, the government should draw long-range sci-tech development plans to maintain continuity and consistency in policies, and make adjustments for changes in domestic and overseas environments as necessary. In view of such, Taiwan's sci-tech development in recent years has been following the "Fundamental Science and Technology Act," wherein overall goals are set once every four years in the "National Science and Technology Development Plan," and macroscopic visions and strategies are proposed once every two years.

3.1 Visions

Technological development will reach the standard of a developed nation by 2010.

Indicators of Input and Output

1. Gross domestic R&D expenditures will account for 3% of GDP by 2006.
2. Research personnel (with university degrees or above) will constitute 32 person-years (FTE) out of every 10,000 persons in the general population by 2007.
3. At least one university will become a world-class university by the year 2013.
4. At least 3.5% of all US patents granted (excluding new design) will go to ROC applicants by 2007.
5. Over six million households will have broadband connections by 2007.

I. Visions for Academic Research

1. The academic research environment will be improved to retain world-class research talent.
2. Accomplished research personnel capable of major contributions within certain fields will be cultivated.
3. Intelligent and creative academic research will be developed autonomously, and results will be exploited to assist industrial development.
4. Taiwan will transform into an academic research and knowledge creation hub in the Asia-Pacific region.

II. Visions for Industrial Technology

1. A competitive industrial technology environment will be created to offer international advantages in the manufacturing and service sectors (e.g., an environment suitable for inventions and significant innovations in industrial technology, for the cultivation of new industries, and for the enhancement of traditional high value-added industries, etc.)
2. Value-added industries will be enhanced, and Taiwan will develop into a global center for the manufacture and supply of high value-added products.
3. Science parks will be developed, and regional R&D resources will be integrated to form regional industry clusters.

III. Visions for Public Welfare

1. Taiwan will develop into a society that reaps the benefits of scientific and technological results. Citizens will draw on science and technology to lead peaceful, secure, and quality lifestyles.
2. Citizens will develop life-long learning habits, and there will be harmonious development among science and technology, ethics of life, culture, and society.
3. Superior national defense technology and R&D systems will be developed, and the civilian sector will be directly involved in the defense technology industry.
4. The development of science or industrial parks will integrate with living functions and sustainable development. Information and communication systems will merge and form innovation networks to create a green island of culture and technology.

3.2 Strategies

To achieve the goals and visions described above, six major strategies for science and technology development have been established as follows:

I. Strengthening the cultivation, training, recruitment, and utilization of scientific and technological manpower resources

1. Since human resources form the foundation of sci-tech development, government's mid- and long-range plans for personnel affairs will focus on the supply and demand needs of the nation's sci-tech workforce. These plans will serve as the basis for the government to integrate the manpower resources of relevant organizations, create flexible measures, and cultivate R&D and innovation personnel systematically at all levels and across all fields, including personnel with multidisciplinary specializations.

2. When shortages of qualified domestic personnel occur within forefront research, high-tech fields, or other areas of science and technology, the government will take immediate action to recruit talent from overseas (including Mainland Chinese), and devise comprehensive measures to retain all necessary personnel by building attractive recruitment systems, breaking through relevant legislation or barriers, and creating favorable environments.
3. A flexible personnel affairs system will be created with effective mechanisms to promote the mobility of sci-tech workers among industry, government, academia, and research, and to harness the powers of R&D, innovations, entrepreneurship, and teamwork.
4. Sci-tech education for all citizens will be promoted to stimulate innovative potential, cultivate personnel with inventive and creative abilities, and increase the general public's capability in science and technology.
5. To expand the international perspectives of young researchers and sci-tech personnel, the government will encourage Ph.D. students, post-doctoral researchers, and sci-tech workers to travel abroad and participate in cross-national or international cooperative research projects, cutting-edge key technology transfers, or other collaborative activities in science and technology. These activities will strengthen domestic research abilities and empower Taiwan's sci-tech workforce with international competitiveness to connect with the world.
6. The vocational education system will be reviewed and enhanced to promote the proper development of vocational schools.
7. Colleges and universities will lay groundwork and establish guidelines to promote industry-university cooperation. Professors participating in industry-university cooperation will receive assistance in resolving such issues as reduction in the number of lecture hours required, calculation of seniority, and reasonable limits on the number of projects. National-level awards will be created for outstanding or excellent work in industry-university cooperation or technology transfers. The performance reviews of colleges and universities will evaluate results from industry-university cooperation so as to encourage more outstanding professors to engage in these activities.
8. The "Guidelines for Promoting Teachers of Junior Colleges or Higher Institutions through Technological (Practical) Research Achievements" will be established, creating a mechanism for college and university teachers who produce practical research results to qualify for academic promotions. This mechanism will motivate teachers with practical working abilities to engage in industry-university cooperation and produce research results that will also benefit their careers.

II. Maximizing and augmenting funds for R&D and innovation, effectively utilizing existing scientific and technological resources

1. The government will formulate policies to allow the sci-tech budget to grow at an annual rate of 12%. And, to stimulate greater investments in R&D and innovation in the private sector, the government will devise mechanisms to provide financial incentives or encourage feedback, and augment funding through new resources in order to raise R&D expenditures to 3% of GDP by 2006.
2. The government will evaluate its sci-tech budgeting scheme from multiple perspectives – including overall considerations, government agencies, uniqueness of organizations, priorities, academics, industrial needs, industry-university cooperation, and performance evaluation – and conduct integrated reviews to avoid ineffective and redundant investment. Moreover, the sci-tech budget will reflect the relative importance of R&D and cutting-edge innovation by devoting appropriate proportions of resources into promising fields or key technologies. Criteria of efficiency and systematization will be considered when administering, examining, and reviewing the effectiveness of sci-tech spending.
3. The government will integrate sci-tech resources and finance R&D and innovations. Moreover, the organizational framework, legal foundations, and measures relating to the R&D and innovations environment will be appropriately adjusted or improved to keep pace with modern trends and the changing environment.
4. Regulations will be eased, and appropriate measures will be taken to encourage higher R&D spending by enterprises in the private sector.

III. Emphasizing academic research, developing distinctive fields of world-class research

1. A favorable environment will be created to attract outstanding overseas scholars to conduct research in Taiwan, facilitate international collaborative research, and introduce and modify foreign advanced technologies for domestic use. These efforts will allow Taiwan to make practical contributions in the creation of knowledge for humanity.
2. The government will actively encourage forefront research, implement cutting-edge scientific research, and foster multidisciplinary collaboration and long-term research. Special emphasis will be placed on innovative and groundbreaking research achievements in order to develop distinctive fields, cultivate world-class professionals, and earn international recognition.
3. The proportion of expenditures devoted to basic research will be increased gradually to sustain the creative source of applied research and experimental development.

4. The quality and quantity of academic research results will be equally stressed with priority given to research topics with potential for international impact or industrial applications.
5. The main strategy for subsidizing academic research will be “quality enhancement,” breaking away from across-the-board funding and targeting outstanding researchers for generous and long-term funding to cultivate world-class researchers.
6. World-class universities will be established, and major support will be given to transform outstanding research-type universities into world-class research centers.

IV. Stimulating technological innovations, building an environment suitable for industrial development

1. Taiwan will foster an environment suitable for high-tech industrial development, and transform into a platform to nurture innovation.
2. Core industrial technologies will be developed, and a comprehensive mechanism to plan roadmaps for industries will be created using the resources of universities and research institutions.
3. Assistance will be given to universities and research institutions to establish mechanisms to protect intellectual property rights and technology transfers.
4. Collaborative efforts between industries, universities, and research communities will be encouraged, creating a variety of mechanisms to facilitate technology transactions, and expediting the commercialization of R&D results.
5. The government will introduce more incentives for universities and research institutions to strengthen integration with industries and apply R&D capabilities to the industrial sector. Universities and research institutes will be encouraged to develop forefront and innovative industrial technologies and produce patents. Also, cross-agency government meetings on industry-university collaborations will be further promoted after the Executive Yuan approves the “Ministry of Economic Affairs Plan for Converting Industrial R&D into Groundbreaking Innovations.”
6. Science parks and other intelligent parks will be established to develop distinctive industrial clusters. Equal emphasis will be placed on the cross-strait division of labor as well as industrial trends towards globalization.
7. International sci-tech cooperation will be implemented to increase the mobility of personnel and technology. Technologies suitable for domestic industries will be developed.
8. Groundwork for security in information communications will be laid, and a secure information communications environment will be established to upgrade industrial competitiveness.

9. The government will strengthen sci-tech programs to stimulate more private sector investments in R&D and personnel training, and encourage domestic and overseas enterprises to establish R&D centers within Taiwan. Personnel serving national defense reserve duty will be able to participate in industrial technology R&D. Loans for research and development will also be made available.

V. Fostering the interactive development of science and technology, society, and the environment, improving public welfare and environmental quality

1. Science and technology will be applied to the improvement of public welfare and environmental quality.
2. Potential impacts from sci-tech development will be studied with greater attention. Science and technology will develop in harmony with other societal systems.
3. Taiwan will gain the approval of all community groups for substantial investments in R&D, and also merge into the world's sci-tech communities.
4. New technologies will be used to preserve traditional culture, promote life-long learning, and disseminate culture to the public.

VI. Building a superior defense technology system, promoting the development of military-civilian dual-use technologies

1. The government will aggressively implement short-, mid-, and long-range strategic plans to develop national defense in order to maintain long-term and continuous development in this field.
2. Taiwan's "autonomous national defense" will aim to achieve breakthroughs and to harness key defense technologies. Policies on defense technology development will accommodate the nation's sci-tech development needs. To achieve significant advances in key defense technologies, inputs into defense technology R&D manpower and expenditures will be studied, and appropriate indicators of defense technology development will be defined to pool limited resources.
3. To optimize military R&D applications in the civilian sector, the structures of the Chung Shan Institute of Science and Technology and other organizations will be modified to integrate research systems from defense technology, academic research, and civilian industries. The mechanism managing dual-use technologies between the military and civilian sectors will be strengthened. Military-civil dual-use technologies will be vigorously applied to the civilian sector via technology transfers to promote the development of national defense technology, and enhance the R&D capabilities of the civilian sector.

CHAPTER FOUR – Challenge 2008: National Development Plan

(2002~2007)

(http://www.cepd.gov.tw/2008/index.htm)

In May 2002, the Executive Yuan announced the "National Development Plan" as a new socioeconomic blueprint to meet the challenges of the new era, manage the explosive developments of new technologies, and respond to the latest trends in globalization and international competition. It serves as guiding principles for the government to follow in boosting national competitiveness and transfiguring Taiwan into a "Green Silicon Island." The "National Development Plan" focuses primarily on elevating Taiwan to world-class levels by achieving specific policy goals, involving the participation of the general public, promoting creativity, establishing an economic lifestyle that reflects local culture, and actively participating in international communities. Moreover, the plan's underlying intentions are to accumulate and apply technological knowledge, enhance R&D capabilities, apply new technologies, and promote knowledge innovation activities. Ten key investment plans have been designated in the "National Development Plan," and the following describes those plans closely related to scientific and technological development:

4.1 Cultural and Creative Industry Development Plan

I. Set up a Promotional Organization for Cultural and Creative Industries (National Development Plan #2.1, 2002~2007, NT$ 46.000 million, MOEA Industrial Development Bureau.)

The Ministry of Economic Affairs (MOEA), Council for Cultural Affairs (CCA), Ministry of Education (MOE), and Government Information Office (GIO) will work together to set up an office and establish the "Cultural and Creative Industries Promotion Committee." This committee will be responsible for the overall planning of annual, mid-term, and long-term strategies and measures used to develop the cultural and creative industries. In addition, plans are underway to establish an interdepartmental "Commission of Development and Supervision of Cultural and Creative Industries," which will have exclusive responsibility for setting relevant national policies and promoting the development of these industries. This commission will be comprised of appointed experts from Taiwan and abroad specializing in culture, art, creativity, design, and related fields.

II. Fields within the Design Industry (NDP #2.2.3.2, 2002~2007, NT$140.000 million, MOEA Industrial Development Bureau.)

To cultivate Taiwan's creative design workforce, the government will select outstanding personnel each year from six key creative design fields (creative furniture, textile and fashion, digital art, creative life, traditional handicrafts, and commercial design) for an international exchange program. The candidates will train in countries with excellent design environments and learn from local professionals through actual working experiences. This cooperative mechanism for hands-on training enables candidates to gain practical product development experiences from overseas and learn techniques for blending distinctive cultural elements into the design process, thereby raising the capabilities of Taiwan's designer workforce. Under this program, the trainee and the government will each contribute to 50% of tuition costs.

III. Promote Creative Life Industries (NDP #2.4.3, 2002~2007, NT$150.500 million, MOEA Industrial Development Bureau.)

As Taiwan's economic development approaches the level of an advanced nation, the public's earning and spending power will continue to grow, leading to greater appetites for fine food, quality clothing, housing, travel, education, and entertainment, as well as higher demands for quality lifestyles that reflect sophistication, creativity, comfort, and refined taste. The plan to promote creative life industries, therefore, builds on existing industries and incorporates creativity, technology and culture to produce an "Integrated Industrial Network of products, spaces, services, and promotions." By compounding the added values of these industries, this concept will boost industrial competitiveness and improve the quality of life at the same time. The MOEA is creating a nurturing environment for this budding industry by providing consultation services, assessing and awarding exemplary creative life companies, promoting creativity logistics platforms, building a creative life industry database, organizing promotional activities, and stimulating the general development of this industry.

IV. Strengthen Textile and Fashion Design Ability (NDP #2.4.4, 2003~2007, NT$455.000 million, MOEA Industrial Development Bureau.)

Rapid changes in the global market in recent years have transformed the manner of textile procurement, where international buyers are no longer simply purchasing large volumes of materials, but also demanding comprehensive services that encompass design, production, and marketing. And while Taiwan enjoys substantial competitive advantages for raw materials and production of textiles on the international market, its overall designing and marketing abilities are still considered by many to be quite weak. Consequently, industry, government, universities, and research institutions are actively collaborating to upgrade workforce skills through various activities, including semi-annual workshops at universities organized by research institution professionals to teach on the latest trends in fashion, annual seminars on fashion shows for high-potential students recommended by schools, and professional training programs at research institutions for ten to twenty selected designers. This systematic farming of professional designers and sales personnel with international savvy will enable the industry to independently upgrade its capabilities and meet market demands. In addition, participation in international design contests will be encouraged, using education and competitive methods to strengthen the abilities of domestic personnel and raise the standards of design. The industry will organize “fashion week” events and invite world-renowned professionals to Taiwan, attracting media attention and creating opportunities for publicity. These events will also be combined with marketing promotions to integrate design and marketing skills in keeping with international trends. With comprehensive planning, the textile workforce will expand their abilities to include design and sales, transforming the industry and boosting national competitiveness.

4.2 International Innovation and R&D Base Plan

I. Attract International R&D Personnel (NDP #3.1, NT$3,783.680 million. Includes: 3.1.1 Recruit Overseas Hi-Tech Personnel 2002~2007, MOEA Department of Industrial Technology, Industrial Development and Investment Center; 3.1.5 Build Global Academic Internet, 2003~2007, NARL National Center for High-performance Computing.)

In order to deal with worldwide economic competition, including the influences from cross-strait economic interaction, local industries will need to shift from large-scale, standardized manufacturing to concentrate on R&D, design, and high value-added products. By focusing on high quality products, Taiwan will be able to differentiate itself from the low-end price competition coming out of developing countries. To this end, the government is committing great efforts to cultivating a highly proficient sci-tech workforce with creativity, independence, and conscientious thinking. The government will also create an attractive environment with effective mechanisms to recruit high-caliber R&D personnel from abroad and accelerate the improvement of domestic capabilities for R&D.

II. Provide NT$50 Billion in R&D Loans (NDP #3.2, 2002~2007, NT$158.000 million. MOEA Industrial Development Bureau.)

The high degree of risk and uncertainty associated with R&D projects have impelled many banking institutions to withdraw invested capital and reject business loan applications due to a prevailing reluctance to underwrite these ventures. To encourage more businesses to engage in R&D, the government is assisting Internet companies, manufacturers, and technology service companies to secure R&D financing through low-interest loans. This scheme operates as follows: companies can submit their R&D loan applications to the MOEA Industrial Development Bureau, where an appointed committee will review applications to determine the amount to approve for any project. Approved amounts are drawn from the development fund and then entrusted to a managing bank for disbursement to applicant companies upon documented proof of loan guarantees. If a company is unable to secure loan guarantees due to insufficient credit, it may request credit assistance from the Small and Medium Business Credit Guarantee Fund (SMEG).

III. Establish Key-Industry Technical Colleges (NDP #3.3, 2002~2007, NT$1,996.955 million. Includes: 3.3.1 Establish Semiconductor Colleges, 3.3.2 Establish Digital Content Colleges, MOEA Industrial Development Bureau.)

Two of the main industries in the "Two Trillion and Twin Stars" program are the semiconductor and digital content industries, both of which require ample supplies of specialized professionals in order to succeed. According to recent projections from the National Science and Technology Program for System-on-Chip, the number of IC design personnel needed by the year 2005 is estimated to be 9,500 persons if projecting for natural industry growth, or as many as 17,000 specialists if projecting for strong growth on optimistic outlooks of national competitiveness. However, schools around the nation are only producing some 800 graduates each year with master's or Ph.D. degrees in IC design; this deficiency in specialists has become the most significant impediment to industrial growth and clearly needs to be resolved very soon. Semiconductor colleges will be established to help relieve this shortage, supported by the pooled resources of industry, government, universities, and research institutions (including the ITRI System-on-Chip Technology Center and the NSC Chip Implementation Center). The digital content industry is also lacking engineering personnel in information software and Internet communications, and experiencing high demands for IT-proficient workers in fine arts, performing arts, literature, music, history, and similar fields. To cultivate more multidisciplinary personnel, the education system is already undergoing adjustments but the changes are not expected to fulfill industry requirements for another five years yet. In the meantime, the government will be devoting great efforts to establishing a number of specialized digital content colleges, providing location sites along with qualified teachers and facilities, introducing training courses from abroad, offering opportunities for practical work experience, collaborating with conventional colleges and universities, and even providing degrees and skill certifications in certain cases to relieve the more pressing needs of the industry.

IV. Establish Innovation and R&D Centers (NDP #3.4, NT$11,963.188 million. Includes: 3.4.1 Attract Multinational Firms to Set up Regional R&D Centers, 2002~2008, MOEA Department of Industrial Technology; 3.4.2 Encourage Set-up of Private Innivation and R&D Centers, 2002~2008, MOEA Department of Industrial Technology; 3.4.3 Genomics Research Center of Academic Sinica (GRCAS), 2002~2004, Academia Sinica; 3.4.4 IC Design Park, 2003~2007, MOEA Industrial Development Bureau; 3.4.5 Wireless Communication Engineering Center (WiCE), 2002~2007, MOEA Department of Industrial Technology; 3.4.6 Hsinchu Nanotechnology Applications R&D Center, 2002~2008, MOEA Department of Industrial Technology; 3.4.7 Telecommunications Technology Center, 2003~2007, MOTC Directorate

General of Telecommunications, MOTC Office of S&T Advisors; 3.4.8 Precision Machinery Innovation and R&D Group in Central Taiwan, 2002~2007, MOEA Department of Industrial Technology; 3.4.9 Industrial Innovation and R&D Park in Southern Taiwan, 2002~2004, MOEA Department of Industrial Technology; 3.4.10 Asia-Pacific Entrepreneurship Center Development Plan, 2002~2007, MOEA Small and Medium Enterprise Administration; 3.4.11 Environmental Technology Incubation Center, 2002~2007, EPA.)

In order to help Taiwan access worldwide resources for innovation and R&D and to raise the island's visibility to transnational firms seeking to expand global operations, the government is aggressively encouraging multinational corporations to establish regional R&D centers in Taiwan. The introduction of foreign professionals, technologies, resources, and operating methods into local industries can generate complementary benefits for domestic and foreign companies alike. Domestic enterprises are being encouraged to make the transition towards high-end technological innovation and R&D, and to establish R&D centers in Taiwan by building on core industries and high-tech capabilities. With R&D headquarters based on the island, domestic enterprises can expand global operations and boost their abilities to compete internationally. In regards to traditional manufacturers in southern Taiwan, an "Industrial Innovation and R&D Park" will be established within the Southern Taiwan Science Park to assist manufacturers make the transition towards innovation and R&D. For small and medium-sized enterprises, the government is planning to set up the "Asia-Pacific Entrepreneurship Center" to create a high-quality environment conducive to entrepreneurialism where small and medium-sized enterprises can better survive and thrive. In regards to high-potential industries, the government is integrating the resources of businesses, research units, and government agencies to create different types of innovation and R&D centers, including the "Genomics Research Center of Academic Sinica (GRCAS)" for the biotechnology industry, the "IC Design Park" for the SoC and software industries, the "Wireless Communication Engineering Center (WiCE)" for the mobile communications industry, the "Hsinchu Nanotechnology Applications R&D Center" for nantotechnology, the "Telecommunications Technology Center" for advanced telecommunications technology, the "Precision Machinery Innovation and R&D Group" to encourage transition in central Taiwan's machinery industry, and the "Environmental Technology Incubation Center" to develop environmental protection technologies.

V. Promote Key Industrial Technology Research

(NDP #3.5, 2002~2008, NT$46,619.090 million. Includes: 3.5.1 Biotechnology Development Plan, 3.5.2 Nanotechnology Development Plan, 3.5.3 System-on-Chip Technology Development Plan, 3.5.4 Telecommunications Technology Development Plan, National Science Council.)

In order to sustain growth in the local economy, the government will help domestic industries capitalize on important core technologies within advanced technological fields by implementing four key industrial research plans: the “Biotechnology Development Plan,” “National Science and Technology Program for Nanoscience and Nanotechnology,” the “National Science and Technology Program for System-on-Chip,” and the “National Science and Technology Program for Telecommunications.”

First, under the “Biotechnology Development Plan” are the national science and technology programs for “Agricultural Biotechnology,” “Biotechnology and Pharmaceuticals,” and “Genomic Medicine.” The agricultural biotechnology program focuses on developing and introducing advanced biotechnology to raise the added values of agricultural and livestock products. The biotech pharmaceutical program focuses on R&D for chemical drugs, biochemical drugs, and biochips, and seeks to build a comprehensive medical care system through new drug R&D and manufacturing, clinical experimentation, testing and management of drugs, and through changes in the regulatory environment. Genomic medicine is primarily focused on the discovery of disease-causing genes and their functions, the mechanics of disease origin, etiology in animal models, genetic chip technology, gene and cell treatment methods, and disease prevention. This program is also developing bioinformatics through computer information technology, studying proteomics to better understand gene functions and disease causes, and conducting more research into the impact of genetic technology on ethical, legal, and social issues.

Second, the “National Science and Technology Program on Nanoscience and Nanotechnology” is concentrating on workforce training and core establishment, turning academic research into industrial applications, and cultivating a multidisciplinary workforce needed to develop nanotechnology into commercial applications. Third, the “National Science and Technology Program for System-on-Chip” is building on Taiwan’s advanced semiconductor industry to move into high value-added product development, and is transforming the island into an international center for chip technology through multifaceted personnel training, cutting-edge product design, advanced platform development, creation of sophisticated intellectual property, and development of emerging industries.

Lastly, the “National Science and Technology Program for Telecommunications” is building on the telecommunication infrastructure to expand into advanced Internet technology, using beyond third generation mobile communications (Beyond 3G) and Gigabit Ethernet services over DWDM in metro networks to create an integrated service environment for B3G multimode systems. DWDM testbeds and the new generation National Experimental Network will be used build an electronic-based communication industry. Customer Premises Equipment (CPE) and Local Area Network (LAN) industries will be upgraded to form a complete industrial chain of telecommunications networks and hardware/software industries across up- and down-stream levels, providing comprehensive services for an all-IP wireless and wireline network, and turning Taiwan into a world model for broadband Internet services and applications.

4.3 Industrial Value Heightening Plan

I. Develop Industrial Core Technologies (NDP #4.2, 2002~2007, NT$82,249.704 million. MOEA Department of Industrial Technology.)

To optimize the use of limited R&D resources, the government is developing core industrial technologies based on three principles, that a core technology can be expanded and applied to different industries, capable of creating differentiated or specialized products, and can support industries in generating competitive advantages. Core technologies will be extracted from the following fields: electronics, information, optoelectronics, communications and optoelectronics, electronic machinery, machinery, automation, transport, aerospace, precision machinery and microelectronic machinery, sustainable development, materials and chemical engineering, materials, chemical engineering, textiles, environmental protection, resources, biotechnology and medicine, life sciences and biotechnology, pharmaceuticals, food products, medicine, telecommunications, common fields, innovative forefront projects, Industrial Technology Development Programs, and Technology Development Programs for Academia.

II. Promote Key Industries (NDP #4.3, 2002~2007, NT$4,818.448 million, Includes: 4.3.1 Higher Value-Added Traditional Industries, 4.3.2.1 Semiconductor Industry, 4.3.2.2 Image Display Industry, 4.3.2.3 Digital Content Industry, 4.3.2.4 Biotechnology Industry, 4.3.3.1 R&D Service Industry, 4.3.3.2 Information Application Service Industry, MOEA Industrial Development Bureau; 4.3.3.3 Chain Stores and Franchise Services Promotion Plan, MOEA Department of Commerce; 4.3.3.4 Modernize Logistic Systems for Agricultural Products, Council of Agriculture; 4.3.4.1 Reusable Trash Sorting Plant, 4.3.4.2 Refuse Incinerator and Ash Recycling Plant, 4.3.4.4 Kitchen Waste Recycling Program, 4.3.4.5 Large-sized Waste Recycling Program, EPA Bureau of Environmental Inspection; 4.3.4.6 Resource Recovery Industry Promotion Project, MOEA Industrial Development Bureau; 4.3.5 National Creativity Movement, MOEA Industrial Development Bureau.)

For the purposes of strengthening international competitiveness, creating new business opportunities, safeguarding environmental quality, and developing the local economy, the government will devote greater efforts to developing various promising industries into key industries. The four key industry groups include high value-added traditional industries (high-tech textiles, organic foods and health products, high grade materials, chemicals for optoelectrical applications, light metals, high-efficiency electrically powered vehicles, and sports and leisure industries), the Two Trillion and

Twin Stars industries (semiconductors, image displays, digital content, biotechnology), four new service industries (R&D, information applications, logistics, and care-providing services), green industries (sorting and reusing wastes, resource recycling, and industrial recycling consultation), and the national creativity movement. Promoting these key industries will result in tangible benefits, e.g., by bringing traditional industries into the high-tech information age, their competitiveness and the added value of related industries will be enhanced, thereby creating more investment and business opportunities. Promoting the Two Trillion and Twin Stars industries will accelerate the development of the semiconductor, image display, digital content, and biotechnology industries, making Taiwan an international R&D and manufacturing center for each of these respective industries. Promoting the four new service industries will facilitate the commercialization of R&D results, increase the value-added content of information application services, boost competitive abilities for logistics services, and create an industrial infrastructure for care-providing services. Promoting green industries will allow for proper solid waste disposal and optimal resource use, and safeguard the quality of Taiwan's natural environment. Promoting the national creativity movement will foster the innovative abilities of citizens, strengthen the nationwide creativity system, and turn Taiwan into "a Nation for Creativity."

III. Upgrade Labor (NDP #4.5, 2002~2007, NT$8,717.552 million, Council of Labor Affairs.)

The government's main policies and guidelines for raising national competitiveness in the new millennium are to seize opportunities to globalize, digitize, and aggressively develop the knowledge-based economy. This is reflected in government efforts to promote a digital and knowledge-based economy, upgrade traditional industries, develop industrial core technologies, promote high-tech industrial R&D, and achieve the Industrial Value Heightening Plan's ultimate objective of transforming Taiwan into a global center for the production and supply of high value-added products. And one of the most important factors needed to reach this objective is to upgrade labor into a high-quality workforce.

IV. Construct Industrial Parks (NDP #4.6, 2002~2007, NT$94,592.150 million, includes: 4.6.1 Biomedical Park, 2003~2007, NSC Science Park Administration; 4.6.2 IC Design Park, 2002~2007, MOEA Industrial Development Bureau; 4.6.3 Central Taiwan Science Park, 2002~2011, NSC Science Park Administration; 4.6.4 Horticultural Biotechnology Park, 2002~2007, COA Department of Food and Agriculture; 4.6.5 Southern Taiwan Science Park, 2002~2010, NSC Southern Taiwan Science Park Administration; 4.6.6 Agricultural Biotechnology Park, 2002~2007, COA Department of Food and Agriculture; 4.6.7 Environmental Technology Park, 2002~2007, EPA and local governments.)

To improve the industrial environment and integrate R&D resources across Taiwan for the purpose of developing high value-added industries, the government is actively planning the construction of various science parks around Taiwan that reflect the local characteristics of each region. These science parks will accommodate future changes in the industry's infrastructure, comply with policies of balanced regional development, and attract businesses suited to the local resources of each region. Plans include the Hsinchu Biomedical Park, IC Design Park, Central Taiwan Science Park, Horticultural Biotechnology Park, Southern Taiwan Science Park, Agricultural Biotechnology Park, Environmental Technology Park, and Nankang Biotechnology Park. These parks will also integrate with local communities, nearby facilities, and existing industrial clusters to form specialized industrial zones, core satellite parks, and recycling technology parks. Together, these networks will transform and upgrade local businesses and produce synergistic partnerships by integrating the development of similar industries.

4.4 e-Taiwan Construction Plan

I. Bring Broadband to Six Million Households (NDP #6.1, NT$3,191.516 million. Includes: 6.1.1 Bring Broadband to Six Million Households, 2002~2007, MOTC Directorate General of Telecommunications; 6.1.2 Promote Wireless Broadband Network, 2002~2007, MOEA Industrial Development Bureau; 6.1.3 Develop IPv6 Protocol, 2002~2007, MOTC Directorate General of Telecommunications; 6.1.4 Bring Broadband to Small and Medium Enterprises, 2003~2007, MOEA Small and Medium Enterprise Administration; 6.1.5 Establish Secured Information and Telecommunication Environment, 2002~2007, National Information and Communication Security Taskforce.)

The revolution of the Internet has reshaped the global economy by challenging the traditional capital and labor markets and combining knowledge with speed and technology to create the "knowledge-based economy," the essential means by which companies and countries succeed in today's market. Yet the key to weaving an intricate information superhighway does not simply lie in configuring industries, business networks, and the knowledge economy, but in transforming all of Taiwan into a "Green Silicon Island." Therefore the government must strengthen the information communications infrastructure and create a secure on-line environment to achieve a comprehensive wirelined, wireless, mobile, and stationary broadband telecommunications network. This plan envisions the proportion of online users to increase to 50% of the general population, with 70% of subscribers using broadband connections.

II. Promote e-Society (NDP #6.2, NT$14,930.300 million. Includes: 6.2.1 National S&T Program for e-Learning, 2003~2007, NSC Department of Science Education; 6.2.2 National Digital Archives Program, 2002~2006, NSC Department of Humanities and Social Sciences; 6.2.3 Digital Entertainment Development Plan, 2003~2007, Government Information Office; 6.2.4 Development Plan for the Digital Repository of Cultural Heritage, 2002~2007, Council for Cultural Affairs; 6.2.5 Develop Government e-Service in Remote Areas, 2003~2007, Research Development and Evaluation Commission; 6.2.6 Promote e-Learning Among Small and Medium Enterprises, 2003~2007, MOEA Small and Medium Enterprise Administration; 6.2.7 Promote Life-long Learning Among Farmers, 2003~2007, Council of Agriculture; 6.2.8 Establish Real Estate Information Center, 2002~2003, Council for Economic Planning and Development; 6.2.9 Plan for Healthcare Services on the Internet, 2002~2005, Department of Health.)

As Internet usage spreads around the world and Taiwan prepares itself for the arrival of the e-society, the tasks of planning and building an information society have become essential concerns for national development. This plan's vision is to "create information with rich cultural content, upgrade the qualities of entertainment and learning, and bridge the digital divide." It also aims to build an integrated digital environment that will transform Taiwan into a culturally sensitive, equitable, and highly efficient information society.

III. Promote e-Commerce (NDP #6.3, NT$2,126.000 million. Includes: 6.3.1 Industrial Collaborative e-Design Project, 2003~2007, MOEA Department of Industrial Technology; 6.3.3 SME Knowledge Management and Application Plan, 2003~2007, MOEA Small and Medium Enterprise Administration.)

The rudimentary types of information produced by the manufacturing-intense economy are no longer suitable for today's penchant for refined information. In a highly connected Internet environment, Taiwan's industries without the ability to generate appealing information may well be eliminated by the competition, but if these businesses can capitalize on e-commerce and Internet technology, they will be able to rise above the traditional production-intensive industries. For this reason, the government is promoting e-commerce in the hopes of transforming Taiwan into a quality production and service center for high value-added products. Major strategies and guidelines for this objective include establishing R&D design systems, strengthening the supply-chain and logistics mechanism, opening new international marketing channels, and expanding financial and customer services.

IV. Promote e-Government (NDP #6.4, NT$14,780.300 million. Includes: 6.4.1 Establish Single Portal for Integrated Government Services, 2002~2007, Research Development and Evaluation Commission; 6.4.2 Provide On-line Government Services, 2003~2007; 6.4.3 Promote G2B2C Electronic Documentation Exchange, 2003~2007; 6.4.4 Establish Virtual Conference System for Government Agencies, 2003~2004; 6.4.5 Allow Access to Government Information on the Internet, 2002~2007; 6.4.6 Establish Integrated Communication System for Emergency Management, 2002~2005, Ministry of the Interior - National Fire Agency.)

In addition to improving administrative efficiency and providing innovative government services, information and communication technology can also improve the quality and convenience of services to citizens, support government re-engineering, and create a highly efficient government that provides intelligent electronic service to all citizens. Under this plan, government agencies, businesses, and the general public can easily access all types of government services from anywhere, at anytime, through multiple means. Citizens can perform information inquiries, submit applications, and enjoy such innovative services as "exemption from the need for physical transcripts," "paperless applications," "one-stop services," "multi-point, multi-channel, 24-hour services," and "service to the home." This plan aims to raise Taiwan's e-government ranking in World Economic Forum reports to one of the world's top five.

V. Promote e-Traffic System (NDP #6.5, NT$1,800.300 million. Includes: 6.5.1 Develop ITS Technical Platform and System, 6.5.2 Promote e-Traffic Services, 6.5.3 Promote Intelligent Bus Program and Integrated IC Smart Cards, 6.5.4 Establish Electronic Security Management System, 6.5.5 Develop Intelligent Traffic Control System, 2003~2007, MOTC Institute of Transportation.)

Intelligent Transportation Systems (ITS) is an innovative technology that provides superior transportation services and facilitates international interchange. It uses a broad range of sophisticated technologies including information processing, telecommunications, control, vehicle operations, and mechanical technologies, which, when applied to transportation systems can optimize the performance and effectiveness of existing transport facilities with limited resources. And thanks to rapid developments in information application and communications technology, ITS technology has now evolved from experimental prototype models into practical tools for relieving traffic problems and integrating transportation systems, even becoming the prevailing trend in traffic and transportation systems around the world. Taiwan's "e-Traffic System Plan" takes advantage of ITS design to create a sophisticated traffic system that will allow future visitors from abroad to personally experience Taiwan's technological success. This plan will stimulate the development of integrated innovation industries, provide quality transportation services to the public, and facilitate international reciprocity and cooperation in order to realize the vision of "strengthening national competitiveness and raising Taiwan's international profile." The plan includes specific objectives of "integrating innovation technology," "providing quality transportation service," "facilitating international interchange," and will commit efforts to improving "traffic service," "application information," and "personnel training." Five main strategies include "develop ITS technical platform and system," "develop intelligent traffic control system," "establish electronic security management system," "promote intelligent bus program and integrated IC smart cards," and "promote e-traffic services." By the year 2008, these efforts will enable Taiwan to achieve "an integrated and innovative technology industrial environment," "a superior and sustainable intelligent transport environment," and "an improved and open image in the international community."

4.5 Operations Headquarters Development Plan

I. Digitize Global Logistics (NDP #7.5, NT$2,037.300 million, includes: 7.5.1 Strengthen Digitization of Global Logistics, 2003~2006, MOEA Department of Industrial Technology; 7.5.2

Expand Digitization of Global Logistics, 2003~2007, MOEA Industrial Development Bureau; 7.5.3 Integrate Global Supply Chains and Digitize Global Logistics, 2003~2006, MOEA Department of Commerce.)

Before enterprises can fully embrace global logistics, the government must first assist in establishing the flow of information to better manage logistics procedures. This plan will employ a prototype information application and subsidy mechanism to guide the information electronics, semiconductor, communications, and optoelectronics industries in setting up a basic logistics infrastructure with the latest technologies. The plan will strengthen relationships among global clients, partners, suppliers, and service providers by integrating collaborative electronic procedures and strengthening systems capabilities for product development, manufacturing processes, logistics, account receipts/payments, etc. Assistance will be given to manufacturers for integrating into the supply chain, and to logistics companies for setting up comprehensive shipment tracking and instant information update systems. This will allow businesses to better evaluate their overall operations and provide comprehensive sales services, leading to a high-quality supply chain and sales system, and raise entrepreneurial and national competitiveness.

PART TWO

Science and Technology Development at Government Agencies

Based on the overall goals, visions, and strategies previously described, each government agency will plan its own sci-tech goals and strategies in accordance with its organizational mission, and implement these efforts through the annual sci-tech budgets. Table 14 presents the sci-tech development spending plans for sixteen government agencies from 2003 through 2006.

Table 14 Sci-Tech Spending Plans at Agencies, 2003~2006

Unit: NT$ Millions

Agency	2003	2004	2005	2006	Total 2003~2006
Academia Sinica	5,843	6,708	7,513	8,415	28,479
Science and Technology Advisory Group	:	:	:	:	:
Minister of the Interior	197	310	319	258	1,084
Ministry of National Defense	:	:	:	:	:
Ministry of Education	727	692	855	855	3,129
Ministry of Economic Affairs	24,383	28,982	31,861	35,047	120,273
Ministry of Transportation and Communications	674	808	970	1,165	3,617
Department of Health	2,832	3,115	3,427	3,770	13,144
Environmental Protection Administration	59	71	77	86	293
Atomic Energy Council	646	975	1,097	1,255	3,973
National Science Council	24,511	26,997	28,542	30,228	110,278
Council of Agriculture	3,197	3,517	3,868	4,255	14,837
Council for Cultural Affairs	20	25	25	25	95
Council of Labor Affairs	143	173	187	201	704
Public Construction Commission	55	62	64	65	246
National Palace Museum	65	104	121	141	431

“:” - No data

Notes: 1. Figures for 2003 are legal budgets, figures for 2004 through 2006 are estimates.

2. Website addresses for these agencies are available in the directory of ROC sci-tech organizations (www.nsc.gov.tw/pub/yearbook).

APPENDICES

FIGURE APPENDIX

TABLE APPENDIX

White Paper on Science and Technology (2003 — 2006)

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