

Chapter 13

Science and Technology

13

SCIENCE AND TECHNOLOGY

I. INTRODUCTION

13.01 High priority will continue to be accorded to the promotion of science, research and technological innovation, as an essential part of the Government's development strategy to maintain high rates of growth and improve living standards. This is critical as science and technology (S&T) provides the means for economic advancement and enhances international competitiveness of the economy.

13.02 During the Sixth Plan period, considerable attention was given to effecting organizational, management and strategy changes in line with the efforts of the Government to increase technological capability and make public sector Research and Development (R&D) programmes more demand-oriented and relevant to industry. The private sector, on its part, contributed much more to the expansion of research activities and innovations, especially in the manufacturing sector, when compared with the Fifth Plan period.

13.03 Many of the new changes will be effected during the Seventh Plan, enabling S&T to make further contributions to productivity-driven growth and development as well as the shift into technology-intensive industries and services. Efforts to enhance productivity and the nation's competitiveness will involve stimulating the search for greater process and product innovation, diffusing technological change more rapidly within and across sectors, and accelerating complementary institutional and organizational changes.

II. PROGRESS, 1991-95

13.04 Amidst rapid and robust economic growth during the Sixth Plan period, considerable achievements were made in terms of S&T development within the

country. This was seen not only in terms of the size of R&D expenditure and magnitude of technology development activities but also in S&T policy and management initiatives.

S&T Policy

13.05 As stipulated in the Second Outline Perspective Plan (OPP2) and Sixth Plan, the goals of the national S&T policy are to ensure continuous scientific and technological developments that will support and sustain high rates of economic growth, accelerate overall industrial development and lay the foundation for the attainment of a scientific and technologically advanced society by the year 2020. Mindful that S&T activities are strongly influenced by increasing globalization and competition arising from new technologies and product development, the policy focus was to promote technological innovation, increase highly skilled technical and research manpower, push for greater productivity as well as better utilize and commercialize public sector S&T resources.

S&T Management

13.06 The S&T planning and implementation machinery in the public sector was strengthened and streamlined with a view to emplacing a more coordinated and effective approach towards enhancing national technological capability. Among the major measures was the establishment of the Cabinet Committee on S&T, under the chairmanship of the Prime Minister, to provide policy directions on S&T issues. The National Council for Scientific Research and Development (MPKSN), under the chairmanship of the Chief Secretary to the Government, was reconstituted and restructured during the early part of the review period. The MPKSN assumed the role and responsibility of coordination, and monitoring of research, science and technology activities through an interactive process among research institutions and universities as well as the private sector. In addition, the MPKSN supervised the management and implementation of the Intensification of Research in Priority Areas (IRPA) programme. It was also assisted by working groups assigned with the task of proposing specific measures to enhance capabilities in the key technologies of microelectronics, advanced materials, biotechnology, information technology (IT) and advanced manufacturing technology as well as energy and environmental-related technologies.

13.07 Several other measures to expand the institutional support structure for S&T were implemented. Apart from strengthening the existing R&D institutions

and agencies covering a wide range of research areas, a number of new centres and committees were established to increase technology-oriented activities in specific areas. These included the National Information Technology Council, the Biotechnology Directorate, the Academy of Sciences, the Malaysian Science and Technology Information Centre (MASTIC) and the Space Science Studies Centre as well as the Design Council Malaysia. Plans are also underway to set up the National Measurement Centre at the Technology Park Malaysia (TPM), Wilayah Persekutuan Kuala Lumpur and the Advanced Materials Research Centre at Kulim Hi-Tech Park (KHTP) in Kedah.

13.08 The Government promoted the adoption of a contract research system in public sector research institutions and universities. This was in line with the recommendation of the National Plan of Action on Industrial Technology Development, that public research organizations be transformed into contract research organizations to achieve the 65 per cent self-financing target by the year 2000. The establishment of a contract research system will require a significant change in the way R&D organizations are being managed. It would require comprehensive reevaluation of their management system, strategies, organizational structures and the way R&D activities are being selected and funded. In essence, the research institutions as well as the consultancy units in universities are to take on a commercial orientation. Guidelines were prepared to gradually steer research institutions towards this direction, and ensure that organizational infrastructure in public sector agencies undertaking R&D is in line with the demand and technological changes taking place in the economy.

13.09 As part of the national efforts to enhance the effectiveness and efficiency of public sector organizations, the Government initiated the corporatization of a number of research-related institutions. Currently, the Standards and Industrial Research Institute of Malaysia (SIRIM), Malaysian Institute of Microelectronics System (MIMOS) and TPM are undergoing corporatization to meet the R&D challenges required by the commercial world. With this restructuring, research organizations are expected to be better equipped to provide R&D services to the private sector and assist selected industries to undertake innovations as well as new product and process development.

13.10 In order to create a more conducive environment for private sector product innovation, the Government undertook measures to encourage greater involvement of industry in R&D activities. These included the provision of fiscal incentives, and infrastructure such as the TPM and KHTP, as well as promotion of collaborative efforts among the private sector, universities and research

institutions. The Malaysian Technology Development Corporation (MTDC) and Malaysian Industry–Government Group for High Technology (MIGHT), established to assist in public–private sector cooperation in industrial development, embarked on a number of proposals to initiate wider usage of emerging technologies. This was with the view to building competitiveness in industries such as telecommunications, automobiles, pharmaceuticals, healthcare and construction. The Working Committee on S&T under the auspices of the Malaysian Business Council (MBC) arranged a number of dialogues between the public and private sectors on the formulation of strategies for technological upgrading.

National R&D Expenditure

13.11 The findings of a R&D expenditure survey¹, conducted by the Government, indicated that a total of RM552 million was spent on research and development in 1992. This indicated that Malaysia's R&D efforts, as measured by R&D expenditure as a proportion to GNP was 0.4 per cent. This is considered low since at least one per cent of GNP is usually the accepted level at which R&D can begin to effectively support socio-economic development in a country. Generally, this reflected the need to increase national R&D expenditure in order to accelerate the building up of domestic R&D and technological capability in the country.

13.12 Notwithstanding the low level of R&D expenditure, it is recognized that expenditure on formal R&D cannot by itself be a measure of a country's capability to utilize technology for growth and development. It is significant to note that the country's high economic growth has been supported by other developments that have high technological content. This includes investment, infrastructure development and increases in labour and capital utilization, as well as total factor productivity (TFP). The TFP measures the residual contribution to growth, apart from contribution of labour and capital, and includes technical progress, management expertise, skills and entrepreneurship. Thus, the TFP contains significant elements of technology absorption and utilization. Of the 8.7 per cent growth in GDP during the period, the TFP contributed 2.5 per cent or 28.7 per cent of the expansion.

¹ The survey, the first of its kind in the country, was undertaken with the aim to gauge the general level of national R&D expenditure.

13.13 Generally, increases in TFP growth are associated with increases in investment. In this regard, the substantial increase in investment, particularly foreign direct investment (FDI), has been the vehicle by which new technologies entered the production process. Sustained investment growth over the years had led to more rapid acquisition, absorption and diffusion of technology and innovation in the country. This was reflected in a recent study on Malaysia's competitiveness, in which the country ranked high in the level of investment and capacity to disseminate, absorb and utilize imported technology. However, the development and use of locally generated technologies in the production process, still lagged behind indicating the country's need to increase indigenous capability in developing new and improved technologies for industry.

13.14 Nonetheless, recognizing that formal R&D expenditure is an important performance indicator, the national 1992 R&D survey was undertaken to gauge the size and scope of research activities in the country. The survey showed that the public sector accounted for 55 per cent of R&D expenditure, and the private sector, 45 per cent. In terms of types of research, about half of the total expenditure was devoted mainly to applied research, and 38 per cent for developmental research. Strategic research accounted for 9.0 per cent, and pure basic research about 4.0 per cent of expenditure. From an economic perspective, general R&D efforts were concentrated in plant production, primary products, and animal production, followed by manufacturing. Public sector R&D had a strong focus in plant and animal production, with increasing research activities in information technology, computers and communications. Private sector R&D, on the other hand, was concentrated in the manufacturing area, particularly electronics and computer hardware, transportation and machinery, communications, as well as processed food products and beverages.

13.15 Of particular significance was the more than three-fold increase in private sector investment in R&D since the end of the Fifth Plan period. The private sector reported a total expenditure of RM246.4 million. Of this, RM67.8 million was spent on research personnel, RM57.6 million on other operating expenses and RM121 million on land, buildings and equipment. With nearly half of the total expenditure attributed to capital formation, this indicated the likelihood of an expansion of future R&D activities and industrial technology capability in the private sector. The survey, however, highlighted that most of the private sector expenditure on R&D was undertaken by foreign entities and the domestic component was still not significant.

13.16 The relatively higher R&D expenditure by industry reflected the favourable response of the private sector to incentives provided by the Government.

Incentive schemes included double deduction of expenditure incurred for R&D, five-year tax exemption for R&D companies, reduced import duties for research equipment, and investment tax allowance of up to 100 per cent of qualifying R&D related capital expenditure.

13.17 The small- and medium-scale industries (SMIs), generally dominated by domestic investors, continued to be plagued with problems such as low technology and poor production techniques and processes. Improvements were largely geared towards marginal adaptations to meet local needs while original design and development of new products were limited. This highlighted the need to strengthen domestic innovation, design and engineering capabilities.

Intensification of Research in Priority Areas

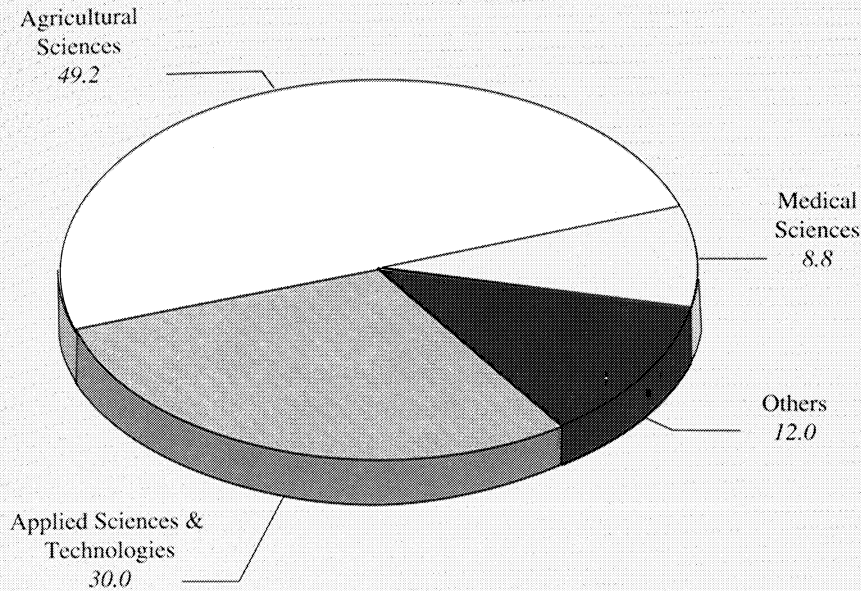
13.18 During the Sixth Plan period, the budgetary allocation for direct R&D in the public sector was RM629 million. This allocation covered R&D activities utilizing the IRPA funds and excluded related capital and operating expenditures. As shown in *Table 13-4*, a total of RM567.1 million or 90 per cent of the allocation was spent in major fields of research. Of the total expenditure, 49.2 per cent was in agricultural sciences, 30 per cent in applied sciences and technologies and 8.8 per cent in the medical sciences, as shown in *Chart 13-1*. The continuous predominance of research in agriculture, while reflecting the country's superiority in agricultural R&D, especially with regard to perennial crops, indicated the need to redirect resources towards downstream industrial R&D in order to generate potentially higher value-added commercial activities.

13.19 As a follow-up, an assessment² of the benefits and effectiveness of research funded under the IRPA programme was carried out, especially within the context of its contribution to income-generating activities. Findings of the evaluation showed significant improvements in the quality of technical outputs, covering developmental and applied areas, generating new knowledge, methods, techniques and applications at increasing efficiency and productivity. About 40 per cent of the projects generated technical results that gained national and international acclaim as these were considered major technical contributions generated by S&T activities. These new and improved S&T applications indicated the potential expansion of future downstream research activities for end-use product and process development. In addition, R&D in basic sciences augmented the build up of fundamental strengths required by research agencies and universities to handle core technologies such as biotechnology, advanced materials and microelectronics.

² The assessment covered a sample of 200 projects which represented about 10 per cent of total IRPA projects, 15 per cent of allocation and 14 institutions.

CHART 13-1

IRPA EXPENDITURE BY MAJOR FIELDS OF RESEARCH, 1991-95
(%)



Total: RM567.1 million

13.20 Notwithstanding the substantial technical progress achieved, the evaluation confirmed observations made of local R&D that it is generally not market-oriented. The IRPA projects were not always economically relevant and thus not exploited for commercial application. Of the 200 projects assessed, about a quarter had the potential to generate near-market product or process development outputs. Research outputs likely to have a significant business impact, as indicated by patents granted or pending, comprised 7.0 per cent of the total number of projects assessed. Linkages with industry were essentially informal, and joint or collaborative R&D was still negligible, thus reflecting the need to coordinate closely with the private sector to generate more R&D projects with commercial potential.

13.21 In preparation for the Seventh Plan, the IRPA mechanism was reviewed and improved upon. This was with a view to putting in place a more effective system for the utilization of resources directed particularly at increasing market-oriented R&D and technology development activities.

Technology Inflows

13.22 While the primary concern was to build and develop a stronger indigenous technological base, the transfer of technology from abroad continued to be important. During the Sixth Plan period, in line with the expanding investment in high value-added capital and technology-intensive industries, there was a concurrent rise in technology imports. The changing industrial structure had an influence on the growing demand for a wide range of technologies from abroad, particularly those used in new growth areas such as the automobile, oil and gas and aerospace industries. Even in the traditional electrical and electronic product category, demand was for high-order technologies required for intensive process and systems development.

13.23 The inflow of technology as indicated by the number of contractual agreements approved by the Government during the Sixth Plan, is shown in *Tables 13-1* and *13-2*. However, this indicator is reflective of only those agreements required under the Industrial Coordination Act (ICA), 1975, or the Promotion of Investment Act (PIA), 1986, or when specifically required under any Foreign Investment Committee (FIC) rulings.

13.24 Payment for technology acquisition from abroad registered a growth of 34 per cent during the period 1991-95, from about RM240 million in 1990 to an estimated RM1.0 billion in 1995, compared with 24 per cent during the Fifth Plan. These were royalties and fees mainly for procurement of franchises, use of international brand names and payment of licences for utilization of new and improved technology. The various payments, which are reflected as outflows in the services account of the balance of payments, indicated the relative importance of sourcing of technology from overseas. These royalties and fees, however, did not cover imports of technology embedded in machinery and equipment, as well as contract and professional charges by foreign personnel.

Standardization and Quality Assurance

13.25 In line with the national strategy to sustain and enhance the competitiveness of exports, the Government undertook measures to intensify the provision of technical services by relevant public sector agencies to assist the private sector in ensuring the quality of Malaysian goods and services for the international market. Due to the increasing demand for quality assurance schemes by major

TABLE 13-1

TECHNOLOGY INFLOWS BY INDUSTRY GROUP, 1990-95
(number)

<i>Industry Group</i>	<i>1990</i>	<i>1991</i>	<i>1992</i>	<i>1993</i>	<i>1994</i>	<i>1995</i>	<i>6MP</i>
Electrical & Electronic Products	41	45	38	69	44	25	221
Chemical & Chemical Products (including Pharmaceutical)	24	21	19	20	12	17	89
Transport Equipment	18	16	28	25	21	9	99
Fabricated Metal Products	4	13	6	11	4	4	38
Food Manufacturing	4	6	2	11	2	2	23
Rubber & Rubber Products	8	10	8	5	4	3	30
Non-metallic Mineral Products	7	7	12	5	8	1	33
Basic Metal Products	4	7	2	5	4	0	18
Textiles & Wearing Apparel	7	6	7	3	1	1	18
Hotel & Tourist Complexes	3	8	1	5	0	0	14
Plastic & Plastic Products	5	6	6	11	3	6	32
Wood & Wood Products (including Furniture)	6	5	0	4	0	1	10
Paper & Paper Products, Printing & Publishing	4	4	2	3	1	4	14
Manufacture of Machinery	6	6	5	2	2	4	19
Beverages & Tobacco	10	3	1	4	2	1	11
Petroleum & Coal	0	0	1	1	19	1	22
Leather & Leather Goods	1	0	1	1	0	0	2
Miscellaneous	3	2	1	0	1	0	4
Total	155	165	140	185	128	79	697

Note: The total number of technology transfer agreements in specific years depends on the number of approved manufacturing licences, expected project implementation, as well as timing of submission and approval of the agreements.

TABLE 13-2
TECHNOLOGY INFLOWS BY TYPE OF AGREEMENT, 1990-95
(number)

<i>Type of Agreement</i>	<i>1990</i>	<i>1991</i>	<i>1992</i>	<i>1993</i>	<i>1994</i>	<i>1995</i>	<i>GMP</i>
Joint Venture	15	11	7	7	3	3	31
Technical Assistance	72	93	80	85	55	36	349
Licences & Patents	17	28	14	44	32	20	138
Knowhow	12	10	21	23	11	4	69
Trade Mark	19	9	12	14	4	2	41
Management	5	6	2	2	1	1	12
Turnkey & Engineering	1	1	0	1	6	1	9
Services	6	4	4	9	5	5	27
Sales, Marketing/Distribution	5	0	0	0	0	1	1
Supply & Purchase	2	0	0	0	0	0	0
Others	1	3	0	0	11	6	20
Total	155	165	140	185	128	79	697

trading partners, local companies were encouraged to adopt and implement internationally accepted quality management systems. During the Sixth Plan period, more than 700 companies were successfully certified for ISO 9000 series of standards. In order to ensure international credibility of registration activities, the Malaysian Accreditation Council (MAC) was established to provide a system of recognition to bodies operating quality system registration and laboratory accreditation in Malaysia. The Government also took steps to facilitate participation in international standardization activities. In this regard, Malaysia became the secretariat to the Technical Committee on Rubber and Rubber Products and a participating member in a number of other technical committees of importance to the country.

S&T Manpower

13.26 Despite efforts in the development of high level and specialized skills, particularly scientific and technological manpower, disparities still continued to exist between the type and number of manpower produced and that required by the nation. In particular, the expansion in R&D manpower, a crucial element in our effort towards technological advancement, did not keep pace with the increasing demand for highly trained, knowledge-based scientific, engineering and technical personnel.

13.27 An analysis of the output of graduates from local public tertiary institutions for the period 1985-95, revealed the continued predominance of arts in comparison with science and technical graduates, as shown in *Table 13-3*. Arts graduates during the Fifth and Sixth Plan periods made up the majority of graduates, that is, 53 per cent and 62 per cent, respectively. In comparison, science graduates accounted for 33 per cent and 25 per cent for the two Plan periods, respectively, indicating a decline in the share of total output, over the ten-year period. The output of technical graduates, on the other hand, remained at about 14 per cent for both periods. This means that by the end of the Sixth Plan period, local public institutions produced many more arts graduates compared with science and technical graduates, a trend that does not augur well for the establishment of a strong technological base.

13.28 The relatively lower share of output of science graduates, though supplemented by Malaysians trained overseas, had affected the number of qualified personnel available for R&D activities. The current number of full and part-time researchers and scientists is estimated to be at 8,300. This gives a ratio of 400 per million population which is considered low compared with the ratios ranging from 1,000 per million to 1,500 per million population found in some Newly Industrializing Economies (NIEs), when they were at Malaysia's current level of economic development. The total number of support staff including sub-professionals and technicians was estimated at 12,450. The public sector represented the largest source of R&D manpower in the country, a substantial portion of whom were engaged in applied or developmental research. The proportion of R&D personnel in market-oriented research, however, was limited, thus the consequent low impact of R&D on industry. The pool of R&D personnel in the private sector was too small to stimulate significant indigenous market-driven research.

TABLE 13-3

OUTPUT OF DEGREE COURSES¹, 1986-2000
(number)

<i>Course</i>	<i>5MP</i>		<i>6MP</i>		<i>7MP²</i>	
	<i>Number</i>	<i>%</i>	<i>Number</i>	<i>%</i>	<i>Number</i>	<i>%</i>
Arts & Humanities including Economics, Business & Law	27,780	53	49,018	62	82,123	57
Science including Medicine, Agricultural Sciences, Pure Sciences & Others	17,510	33	19,642	25	40,077	28
Technical, Engineering, Architecture, Surveying & Others	7,550	14	10,508	13	21,953	15
Total	52,840	100	79,168	100	144,153	100

*Notes:*¹ Output for First Degree, Masters, Ph.D. and post-degree diploma² Estimate

13.29 In view of the need to expand the R&D human resource base, the Government reviewed the training programmes for public sector R&D personnel. Apart from strengthening the existing programmes, the Industrial Technology Development and Management Programme was launched to provide advanced training to R&D personnel from a number of research agencies and universities. This programme increased opportunities for post-graduate and post-doctoral training, especially in areas of new technologies and industrial research. Besides increasing the number of scholarships at the degree level in R&D priority areas, specific training in specialized technical areas was also made available. The programme trained a total of 1,617 personnel from 17 research institutions and universities, at both degree and non-degree levels. Research institutes and universities also used financial resources under the programme to employ short-term S&T experts and consultants from overseas to provide in-house training to their personnel.

13.30 In 1994, the Government initiated a programme to bring back Malaysian scientists and engineers working overseas as well as allow local research institutions and universities to employ foreign R&D personnel, where necessary.

The purpose of this programme is to fill the gaps for specific expertise required by public research institutions, universities and the private sector, with the aim to accelerate the rate of technology transfer and upgrade indigenous R&D capabilities. However, at this juncture, it is premature to evaluate the impact and potential contribution of the programme.

Commercialization of Research and Technology

13.31 While public sector R&D activities contributed significantly to technical improvements, the progress on the commercialization of such output was limited. This was largely attributed to problems related to lack of industry-relevant R&D projects and finance to fund the various stages of commercialization from the laboratory to the market place. To date, from the RM1 billion allocated under the IRPA mechanism during the Fifth and Sixth Malaysia Plans, a total of 2,000 R&D projects was completed. Of this, about 240 projects were identified as potential candidates for commercialization.

13.32 The R&D projects for potential commercial exploitation were at various stages of implementation. Research institutes such as the Malaysian Agriculture Research and Development Institute (MARDI), Malaysian Institute for Nuclear Technology Research (MINT), Palm Oil Research Institute of Malaysia (PORIM), Rubber Research Institute of Malaysia (RRIM), and SIRIM as well as the universities had more than 150 projects under investigation, while another 55 were in the advanced stage of being commercialized. The MTDC received more than 100 proposals for potential commercialization from public sector research agencies. Of these, 18 were successfully commercialized and the rest are under further scrutiny. Apart from this, the MTDC invested in 28 technology-based companies with a total investment of RM54.6 million, in the areas of advanced manufacturing, biotechnology, electronics, information technology and precision manufacturing. MIGHT initiated activities to promote public-private sector collaboration in new technologies with potential business and investment opportunities, especially in the telecommunications, advanced materials and aerospace industries.

S&T Awareness, Promotion and Popularization

13.33 Activities aimed at promoting greater interest, awareness and understanding of S&T, and its role in national development were organized at various levels throughout the Sixth Plan period. These activities for scientists, students and

members of the public included scientific conferences and exhibitions, S&T excellence achievement awards, educational visits and workshops, and environmental programmes. As part of the promotional activities, students were encouraged to participate actively in science essay competitions, science fiction writings, science quizzes, inventor competitions as well as computer software and graphic development activities. The media, largely television and newspapers, provided reasonable S&T coverage considering the time and space available. The National Planetarium, opened to the public in 1994, provided innovative ways of appreciating the sciences. The new National Science Centre (NSC), now in the final stages of its development, incorporated elaborate theme based hands-on exhibits and events in order to popularize and promote S&T, especially among school children. A number of these exhibits were sponsored by private companies.

13.34 The National S&T Awareness Survey 1994, was a first attempt to gauge the level of S&T awareness among Malaysians as well as the impact of S&T promotional activities undertaken by various organizations in the country. The survey showed that there was generally a high level of interest in S&T among the general public, adolescents between the ages of 15 to 20 years and children aged 12 to 14 years. Malaysians recognized the critical contribution of S&T towards growth and development of the economy, and especially in the achievement of the goals of Vision 2020. However, in terms of career preference, a career in business and economics featured relatively high on the list of all students in general. The survey provided a useful basis for planning school curriculum and instituting measures to encourage greater student interest in S&T through special incentive schemes. This will be with a view to formulating more effective strategies to promote S&T as a career choice of the future and, more importantly, to increase the pool of S&T personnel in the country. In addition, the survey indicated that the media, NSC and the National Planetarium should be used more extensively as important channels for raising the general S&T interest and awareness levels.

III. PROSPECTS, 1996-2000

13.35 It is recognized that Malaysia must keep abreast with rapid advances in new technologies and move into intensive application of the emerging new generation of technologies in order to promote innovation-oriented industries and services, as they are the growth areas of the future. In line with this, the Government will continue to place high priority on innovation-driven and technology-led industrial development. The goal is to contribute much more to

long-term sustainable growth, development and competitiveness of the economy. The primary source of technology will continue to be foreign enterprises, which will serve as a base to enhance Malaysia's participation in high level technology-intensive industrial activities and services.

The Thrust for S&T Development

13.36 The thrust for S&T development under the Seventh Plan will be to meet the objectives of productivity-driven growth and competitiveness. The development of Malaysia in the long-term, *inter alia*, will depend on the increased use of technology, knowledge and skills to enhance industrial competence and productivity, as well as improve standards of living. Greater emphasis will be placed on increasing indigenous innovation capability, and accelerating the strategic development of industrial technology. The focus will be to provide an enabling environment for technology development, with greater complementarity and proper balance between the supply and demand side initiatives for technology upgrading. Emphasis will, therefore, be given not only to the enhancing of technology infrastructure but also to the strengthening of demand for, and capacity to use, technology at the firm level. This will be done mainly through:-

- o implementing appropriate policy and institutional reforms to strengthen the S&T planning and management system;*
- o optimizing the utilization of skills and capital by promoting adaptation and application of new and improved technologies, undertaking more commercially-oriented R&D and increasing capability to innovate, design and market domestic technologies;*
- o increasing investments in R&D as well as scientific and technological education and training with a view to developing a critical mass of scientists, engineers and researchers, fostering creativity and innovativeness in the young, and raising the general S&T interest and awareness levels;*
- o building domestic technological capability in new enabling technologies that will yield higher economic returns. Among others, this will include enhancing the practice of technology management and the preparation of a national technology map to identify long-term technology development targets;*
- o fostering stronger cooperation in R&D and technology development amongst and between industry, universities and research institutes;*

- o promoting greater private sector participation in the acquisition, development and transfer of new and specialized technologies;*
- o providing an enabling environment for MNCs and local conglomerates to invest, expand and diversify into new high-technology industries with greater local content and linkages;*
- o undertaking special programmes to augment technological capability among the SMIs;*
- o providing strategic linkages and joint ventures through international cooperation in S&T; and*
- o nurturing domestic innovations and inventions in the context of the changing international environment for technology transfer.*

13.37 In order to build upon present growth trends and productivity gains in the economy, a critical thrust will be to focus upon improvements in the TFP. Concurrent and complementary developments must take place in the various sources of TFP in order for it to have a spread effect on the economy as a whole, and in particular, industry. This implies that the public and private sectors must find ways to optimize the utilization of the potential of labour and capital by improving the quality of capital, workforce and work systems. Thus, issues pertaining to education and training, technical progress, entrepreneurship development, application of new and improved technologies, more commercially-oriented R&D and increased capability to innovate, will be important areas to focus upon.

13.38 The efficiency and applicability of R&D will be increased by reorientating such activities towards economic needs. In this regard, increased efforts will be made to sensitize public sector R&D to meeting market needs and generating economic spin-offs. While basic research will continue to be supported, greater emphasis will be accorded to ensuring more effective and productive utilization of resources earmarked for R&D activities. This will also include the promotion of co-financing and joint public-private sector cooperation in the commercialization of research results as well as technology upgrading and development. For this purpose, appropriate policy and institutional reforms at strengthening S&T planning and management will be undertaken. Apart from this, business and consultancy units within research institutions and universities will be restructured to take on a commercial stance and promote their R&D services, particularly to the private sector.

13.39 In line with the anticipated demand for scientific and technological manpower during the Seventh Plan period and beyond, a long range scientific and technological human resource development policy to enhance technology capability will be formulated. This is to ensure availability of a critical mass of higher level S&T related manpower needed by industry, especially to master core technologies in order to get a clear competitive edge, to undertake and sustain industrial R&D as well as generate indigenous technology.

13.40 In order to ensure sustained and competitive industrial technology development, the private sector must assume a more significant role in technology acquisition, transfer and commercialization. In line with this, industry will be encouraged to specialize in new and promising technologies in the form of niche strategies. This is part of the move towards the establishment of technologically-sophisticated industries producing better quality and competitive products to meet new demands. Domestic firms, particularly the larger enterprises, will be encouraged to set up their own R&D and innovation systems.

13.41 The scope of technology development will encompass the strategy to exploit more fully the competence-building potential of international technology transfer. In this regard, the larger local firms are expected to play a significant role. By importing the requisite technology, they are potential vehicles for building indigenous R&D capabilities and undertaking higher risk projects. This role is expected to be boosted by a system of improved incentives and risk-sharing ventures in key technologies.

13.42 For the medium- and long-term, the strategic focus will be on building up a strong competence in growth-generating technologies, especially in the field of advanced materials, IT and microelectronics, advanced manufacturing technology, biotechnology, as well as energy and environmental-related technologies. These targeted technologies are expected to spawn new growth areas in industry. In this regard, it will be important to develop centres of excellence, with sufficient resources to undertake future R&D activities in these advanced technology areas.

13.43 Priority will be accorded to extending financial and technical assistance to existing SMIs and, more importantly, to promote the growth of new technology-based start-up companies. Technical services provided by various government agencies to enhance the performance of SMIs in the economy, will be further expanded and strengthened.

Programmes

R&D in Priority Areas

13.44 The country will support R&D and technology that will promote growth, enhance industrial efficiency, productivity and competitiveness, generate home-grown technology with own brands of goods and services and improve quality of life. Within this context, the recently redesigned IRPA mechanism will ensure that national R&D resources are invested in areas that can reap the most benefits. This will be effected through better coordination, as well as more stringent assessment and selection of R&D activities. A prominent feature will be the management of the IRPA funding by a single entity to ensure optimum utilization of research resources. Another new component will be the establishment of an efficient mechanism to monitor the performance of on-going projects, as well as appraise and formulate new projects for the future.

13.45 In the allocation and utilization of resources for R&D, a new evaluation process will be introduced whereby research agencies and universities are subject to a competitive bidding process. Research institutions and universities will be allowed to bid for funding of projects that cut across socio-economic objectives and major fields of research. This is essentially aimed at allocating funds to the best proposals and reducing excessive overlaps and duplication of research activities and wastage of resources. In the process of evaluating and selecting research project proposals, greater emphasis will be placed on ensuring, where possible, that the potential output of the project will be required by specific clients, whether Government or industry.

13.46 A national approach towards accelerating the development of strategic technologies will be adopted in view of the high risks and high costs associated with investments in such areas. Specific research institutions, singly or jointly with industry partners, will be provided with resources to develop targeted areas of industrial technology to promote specific sectors such as microelectronics, advanced materials and aerospace. Priority will also be accorded to the development of innovative, but simple and practical, technologies that will contribute towards improving the quality of life of Malaysians taking into account, among others, the lifestyles of the local population and the environmental and climatic conditions. The development of such national R&D projects will involve multi-disciplinary and multi-institutional research teams, including participation from the private sector.

13.47 In order to enhance R&D and technology development, international cooperation in selected S&T areas will be further strengthened. Cooperation arrangements will be expanded to increase exchange of technological information, as well as joint development of industrial technology and training in specific areas of S&T. This will include mutually beneficial activities such as exchange of technical information on fundamental and applied research, as well as exchange of researchers and scientists in specific technologies.

Strategic Technologies and Emerging Industries

13.48 In order to support the implementation of the technology-based industrial strategies, several advanced technologies are being promoted. Development in these areas, both domestically and internationally, are expected to create new investment opportunities for the economy as a whole, and in particular industry. The core technologies, *inter alia*, are as follows:

- a. information technology and communications
 - high performance computing
 - networking
 - communications
 - digital imaging
 - multimedia
 - high definition display
 - high density storage
 - software
 - simulation and modelling
- b. microelectronics
 - sensor technology
 - semiconductor materials and microelectronics circuits
 - optoelectronics
 - avionics
 - advanced semiconductor devices
- c. biotechnology and life sciences
 - biotechnology materials and processes
 - medical devices and diagnostics
 - medical technology

- d. advanced manufacturing technology
 - flexible computer integrated manufacturing
 - machine intelligence and robotics
 - micro and nano fabrication
 - systems management technology

- e. advanced materials
 - composites
 - ceramics
 - semiconductor materials, microelectronics circuits and photonic materials
 - materials synthesis and processing
 - superconductors
 - high performance metals and alloy

- f. environment and energy-related
 - green materials
 - agro-based waste
 - renewable energy
 - portable energy
 - pollution minimization, remediations and waste management

These advanced technologies will have a significant impact not only on new industries but also on established industries, where production processes and demand patterns are expected to alter radically.

13.49 In identifying these broad-based technologies for development, the aim is to develop competence in a selected number of areas to enable industries to upgrade by fully exploiting the latest advances in technology. Towards this end, a more detailed technology development strategy will be formulated. As an initial step, a national competency mapping study will be undertaken to, among others, reexamine and identify technology needs of the country in the context of the nation's development policy, and provide specific strategies for the future expansion of selected technology areas.

13.50 As part of the long term technology-based industrial strategy, Malaysia has begun to move into some of the abovementioned areas. However, it will be necessary to accelerate the process of building up the development prerequisites especially in terms of adequate S&T infrastructure, related manpower and domestic R&D. In its efforts to upgrade its technological capabilities, Malaysia will continue to rely, to a large extent, on multinational companies which have vast global networks in research and technology-based projects, including modern manufacturing plants, systems and related services. This will provide the impetus and inputs as well as expertise to the learning process by domestic industry.

13.51 To promote the development of these high-technology content industries, a number of measures will be implemented to attract investment and other resources to these areas. The Government will finetune the package of incentives and assistance currently available for high-technology industries. Among others, risk-sharing investment projects between Government and industry will be promoted in order to reduce the high risks associated with such ventures. Special efforts will be made to identify opportunities to assist the private sector to establish smart partnerships and strategic alliances overseas to enable local industry to gain access to new technologies, services and markets, and be cost competitive in a global environment. In addition, the Government will review current mechanisms for the acquisition, dissemination and transfer of technology with a view to strengthening these mechanisms, thereby fostering the development of higher technology and value-added activities.

Commercialization of Research and Technology

13.52 As part of the efforts to accelerate technology development in the country, the Government will mount a comprehensive strategy for the commercialization of indigenous R&D. Concerted efforts will be taken to develop and commercially exploit the large pool of untapped research findings in public sector research agencies and universities. This is with the view to ensuring that Malaysia can reap the full commercial benefits of local research, consequently creating new investment opportunities.

13.53 For this purpose, at the institutional level the organizational, legal and administrative framework will be revamped. Among others, the commercial and investment units of research institutes and universities will be restructured, and gradually corporatized. It is appropriate at this juncture for research agencies and universities to play a major role in identifying and marketing intellectual property with commercial potential, and proposing new ways of sharing intellectual

property rights with inventors and researchers. In order to attract more people into research activities, added incentives will be promoted to ensure that R&D personnel, especially those who contribute to successful commercialized ventures, are appropriately rewarded, including offer of share options in subsidiaries of corporatized research institutes or companies they serve.

13.54 At the national level, a mechanism for effective coordination and management of R&D commercialization activities will be established. In this regard, the MTDC has been identified to undertake this role. The private sector will be encouraged to participate in such activities through joint ventures and establishment of collaborative R&D programmes with research agencies.

13.55 Technical assistance and financial resources are often required at many stages of the commercialization process in view of the associated high risks and long gestation period. For this purpose, a special fund will be established to finance, in particular, the market phase of the commercialization process. This fund is expected to assist the MTDC and business units in universities and research institutes to intensify the development and marketing of local technologies.

Strategies for Private Sector Investment in R&D

13.56 Technology efforts by the private sector will continue to be supported by the Government in several ways. Greater private sector R&D will be directly promoted through a number of incentives, the provision of infrastructure and other forms of assistance. Incentives will be expanded to cover new areas such as acquisition of technology, commercialization of research results from local agencies, transfer of technology, and development of human capital related to research.

13.57 In addition to fiscal incentives, the Government will consider direct financial grants and long-term low interest loans to enterprises that participate in development and commercial applications of new technologies, especially in strategic industries. The larger enterprises are expected to play a major role in working towards the development of high-technology content industries which can produce own brands of internationally competitive goods and services. It is anticipated that the bigger corporations will, among others, contribute significantly to the advancement of industrial technology capabilities in areas such as precision engineering, advanced manufacturing knowhow, process-product interfacing and product design. The SMIs, which have different technical needs from the large conglomerates, are expected to be further assisted by

special technology development programmes. For this purpose, an initial budget of RM100 million will be allocated, and priority accorded to the build up of local technology capability through technology absorption, modification and adaptation, particularly in the development of improved as well as innovative products, processes and services.

13.58 In order to propagate the expansion of technology-based enterprises, the Government will continue to provide direct equity financing to, and nurture, early stage technology projects as they evolve through the various stages of technology innovation from incubation and commercialization, to market entry and expansion. Apart from this, the Government will consider the setting up of a third securities board to provide for the listing of technology-oriented companies seeking to source investible funds. In addition, technology-based private sector companies will be encouraged to forge linkages with overseas investors in specific areas such as telecommunications, aerospace and pharmaceuticals as well as medical and chemical products. These are areas which can create specialized usages in a wide range of industries and as such provide immense investment opportunities.

13.59 The Government will continue to invest in a large way in technology infrastructure to support the development of industrial technological capabilities. The expansion of TPM will provide facilities not only for small technology start-up companies but also for large enterprises undertaking product development and manufacturing process engineering. The TPM will house major public sector research institutes such as MIMOS, and the National Measurement Centre. The KHTP in Kedah, Composite Technology City, Melaka as well as the Subang Industrial Aerospace Park and Avionics Park, in Selangor, will play an important role in building the country's high technology base. These parks are expected to house corporate, academic and Government tenants specializing in R&D activities related to electronics, telecommunications, new materials and biotechnology. This approach will create the requisite synergy among industry, universities and the public sector in upgrading and augmenting technology capability. The proposed Techno-Centre within KHTP is anticipated to provide specialized R&D support services such as information exchange and networking, training and technical consultancies, as well as linkages with major international high-technology hubs. In addition, the Natural Resource Park in Sarawak and the Science Parks in Pulau Pinang and Johor are expected to generate extensive innovation and R&D activities, particularly in the fields of plant biotechnology, microelectronics and communications, respectively. The private sector will also be encouraged to set up business parks that focus on R&D activities.

13.60 Increased efforts will be undertaken to strengthen and institutionalize the currently informal R&D collaboration among universities, research agencies and industry. The gradual institutionalization of the contract research system within research agencies and universities as well as the partial or total corporatization of selected research institutes will facilitate greater utilization of their R&D services by the private sector. These developments will provide for greater synergy and linkage between industrial demand for technology and more advanced R&D, and contribute towards research syndication among the public and private sectors.

S&T Manpower

13.61 An area of major concern in S&T manpower development will be to ensure that expansion and improvements in education and training will effectively increase technological capabilities in strategic areas. In this respect, allocations amounting to more than RM1.6 billion will be made to universities and institutes of higher learning to produce the type of high-level S&T manpower required by the economy, especially for R&D, and technology management and development activities. Emphasis will be given to ensure adequate output of graduates in science and engineering fields which is anticipated to expand by more than two-fold during the Seventh Plan period, as shown in *Table 13-3*. The supply of S&T manpower is expected to be supplemented by increases of local science and engineering graduates trained abroad, as well as the employment of foreign scientists, technologists and researchers, where relevant.

13.62 Given the need to build up technological capability, greater emphasis will be placed on the teaching and learning of basic sciences and the provision of technical-oriented instruction at the primary, secondary and tertiary levels of education. Improvements and adjustments to the requisite curricula will be made to keep abreast with the expansion of knowledge, knowhow and applications especially in the mathematical, scientific and technological fields. Increased resources, in terms of manpower and improved facilities, will be made available to schools and institutions of higher learning to strengthen the teaching and learning of science and related subjects.

13.63 In order to ensure that research institutes and universities continue to be an important source of technology experts and R&D specialists, existing education and training programmes such as in-service training, off-campus schemes and distance learning will be further strengthened. In addition, a new

S&T human resource fund, with an initial allocation of RM300 million, will be established to build up capability in targeted technologies on a continuous basis so as to augment efforts to improve industrial competitiveness and growth. The fund will provide scholarships particularly at the post-graduate and post-doctoral levels as well as fellowships for graduate research and advanced studies, both locally and abroad. In addition, on-the-job and in-house training, as well as formal training will be provided to high- and middle-level technical manpower to support R&D activities. These measures will form part of the efforts to make available the requisite S&T manpower, as well as increase the national target of R&D personnel to 1,000 per million population by the year 2000.

13.64 Notwithstanding the above measures, a long-term S&T manpower development strategy will be pursued to systematically enlarge the pool of technology-oriented manpower, and replace the loss of such manpower due to retirement and emigration. For this purpose, a study has been commissioned to, among others, undertake an assessment of the country's scientific and technological manpower needs and prepare a long-term S&T human resource development plan.

Improving Standardization and Quality Assurance

13.65 The rapid advancement in technology and consequent regulatory changes, in both the domestic and international economies, make it necessary for the country to continuously review and upgrade the standards and quality assurance infrastructure and services which include standards development, metrology and measurements, as well as testing and quality assurance. This will be with the aim to enhance domestic capability in meeting standardization requirements in traditional areas related to the protection of health and safety as well as keep abreast with new developments. The latter, in particular, includes new international regulations pertaining to large-scale electronic products manufacture, environmental management and labelling systems, and the development of standards for the services industry as well as domestic regulations catering for automotive safety and emission control. At the same time, expansion in international trade and reduction of trade barriers will make it necessary for the country to increase active participation in international standards and systems development activities in order to ensure, among others, that national needs are protected.

Intellectual Property Protection

13.66 As a result of the scope and intensity of the obligations contained in the Agreement on Trade-Related Intellectual Property Rights (TRIPs), globally there will be stronger application of provisions that relate to protection of key technology transfer instruments such as patents, trade marks, copyrights, technical knowhow and industrial designs. This has implications on the extent to which technology transfer from abroad can take place and, more importantly, the need to accelerate the development and commercialization of indigenous technology. In this regard, relevant agencies will continually monitor and study the changes in the international environment for technology transfer, with the aim to take early measures to lessen any adverse impact on the economy.

13.67 Special emphasis will be accorded to creating a favourable climate to nurture domestic innovations and inventions, and promote commercialization of potential technologies. R&D incentives, which are expected to be further improved, will provide for a more conducive environment to increase private sector spending on technological advancement. Another important aspect will be to expedite the implementation of an intellectual property policy and guidelines for universities and research institutions, as these agencies are major sources of potential technologies for industry. Other measures will include the establishment of public-private sector technology partnerships with the view to adopting and diffusing new technologies as well as providing venture capital for downstream commercialization and patenting activities.

13.68 The Government will continue to strengthen and expand the requisite infrastructure for the development and management of intellectual property rights. Increased efforts will be made to monitor changes on the international front, review existing intellectual property legislations, formulate new legislations and adopt appropriate judicial, administrative and enforcement measures. The major thrust will be to stimulate development of home-grown technologies and, where necessary, to fulfil commitments under the TRIPs Agreement.

Increasing S&T Awareness

13.69 In line with current momentum to promote technology-led development, S&T awareness activities will be further expanded and diversified. This will be with a view to increasing public understanding of the role and importance

of S&T in development as well as encouraging students to take up S&T related careers. Apart from public sector agencies, the mass media, non-governmental organizations, private companies and professional groups are expected to contribute substantially to these activities.

13.70 Aside from existing promotional activities, new programmes and projects initiated by the NSC and the National Planetarium are anticipated to play a significant role in enhancing interest in S&T. The NSC will contain the largest display of interactive exhibits in the country, where students and members of the public can acquire some hands-on knowledge on S&T related principles and concepts. It aims at making S&T more appealing to students of all ages and academic abilities. In addition, a number of galleries will contain technology-oriented exhibits to expose visitors to historical and new developments in areas such as aeronautics, computers and IT, automobiles, telecommunications, and oil and gas. These exhibits will also incorporate local discoveries and developments.

13.71 During the Seventh Plan period, the NSC and the National Planetarium will be involved in many new promotional programmes. These will also provide opportunities for private sector participation in exhibit development by way of innovating, designing and constructing exhibits connected with the formal education system. Some of the new activities will include mobile S&T exhibitions, design and production of interactive exhibits and exhibitions for schools and the general public, and science support services, such as science kits, especially for primary school pupils and teachers.

Coordination and Management of S&T Strategies and Programmes

13.72 As the country seeks to accelerate technological innovation to generate greater economic growth, productivity and competitiveness, the Government will place increasing emphasis on the coordination of S&T strategies and programmes. In this regard, the role of MPKSN will be enhanced in order to effect a more integrated approach towards S&T development. Better integration of S&T policies with economic and other policies will be essentially aimed at harmonizing activities across sectors and institutions, as well as synthesizing the needs of the academia, research agencies and the private sector.

IV. ALLOCATION

13.73 The Federal Government development allocation and estimated expenditure for the period 1991-95 and the allocation for the period 1996-2000, are as shown in *Table 13-4*. The Government will increase direct R&D funding to RM1 billion, while approximately RM2.0 billion will be provided for related infrastructure facilities and services. Increasing emphasis will be accorded to making R&D more relevant to industry by accelerating the institutionalization of a contract research system within research agencies and universities, thus ensuring greater utilization of research services by the industry. In order to get better returns on investment in R&D activities, a sizeable budgetary allocation will be for the commercialization of research output. In essence, priority will be given to S&T related projects that will build up competence in enabling technologies, in line with the need to adapt, modify and diffuse technology advances for economic development.

<i>Programme</i>	<i>6MP</i>		<i>7MP</i>
	<i>Allocation</i>	<i>Expenditure</i>	<i>Allocation</i>
Direct R&D	629.0	567.1	1,000.0
Technology Development for SMIs	—	—	100.0
Technology Acquisition	—	—	100.0
Commercialization of Technology	—	—	100.0
S&T Infrastructure and Development	807.7	629.2	1,749.0
Total	1,436.7	1,196.3	3,049.0

V. CONCLUSION

13.74 During the Sixth Plan period, the S&T policy directions emphasized improvements related to the institutional and organizational infrastructure required to promote market-oriented R&D, and contribute to the development of capital and technology-intensive industries and services. For the Seventh Plan, the thrust of S&T will be to move rapidly from absorptive and assimilative to original design and more complex development work, as the country moves into more demanding high-technology areas, and access to new technologies becomes more difficult. In an increasingly competitive global environment, where technology has become the focus of new opportunities for investment and growth, the emphasis will be to fully exploit and utilize existing technologies, improve upon imported technologies, as well as generate indigenous technology.

