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MAIN DEFINITIONS AND CONVENTIONS FOR THE MEASUREMENT OF RESEARCH AND EXPERIMENTAL DEVELOPMENT (R&D)

A SUMMARY OF THE FRASCATI MANUAL 1993

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Foreword

The OECD manual for the measurement of resources devoted to research and experimental development, the "Frascati Manual", was written by and for the national experts in OECD countries who collect and issue national R&D data and who submit responses to OECD international R&D surveys, aided by the staff of the OECD Economic Analysis and Statistics Division. Planners and policy analysts do not need the statistical minutiae but need to be able to refer to the appropriate definitions in the course of preparing for negotiations or briefings. This is a summary of the definitions and conventions contained in the fifth edition of the Frascati Manual. The numbers in brackets at the beginning of each paragraph refer to the corresponding paragraph in the Frascati Manual 1993. Some paragraphs have been edited or truncated, but any text which has been added is in italics. The main classifications used are reproduced in the annex.

The full text of this fifth edition has been published as *The Proposed Standard Practice for Surveys of Research and Experimental Development, Frascati Manual 1993* and is available from the main OECD sales outlets.

The Frascati Manual is only one volume in the OECD series, "The measurement of scientific and technological activities". Guidelines have already been issued on the Technology Balance of Payments (TBP) and on collecting and interpreting technological innovation data (the Oslo Manual). Two more, one for the use of patent data as science and technology indicators, and the second on human resources for science and technology, will be issued shortly.

The summary of the Frascati Manual is derestricted under the responsibility of the Secretary-General of the OECD.

Table of Contents

I. Introduction

a) R&D input

3) This Manual, first issued nearly 30 years ago, deals exclusively with the measurement of human and financial resources devoted to Research and Experimental Development (R&D) often referred to as R&D "input" data.

(4) Over the years, input statistics have proved to be valuable indicators, as various national and international reports show. The OECD reports on science and technology indicators provide useful measures of the scale and direction of R&D in various countries, sectors, industries, scientific fields and other categories of classification. Administrations concerned with economic growth and productivity rely on R&D statistics as one possible type of indicator of technological change. Advisors concerned not only with science policy, but also industrial policy, and even general economic and social policies use them extensively. R&D statistics are now an essential background element in many government programmes and provide an important tool for evaluating them.

(5) However, R&D statistics are not enough. It has become increasingly clear that such data need to be examined within a conceptual framework that relates them both to other types of resources and to the desired outcomes of the R&D activities concerned. This link may be made, for example, via the innovation process (see below) or within the broader framework of "intangible investment", which covers not only R&D and related S&T activities but also expenditures on software, training, organisation, etc. Similarly, R&D personnel data need to be viewed as part of a model of the training and use of scientific and technical personnel. It is also of interest to analyse R&D data in conjunction with other economic variables, such as value added and investment data. The Manual is not based on a unique model of the S&T system and how that system meshes with the economy and society; its aim is to produce statistics that can be used to calculate indicators for use in various models.

b) R&D and the innovation process

(20) Scientific and technological innovation may be considered as the transformation of an idea into a new or improved product introduced on the market, into a new or improved operational process used in industry and commerce, or into a new approach to a social service. The word "innovation" can have different meanings in different contexts and the one chosen will depend on the particular objectives of measurement or analysis. So far, international norms for data collection proposed in the Oslo Manual have only been developed for technological innovation.

Technological innovations comprise new products and processes and significant technological changes in products and processes. An innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). Innovations therefore involve a series of scientific, technological, organisational, financial and commercial activities.

R&D is only one of these activities and may be carried out at different phases of the innovation process, acting not only as the original source of inventive ideas but also as a form of problem-solving which can be called on at any point up to implementation.

(21) Besides R&D, six fields of innovative activities may often be distinguished in the innovation process:

Tooling-up and industrial engineering cover acquisition of and changes in production machinery and tools and in production and quality control procedures, methods, and standards required to manufacture the new product or to use the new process.

Manufacturing start-up and preproduction development may include product or process modifications, retraining personnel in the new techniques or in the use of the new machinery, and trial production if it implies further design and engineering.

Marketing for new products covers activities in connection with the launching of a new product. These may include market tests, adaptation of the product for different markets and launch advertising, but will exclude the building of distribution networks for market innovations.

Acquisition of disembodied technology includes acquisition of external technology in the form of patents, non-patented inventions, licences, disclosure of know-how, trademarks, designs, patterns, and services with a technological content.

Acquisition of embodied technology covers acquisition of machinery and equipment with a technological content connected to either product or process innovations introduced by the firm.

Design is an essential part of the innovation process. It covers plans and drawings aimed at defining procedures; technical specifications; and operational features necessary to the conception, development, manufacturing and marketing of new products and processes. It may be a part of the initial conception of the product or process, i.e. research and experimental development, but it may also be connected to tooling-up, industrial engineering, manufacturing start-up, and marketing of new products.

c) Coverage and characteristics of the manual

(9) The OECD has not set out to establish international norms for S&T where these already exist. Thus, this Manual is consistent with UNESCO recommendations for **all** scientific and technological activities, but is specific to R&D and to the needs of OECD Member countries whose rather similar economic and scientific systems distinguish them from non-OECD countries.

(10) Because of the need to place R&D in a wider context, both conceptually and in terms of databases, United Nations classifications are used as far as possible. However, it has proved necessary in some cases to deviate from these international norms in order to obtain internationally comparable R&D statistics. Furthermore, wherever possible, the Manual draws on the experience of regional organisations within the OECD area, notably NORDFORSK (and later the Nordic Industrial Fund) and the European Community (EC).

(25) The Manual deals not only with R&D in the natural sciences and engineering (NSE) which cover the physical sciences, the life sciences, including the medical and agricultural sciences, and engineering but also the social sciences and humanities (SSH).

(28) For statistical purposes two inputs are measured: R&D expenditures and R&D personnel. Both inputs are normally measured on an annual basis: so much spent during a year, so many person-years used during a year. Both series have their strengths and weaknesses, and, in consequence, both are necessary to secure an adequate representation of the effort devoted to R&D.

(29) Data on the utilisation of scientific and technical personnel provide concrete measurements for international comparisons of resources devoted to R&D. It is recognised, however, that R&D inputs are only one part of a nation's human resource input to the public welfare and that scientific and technical personnel contribute much more to industrial, agricultural and medical progress through their involvement in production, operations, quality control, management, education, and other functions. The measurement of these stocks of scientific and technical manpower is the subject of another OECD manual; the focus in this Manual is on the measurement and classification of R&D resources.

(33) The basic measure is "intramural expenditures", *i.e.* all expenditures for R&D performed within a statistical unit or sector of the economy. For R&D purposes, both current and capital expenditures are measured. In the case of the government sector, expenditures refer to direct rather than indirect fiscal expenditures.

(35) The main disadvantage of R&D input series expressed in monetary terms is that they are affected by differences in price levels between countries and over time. It can be shown that current exchange rates often do not reflect the balance of R&D prices between countries and that in times of high inflation general price indices do not accurately reflect trends in the cost of performing R&D. The Manual recommends the use of purchasing power parities (PPP) and the implicit GDP price index for use with R&D statistics, although it is recognised that they reflect the opportunity cost of the resources devoted to R&D rather than the "real" amounts involved. Methods of developing special R&D deflators and R&D exchange rates are discussed in *an annex to the full version of the Manual.*

(37) Although R&D activities are widespread throughout the economy, they are often perceived as a national whole for science policy purposes, *i.e.* as the "national R&D efforts". One of the aims of the Manual is, thus, to establish specifications for R&D input data which can both be collected from a wide range of performers and also be aggregated to find meaningful national totals. The main expenditure aggregate used for international comparison is the gross domestic expenditure on R&D (GERD) which covers all expenditures for R&D performed on national territory in a given year. (It includes domestically performed R&D which is financed from abroad but excludes R&D funds paid abroad, notably to international agencies.) The corresponding personnel measure does not have a special name. It covers total personnel working on R&D (in full-time equivalence -- FTE) on national territory during a given year. International comparisons are sometimes restricted to researchers (or university graduates) because it is considered that researchers are the true core of the R&D system.

(44) The distinction between military and civil R&D is considered one of the most important functional breakdowns of national R&D efforts. In most OECD countries, defence R&D plays a relatively minor role. However, in a few countries performing a high level of R&D, defence R&D expenditure approaches or exceeds half of total government R&D expenditure. As a result, patterns of international comparisons differ, depending on whether defence R&D is included or excluded. The demand for defence R&D fluctuates with changing political situations, and therefore its long-term trend varies differently from that of civil R&D. This means that there will always be a demand for the separation of the two categories of R&D expenditure within the overall picture of national R&D effort.

(47) One area which has received considerable attention is that of strategic research. This is generally taken to mean research that a nation sees as a priority for the strategic development of its research base and ultimately its economy. Strategic research is not to be confused with what are called the strategic objectives of the business sector. Nor should it be confused with that of strategic technologies, on which discussions are taking place in the context of defining "rules of the game" for governments that subsidise so-called strategic industries or technologies. Such industries and technologies are characterised by: high dependence on a strong technology base and vigorous research efforts; considerable strategic significance for governments; long leadtimes from basic research to industrial application; competitive pressure of new product and process introductions; high risks and large capital investments; high degree of international co-operation and competition in R&D, production and world-wide marketing. Understanding of what is and is not strategic varies between Member countries.

II. Basic definitions and conventions

a) Research and experimental development (R&D)

(57) **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.

(58) R&D is a term covering three activities: basic research, applied research, and experimental development.

(224) **Basic research** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.

(225) Basic research analyses properties, structures, and relationships with a view to formulating and testing hypotheses, theories or laws. The results of basic research are not generally sold but are usually published in scientific journals or circulated to interested colleagues. Occasionally, basic research may be "classified" for security reasons.

(229) **Applied research** is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.

(231) The results of applied research are intended primarily to be valid for a single or limited number of products, operations, methods, or systems. Applied research develops ideas into operational form. The knowledge or information derived from it is often patented but may also be kept secret.

(233) **Experimental development** is systematic work, drawing on existing knowledge gained from research and practical experience, that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed.

(236) The following examples illustrate the general differences between basic and applied research and experimental development in the natural sciences and engineering and in the social sciences and humanities.

(237a) The study of a given class of polymerisation reactions under various conditions, of the yield of products, and of their chemical and physical properties is basic research. The attempt to optimise one of these reactions with respect to the production of polymers with given physical or mechanical properties (making it of particular utility) is applied research. Experimental development then consists of the "scaling up" of the process which has been optimised at the laboratory level and the investigation and evaluation of potential methods of production of the polymer and perhaps of articles to be made from it.

(238a) Theoretical investigation of the factors determining regional variations in economic growth is basic research; however, such investigation performed for the purpose of developing government policy is applied research. The development of operational models, based upon laws revealed through research, aimed at modifying regional disparities is experimental development.

(239) *In software*. Pure basic research includes the development of software for algebraic manipulations and numerical analysis. Oriented basic research includes investigation into the formalisation of human speech and of specific tasks (*e.g.* work in the field of man/machine communication using direct speech input and output, research into basic algorithms for possible information processing applications, and investigation into the possibility of formalising programming procedures). Applied research includes investigation into the application of information processing in new fields or in new ways (*e.g.* developing a new programming language, new operating systems, programme generators, etc.) and investigation into the application of information processing to develop such tools as geographical information and expert systems. Experimental development is the development of new applications software, substantial improvements to operating systems and application programmes, etc.

b) The boundaries of R&D: general principles

(59) For survey purposes, R&D must be distinguished from a wide range of related activities with a scientific and technological base. These other activities are very closely linked to R&D both through flows of information and in terms of operations, institutions and personnel, but they should, as far as possible, be excluded when measuring R&D.

(79) The basic criterion for distinguishing R&D from related activities is the presence in R&D of an appreciable element of novelty and the resolution of scientific and/or technological uncertainty, *i.e.* when the solution to a problem is not readily apparent to someone familiar with the basic stock of commonly used knowledge and techniques in the area concerned.

(80) One aspect of this criterion is that a particular project may be R&D if undertaken for one reason, but if carried out for another reason, will not be considered R&D. This is shown in the following examples:

- In the field of medicine, routine autopsy on the causes of death is simply the practice of medical care and not R&D; special investigation of a particular mortality in order to establish the side effects of certain cancer treatments is R&D. Similarly, routine tests such as blood and bacteriological tests carried out for doctors are not R&D, but a special programme of blood tests in connection with the introduction of a new drug is R&D.

-- The keeping of daily records of temperatures or of atmospheric pressure is not R&D but rather the operation of a weather forecasting service or general data collection. The investigation of new methods of measuring temperature is R&D, as are the study and development of new systems and techniques for interpreting the data.

-- R&D activities in the mechanical engineering industry often have a close connection with design and drawing work. Usually there are no special R&D departments in small and medium-size companies in this industry, and R&D problems are mostly dealt with under the general heading "design and drawing". If calculations, designs, working drawings and operating instructions are made for the setting up and operating of pilot plants and prototypes, they should be included in R&D. If they are carried out for the preparation, execution and maintenance of production standardisation (*e.g.* jigs, machine tools) or to promote the sale of products (*e.g.* offers, leaflets, spare parts' catalogues), they should be excluded from R&D.

-- In the systems software area, individual projects may not be considered as R&D but their aggregation into a larger project may qualify for inclusion. For example, changes in file structure and user interfaces in a fourth generation language processor may be made necessary by the introduction of relational technology. The individual changes may not be considered R&D if viewed in their own right, but the whole modification project may result in the resolution of scientific and/or technological uncertainty and thus be classified as R&D.

c) R&D and education and training

(62) All education and training of personnel in the natural sciences, engineering, medicine, agriculture, the social sciences, and the humanities in universities and special institutions of higher and post-secondary education should be excluded. However research by postgraduate students carried out at universities should be counted, wherever possible, as a part of R&D.

(81) In institutions of higher education, research and teaching are always very closely linked, as most academic staff do both, and many buildings, as well as much equipment, serve both purposes.

(82) Because the results of research feed into teaching, and because information and experience gained in teaching can often result in an input to research, it is difficult to define where the education and training activities of higher education staff and their students end and R&D activities begin, and vice versa. R&D is an activity whose elements of novelty distinguish it from routine teaching and other work-related activities. There is, however, a problem in deciding whether or not to consider as R&D those scientific activities which are the by-products of educational or training activities.

(85) In countries where postgraduates are a recognised group, the borderline between their R&D and their education and training is particularly hard to establish. The activities of both the postgraduate students themselves and of their teachers need to be taken into consideration.

(87) In order to obtain a final qualification at postgraduate level (ISCED 7), students are expected to prove their competence by undertaking a relatively independent study or project and by presenting its results. As a general rule, these studies contain the elements of novelty required for R&D projects. Such activities of students should, therefore, be attributed to R&D, and any supervision by the teacher should

also be considered as R&D. In addition to R&D performed within the framework of courses of postgraduate education, it is possible for both teachers and students to be engaged in other R&D projects.

(90) Closely allied to the problem of identifying the R&D element of postgraduate students' work is that of extracting the R&D component of academic supervisors' time spent on supervising the same students and their research projects.

(91) Such supervision activities should be included in R&D only if they are equivalent to the direction and management of a specific R&D project, containing a sufficient element of novelty and having as its object to produce new knowledge. In such cases, both the academic staff member's supervision and the student's work should be included as R&D. If the supervision merely deals with the teaching of R&D methods and the reading and correction of theses and dissertations or the work of undergraduate students, it should be excluded from R&D.

(94,96) Personal education of academic staff covers time spent on activities such as professional continued learning ("own reading"), attendance at conferences and seminars, etc. Only personal education carried out specifically for a research project should be considered as an R&D activity.

d) R&D and other related scientific and technological activities

(97) Institutions or units of institutions and firms whose principal activity is R&D often have secondary, non-R&D activities (*e.g.* scientific and technical information, testing, quality control, analysis). Insofar as a secondary activity is undertaken primarily in the interests of R&D, it should be included in R&D activities; if the secondary activity is designed essentially to meet needs other than R&D, it should be excluded from R&D.

Institutions whose main purpose is an R&D-related scientific activity often undertake some research in connection with this activity. Such research should be isolated and included when measuring R&D.

(98) The activities of a scientific and technical information service or of a research laboratory library, maintained predominantly for the benefit of the research workers in the laboratory, should be included in R&D. The activities of a firm's documentation centre open to all the firm's staff should be excluded from R&D even if it shares the same premises as the company research unit. Similarly, the activities of central university libraries should be excluded from R&D.

Public bodies and consumer organisations often operate laboratories whose main purpose is testing and standardisation. The staff of these laboratories may also spend time devising new or substantially improved methods of testing. Such activities should be included in R&D.

(100) The difficulty with **space exploration** is that, in some respects, much space activity may now be considered routine; certainly the bulk of the costs are incurred for the purchase of goods and services which are not R&D. However, the object of all space exploration is still to increase the stock of knowledge, so that it should all be included in R&D. It may be necessary to separate those activities associated with space exploration, including the development of vehicles, equipment, and techniques, from

those involved in the routine placing of orbiting satellites or the establishment of tracking and communication stations.

(101,103) **Mining and prospecting** sometimes cause problems due to a linguistic confusion between research for new or substantially improved resources (food, energy, etc.) and the search for existing reserves of natural resources, a confusion which blurs the distinction between R&D and surveying and prospecting. The surveying and prospecting activities of commercial companies will be almost entirely excluded from R&D. For example, the sinking of exploratory wells to evaluate the resources of a deposit should be considered as scientific and technological services.

e) Social sciences and social systems

(80) More than other fields of science, the social sciences and humanities draw on disciplines and techniques beyond their own areas to support their research activities. In particular, mathematics and statistics are used in almost all social and economic research. Disciplines such as psychology, geography, and anthropology also depend on techniques in their allied sciences of clinical psychology, geology, and anatomy. Research in the economic and social sciences particularly is interdisciplinary, with, at times, rather uncertain boundaries between the individual disciplines. Because of the different research methodologies employed, a definition encompassing the R&D component of the social sciences and humanities has to be much broader than one for natural sciences and engineering.

The Manual has gone a long way towards solving this problem by including in the definition of R&D "knowledge of man, culture and society" (para. 57). The concept of novelty should still be the underlying criterion for defining the boundaries between R&D and related (routine) scientific activities. Such related activities can only be included in R&D if they are undertaken as an integral part of a specific research project or undertaken for the benefit of a specific research project. Therefore, there are a number of areas in which social scientists bring established methodologies and facts of the social sciences to bear on a particular problem, that cannot be classified as research.

The following are examples of work which might fall into this category but are not R&D: interpretative commentary on the probable economic effects of a change in the tax structure, using existing economic data; forecasting future changes arising from an altered demographical structure in the patterns of the demand for social services within a given area; operations research (OR) as a contribution to decision making, *e.g.* planning the optimal distribution system for a factory; the use of standard techniques in applied psychology to select and classify industrial and military personnel, students, etc., and to test children with reading or other disabilities.

(70) Policy related studies *should be generally excluded*. In this context, "policy" refers not only to national policy but also to policy at the regional and local levels, as well as that of business enterprises in the pursuit of their economic activity. Policy-related studies cover a range of activities such as the analysis and assessment of the existing programmes, policies, and operations of government departments and other institutions; the work of units concerned with the continuing analysis and monitoring of external phenomena (*e.g.* defence and security analysis); and the work of legislative commissions of inquiry concerned with general government or departmental policy or operations.

(104) In general, but more particularly in the field of the social sciences, the purpose of studies is to prepare the way for decisions to be taken by policy makers at the level of government (central, regional, local) or in industrial and trading enterprises. Usually, only established methodologies are employed in such studies, but sometimes in elaborating operational models it is necessary to modify existing methodology, or to develop new ones which would require an appreciable proportion of research. In theory, such modifications or development should be considered in the measurement of R&D, but one must be aware of the difficulties involved in the evaluation of appropriate parts (if any) of R&D in a given study. In practice, despite technical and conceptual problems, it may be feasible either to assign studies which include an appreciable element of research entirely to research, or to make an attempt to estimate the proportion of research in those studies and then attribute it to R&D. For determining whether a particular activity can be regarded as R&D or be attributed to R&D, it is irrelevant whether the activity is called a study or the report resulting from the activity performed is called a study. If a particular activity falls within the definition of R&D, then it is regarded as or attributed to R&D; if not, it is excluded.

f) R&D and software development

(105,106) For a software development project to be classified as R&D, its completion must be dependent on the development of a scientific and/or technological advance, and the aim of the project must be resolution of a scientific and/or technological uncertainty on a systematic basis. In addition to software which is part of an overall R&D project, research and development associated with software as an end-product should also be classified as R&D.

(107) Software development, by its nature, makes identifying its R&D component, if any. It is an integral part of many projects which of themselves have no elements of R&D. The software development component of such projects, however, may be classified as R&D if an advance occurs in the area of computer software. Advances in software are normally incremental rather than revolutionary. Therefore, an upgrade, addition or change to an existing programme or system may be classified as R&D if it embodies scientific and/or technological advances which result in an increase in the stock of knowledge. Use of software for a new application or purpose, however, does not by itself constitute an advance.

(71) Software-related activities of a routine nature are not considered to be R&D. Such activities include work on system-specific or programme-specific advancements which were publicly available prior to the commencement of the work. Technical problems which have been overcome in previous projects on the same operating systems and computer architecture are likewise excluded. Software-related activities such as:

- supporting existing systems;
- converting and/or translating computer languages;
- adding user functionality to application programmes;
- de-bugging of systems;
- adaptation of existing software;
- preparation of user documentation,

which do not involve scientific and/or technological advances, are not classified as R&D.

(72) Routine computer maintenance is not included. Quality assurance, routine data collection, and market research are also excluded.

g) *Problems on the borderline between R&D and other industrial activities*

(111) Care must be taken to exclude activities which, though undoubtedly a part of the innovation process, rarely involve any R&D, *e.g.* patent filing and licensing, market research, manufacturing start-up, tooling up and redesign for the manufacturing process. Some activities, such as tooling up, process development, design and prototype construction, may contain an appreciable element of R&D, thus making it difficult to identify precisely what should or should not be defined as R&D. This is particularly true for defence and large-scale civil industries such as aerospace. Similar difficulties may arise in distinguishing public technology-based services such as inspection and control from related R&D, as for example in the area of food and drugs.

(23,112) Possibly the greatest source of error in measuring R&D lies in the difficulty of locating the cut-off point between experimental development and the related activities required during the realisation of an innovation. It is difficult to define precisely the cut-off point between experimental development and preproduction developments, such as producing user demonstration models and testing, and production that is applicable to all industrial situations. It would be necessary to establish a series of conventions or criteria by type of industry. The basic rule originally laid down by the US National Science Foundation (NSF) provides a practical basis for the exercise of judgement in difficult cases. Slightly expanded, it states:

> "If the primary objective is to make further technical improvements on the product or process, then the work comes within the definition of R&D. If, on the other hand, the product, process or approach is substantially set and the primary objective is to develop markets, to do preproduction planning, or to get a production or control system working smoothly, then the work is no longer R&D."

(114) Some common problem areas are described below.

(115,116) A **prototype** is an original model constructed to include all the technical characteristics and performances of the new product. For example, if a pump for corrosive liquids is being developed, several prototypes are needed for accelerated life tests with different chemicals. A feedback loop exists so that if the prototype tests are not successful, the results can be used for further development of the pump. The design, construction and testing of prototypes normally falls within the scope of R&D. The construction of several copies of a prototype to meet a temporary commercial, military or medical need after successful testing of the original, even if undertaken by R&D staff, is not part of R&D.

(117) The construction and operation of a **pilot plant** is a part of R&D as long as the principal purposes are to obtain experience and to compile engineering and other data.

(118) But if, as soon as this experimental phase is over, a pilot plant switches to operating as a normal commercial production unit, the activity can no longer be considered R&D even though it may still be described as a "pilot plant".

(119) **Large-scale projects**, of which defence and aerospace are the most significant types, usually cover a spectrum of activity from experimental to preproduction development. In such circumstances, the funding and/or performing organisation often cannot distinguish between the R&D and other elements of expenditure. This distinction between R&D and non-R&D expenditures is particularly important in countries where a large proportion of government R&D expenditure is directed to defence.

(120) It is very important to look closely at the nature of very costly pilot plants or prototypes, such as the first of a new line of nuclear power stations or of ice-breakers. They may be constructed almost entirely from existing materials and using existing technology, and they are often built for simultaneous use for R&D and for providing the primary service concerned (power generation or ice breaking). The construction of such plants and prototypes should not be wholly credited to R&D.

(121) After a prototype has been satisfactorily tested, with any necessary modifications, there is the **manufacturing start-up phase**. It is a process related to full-scale production; it may consist of product or process modification, or retraining personnel in the new techniques or in the use of new machinery. Unless the manufacturing start-up phase implies further design and engineering it should not be counted as R&D, since the primary objective is no longer to make further improvements to the products but to get the production process going. The first units of a trial production run for a mass production series should not be considered as R&D prototypes even if they are loosely described as such.

(123) **Trouble-shooting** occasionally brings out the need for further R&D, but more frequently it involves the detection of faults in equipment or processes and results in minor modifications of standard equipment and processes. It should not, therefore, be included in R&D.

(124) After a new product or process has been turned over to production units, there will still be technical problems to be solved, some of which may demand further R&D. Such **"feedback" R&D** should be included.

(125) The vast bulk of **design** work in an industrial area is geared towards production processes and as such is not classified as R&D. There are, however, some elements of design work which should be included as R&D. These include plans and drawings aimed at defining procedures, technical specifications and operational features necessary to the conception, development and manufacturing of new products and processes.

(127,129) In the majority of cases the **tooling-up and industrial engineering** phases of any project are considered to be part of the production process. However, if the tooling-up process results in further R&D work, such as developments in the production machinery and tools, changes to the production and quality control procedures, or the development of new methods and standards, then these activities are classified as R&D.

h) Other activities excluded from R&D

(63) The following activities should be excluded from R&D except where carried out solely or primarily for the purposes of an R&D project.

(64) **Scientific and technical information services**. The specialised activities of collecting, coding, recording, classifying, disseminating, translating, analysing, and evaluating, by scientific and technical personnel, bibliographic services, patent services, scientific and technical information extension and advisory services, and scientific conferences, except where conducted solely or primarily for the purpose of R&D support (*e.g.* the preparation of the original report of R&D findings should be included in R&D).

(65) **General purpose data collection** undertaken generally by government agencies to record natural, biological or social phenomena that are of general public interest or that only the government has the resources to record. Examples are routine topographical mapping; routine geological, hydrological, oceanographic, and meteorological surveying; astronomical observations. Data collection conducted solely or primarily as part of the R&D process is included in R&D (*e.g.* data on the paths and characteristics of particles in a nuclear reactor). The same reasoning applies to the processing and interpretation of the data. The social sciences, in particular, are very dependent on the accurate record of facts relating to society in the form of censuses, sample surveys, etc. When these are specially collected or processed for the purpose of scientific research, the cost should be attributed to research and should cover the planning, systematising, etc., of the data. But data collected for other or general purposes, such as quarterly sampling of unemployment, should be excluded even if exploited for research. Market surveys are also excluded.

(66) **Testing and standardisation**. Refers to the maintenance of national standards, the calibration of secondary standards and routine testing and analysis of materials, components, products, processes, soils, atmosphere, etc.

(67) **Feasibility studies**. Investigation of proposed engineering projects using existing techniques in order to provide additional information before deciding on implementation. In the social sciences, feasibility studies are investigations of the socio-economic characteristics and implications of specific situations (*e.g.* a study of the viability of a petrochemical complex in a certain region). However, feasibility studies on research projects are part of R&D.

(68) **Specialised medical care**. Refers to routine investigation and normal application of specialised medical knowledge. There may, however, be an element of R&D in what is usually called "advanced medical care", carried out, for example, in university hospitals.

(93) Usually such advanced medical care is not considered R&D, and all medical care not directly linked to a specific R&D project should be excluded from the R&D statistics.

(69) **Patent and licence work**. All administrative and legal work connected with patents and licences. However, patent work connected directly with R&D projects is R&D.

i) R&D administration and supporting activities

(24) In order to actually carry out the R&D activities, the funds must be provided and the project and its finance must be managed. **The R&D funding activities of policy agencies** such as ministries of science and technology or research councils are not themselves R&D. In the case of the in-house management of R&D projects and their finance a distinction is made between **direct support** for R&D by persons such as R&D managers closely associated with individual projects, who are included in both the personnel and

expenditure series, and persons whose support is indirect or auxiliary, who are included in the expenditure series only as an element of overheads.

(78) **Indirect supporting activities** cover a number of activities which are not themselves R&D but which provide support for R&D. By convention, R&D personnel data cover R&D proper and exclude the indirect support activities, whereas an allowance for them is included in R&D expenditure of performers under overheads. Typical example are transportation, storage, cleaning, repair, maintenance, and security activities.

(134) Some activities, such as the provision of library or computer services are R&D proper if they are intended exclusively for R&D, but indirect supporting activities if they are provided by central departments for both R&D and non-R&D uses. The same argument applies in the case of management, administration and clerical activities. When these contribute directly to R&D projects and are undertaken exclusively for R&D, then they are part of R&D proper and included in R&D personnel. Typical examples are the R&D manager who plans and supervises the scientific and technical aspects of the project or the word-processor who produces the interim and final result of the project. It remains a moot point whether the bookkeeping associated with a specific R&D project is direct (R&D proper) or indirect (ancillary) activity. By convention it is R&D proper rather than an indirect support activity if it is carried out in close proximity to the R&D.

III. Sectors of the economy

(145) The **business enterprise sector** includes all firms, organisations and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price, and the private non-profit institutes mainly serving them.

(146-48) The core of the sector is made up of private enterprises (corporations or quasi-corporations) whether or not they distribute profit. Among these enterprises may be found some firms for which R&D is the main activity (commercial R&D institutes and laboratories). Any private enterprises producing higher education services should be included in the higher education sector. In addition, this sector includes public enterprises (public corporations and quasi-corporations owned by government units) mainly engaged in market production and sale of the kind of goods and services which are often produced by private enterprises, although, as a matter of policy, the price set for these may be less than the full cost of production. This sector also includes non-profit institutions (NPIs) who are market producers of goods and services other than higher education. *The industrial classification used for this sector is shown as Table 1 in the annex.*

(168) The **government sector** is composed of all departments, offices and other bodies which furnish but normally do not sell to the community those common services, other than higher education, which cannot otherwise be conveniently and economically provided and administer the state and the economic and social policy of the community. Public enterprises are included in the business enterprise sector, and NPIs controlled and mainly financed by government.

(178,179) The **private non-profit sector** covers non-market, private non-profit institutions serving households (*i.e.* the general public), such as professional or learned societies, charities, relief or aid agencies, trades unions, consumers' associations, etc., plus any funds contributed directly to R&D by households.

(181,182) By convention, this sector also covers the residual R&D activities of the general public (households). R&D performed by individuals exclusively on their own time and with their own facilities and at their own expense or supported by an uneconomic grant.

(183) The following types of private non-profit organisations should be excluded from this sector:

- -- those mainly rendering services to enterprises;
- -- those that primarily serve government;
- -- those entirely or mainly financed and controlled by government;
- -- those offering higher education services or controlled by institutes of higher education.

(190) The **higher education sector** is composed of all universities, colleges of technology, and other institutes of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating **under the direct control of** or administered by or **associated with** higher education establishments.

(192) The above definition describes the general coverage of the sector. However, it is difficult to provide clear guidelines which ensure internationally comparable reporting of data because it is not backed by SNA. As it is based on mixed criteria, it is particularly susceptible to varying interpretation resulting from national policy preoccupations and definitions of the sector. *The classification for this and the private non-profit sector is the highest level shown in Table 2 in the annex.*

(215) **Abroad**. This sector consists of all institutions and individuals located outside the political frontiers of a country except for vehicles, ships, aircraft and space satellites operated by domestic organisations and testing grounds acquired by such organisations, and all international organisations (except business enterprises), including facilities and operations within the frontiers of a country.

IV. Measurement of personnel devoted to R&D

a) Headcount and full-time equivalent

(288) The measurement of personnel employed on R&D involves three exercises:

- -- identifying which types of personnel should be initially included;
- -- measuring their number;
- -- measuring their R&D activities in full-time equivalent (person-years).

(279,280) All persons employed directly on R&D should be counted, as well as those providing direct services such as R&D managers, administrators, and clerical staff. Those providing an indirect service, such as canteen and security staff, should be excluded, even though their wages and salaries are included as an overhead cost in the measurement of expenditure.

i) Headcount

(289,290) Data on the total number of persons who are mainly or partially employed on R&D allow links to be made with other series of data, for example education or employment data or the results of population censuses. This is particularly important when examining the role of R&D employment in total stocks and flows of scientific and technological personnel. Headcount data are also the most appropriate measure for collecting additional information about R&D personnel, such as their age, gender, or national origin.

ii) Full-time equivalent

(291,295,296)

While data series measuring the number of R&D staff, and notably researchers, have many important uses, they are not a substitute for a series based on the number of full-time equivalent staff. R&D may be the primary function of some persons (*e.g.* workers in an R&D laboratory) or it may be a secondary function (*e.g.* members of a design and testing establishment). It may also be a significant part-time activity (*e.g.* university teachers or postgraduate students). To count only persons employed in R&D establishments would result in an underestimate of the effort devoted to R&D; to do a headcount of everyone spending some time on R&D would lead to an overestimate. The number of persons engaged in R&D should, therefore, be expressed in full-time equivalents (FTE). One FTE may be thought of as one person-year.

b) Categories of R&D personnel

(307) Two approaches are used by OECD Member countries for classifying R&D personnel: one by occupation, the other by level of formal qualification.

(329) It would be desirable to have a single measure of all high-level personnel working on R&D. Unfortunately, because of the continued existence of alternative classifications by occupation and by qualification this is not possible.

i) Occupation

(311) 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.

(313) Included are managers and administrators engaged in the planning and management of the scientific and technical aspects of a researcher’s work. They are usually of a rank equal to or superior to that of persons directly employed as researchers and will often be former or part-time researchers.

(315) Postgraduate students engaged in R&D should be considered as researchers, and should be reported separately. Where they are not a separate category and are treated as employed as technicians as well as researchers, this may cause inconsistencies in the researcher series.

(316) Technicians and equivalent staff are persons whose main tasks require technical knowledge and experience in one or more fields of engineering, physical and life sciences, or social sciences and humanities. They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers. Equivalent staff perform the corresponding R&D tasks under the supervision of researchers in the social sciences and humanities.

(318) Their tasks include:

- -- carrying out bibliographic searches and selecting relevant material from archives and libraries;
- -- preparing computer programmes;
- -- carrying out experiments, tests, and analyses;
- -- preparing materials and equipment for experiments, tests and analyses;
- -- recording measurements, making calculations, and preparing charts and graphs;
- -- carrying out statistical surveys and interviews.

(319) Other supporting staff include skilled and unskilled craftsmen, secretarial and clerical staff! participating in R&D projects or directly associated with such projects.

(321) Included under this heading are all managers and administrators dealing mainly with financial and personnel matters and general administration, insofar as their activities are a direct service to R&D. The

ii) Level of formal qualification

(322) International Standard Classification of Education (ISCED) (UNESCO, 1976) provides the basis for classifying R&D personnel by formal qualification.

(323) Holders of doctorate degrees of university level or equivalent in all fields of the upper part of ISCED level 7. This category includes holders of degrees earned at universities proper and also at specialised institutes of university status.

(324) Holders of third-level degrees below the PhD level in all fields at ISCED level 7 lower part and level 6. This category includes holders of degrees earned at universities proper and also at specialised institutes of university status.

(325) Holders of third-level diplomas not equivalent to a university degree in all fields (ISCED level 5). Studies are typically specialised in subject matter, presented at a level that requires the equivalent of full secondary level education for their mastery. They provide a more practically oriented education than the universities. Many of the courses are offered in part-time, evening, sandwich and refresher programmes.

(326) Holders of diplomas at the second level, second stage (ISCED level 3). This class includes not only all ISCED level 3 diplomas obtained within the academic school system but also the equivalent level 3 vocational diplomas obtained from other types of educational establishments.

(327) Includes all those with secondary diplomas at less than ISCED level 3 or with incomplete secondary qualifications or education not falling under any of the other four classes.

c) ***National aggregates***

(328) The recommended aggregate is for total person-years spent in the performance of R&D on national territory for a given 12-month period. This should be broken down by sector and by occupation and/or formal qualification. The other institutional classifications (and sometimes the functional distributions) are applied within this framework.

V. Measurement of expenditure on R&D

a) ***Intramural and extramural R&D***

(334) Expenditure on R&D may be made within the statistical unit (intramural) or outside it (extramural) R&D expenditure data should be compiled on the basis of performers' reports of intramural expenditures. The collection of extramural expenditures is, however, also desirable as a supplementary source.

b) ***Measuring intramural R&D***

(335,336) Intramural expenditures are all expenditures for R&D performed within a statistical unit or sector of the economy, whatever the source of funds. Expenditures made outside the statistical unit or sector but in support of intramural R&D (*e.g.* purchase of supplies for R&D) are included. Both current and capital expenditures are included.

(338,342) **Labour costs**. These comprise annual wages and salaries and all associated costs or fringe benefits such as bonus payments, holiday pay, contributions to pension funds and other social security payments, payroll taxes, etc. The labour costs of persons providing indirect services and which are not included in the personnel data (such as security and maintenance personnel or the staff of central libraries, computer departments, or head offices) should be excluded and included in other current costs. Only the actual "salaries"/stipends and similar expenditures associated with postgraduate students should be reported.

(343) **Other current costs**. These comprise non-capital purchases of materials, supplies and equipment to support R&D performed by the statistical unit in a given year. Examples are: water and fuel (including gas and electricity); books, journals, reference materials, subscriptions to libraries, scientific societies and so on; imputed or actual cost of small prototypes or models made outside the research organisation; materials for laboratories (chemicals, animals, etc.). Administrative and other overhead costs (such as interest charges and office, post and telecommunications, and insurance costs) should also be included, prorated if necessary to allow for non-R&D activities within the same statistical unit. All expenditures on indirect services should be included here, whether carried out within the organisation concerned or hired or purchased from outside suppliers. Examples of such services are security; storage; use, repair and maintenance of buildings and equipment; computer services; and printing of R&D reports.

(351) Data on R&D expenditure on both a provider and funder basis should be at factor cost. This means **excluding VAT** and similar sales taxes from the measured cost of the R&D and specifically of R&D financed by government.

(354) All **depreciation** provisions for building, plant, and equipment, whether real or imputed, should be excluded from the measurement of intramural expenditures.

(355) **Capital expenditures** are the annual gross expenditures on fixed assets used in the R&D programmes of statistical units. They should be reported in full for the period when they took place and should not be registered as an element of depreciation. They are composed of expenditures on:

(356) **Land and buildings.** This comprises land acquired for R&D (*e.g.* testing grounds, sites for laboratories and pilot plants) and buildings constructed or purchased, including major improvements, modifications, and repairs.

(360) **Instruments and equipment**. This comprises major instruments and equipment acquired for use in the performance of R&D.

c) Gross domestic expenditure on R&D (GERD)

(385) GERD is total intramural expenditure on R&D performed on the national territory during a given period.

(386) GERD includes R&D performed within a country and funded from abroad but excludes payments made abroad for R&D. GERD is constructed by adding together the intramural expenditures of the four performing sectors. It is often displayed as a matrix of performing and funding sectors. The GERD and GERD matrix are fundamental to the international comparison of R&D expenditures. They also provide the accounting system within which the institutional classifications and functional distributions may be applied.

VI. Sources of funds

(366) R&D is an activity where there are significant transfers of resources between units, organisations, and sectors. Every effort should be made to trace the flow of R&D funds. These transfers may be measured in two ways:

- -- **Performer-based** reporting of the sums which one unit, organisation, or sector has received from another unit, organisation, or sector for the performance of intramural R&D.

- -- **Source-based** reporting of extramural expenditures which are the sums a unit, an organisation, or a sector reports having paid to another unit, organisation, or sector for the performance of R&D.

(367) The first of these approaches is strongly recommended.

(368) For such a flow of funds to be correctly identified, two criteria must be fulfilled:

- -- there must be a direct transfer of resources:
- -- this transfer must be both intended and used for the performance of R&D.

(369) Such transfers may take the form of contracts, grants, or donations and may take the form of money or of other resources (*e.g.* staff or equipment lent to the performer). When there is a significant non-monetary transfer, the current value has to be estimated since all transfers must be expressed in financial terms.

(371) Contracts or grants paid for the performance of current or future R&D are clearly identifiable as a transfer of funds. Transfer of funds from the government to other sectors is particularly important to the users of R&D data.

(372) Two categories of such government funds may be identified:

- -- those which are specifically for the procurement of R&D, *i.e.* the results of the R&D belong to the recipient of the output or product of the R&D, who is not necessarily the funder of the R&D;

- -- those which are provided to the performers of R&D in the form of grants or subsidies, with the results of the R&D becoming the property of the R&D performers.

(374) In theory, when a government allows a firm or university to use, free of charge, facilities such as a wind-tunnel, observatory or launching site while carrying out R&D, the value of the service (an imputed rental) should be identified as a transfer. In practice, the beneficiary would not normally be able to make such an estimate, and the donor might not be able to do so either.

(375) In some cases, a firm's R&D project may be financed by loans from a financial institution, an affiliated company, or a government. Loans which are to be repaid are not to be considered transfers; loans which may be forgiven are to be considered transfers (by convention).

(376) There are also a variety of other government incentives for R&D in the business enterprise sector. Examples are the remission of income taxes for industrial R&D, the payment by a government, on demand and after audit, of a certain portion of some or all of a firm's R&D expenditures, bonuses added to R&D contracts to encourage a firm in its own R&D, remission of taxes and tariffs on R&D equipment, and the reimbursement of part of a firm's costs if it hires more R&D staff. For the present, even where these transfers can be separately identified, they should not be counted as direct support for R&D. The statistical units should therefore report gross expenditures as incurred, even when their actual costs may be reduced because of remissions, rebates, or post-performance grants.

(380) Further problems arise when money passes through several organisations. This can occur when R&D is subcontracted, as is sometimes the case in the business enterprise sector. The performer should indicate, so far as possible, the original source of the funds for R&D. In some countries, intermediary non-performing organisations play an important role in the financing of R&D by distributing among performers grants received from several different sources but not "earmarked" for specific purposes. Well-known examples are the Stifterverband für die Deutsche Wissenschaft and the Deutsche Forschungsgemeinschaft in Germany. In such cases it is acceptable to regard these organisations as the source, although it is preferable to attempt to trace the funds to their original sources.

(381) **Public general university funds**. Probably the largest single area of disagreement about sources of funds occurs with public general university funds (GUF). Universities usually draw on three types of funds to finance their R&D activities:

a) R&D contracts and earmarked grants received from government and other outside sources. These should be credited to their original source.

b) Income from endowments, shareholdings, and property, plus receipts from the sale of non-R&D services such as fees from individual students, subscriptions to journals, and sales of serum or agricultural produce. These retained receipts are clearly the universities' "own funds". In the case of private universities, these may be a major source of funds for R&D.

c) The general grant they receive from the Ministry of Education or from the corresponding provincial or local authorities in support of their overall research/teaching activities. This case gives rise to a conflict between the principle of tracing the original source and that of using the performer's report and also to some disagreement about how the criterion concerning the intentions of the funder should be applied. In the first approach one argues that, as government is the original source and has intended at least part of the funds concerned to be devoted to R&D, the R&D content of these public general university funds should be credited to government as a source of funds. Using the second approach, one argues that it is within universities that the decisions are taken to commit money to R&D out of a pool which contains both "own funds" as narrowly defined in (b) and public general university funds; therefore, the sums concerned should be credited to higher education as a source of funds. While no recommendation can be made for national practice, government-financed GUF should be credited to the public sector as a source of funds for the purposes of international comparisons. For clarity, publicly financed GERD is divided into two sub-categories:

-- direct government funds;
-- GUF.

(382) The following procedures should be adopted:

-- GUF should be separately reported and any adjustments to the R&D costs series should take account of real or imputed social security and pensions provisions, which should be credited to GUF as a source of funds;

-- monies from the higher education "block grant" should be classified as GUF, and other monies generated by the sector should be considered as "own funds";

-- adjustments related to "other current costs" to account for real or imputed payments of rents, etc., should be debited to direct government funds.

VII. Government budget appropriations for R&D (GBAORD)

a) General approach

(422) There are two ways of measuring how much governments spend on R&D. The first and most accurate is to hold surveys of the units which actually carry out R&D (firms, institutes, universities, etc.) in order to identify the amount actually spent on R&D over the previous year and the share which was financed by government. The sum of the R&D spending in a national territory is known as "government-financed gross domestic expenditure on R&D".

(424) A second way of measuring government support for R&D has been developed using data collected from budgets. This essentially involves identifying all the budget items involving R&D and measuring or estimating their R&D content in terms of funding. These estimates are less accurate than the performance-based data described above but, as they are derived from the budget, they can be linked to policy issues by means of classification by "objectives" or "goals". It is the specifications of such budget-based data which are described in this chapter.

(425) The budget-based data are now officially referred to as "government budget appropriations or outlays for R&D" (GBAORD). The use of the term "budgetary appropriations for R&D" in this Manual is intended to be a general term to describe government allocations to R&D and should not be interpreted as a direct reference to any national government's budgetary practice.

(427) Data on the socio-economic objectives of GBAORD are rarely obtained by special surveys. They generally have to be extracted in some way from national budgets which already have their own methodology and terminology. The preparation of such data is therefore subject to special constraints and norms cannot be described as categorically as other types of R&D data.

(434) GBAORD data should be based on reports by the funder rather than the performer.

(435) GBAORD clearly includes all outlays to be met from taxation.

(431) For the purposes of GBAORD, it is recommended that:

- -- central or federal government should always be included;
- -- provincial or state government should be included where its contribution is significant;
- -- local government funds (*i.e.* those raised by local taxes) should be excluded.

(432,439) GBAORD covers not only government-financed R&D performed in government establishments, but also government-financed R&D in the other three national sectors (business enterprise, private non-profit, higher education) and also abroad (including international organisations). GBAORD includes public general university funds (GUF).

(440) Loans that may be forgiven should be included in GBAORD, but loans that are to be repaid and indirect support of industrial R&D via tax rebates, etc., should in principle be excluded. Nevertheless, when such indirect support programmes are undertaken as part of an integrated R&D policy (for example, when the sources are documented and are included in interministerial discussions of a science budget), they

may be included in GBAORD. However, indirect funding should always be declared separately so that it can be excluded when making certain international comparisons.

(441) GBAORD includes both current and capital expenditure.

(444,445) The point *in time* at which it is both meaningful and practical to measure GBAORD varies from one country to another. Nevertheless, it is suggested that:

-- Data for the current and coming years should be based on initial intentions, *i.e.* the data should reflect the amount the government intends to devote to R&D.

-- Data for past years should be based on final measures of GBAORD ranging from final intentions as reflected in the definitive budget to final outlays.

b) Distribution by socio-economic objective

(446) Two approaches to distribution are possible:

a) according to the purpose of the R&D programme or project;
b) according to the general content of the R&D programme or project.

(448) Purpose is the more fundamental from the viewpoint of government policy, and this approach is used in principle for the collection of GBAORD by socio-economic objective.

(449) Though some government-supported R&D programmes have only one purpose, others may be supported for a number of complementary reasons. For example, a government may commit money to an aircraft project primarily for military reasons but also to encourage export sales by the aerospace industry and even to assist spin-off to civil aviation. However, in reports to the OECD R&D should be classified according to its primary objective.

(450) Where there are problems in identifying the primary purpose of the funder of the R&D or where there seem to be differences between the "purpose" and the "content" of a programme, two principles originally developed for NABS may be of use:

-- Direct derivation: A project which owes its existence solely to the technical needs of another programme is directly derived from the said programme and should be classified with it.

-- Indirect spin-off: Where the results of R&D undertaken for one purpose are subsequently reworked to give an application relevant to another objective, this is indirect spin-off and should be credited to the objective to which the subsequent R&D is oriented.

(55) The aim of classifying GBAORD by socio-economic objective is to assist government science and technology policy formulation. Consequently, the categories have to be broad, and the series are intended to reflect the amount of resources devoted to each primary purpose (defence, industrial development, etc.). Governments in OECD countries generally pursue science policies and thus distribute their R&D funds in ways which match, to a large extent, the 11 broad categories used by the OECD. Nevertheless, the fit is

never perfect and always reflects the policy intentions of a given programme rather than its precise contents. Because of this and because of methodological constraints on the way they are compiled, the strict level of international comparability is probably lower for GBAORD data than for most of the other series discussed in the Manual.

(271) The following distribution list is suggested:

1. Development of agriculture, forestry and fishing
2. Promotion of industrial development
3. Production and rational use of energy
4. Development of the infrastructure
   4.1 Transport and telecommunications
   4.2 Urban and rural planning
5. Monitoring and protection of the environment
   5.1 Prevention of pollution
   5.2 Identification and treatment of pollution
6. Health (excluding pollution)
7. Social development and services
8. Exploration and exploitation of the Earth and the atmosphere
9. General advancement of knowledge
   9.1 Advancement of research
   9.2 GUF
10. Civil space
11. Defence.

VIII. Conclusions

(56) To conclude, four general points about the use of both R&D statistics and R&D funding data:

a) Such series are only a summary quantitative reflection of very complex patterns of activities and institutions. For this reason, it can be dangerous to use them "neat". They should, as far as possible, be analysed in the light of any relevant qualitative information. Particularly in the case of international comparisons, the size, aspirations, economic structure and institutional arrangements of the countries concerned should be taken into consideration.

b) Users generally refer to R&D data with a question in mind: "Is our national university research effort declining?" "Does my firm spend a higher proportion of its funds on basic research than the average for my industry?", etc. In order to answer these questions it is necessary to identify the relevant basic data and then use them to construct an R&D indicator to answer the question. Some basic data may be accurate enough to answer one question but not another. For example, GBAORD data are usually accurate enough to answer general questions about trends in easily defined objectives -- "Is there any sign that defence R&D is picking up again in the OECD area?" -- but are not suitable for specific questions about less easily defined objectives -- "Does my country spend more or less in absolute terms on environmental protection R&D than country X?"

c) One way of constructing such indicators that is particularly useful for making international comparisons is to compare R&D inputs with a corresponding economic series, for example, by taking GERD as a percentage of GDP. Such broad indicators are fairly accurate but can be biased if there are major differences in the economic structure of the countries being compared. The classifications and norms used to collect R&D statistics are, as far as possible, compatible with those for general statistics, and although it is much more difficult to make detailed comparisons between R&D and non-R&D series, establishing such "structural" R&D indicators can be particularly revealing.

d) The problems of data quality and comparability which have been noted above are characteristic of the whole range of data on dynamic socio-economic activities -- such as employment or international trade -- which are important to policy makers, managers, analysts and others. The philosophy underlying the evolution of R&D statistical standards in the Manual has been to identify and gradually resolve these problems by exploring various approaches and learning from Member countries' experience.

Annex. Selected Classifications

Table 1. **Revised industrial classification for resources devoted to R&D in the business enterprise sector in the OECD 1993 R&D Questionnaire and correspondence with ISIC Rev.3, ISIC Rev.2 and NACE Rev.1**

Title	ISIC Rev.3 Division/Group/ Class	Approximate correspond. ISIC Rev.2 Division/Group/Class	Corresponding NACE Rev.1 Division/Group/ Class
1. AGRICULTURE, HUNTING AND FORESTRY	**01+02+05**	**1**	**01+02+05**
2. MINING	**10-14**	**2**	**10-14**
3. MANUFACTURING	**15-37**	**3**	**15-37**
4. Food, beverages and tobacco	**15+16**	**31**	**15+16**
5. Food products and beverages	15	311-313	15
6. Tobacco products	16	314	16
7. Textiles, wearing apparel, fur and leather	**17-19**	**32**	**17-19**
8. Textiles	17	321	17
9. Wearing apparel and fur	18	}	18
10. Leather products and footwear	19	}322-324	19
11. Wood, paper, printing, publishing	**20-22**	**331+34+3832 (part)**	**20-22**
12. Wood and cork (not furniture)	20	331	20
13. Pulp, paper, and paper products	21	341	21
14. Publishing, printing, and reproduction of recorded media	22	342+3832 (part)	22
15. Coke, petroleum, nuclear fuel, chemicals and products, rubber and plastics	**23-25**	**35**	**23-25**
16. Coke, refined petroleum products, and nuclear fuel	23	353+354	23
17. Chemicals and chemical products	24	351+352	24
18. Chemicals and chemical products (less pharmaceuticals)	24 less 2423	351+352 less 3522	24 less 24.4
19. Pharmaceuticals	2423	3522	24.4
20. Rubber and plastic products	25	355+356	25
21. Non-metallic mineral products ("Stone, clay, and glass")	**26**	**36**	**26**
22. Basic metals	**27**	**37**	**27**
23. Basic metals, ferrous	271+2731	371	27.1-27.3+27.51/52
24. Basic metals, non-ferrous	272+2732	372	27.4+27.53/54
25. Fabricated metal products (except machinery and equipment)	**28**	**381**	**28**
26. Machinery equipment, instruments and transport equipment	**29-35**	**38 less 381 and 3832 (part)**	**29-35**
27. Machinery, n.e.c.	29	382 less 3825+3829 (part)	29
28. Office, accounting and computing machinery	30	3825	30
29. Electrical machinery	31	383 less 3832	31
30. Electronic equipment (radio, TV, and communications)	32	3832 (part)	32
31. Electronic components (includes semiconductors)	321		32.1
32. Television, radio and communications equipment	32 less 321		32 less 32.1
33. Medical, precision and optical instruments, watches and clocks (instruments)	33	385	33
34. Motor vehicles	34	3843	34
35. Other transport equipment	35	384 (part)+3829 (part)	35
36. Ships	351	3841	35.1
37. Aerospace	353	3845+3829 (part)	35.3
38. Other transport n.e.c.	352+359	3842+3844+3849	35.2+35.5
39. Furniture, other manufacturing n.e.c.	**36**	**332+39**	**36**
40. Furniture	361	332	36.1
41. Other manufacturing n.e.c.	369	39	36.5
42. Recycling	**37**	**NA**	**37**
43. ELECTRICITY, GAS AND WATER SUPPLY (UTILITIES)	**40+41**	**4**	**40+41**
44. CONSTRUCTION	**45**	**5**	**45**
45. SERVICE SECTOR	**50-99**	**6-9**	**50-99**
46. Wholesale, retail trade and motor vehicle, etc., repair	**50-52**	**61+62+6 (part)**	**50-52**
47. Hotels and restaurants	**55**	**63**	**55**
48. Transport and storage	**60-63**	**71**	**60-63**
49. Communications	**64**	**72**	**64**
50. Post	641		64.1
51. Telecommunications	642		64.2
52. Financial intermediation (including insurance)	**65-67**	**81+82**	**65-67**
53. Real estate, renting and business activities	**70-74**	**83+932**	**70-74**
54. Computer and related activities	72	8323	72
55. Software consultancy	722		72.2
56. Other computer services n.e.c.	72 less 722		72 less 72.2
57. Research and development	73	932	73
58. Other business activities n.e.c.	70+71+74	83 (part)	70+71+74
59. Community, social and personal service activities, etc. (1)	**75-99**	**9 less 932**	**75-99**
60. GRAND TOTAL	**01-99**	**1-9**	**01-99**

(1) Activities carried out in these industries by the business enterprise sector only. Figures are expected to be negligible; the heading is included as an aide-memoire.
n.e.c. = not elsewhere classified.

Table 2. **Fields of science and technology**

1. NATURAL SCIENCES

1.1 Mathematics and computer sciences
[Mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified with the engineering fields).]

1.2 Physical sciences
(Astronomy and space sciences, physics, other allied subjects).

1.3 Chemical sciences
(Chemistry, other allied subjects).

1.4 Earth and related environmental sciences
(Geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences).

1.5 Biological sciences
(Biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences).

2. ENGINEERING AND TECHNOLOGY

2.1 Civil engineering
(Architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects).

2.1 Electrical engineering, electronics
[Electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects.]

2.3 Other engineering sciences
(Such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, *e.g.* systems analysis, metallurgy, mining, textile technology, other allied subjects).

3. MEDICAL SCIENCES

3.1 Basic medicine
(Anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology).

3.2 Clinical medicine
(Anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology).

3.3 Health sciences
(Public health services, social medicine, hygiene, nursing, epidemiology).

4. AGRICULTURAL SCIENCES

4.1 Agriculture, forestry, fisheries and allied sciences
(Agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects).

4.2 Veterinary medicine

5. SOCIAL SCIENCES

5.1 Psychology

5.2 Economics

5.3 Educational sciences
(Education and training and other allied subjects).

5.4 Other social sciences
[Anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary, methodological and historical S&T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences.]

6. HUMANITIES

6.1 History
(History, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.).

6.2 Languages and literature
(Ancient and modern languages and literatures).

6.3 Other humanities
[Philosophy (including the history of science and technology), arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S&T activities relating to the subjects in this group.]