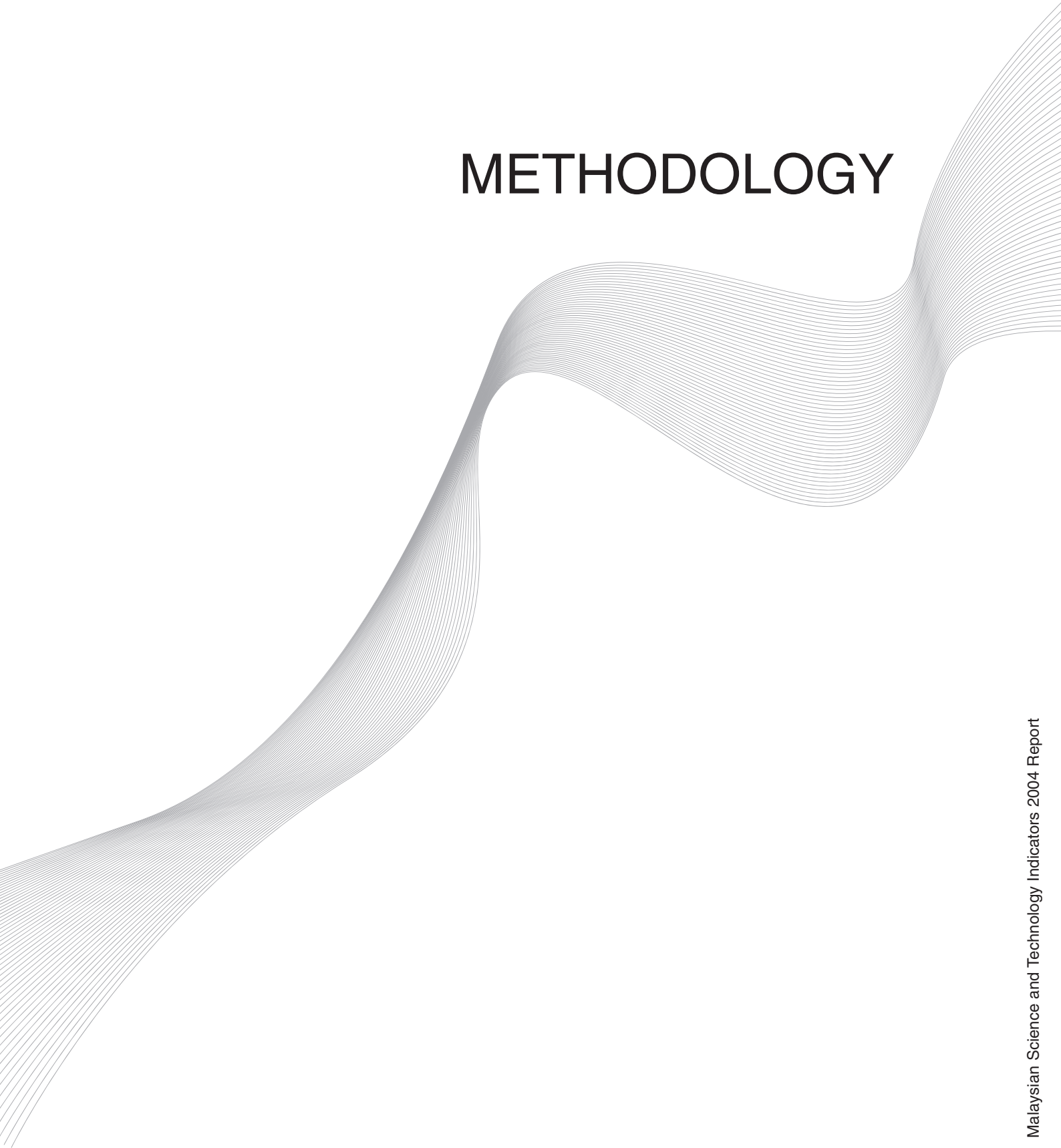


# METHODOLOGY



# Methodology

This appendix provides methodological details about the type of indicators that are used in the report. It will help clarify not only definitions and sources of data but their limitations as well.

## A. Education in Science and Technology

### Data Sources

Data on enrolment and graduation at public and private educational institutions are obtained from the Ministry of Education, Malaysia.

### Definition / Classification

In general, this report follows the OECD's classification/aggregation scheme for the field of studies. See Table A1 for more details. Due to the importance of information technology and computer science, this field of study is not included in the "natural sciences" and is reported separately. In the 1994 S&T Indicators report, information technology and computer science was classified under "information and computer technologies". "Engineering sciences & applied S&T" is now classified under the heading "engineering and technology". Two problematic categories in the previous reports are NSE nec (Natural Sciences and Engineering not elsewhere classified) and SSH nec (Social Sciences and

Humanities not elsewhere classified). Since these two categories are not very informative and were not used in the 1998 report, they have been dropped. Instead, a new category, 'Other Fields', has been added in the 2000 report. This category comprises education science, service trades, languages and other fields of education (Table A2).

It is not always possible to maintain a strict adherence to OECD's classification due to the format in which data are collected. For example, the Malaysian Ministry of Education (MOE) has its own classification scheme. In addition, data from public and private educational institutions are collected in different formats, thus making a direct comparison of these data impossible. The re-grouping of MOE's data to fit the OECD classification scheme is presented in Table A2. There are a few problems when attempts are made to re-classify data from MOE in accordance to the OECD classification scheme. The category "Art-others" includes education arts and communication – two fields that come under the social sciences (see mass communication) and humanities (art). Similarly, the category "Technical-others" includes property management that can be classified under social sciences rather than engineering and technology.

**Table A1: OECD's Classification Scheme for Field of Study in Education**

Aggregated Field of Study	Field of Study
Natural Sciences	Natural science Mathematics and computer science
Engineering and Technology	Engineering Architecture and town planning Trade, craft and industrial programs Transport and communications
Medical Sciences	Medical science and health related
Agricultural Sciences	Agriculture, forestry and fishery
Social Sciences	Law Social and behavioral science Commercial and business administration Mass communication and documentation Home economics (domestic science)
Humanities	Humanities Religion and Theology Fine and Applied Arts
Other Fields	General programs Education science and teacher training Service trades Other programs

**Table A2: Comparison Between OECD and MOE Classification Scheme for Education**

OECD SCHEME		MOE'S SCHEME	
		Public Educational Institutions	Private Educational Institutions*
Natural Sciences	Natural science Mathematics	Natural Sciences	Science and Mathematics
	IT and Computer Science	Computer Sciences and IT	Computer and Technology
Engineering and Technology	Engineering Architecture and town planning Trade, craft and industrial programs Transport and communications	Engineering and Engineering Trades Manufacturing and Processing Architecture and Planning	Engineering and Technical Skills Manufacturing and Construction Aviation and Maritime
Medical Sciences	Medical science and health related	Health Veterinary	Medicine Health and Welfare
Agricultural Sciences	griculture, forestry and fishery	Agriculture, forestry & fishery	Agriculture
Social Sciences	Law Social and behavioral science Commercial and business administration Mass communication and documentation Home economics (domestic science)	Law Social and behavioral science Business and Administration Journalism and Information	Law Social Sciences Business Administration
Humanities	Humanities Religion and Theology Fine and Applied Arts	Arts and Humanities Religion and Theology	Humanities Art, Design and Music
Other Fields	General programs Education science and teacher training Service trades Other programs	General programs Teacher training and education science Other programs	General programs Education Service trades Language

Note: (\*) Based on the International Standard Classification of Education (ISCED) published by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1997

## B. Human Resources for Science and Technology

### Data Sources

Data on R&D personnel are obtained from the 2002 National Survey of Research and Development conducted by MASTIC.

### Definitions / Classifications

#### Research and Development (R&D)

This report adopts OECD's definition of R&D that is stated in the Frascati Manual (1994, p.29):

" ... research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."

The three types of R&D activities are defined as follows.

**Basic research** – as experimental or theoretical work undertaken primarily to acquire

new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.

**Applied research** – as also original investigation undertaken in order to acquire new knowledge, however, directed primarily towards a specific practical aim or objective.

**Experimental development** – in the sense of systematic work, drawing on existing knowledge gained from research and/or practical experience, that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

**Researchers** are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, and in the management of the projects concerned. (OECD, 1997)

**Full Time Equivalent (FTE)** is a measure of the proportion of time a researcher, technician or other support staff spend on R&D work during the surveyed year. (MASTIC, 1998). FTE in year x can be calculated based on the following formula:

$$\frac{\text{Hours or days spent on R\&D in year x}}{\text{Total working hours or days in year x}} \times \frac{\text{No.of months in year x doing R\&D}}{12 \text{ months}}$$

## C. Research and Development Activities

### Data Sources

Data on R&D personnel are obtained from the 2002 National Survey of Research and Development conducted by MASTIC.

### Definitions

**Gross Domestic Expenditure on R&D (GERD)** comprise of current expenditures as well as gross capital expenditures that incurred in R&D activities in a given year. Current expenditures consist of labor costs and other current costs, while capital expenditures consist of land and buildings, and instruments and equipments.

## D. Innovation

### Data Sources

Data on the incidence of technological innovation and innovation activities among manufacturing firms are obtained from the National Survey of Innovation (2001-2002) conducted by MASTIC.

### Survey Methodology

A sample size of 4,000 respondents in the manufacturing sector was used in the survey. The survey adopted a stratified sampling method based on the size and the principal activity of the firms.

## Definitions

The definitions used in the survey to identify technological innovation are based on the recommendations of the Oslo Manual, published in 1992 by the OECD and the EC and revised in 1997. The following definitions were used for the manufacturing sector:

**“Technological product and process (TPP) innovations** comprise implemented technologically new products and processes and significant technological improvements in products and processes.” (Oslo Manual, p.47)

**“A technologically new product** is a product whose technological characteristics or intended uses differ significantly from those of previously produced products. Such innovations can involve radically new technologies, can be based on combining existing technologies in new uses, or can be derived from the use of new knowledge.” (Oslo Manual, p.48)

**“A technologically improved product** is an existing product whose performance has been significantly enhanced or upgraded. A simple product may be improved (in terms of better performance or lower cost) through use of higher-performance components or materials, or a complex product which consists of a number of integrated technical subsystems may be improved by partial changes to one of the subsystems.” (Oslo Manual, p.49)

**“Technological process innovation** is the adoption of technologically new or significantly improved production methods, including methods of product delivery. These methods may involve changes in equipment, or production organization, or a combination of these changes, and may be derived from the use of new knowledge. The methods may be intended to produce or deliver technologically new or improved products, which cannot be produced or delivered using conventional

production methods, or essentially to increase the production or delivery efficiency of existing products.” (Oslo Manual, p.49)

## E. Trade in Technology

### Data Sources

Trade data for high-technology goods and medium-high technology goods are obtained from Department of Statistics. Data on royalties, contracts and professional fees, construction and engineering are obtained from Bank Negara Malaysia (BNM). These data refer to cash transactions between residents of Malaysia and the rest of the world, as reported for the Cash Balance of Payments Reporting System.

### High-Technology and Medium-High-Technology Goods

The technology level of industries is determined in this report based on OECD's classification scheme. This scheme is based on R&D intensity in each industry. The products that come under some of the high technology and medium-high technology industries and their SITC codes are listed in Table F1.

**Table F1: Classification of Products by Technology Intensity**

High-technology industries				
Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
<b>Aircraft and spacecraft</b>	353	353 - Manufacture of aircraft and spacecraft	7921, 7922, 7923, 7924, 7925, 79291, 79293, 714, 87411 - 71489 - 71499	792.1 - Helicopters 792.2 - Aeroplanes and other aircraft, mechanically-propelled (other than helicopters), of an unladen weight not exceeding 2,000 kg 792.3 - Aeroplanes and other aircraft, mechanically-propelled (other than helicopters), of an unladen weight exceeding 2,000 kg but not exceeding 15,000 kg 792.4 - Aeroplanes and other aircraft, mechanically-propelled (other than helicopters), of an unladen weight exceeding 15,000 kg 792.5 - Spacecraft (including satellites) and spacecraft launch vehicles 792.91 - Propellers and rotors, and parts thereof 792.93 - Undercarriages, and parts thereof 714 - Engines and motors, non-electric (other than those of groups 712, 713 and 718); parts, n.e.s., of these engines and motors 874.11 - Direction-finding compasses; other navigational instruments and appliances <b>Exclude: 714.89</b> - Other gas turbines and <b>714.99</b> - Parts for the gas turbines of heading 714.89
<b>Pharmaceuticals</b>	2423	2423 - Manufacture of pharmaceuticals, medicinal chemicals and botanical products	5413, 5415, 5416, 5421, 5422	541.3 - Antibiotics, not put up as medicaments of group 542 541.5 - Hormones, natural or reproduced by synthesis; derivatives thereof, used primarily as hormones; other steroids used primarily as hormones, not put up as medicaments of group 542 541.6 - Glycosides; glands or other organs and their extracts; antisera, vaccines and similar products 542.1 - Medicaments containing antibiotics or derivatives thereof 542.2 - Medicaments containing hormones or other products of subgroup 541.5 but not containing antibiotics
<b>Office, accounting and computing machinery</b>	30	300 - Manufacture of office, accounting and computing machinery	75113, 75131, 75132, 75134, 7521, 7522, 7523, 7526, 7527, 7529	751.13 - Automatic typewriters; word-processing machines 751.31 - Electrostatic photocopying apparatus operating by reproducing the original image directly onto the copy (direct process) 751.32 - Electrostatic photocopying apparatus operating by reproducing the original image via an intermediate onto the copy (indirect process) 751.34 - Non-electrostatic photocopying apparatus of the contact type 752 - Automatic data-processing machines and units thereof; magnetic or optical readers, machines for transcribing data onto data media in coded form and machines for processing such data, n.e.s. 759.97 - ....for the machines of group 752 <b>Exclude: 752.9</b> - Data-processing equipment, n.e.s.

## High-technology industries

Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
<b>Radio, television and communications equipment</b>	32	321 - Manufacture of electronic valves and tubes and other electronic components 322 - Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy 323 - Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods	76381, 76383, 764 - 76493 - 76499, 7722, 77261, 77318, 77625, 77627, 7763, 7764, 7768	763.81 - Video-recording or reproducing apparatus, whether or not incorporating a video tuner 763.83 - Other sound-reproducing apparatus 764 - Telecommunications equipment, n.e.s., and parts, n.e.s., and accessories of apparatus falling within division 76  <b>Exclude : 764.93</b> - ....with the apparatus and equipment of groups 761 and 762 and subgroups 764.3 and 764.8 and <b>764.99</b> - ....with the apparatus falling within group 763 772.2 - Printed circuits 772.61 - ....for a voltage not exceeding 1,000 V 773.18 - Optical fibre cables 776.25 - Microwave tubes (excluding grid-controlled tubes) 776.27 - Other valves and tubes 776.3 - Diodes, transistors and similar semiconductor devices; photosensitive semiconductor devices (including photovoltaic cells, whether or not assembled in modules or made up into panels); light-emitting diodes 776.4 - Electronic integrated circuits and microassemblies 776.8 - Piezoelectric crystals, mounted; parts, n.e.s., of the electronic components of group 776 898.79 - Recorded media, n.e.s.
<b>Medical, precision and optical instruments</b>	33	331 - Manufacture of medical appliances and instruments and appliances for measuring, checking, testing, navigating and other purposes, except optical instruments 332 - Manufacture of optical instruments and photographic equipment 333 - Manufacture of watches and clocks	774, 8711, 8713, 8714, 8719, 87211, 874, 88111, 88121, 88411, 88419, 89961, 89963, 89966, 89967	774 - Electrodiagnostic apparatus for medical, surgical, dental or veterinary purposes, and radiological apparatus 871.1 - Binoculars, monoculars, other optical telescopes, and mountings therefor; other astronomical instruments and mountings therefor (excluding instruments for radio astronomy) 871.3 - Microscopes (other than optical microscopes); diffraction apparatus; parts and accessories thereof, n.e.s. 871.4 - Compound optical microscopes (including those for photomicrography, cinephotomicrography or microprojection) 871.9 - Liquid crystal devices, n.e.s.; lasers (other than laser diodes); other optical appliances and instruments, n.e.s. 872.11 - Dental drill engines, whether or not combined on a single base with other dental equipment 874 - Measuring, checking, analysing and controlling instruments and apparatus, n.e.s. <b>Exclude : 874.11</b> - Direction-finding compasses; other navigational instruments and appliances and 874.2 - Drawing, marking-out or mathematical calculating instruments (e.g., drafting machines, pantographs, protractors, drawing sets, slide-rules, disc calculators); instruments for measuring length, for use in the hand (e.g., measuring rods and tapes, micromete...

# Methodology

High-technology industries				
Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
				881.11 - Photographic (other than cinematographic) cameras 881.21 - Cinematographic cameras 884.11 - Contact lenses 884.19 - Optical fibres and optical fibre bundles and cables; sheets and plates of polarizing material; unmounted optical elements, n.e.s. 899.61 - Hearing-aids (excluding parts and accessories) 899.63 - Orthopaedic or fracture appliances 899.66 - Other artificial parts of the body 899.67 - Pacemakers for stimulating heart muscles (excluding parts and accessories)

Medium-high-technology industries				
Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
<b>Electrical machinery and apparatus, n.e.c.</b>	31	311 - Manufacture of electric motors, generators and transformers 312 - Manufacture of electricity distribution and control apparatus 313 - Manufacture of insulated wire and cable 314 - Manufacture of accumulators, primary cells and primary batteries 315 - Manufacture of electric lamps and lighting equipment	77862, 77863, 77864, 77865, 7787, 77884	778.62 - Tantalum fixed capacitors 778.63 - Aluminium electrolytic fixed capacitors 778.64 - Ceramic dielectric fixed capacitors, single layer 778.65 - Ceramic dielectric fixed capacitors, multilayer 778.7 - Electrical machines and apparatus, having individual functions, n.e.s.; parts thereof 778.84 - Electric sound or visual signalling apparatus (e.g., bells, sirens, indicator panels, burglar and fire-alarms), other than those of heading 778.34 or 778.82
<b>Motor vehicles, trailers and semi-trailers</b>	34	319 - Manufacture of other electrical equipment n.e.c. 341 - Manufacture of motor vehicles 342 - Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers 343 - Manufacture of parts and accessories for motor vehicles and their engines	781-784, 786	781 - Motor cars and other motor vehicles principally designed for the transport of persons (other than motor vehicles for the transport of ten or more persons, including the driver), including station-wagons and racing cars 782 - Motor vehicles for the transport of goods and special-purpose motor vehicles 783 - Road motor vehicles, n.e.s. 784 - Parts and accessories of the motor vehicles of groups 722, 781, 782 and 783 786 - Trailers and semi-trailers; other vehicles, not mechanically-propelled; specially designed and equipped transport containers

Medium-high-technology industries				
Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
<b>Chemicals excluding pharmaceuticals</b>	24 excl. 2423	241 - Manufacture of basic chemicals 242 - Manufacture of other chemical products 243 - Manufacture of man-made fibres 2411 - Manufacture of basic chemicals, except fertilizers and nitrogen compounds 2412 - Manufacture of fertilizers and nitrogen compounds 2413 - Manufacture of plastics in primary forms and of synthetic rubber 2421 - Manufacture of pesticides and other agro-chemical products 2422 - Manufacture of paints, varnishes and similar coatings, printing ink and mastics 2424 - Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations 2429 - Manufacture of other chemical products n.e.c. 2430 - Manufacture of man-made fibres	52222, 52223, 52229, 52269, 525, 531, 57433, 591	522.22 - Selenium, tellurium, phosphorus, arsenic and boron 522.23 - Silicon 522.29 - Calcium, strontium and barium; rare earth metals, scandium and yttrium, whether or not intermixed or interalloyed 522.69 - Other inorganic bases; other metal oxides, hydroxides and peroxides 525 - Radioactive and associated materials 531 - Synthetic organic colouring matter and colour lakes, and preparations based thereon 574.33 - Polyethylene terephthalate 591 - Insecticides, rodenticides, fungicides, herbicides, anti-sprouting products and plant-growth regulators, disinfectants and similar products, put up in forms or packings for retail sale or as preparations or articles (e.g., sulphur-treated bands, wicks and...
<b>Railroad equipment and transport equipment, n.e.c.</b>	352, 359	3520 - Manufacture of railway and tramway locomotives and rolling stock 3591 - Manufacture of motorcycles 3592 - Manufacture of bicycles and invalid carriages 3599 - Manufacture of other transport equipment n.e.c.	791, 785	791 - Railway vehicles (including hovertrains) and associated equipment 785 - Motor cycles (including mopeds) and cycles, motorized and non-motorized; invalid carriages

# Methodology

Medium-high-technology industries				
Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
<b>Machinery and equipment, n.e.c.</b>	29	291 - Manufacture of general purpose machinery 292 - Manufacture of special purpose machinery 293 - Manufacture of domestic appliances n.e.c. 2911 - Manufacture of engines and turbines, except aircraft, vehicle and cycle engines 2912 - Manufacture of pumps, compressors, taps and valves 2913 - Manufacture of bearings, gears, gearing and driving elements 2914 - Manufacture of ovens, furnaces and furnace burners 2915 - Manufacture of lifting and handling equipment 2919 - Manufacture of other general purpose machinery 2921 - Manufacture of agricultural and forestry machinery 2922 - Manufacture of machine-tools 2923 - Manufacture of machinery for metallurgy 2924 - Manufacture of machinery for mining, quarrying and construction 2925 - Manufacture of machinery for food, beverage and tobacco processing 2926 - Manufacture of machinery for textile, apparel and leather production 2927 - Manufacture of weapons and ammunition 2929 - Manufacture of other special purpose machinery 2930 - Manufacture of domestic appliances n.e.c.	71489, 71499, 71871, 71877, 71878, 72847, 7311, 73131, 73135, 73142, 73144, 73151, 73153, 73161, 73163, 73165, 73312, 73314, 73316, 7359, 73733, 73735	714.89 - Other gas turbines 714.99 - Parts for the gas turbines of heading 714.89 718.71 - Nuclear reactors 718.77 - Fuel elements (cartridges), non-irradiated 718.78 - Parts of nuclear reactors 728.47 - Machinery and apparatus for isotopic separation, and parts thereof, n.e.s. 731.1 - Machine tools for working any material by removal of material, by laser or other light or photon beam, ultrasonic, electrodischarge, electrochemical, 731.31 - Horizontal lathes, numerically controlled 731.35 - Other lathes, numerically controlled 731.42 - Other drilling machines, numerically controlled 731.44 - Other boring-milling machines, numerically controlled 731.51 - Milling machines, knee-type, numerically controlled 731.53 - Other milling machines, numerically controlled 731.61 - Flat-surface grinding machines, numerically controlled, in which the positioning in any one axis can be set up to an accuracy of at least 0.01 mm 731.63 - Other grinding machines, numerically controlled, in which the positioning in any one axis can be set up to an accuracy of at least 0.01 mm 731.65 - Sharpening (tool- or cutter-grinding) machines, numerically controlled 733.12 - Bending, folding, straightening or flattening machines (including presses), numerically controlled 733.14 - Shearing machines (including presses), numerically controlled, other than combined punching and shearing machines 733.16 - Punching or notching machines (including presses), including combined punching and shearing machines, numerically controlled 735.9 - Parts, n.e.s., and accessories suitable for use solely or principally with the machine tools of groups 731 and 733 737.33 - Machines and apparatus for resistance welding of metal, fully or partly automatic 737.35 - Machines and apparatus for arc (including plasma-arc) welding of metal, fully or partly automatic

## **Technology Balance of Payments**

The basis for the technology balance of payments and the methodology used are laid out in the OECD document titled Proposed Standard Method of Compiling and Interpreting Technology Balance of Payments Data – TBP Manual (1990).

The OECD defines the technology balance of payments (TBP) in the following manner:

“The technological balance of payments measures the flows of funds for transactions concerning industrial property rights. It covers invisible transaction in a country’s balance of payments concerning the purchase and sale of “disembodied” technology in the form of intellectual and industrial property rights including patents, licenses, know-how and technical assistance. It is therefore an indicator of technology transfer across countries.”

In Malaysia, there are no efforts as yet to collect technology transfer data in accordance to the guidelines such as the TBP Manual. The closest proxy to TBP is the compilation of cash balance of payments data for the following three categories:

- i) royalties and license fees;
- ii) contracts and professional fees; and
- iii) construction and engineering.

These data are used as proxies for TBP in the report. Items included in each of the above categories are as follows:

- i) Royalties and license fees – comprise of fees for authorized use of patents, copyrights, trademarks, industrial processes, franchises etc. and the use through licensing agreements, of produced originals or prototypes (such as manuscripts and films).
- ii) Contracts and Professional Fees – comprise of: (a) payments to/receipts from non-resident head-offices and branches arising from sharing of administrative

and operating expenses, and (b) fees for services provided in the form of legal, accounting, management consulting, public relations, advertising, market research and all commissions, brokerage fees levied by non-financial intermediaries.

- iii) Construction and Engineering – comprise of: (a) construction (e.g. ports, dams, bridges, roads, airports, refineries and plants) and installation of electrical and mechanical systems. It also includes activities undertaken in connection with the prospecting and exploration of all types of minerals (exclude imports and exports of goods), (b) fees for provision of expertise in engineering, architectural and other technical services, including planning, project design and supervision of turnkey projects; research and development; product testing and certification.

## **F. Publications and Citations**

### **Data Sources**

Bibliometric data in this report is obtained from the following ISI Thompson Scientific databases available on CD-ROM from MASTIC:

- i) National Science Indicators (NSI) Especially Prepared for MASTIC, 1981-2002
- ii) National Citation Report-Malaysia (NCR) Especially Prepared for MASTIC, 1981-2002, and
- iii) The National Bibliometric Study of Science & Technology Knowledge Productivity in Malaysia: 2003, undertaken by MASTIC

The ISI databases were queried by publication and citation counts for countries, subfields, authors, institutions and collaboration.

## **G. Awareness, Knowledge, and Attitude Towards Science and Technology**

### ***Data Sources***

Data for public awareness, knowledge and attitude towards S&T issues are obtained from the 2002 Public Awareness of Science and Technology Malaysia Survey conducted by MASTIC.

### ***A Brief Tour of the Survey Methodology***

A sample size of 5,000 respondents was used for the survey. Proportional sampling was employed in terms of characteristics such as race, rural/urban, age group, and gender. In the survey, knowledge and interest in S&T issues are surveyed in 11 categories: (1) space exploration; (2) application of computer technology; (3) application of nuclear technology for electricity generation; (4) business and economy; (5) environmental pollution; (6) foreign affairs; (7) national education policy; (8) new discoveries in medicine; (9) new discoveries in the sciences; (10) new inventions in Malaysia; and (11) new technology and innovation. A scale of one to four is used in the survey.

A set of ten questions was posed to the survey respondents' to gauge their perceived S&T knowledge. These were questions requiring yes/no responses. To assess the public's perception and attitude, a set of 11 questions were asked. Respondents were required to state whether they agree, disagree or are not sure about each of these statements.