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Manual for Statistics on Scientific and Technological Activities

Division of Statistics
on Science and Technology,
Office of Statistics

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UNITED NATIONS EDUCATIONAL, SCIENTIFIC

AND CULTURAL ORGANIZATION

MANUAL FOR STATISTICS ON SCIENTIFIC AND TECHNOLOGICAL ACTIVITIES

Division of Statistics on Science and Technology,
Office of Statistics

PREFACE

The first version of this Manual was prepared in 1979 by Dr. Giorgio Sirilli of the Institute for Studies on Research and Scientific Documentation of the National Research Council of Italy in co-operation with the Division of Statistics on Science and Technology of Unesco's Office of Statistics. After discussion and consultations with experts in the field of science statistics during that same year it was published on a provisional basis in September 1980 (ST-80/WS/8) and circulated worldwide to specialists for comments and observations. It was also used as background document at the several training seminars organized in the different regions of the world (Asia, Latin America and the Caribbean, Africa and the Arab States) to assist Member States in the implementation of the international standards and methods of date collection on scientific and technological activities.

In the preparation of this revised version particular consideration has been given to the various proposals and suggestions received from interested organizations and individuals and to the comments and observations made during the above-mentioned seminars. It is hoped that with these modifications, the Manual will facilitate the reader in interpreting the concepts and definitions as specified in the Recommendation concerning the International Standardization of Statistics on Science and Technology and will prove useful to those having to respond to the Unesco questionnaires as well as to those in countries which are still in the early phases of developing their science and technology resources statistics.

The concepts, definitions and classifications obviously have remained unchanged and the original layout has been retained. The modifications reflect rather concern for clarification and further explanation. In this connection, a significant addition is that part of the Appendix intended more particularly for the guidance of those Member States of Unesco who also report to OECD and to CMEA (see Appendices D and E) and the presentation of an index.

It is hoped that the guidelines provided therein will lead to an improvement in the quality and comparability of international statistics related to scientific and technological activities.

This present Manual, like the previous one, is issued on a provisional basis and will be subject in the future to further modifications and detail in view of the rapid development in this relatively new field of statistics. It should be noted in this connection that Unesco is currently engaged in the preparation of other methodological documents related directly to the subject, notably in regard to scientific and technological education and training (STET) at broadly the third level and to scientific and technological information and documentation (STID) activities.

Comments and suggestions from the users of this Manual will be welcomed by Unesco. Correspondence concerning the Manual should be addressed to: Division of Statistics on Science and Technology, Office of Statistics, Unesco, Place de Fontenoy, 75700 Paris (France).

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INTRODUCTION

1. The statistical methodology adopted in the surveys carried out by Unesco since 1969 has been progressively developed with the aid of national specialists from different continents and has been discussed at length during missions to Member countries and at meetings convened for this purpose by UNESCO. Its aim is the collection of information on scientific and technological activities (STA) in a form that will provide the maximum international comparability of data.

The most recent initiative of UNESCO in the field of science statistics was the organization of a meeting of a Special Committee of Governmental Experts, which met in Paris from 5 to 14 June 1978, charged to prepare a draft recommendation on the international standardization of statistics on science and technology.

The Recommendation, which was adopted by the General Conference at its twentieth session, on 27th November 1978, (see Appendix A), deals with the scope and definitions of the UNESCO exercise as well as the various phases Member countries are expected to go through in the collection of statistical data.

The scope of the data collection covers the most important scientific and technological activities (Research and experimental development (R&D), Scientific and Technological Education and Training at broadly the third level (STET), Scientific and Technological Services (STS)) but in the Recommendation it is suggested that the extension of international S&T statistics should be developed gradually on the basis of the state of progress of national and international experience.

In view of the fact that the statistical systems of Member countries are not all at the same stage of development, and having in mind the basic needs of the science policy-maker, the data should be presented at two levels of detail or complexity : a first level of detail, consisting of a limited quantity of basic information that is indispensable for establishing international comparisons, which should, if possible, be compiled by all Member states ; a second level of detail, characterized by fuller statistical data which not all Member countries are able to provide but which, taken as a whole, could constitute a guide for those who wish to improve and enlarge their national statistical systems.

In the Recommendation two successive stages are proposed in the process of data collection on scientific and technological activities (STA) at international level: the first, covering a period of at least five years starting from the time the UNESCO General Conference adopted the Recommendation, should cover only research and experimental development (R&D) activities in all sectors of performance, together with S&T manpower resources ; in the second stage, which would be regarded as being of an experimental nature, the statistical observation would be extended to STS and STET.

2. Various other international organizations are also carrying out programmes for the promotion, organization, collection, analysis and interpretation, publication and dissemination of quantitative information

on scientific and technological activities, more particularly on R&D.

OECD

The first efforts to standardize at international level definitions for a survey on R&D were made by the Organization for Economic Co-operation and Development which, in 1963, convened a conference in Frascati, Italy, where a "Proposed Standard Practice for Surveys on Research and Development was discussed and accepted by experts of Member countries. From then on, every two years an "International Statistical Year"(ISY) is carried out in which manpower and expenditure devoted to research and experimental development in the most developed western countries are measured.

On account of the varied and dynamic nature of R&D activities, the Frascati Manual (1) underwent revisions in 1969, 1973 and 1980.

In the course of the last revision, in order to meet the growing demand from science policy makers, the scope of the Manual was widened to cover research, not only in the natural sciences, but also in the social sciences and humanities. Moreover, the need to have more detailed information on the role of government in the promotion of R&D has led to the adoption of a classification by "objectives" to be used in the breakdown of government expenditure for R&D. (Comparison of the standard practice for R&D surveys proposed by OECD with that recommended by Unesco is presented in Appendix D).

At present, given the generally satisfactory quality of the indicators of input (manpower and expenditure), the Science Indicators Unit of OECD, which is in charge of the ISY, is studying the possibility of standardizing at international level some indicators of the output of R&D activity.

In view of the fact that the time series of financial data cover a rather long time span and that, especially after the oil crisis, the inflation rate rose in practically all Member countries, the data on R&D expenditure in the private sector are expressed not only in current prices, but also in constant prices using, for the majority of countries, an ad hoc index calculated by the Secretariat.

The European Communities

Within the framework of the activity of comparison of national and Community science policies, in 1969 a working group of national statistical experts was appointed by the working Group on Scientific and Technical Research Policy (the PREST group), later transformed into the Committee for Scientific and Technical Research (CREST) with the aim of analyzing the funds committed to R&D by the central public administrations.

The data collected by this group - now called Sub-Committee "R&D Statistics" of the CREST - which are drawn from the budgets and therefore have the character of appropriations, are classified by "objective" of the funder according to NABS (Nomenclature for the Analysis and Comparison of Science Programmes and Budgets).

This nomenclature, of which the first version was issued in 1970 and the second, presently in use, in 1975 (2), has been set up following insofar as possible the standards and definition set forth in the Frascati Manual. Some differences exist between the two, however, on account of the fact that NABS deals with budget appropriations whereas the Frascati Manual deals with actual expenditures.

Also, the EEC recently introduced the practice of publishing financial data in constant prices. Previously, the consumer price index was used; at present however, an ad hoc deflator is employed.

NORDFORSK

The Scandinavian Council for Applied Research (NORDFORSK) represents research organizations in Denmark, Finland, Iceland, Norway and Sweden and was set up principally with the aim of initiating, promoting and organizing Nordic co-operation in scientific and industrial research. A special committee on R&D statistics was appointed in 1968 and its several working groups have dealt with the various problems concerned with the production and utilization of R&D statistics, mainly with reference to inter-Nordic comparability of data. The result of this methodological work was a "Nordic Manual" (3) (available in the Nordic languages) issued in 1974 which is a detailed supplement to the Frascati Manual. Some of the preliminary chapters are also available in English.

CMEA

Within the Council for Mutual Economic Assistance (CMEA) system, certain "indicators" in the field of science and technology have been defined (4) which differ somewhat from those adopted by Unesco and those in the Frascati Manual. The improvement of comparability between standards for data used in the two economic areas has been fostered through the UNESCO/ECE (United Nations Economic Commission for Europe) Joint Working Group on Science Statistics. An attempt to compare the R&D statistical concepts followed by the CMEA with those adopted by Unesco can be found in Appendix E.

OAS

The Organization of American States (OAS) has also embarked on a programme in the field of science statistics. A Committee on Improvement of National Statistics (COINS) was set up within the framework of the OAS and the Inter-American Statistical Institute (IASI) having as its main objective the improvement of all types of official statistics and the coordination of these into a statistical programme as a whole. /It may be noted that since 1981 COINS changed its name to Conference of Governmental Statisticians of the Americas (CEGA), CEGA being a new specialized agency, organ of IASI./ Statistics on science and technology are one of the fields being given special consideration in the Inter-American Programme of Basic Statistics (PIEB) and Inter-American standards for this field were adopted by COINS at its XII session in 1975 (5). These standards are particularly relevant to institutions undertaking research and experimental development activities and/or the dissemination of scientific and technical knowledge and are proposed for the collection of scientific and technological data particularly appropriate to the characteristics of the Latin-American countries. (6)

CHAPTER I

SCIENCE STATISTICS AND THE ROLE OF THE MANUAL

1. Science policy-making and science statistics

The formulation of science policy and development of S&T plans and programmes call for sound information on the country's scientific and technical potential. This implies the need of a set of indicators able to detect the relevant aspects of that complex mechanism constituted by the national scientific and technical system. In other words, it is necessary to have available comprehensive data on the overall resources at the disposal of a country for its scientific and technological activities. These data may be administrative, functional, operational or structural in nature; they may or may not be numerical or statistical and they relate to all scientific units of the country(7).

It goes without saying that, as for any social phenomenon, only a part of the necessary inputs for a decision process is quantifiable (personnel involved, budgets, expenditures) whereas other aspects (priorities, coherence of scientific goals with other social plans, evaluation of the national scientific apparatus) remain in the domain of the qualitative sphere.

Regarding the quantitative aspects, in practice one has under control only a limited number of variables, both because a few of them are sufficient to give an adequate picture of the operativity of the scientific structure and of its evolution, and because of the cost in human and financial resources for collecting the relevant information.

Science statistics, which may be defined as a field of statistics dealing with the quantitative measurement of the volume and structure of scientific and technological activities of a given country, provides a conceptual framework wherein information is organized with the aim of measuring, analyzing and evaluating a set of variables relevant to science policy-making.

It tries to reconcile, on the one hand, the need for completeness of information and, on the other hand, the practical possibility of acquiring complete and reliable data. The role of the science statistician is therefore to provide a reliable quantified basis for the study of the national system of science and technology, including not only research and experimental development, but also other scientific and technological activities.

To achieve its aim , science statistics should be consistent with, and fit into the general body of statistics on the various aspects of the national socio-economic context. This need for integration is evident in the statistical systems presently in use which adopt, to the maximum possible extent, the current existing classifications, such as those relating to the national accounting systems - the System of National Accounts (SNA) (8) and the System of Balances of the National Economy (MPS) (9) - and those in respect of industrial activity (10), manpower (11) and education (12).

Another fundamental characteristic of science statistics is international comparability. Given the very nature of science and technology, which implies a strict interdependence amongst countries, no sound science policy may be conceived without an appropriate basis of comparable statistical data.

2. Aim of the Manual

The aim of this Manual, which is intended for use by specialists in various countries entrusted with the task of collecting, processing and analyzing science statistics data, is the harmonization of categories and definitions used by science statisticians in the Unesco Member states. In this perspective, one has to bear in mind that the existence of various types of socio-economic systems and the great variation in the level of development of countries, make this task both difficult and necessary.

For this reason in this Manual the international standards for statistics on science and technology (and more specifically on R&D) recommended by Unesco (see Appendix A) are set forth and explained, with a view to their application by Member states and in particular to their utilization for reporting information to Unesco.

There is no reason why countries which adopt their own standards should not continue to follow their own practice; however, they should make every effort in the case of inconsistency, to translate their data into this framework. The planner and policy-maker, at the national as well as at the international level, need complete, accurate and comparable information in the form of basic and significant data which can only be achieved by conforming to a set of accepted standards and definitions. In this context, with regard to Latin America, the Office of Statistics has published three studies of national statistical practices in relation to scientific and technological activities in 9 countries (13). These comparative analyses describe the classifications, categories and concepts used in national statistical methodologies for science and technology and set out adaptations of these statistical categories with a view to their harmonization with the standards contained in the Unesco Recommendation. A practical guide (14), based on these three studies has also been published (in Spanish only) to show concisely, and as clearly as possible, the equivalent terms for concepts and classifications used in 8 countries of Latin America and those established by Unesco. This should also prove very valuable to these countries in particular when reporting information on science and technology and more specifically on R&D to Unesco.

It should be borne in mind that the reporting of statistical information to Unesco does not constitute an end in itself nor does it serve a purely academic purpose (so far this information relates to research and experimental development (R&D) only). The information reported in a standardized and internationally comparable form, is elaborated by Unesco's Office of Statistics and published in, among others, the Unesco Statistical Yearbook so that each Member state has access to it. As a result, each country can see and evaluate its position, in respect of the magnitude of human and financial resources devoted to R&D, in relation to all other reporting countries. From such a comparison, every country can judge the volume and structure of its own outlays for R&D; in the light of the full international context, such a judgement constitutes an input in science policy and planning decisions. Another use made by Unesco of the reported information relates to the regional and world level. If the information is sufficiently comparable, regional and world aggregates can be made and analyzed in studies prepared for various inter-governmental or international conferences.

The following flow-chart describes the role of Member states and of Unesco in collecting and distributing information on R&D as well as the utilization of such information for national and international purposes.

MEMBER STATES

UNESCO

Office of Statistics

National statistical services in charge of statistics on science and technology:

- Implement the international standards specified in the Recommendation and the Manual
- In reply to requests from Unesco, supply standardized statistical information on R&D activities

- Establishing international standards in statistics on science and technology
- Preparation of the Recommendation and the Manual; and supplying them to Member States for implementation
- Requesting statistical information from Member States on scientific and technical manpower and on human and financial resources devoted to R&D

- Collection, processing, and storage of data in the data bank
- Computerized data retrieval

- Publication of the Unesco Statistical Yearbook
- Preparation of Conference papers (e.g. for regional and world conferences on science and technology)
- Effecting analytical studies (e.g. in the "Current studies and research in statistics" series)
- Providing selected data for incorporation in the United Nations Statistical Yearbook
- Supplying data to researchers on request

National bodies responsible for the development and the application of science and technology:

- Analysis and research
- Evaluation of the national effort in the light of international comparisons
- Forecasting and planning
- Science policy decision-making

Flow of statistical information - R&D

As for the periodicity of data collection, the Recommendation advocates that the basic international statistics be updated biennially. However, it would be desirable for Member countries which can do so, to update annually certain fundamental data on R&D effort, so that short-term variations can be seen.

It should be noted that a similarity exists between this Manual and the OECD "Frascati Manual". In fact, both of them deal with the measurement of scientific and technological activities and share the main concepts and categories, setting forth appropriate flexible standards. However, whereas the Frascati Manual has been principally designed for the OECD member countries, this Manual has a world-wide scope, being intended to serve as a reference point both for developed and developing countries as well as for the market economy and centrally-planned countries. In practice, the differences arising from this wider scope have very little effect on the key fundamental concepts such as, for example, scientific and technological activites and manpower, but they do play an important role in the classifications proposed.

It is worth mentioning that this is the first Manual on science statistics that the Unesco Office of Statistics has published since it began collecting data on S&T activities. In 1977 a "Guide to the Collection of Statistics on Science and Technology" (15) was issued with the aim of helping countries to develop and improve their national science statistics collection systems.

The Office of Statistics is currently preparing a new version of the Guide which should be published during 1984 taking into consideration the modifications necessitated by the adoption of the Recommendation. In the meantime, science statisticians should consider partI of the Guide as superseded by the present Manual (in which the international standards recommended by Unesco are reported, elaborated and operationalized) but for the moment can consider still valid Parts II and III, which deal respectively with the collection of science statistics and the preparation of the data for statistical analysis.

In order to minimize the arbitrariness involved in setting up and carrying out a survey on science statistics, every effort has been made to render the definitions as clear as possible. However, it should be remembered that the concepts and the definitions contained in this Manual embody a certain degree of incompleteness and that the comparability with other socio-economic statistics is not always assured, even when the same terms are used. This is the price that has to be paid for the multiple utilization of the same standards in different fields, and it is up to the user of science statistics to exercise his judgement.

Finally, one has to bear in mind that the intrinsic remarkable dynamism of the reality under review makes it difficult to establish definitions valid for a long time-span and that definitive standards can never be achieved.

3. Scope of the Manual

Particularly during the last fifteen years or so, valuable experience in surveying scientific and technological activities has been acquired in many Member states, the core of the surveys being the measurement of the resources devoted to research and experimental development.

With a view to progressively broadening the scope of science statistics, the Recommendation covers all the main scientific and technological activities (STA):

- research and experimental development (R&D),
- scientific and technological education and training at broadly the third level (STET),
- scientific and technological services (STS) performed or financed by all national institutions in the fields of natural sciences, engineering and technology, medical and agricultural sciences as well as in the fields of social sciences and humanities.

The Manual, therefore, relates to statistics designed to provide standardized information in each Member State on the aforementioned scientific and technological activities, but this first edition concentrates particularly on research and experimental development.

The measurement of S&T activities hinges on the most relevant inputs - manpower and expenditure - considering that, at this point in time, for the majority of scientific and technological activities no really satisfactory and generally applicable measures of output have yet been found. However, this is the general practice adopted in many other service activities where the results are so broadly diffused in time and in space as to make a complete and exhaustive measurement impossible.

Measuring inputs devoted to S&T activities in terms of manpower and expenditure only is a limited approach and links S&T statistics with economics. There are, of course, still other important inputs of a non-economic and qualitative nature such as intellectual and cultural tradition as well as unpredictable factors (e.g. appearance of geniuses and exceptionally-talented scientists, changes in the intellectual climate more or less conducive to creative thinking, etc).

Despite the economic ties, S&T statistics constitute an indispensable basis for the evaluation of national efforts deployed in developing the potential for scientific and technological output.

CHAPTER II

SCIENTIFIC AND TECHNOLOGICAL ACTIVITIES

1. Definition and scope

For statistical purposes, scientific and technological activities (STA) can be defined as all systematic activities which are closely concerned with the generation, advancement, dissemination, and application of scientific and technical knowledge in all fields of science and technology, that is the natural sciences, engineering and technology, the medical and the agricultural sciences (NS), as well as the social sciences and humanities (SSH).

Two major aspects characterise this definition. The first aspect relates to the nature of S&T activities : they concentrate upon, or are closely connected with, the production, the distribution and the utilization of scientific and technical knowledge. It is within the scope of S&T activities that scientific and technical knowledge is created, distributed, collected, modified, transformed, adapted to use and utilized. The second is connected with the fields covered.

In accordance with the notion of the unity of science, the above definition applies equally to the NS as well to the SSH. An illustration of the content of these two broad groups of sciences is given in Chapter V (Item 3.2).

The activities which should be covered in the statistical practice may be divided into three broad groups :
- Research and experimental development;
- S&T education and training at broadly the third level;
- Scientific and technological services.

There are several other activities, which either are not intimately nor predominantly concerned with the generation, dissemination and application of scientific and technical knowledge or which present particular statistical difficulties, which should be excluded from the scope of the measurement of S&T activities. In particular, this means the exclusion of : general school education at the primary and secondary levels (corresponding to ISCED levels 1, 2 and 3), (see Appendix B) and non-formal industrial training (apprenticeship, on-the-job training, etc.); the routine activities of publishing houses, radio and television broadcasting corporations ; general and specialized medical and health services ; industrial production and distribution of goods and services (including trial production following successful testing of prototypes).

1.1 Research and experimental development (R&D)

Research and experimental development (R&D) can be defined as any systematic and creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications.

From this definition it is evident that the crucial element in identifying R&D is the presence of an element of creativity and innovation. This common character is shared both by scientific research and by experimental development.

In order to identify properly these two activities, the essential elements which characterize them are set forth:

i) the element of creativity;
ii) the element of novelty or innovation;
iii) the use of scientific methods;
iv) the generation of new knowledge.

A scientiric activity may be defined as scientific research only if these four elements are present.

For example, painting, even though it implies a great deal of creativity and leads to a picture which is something new in nature, is not scientific research, as it does not lead to the increase of scientific knowledge and does not use a scientific method.

In surveying S&T activities, and hence R&D, other conditions should be met : the activity under review has to be continuous, structured, i.e., systematic, and institutionalized. Especially relevant is the institutionalization of S&T activities.

The concept of institutionalization implies that only activities performed within the framework of an institution by persons working in the institution, in its service or affiliated to it should be taken into consideration; the concept of structured research (or STA) implies that within an institution only those activities performed on a systematic basis, which usually appear in the institution's programme of work, should be taken into consideration.

These two conditions thus eliminate from the statistics such STA as individuals may exercise outside their professional context, those which are not offset by any financial recompense (voluntary work, for example) and those carried out on a scattered or sporadic basis within an institution. However, this does not imply that, for national purposes, such activities may not, from a conceptual point of view, fall into the category of S&T activities nor that they may not be valuable as such; it only means that international comparability would not gain with their inclusion at the present stage of data collection.

For example, the work carried out by an independent inventor, even though it contributes to the increase of scientific knowledge and meets the other three conditions, should be excluded from the scope of science statistics as it is not necessarily a continuous activity and it is not carried out within an organization.

Of course, there may be cases of systematic and continuous scientific activities performed by outstanding individual scientists outside the institutional framework whose work may contribute enormously to science, or even revolutionize its basic ideas and concepts; however,

these phenomena may be considered exceptions which are by definition outside the scope of science statistics.

The requirement of institutionalization is understandable if one thinks that, for the purposes of the science policy-maker and of the user in general, only those activities which may be to some extent affected by policy decisions are of interest, whereas an intermittent or spontaneous contribution produces its effect outside this framework. Moreover, it goes without saying that the problems involved in surveying these activities would be insurmountable.

In view of the importance attached to the difference between generation on the one hand and adaptation and practical utilization of scientific knowledge on the other, it seems advisable to deal with scientific research separately from experimental development.

1.1.1 Scientific research activities

Scientific research activities can be defined as any systematic and creative work aimed at increasing the stock of scientific knowledge and at applying it in practice.

This is a very general definition which, in order to adhere more strictly to the nature of the NS and the SSH merits two complementary definitions:

Scientific research activities in the natural sciences, engineering and technology, medical and agricultural sciences can be defined as any systematic and creative activities designed to ascertain the links between, and the nature of, natural phenomena, to generate knowledge of the laws of nature and to contribute to the practical application of this knowledge of laws, forces and substances.

Scientific research activities in the social sciences and humanities can be defined as any systematic and creative activity aimed at increasing or improving knowledge of man, culture and society, including use of such knowledge for the solution of social and human problems.

It should be noted that the above two definitions have exactly the same conceptual content: scientific investigation aiming at the understanding of phenomena and at solving problems. The only difference lies in the domain concerned: in the first case, the field is the whole spectrum of the natural phenomena whereas in the second, the definition has been designed to adhere to the problems concerning man and his social environment. At the same time these additional definitions provide some clarification to the general all-embracing definition in which the term "applying it in practice" appears. This term, which is acceptable as a generality, should not be adhered to strictly as it is too limiting. If it were strictly applied, investigative activities could only be called research if they were aimed at applications; in fact, fundamental research projects are not oriented specifically towards any particular application and these should not be excluded (see 1.1.1.1, p. 20).

In statistical practice, experience has shown that concepts originally developed for the NS do not always apply to research activities in the SSH; some countries find that surveys can cover all sciences in all sectors equally, others find that common procedures are not always appropriate.

Scientific research, both in the NS and in the SSH, may be classified according to two categories or types :

- fundamental or basic research;
- applied research.

This subdivision, even though criticized by some experts, has been retained in the Recommendation. One is aware of the subjectivity involved in distinguishing between the two categories and the consequent difficulties respondents often have in evaluating what kind of research their organizations are engaged in, but experience has shown that an analysis of this sort is of great significance for the users of science statistics.

It should be remembered that, in statistical practice, when a subjective judgement is involved in classifying a certain S&T activity and the resources devoted to it, if the funder's and performer's standpoints do not conform, the preference should be given to the performer.

1.1.1.1. Fundamental research

Fundamental (or basic) research can be defined as any experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular or specific application or use in view.

According to the above definition, research has to be considered fundamental when its aim is the fuller understanding of phenomena in th widest sense - thus in the NS as well as in the SSH - and/or its objective is the discovery of new fields of investigation with no immediate practical purpose in mind.

Fundamental research is characterized by a great degree of freedom in the sense that the scientist in charge of it quite often may decide about the subject investigated and organize his own work.

The results of this activity often affect a broad area of science and usually claim general or universal validity; they often take the form of general principles, theories and laws and may be communicated (through publication in scientific journals, circulation to colleagues, papers presented at scientific congresses, etc.).

1.1.1.2. Applied research

Applied research can be defined as any original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.

The decisive character which allows one to identify applied research is then the specific application in view. So, if the process of acquisition of new knowledge has a particular practical aim

it is applied research, whereas if the research has no specific application in view it can be considered as fundamental research.

Applied research is undertaken either to develop the results of fundamental research with a view to their practical application or to determine new methods or ways of achieving some specific and predetermined practical aim.

Thus, in general, one could say that by applied research, theories are developed into operational form. The results of applied research generally affect limited areas of science and technology and have a specialized character as they are intended to be relevant to specific fields, problems or cases.

1.1.2. Experimental development

Experimental development can be defined as any systematic work, drawing on existing knowledge gained from research and/or practical experience that is directed to producing new materials, products and devices, to installing new processes, systems and services, and to improving substantially those already produced or installed.

The concept of experimental development is theoretically and practically applicable both to the natural sciences, engineering and technology, medical and agricultural sciences and to the social sciences; however, it makes very little or no sense in the case of humanities.

The main criterion for distinguishing experimental development from research (fundamental or applied) is the following : whereas fundamental and applied research are primarily directed towards the increase of scientific and technical knowledge, experimental development is directed towards the introduction of new applications (e.g. new materials or new technologies).

The activities involved in adapting imported technology and the activities directed towards a substantial improvement of existing technology in general should be explicitly mentioned here as being experimental development work. Activities of this kind are relatively important in developing countries. In the course of this adaptation work, some applied research may even become necessary. Two representative examples may illustrate this specific kind of experimental development work ; the development of efficient processes for the beneficiation or reduction of low-grade ores in order to be able to exploit available iron-ore resources, which will require some research; and the adaptation of existing textile processes and equipment imported from developed countries to suit locally cultivated fibres.

The activities in the field of the social sciences most frequently referred to as corresponding in some way to the concept of experimental development in the NS are activities in the field of socio-economic planning (such as the development of programmes directed to the solution

of socio-economic problems), as well as in the field of education (such as the development of teaching machines or audio-visual aids). These activities may be either regarded as consequent, more practical phases of applied research, verifying the results of fundamental research and/or the preceding phase of applied research, or, in the case where no element of innovation can be identified, as mere application of the results of (fundamental and applied) research. In this latter case these activities should be excluded from R&D statistics.

Finally, as regards the problem of defence R&D, the practice has been to include R&D activities undertaken for a military purpose or for national defence in R&D statistics (see also Chapter V, item 4).

Examples illustrating the concepts of fundamental research, applied research and experimental development in the NS :

Fundamental research	Applied research	Experimental development
1. Study of the numerical solutions of differential equations	Study of the numerical solutions of differential equations to be used for describing undulation (e.g. for describing intensity and velocity of transmission of radio-waves)	Development of computer programmes for the numerical solution of differential equations used for describing undulation
2. Study of pressure conditions and buoyancy of solids in gas streams	Study of pressure conditions and buoyancy of solids in streaming air with a view to obtaining aerodynamic data required for the construction of missiles and aircraft	Development of the body (fuselage) of an aircraft-prototype
3. Study of the geological setting of geothermal fields and of the geothermal processes going on in order to obtain basic knowledge on their origin	Study of geothermal sources with a view to possibilities of utilizing these natural reservoirs of steam and hot water	Development of processes for using the geothermal steam or hot water for the production of electric power, for heating purposes or as a source of extractable minerals

Fundamental research	Applied research	Experimental development
4. Study of biochemical and biophysical mechanisms related to the radioresistance of microorganisms	Microbiological studies on the influence of combined processes of heat and irradiation on the survival of yeast with a view to obtaining information required for the development of methods for preservation of fruit juice	Development of a process for preservation of fruit juice by means of gamma radiation
5. Study of the process of digestion of lactose (milk sugar) by lactase, the enzyme that breaks it down	Study of the widespread phenomenon of adult intolerance to lactose with a view to obtaining information required for the development of a testing method for determining this intolerance in adults	Development of a testing method for determining lactose intolerance (by measuring blood glucose after ingestion of lactose)
6. Study of the mechanism that enables a living organism to distinguish foreign cells from its own (genes, anti-genes, markers of biological individuality)	Study of the immunological mechanism that causes the rejection of foreign tissue with a view to finding a way to suppress that mechanism in the case of a transplantation of organs	Development of a technique to suppress that rejection mechanism by drugs in order to enable grafts to survive or to make a successful transplantation of organs possible
7. Study of the influence of psychological factors on diseases	Study of the psychological factors (stress, etc.) causing stomach ulcers, with a view to obtaining information required for the development of adequate treatment methods	Development of a new treatment for stomach ulcers caused by psychological factors
8. Study of the iso-electric patterns of iso-enzymes from potato tissue cultures	Studies on the growth of potato tissue cultures in various nutrient media	Development of a technique for the production of virus-free potato plants by means of tissue cultures

Fundamental research	Applied research	Experimental development
9. Study of protein bio-synthesis of plants in relation to the photo-synthetic rate	Study of genetic properties of cereals relating to resistance to diseases in order to obtain information required for the breeding of new varieties of cereals more resistant to disease	Breeding of new varieties of cereals with stronger resistance to disease
10. Study of intrinsic barriers to crossing species of trees	Study of the possibility to eliminate intrinsic barriers using solvents and mentor pollen, to allow the inter-specific cross of poplars	Development of a technique for eliminating intrinsic barriers to the interspecific cross amongst poplar species, in order to produce clones with higher characteristics to be employed in plantation
11. Study of chemical transformations of pollutants in air	Study of analytical methods with a view to identifying and measuring the sulphur dioxide in air	Development of physico-chemical techniques for reducing the emission of sulphur dioxide from combustion processes (e.g. heating plants)

Examples illustrating the concepts of fundamental research, applied research and experimental development in the social sciences and of fundamental and applied research in the humanities :

Fundamental research	Applied research	Experimental development
1. Study of the causal relations between economic conditions and social development	Study of the economic and social causes of the drift of agricultural workers from rural districts to towns for the purpose of preparing a programme to halt this development in order to support agriculture and prevent social conflicts in industrial areas	Development and testing of a programme of financial assistance to prevent rural migration to large cities

Fundamental research	Applied research	Experimental development
2. Study of the social structure and the socio-occupational mobility of a society, i.e. its composition and changes in respect of the socio--occupational strata, social classes, etc.	Development of a model using the data obtained in order to foresee future consequences of recent trends in social mobility	Development and testing of a programme to stimulate upward mobility among certain social or ethnic groups
3. Study of the role of the family in different civilizations past and present.	Study of the role and position of the family in a specific country or a specific region at the present time for the purpose of preparing relevant social measures	Development and testing of a subsidy programme to maintain family structure in low income working groups
4. Study of the reading process in adults and children, i.e. investigation how human visual systems work to acquire information from symbols such as words, pictures and diagrams	Study of the reading process for the purpose of developing a new method of teaching children and adults to read	Development and testing of a special reading programme among immigrant children
5. Study of the international factors influencing the national economic development	Study of the specific international factors determining the economic development of a country in a given period with a view to formulating an operational model for modifying foreign trade policy of government	———
6. Study of specific aspects of a particular language (or of several languages compared with each other) such as syntax, semantics, phonetics, phonology, regional or social variations, etc.	Study of the different aspects of a language for the purpose of devising a new method of teaching that language or of translation from or into that language	———
7. Study of the historical development of a language	———	———

Fundamental research	Applied research	Experimental research
8. Study of sources of all kinds (manuscripts, documents, monuments, works of art, buildings, etc.) in order to better comprehend historical phenomena (political, social, cultural development of a country, biography of a man etc.)	_____	_____

1.1.3 Distinguishing R&D from non-R&D activities

Item 1.1 above sets forth the elements which characterize an R&D activity. It is their presence or absence which distinguishes R&D from non-R&D activities.

In statistical practice the demarcation line between R&D and the so-called "scientific and technological services" on the one hand and between R&D and industrial production and distribution of goods and services on the other, is often not easily identifiable. This is mainly due to the sometimes close institutional, operational, organizational, personal and other links amongst these activities.

In identifying an S&T activity, and consequently an R&D activity, it should be borne in mind that one has to take into consideration not only the nature or character of the activity, but also the immediate aim or the specific reasons for which this activity is performed.

This observation has a practical relevance in those cases in which more than one kind of S&T activity concur to attain the proposed scientific goal. For example, an R&D programme may entail a noticeable amount of routine activities such as simple data collection on natural phenomena..

As a general rule, in statistical practice all those support routine activities which are performed exclusively or predominantly for the purpose of a given S&T activity should be included within this S&T activity. This means that an activity clearly defined in terms of content, e.g. the translating of an ancient manuscript which per se has to be regarded as a scientific information activity, may also be classified, as the case may be, either in the category "education and training" if performed in the course of third-level education with no

intention of producing new scientific knowledge, or in the "research" category if performed within the framework of a research project.

The above rule is particularly important for R&D. Of course, given the nature and the particular attention paid to R&D within S&T activities, any R&D project performed in the field of education or in the context of other scientific and technological activities should, as far as possible, be isolated and counted as R&D.

To illustrate the fact that it is primarily the aim or objective of the activity and, hence, the systematic context (R&D, or non-R&D) in which it is placed that has to be considered (and not the technical character of the activity), two examples are given below:

(i) the routine electro-encephalographic examination of patients suffering from disorders of the brain is a standard examination like the electro-cardiogram and should be considered as general or specialized medical and health services and thus not R&D. If, however, a series of electro-encephalographic examinations (of exactly the same technical nature as the standard examination mentioned above) is performed within the framework of a research project in the field of psychology, for the purposes of determining changes in the electrical activity of the brain as reactions to psychological events, these examinations have to be attributed to R&D. Equally, a specially-arranged series of electro-encephalographic examinations (of exactly the same technical nature as the standard examinations mentioned above) undertaken to establish and analyse the effects and possible side-effects of a new drug should be attributed to R&D.

(ii) the performance of regular statistical surveys by statistical services of various types has to be placed in the category "gathering of information on human, social, economic and cultural phenomena" (see 1.3 (vi) on page 32). If, however, a statistical survey using established techniques like any other regular statistical survey is undertaken exclusively for the purposes of research, i.e. within the frame of a research project in order to collect data specifically required for this particular subject, then it has to be included in R&D. Similarly, if in connection with "gathering of information on human, social, economic and cultural phenomena", special activity is undertaken with a view to improving the data collection techniques and/or to devise methods of data verification, this activity should be assigned to R&D.

In fact, in general, in accordance with the definition of scientific research, those activities in the domain of the social sciences aiming at the elaboration or the improvement of methodological concepts, tools, procedures used in data collection and analysis (such as questionnaire and interviewing techniques, sample design, models, etc.) should be regarded as scientific research.

1.1.3.1 R&D and application of their results

Great care should be taken to distinguish between R&D and mere application of the results of R&D.

This distinction often seems to be rather difficult in practice. It must not be forgotten that R&D prepares the way for application by providing the general principles, and even devising new applications on the basis of the findings of fundamental and applied research, but the actual translation of the results of R&D into terms of action is not R&D but application. The application of known techniques to the study of phenomena in a more or less repetitive or routine way without any intention of producing new scientific and technical knowledge or of devising a new method of application cannot be regarded as R&D. If, however, known scientific methods or techniques are made applicable for use in other scientific fields or disciplines demanding essential modifications and adjustments, then the activity should be regarded as R&D.

1.1.3.2 R&D and "studies"

The problem of establishing the borderline between R&D and "studies" is particularly important in the field of social sciences and humanities.

It may be remarked that the majority of studies will fall within item (viii) of "Scientific and technological services" (i.e. regular routine work on counselling) dealt with below (see page 32), and will consequently be excluded from R&D.

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 of 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 comprise 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 them to the category 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 (see 1.1, page 17), then it is regarded as or attributed to R&D, if not, then it is excluded.

1.1.3.3 R&D and publications

Regarding the relationship between R&D and publications, as a general rule only the drafting of the first report on the results of an R&D project should be included in R&D in so far as it is performed by personnel having been engaged in the performance of the R&D project. In general, the editing and publishing of the results of such activities should be excluded from R&D altogether.

Expenditure for publication of results should only be attributed to R&D if funds have been explicitly earmarked for that purpose or if the expenditure can be identified and attributed to R&D in an unambiguous way.

1.1.3.4 The boundary between experimental development and industrial production

Establishing the dividing line between experimental development and industrial production or, more precisely, between experimental development and those technical services performed at the beginning of the production process immediately following upon the experimental development phase, seems to be an extremely difficult task in statistical practice.

As an initial general rule, it can be assumed that the work of experimental development ends when the management decision to begin production has been taken, assuming that normally, after that decision, no or very few innovations are introduced.

In order to facilitate the distinction between experimental development and those technical services performed at the beginning of the production process which may involve some element of innovation, it is suggested that the immediate aim or the specific reason of the particular activity in question be taken into consideration.

Of course, the general or long-range or ultimate objective of any productive or R&D activity of an enterprise is a commercial one - notably in industrial firms, as R&D activities of some governmental laboratories or even academic institutions may be of a non-commercial nature and oriented primarily towards social objectives. In this context, however, the primary purpose or immediate objective of a particular activity should be considered. If the immediate aim of, or the specific reason for, the innovative activity is further technical improvement of the product or production process, then the activity should be regarded as experimental development, since it is directed towards a substantially modified or possibly new product. If, on the contrary, the immediate aim of the innovative activity is to adapt the product to market conditions and market needs, meaning that it is basically commercial, the activity should no longer be regarded as experimental development, since the product remains substantially unchanged and only minor adaptations or modifications are applied with the intention of creating a market.

Applying the above criteria, some representative bordeline cases in industry are discussed.

(i) Prototypes: A prototype is an original model which possesses the essential characteristics of a new product. The design, construction and testing of prototypes have to be attributed to R&D. As a result of testing, the prototype is usually modified and improved. After successful completion of the final test series, the demarcation line of production has been reached. The construction of several copies of a prototype after successful testing of the original is not part of R&D.

(ii) Pilot plant: The construction and operation of a pilot plant have to be assigned to R&D as long as the immediate aim or the specific reason is non-commercial, i.e. to gain experience leading to further technical improvement of the product or the production process. As soon as the experimental phase is over and the decision has been reached to operate the pilot plant as a normal commercial unit, the dividing line between experimental development and production is reached and the activity can no longer be considered as R&D.

(iii) Trial production (including tooling-up for full-scale production): Since the immediate aim of trial production is no longer to make further technical improvements to the product or the production concerned but to get the production process working smoothly, it has to be excluded from R&D altogether.

1.2 Scientific and technological education and training at broadly the third level

Scientific and technological education and training at broadly the third level (STET) can be defined as all activities comprising specialized non-university higher education and training, higher education and training leading to a university degree, post-graduate and further training and organized lifelong training for scientists and engineers.

The activities mentioned above correspond broadly to ISCED levels 5, 6 and 7 (see Appendix B).

This group covers not only the high-level educational and training activities carried out within colleges, universities, etc., but also includes specialized advanced training courses for scientific and technical manpower provided by public and non-public institutions which do not form an integral part of the traditional education system.

Institutions of education at the third level not only provide students with high-level teaching but also conduct research and other S&T activities. In this integrated context the results of R&D are often distributed and transmitted by university teaching.

The "education and training" activities should be separated from R&D activities and from scientific and technological services. Thus, the research aspects of post-graduate training should be included in R&D. Similarly, activities of university libraries, of scientific museums, or of testing stations and survey work being performed in the institutions of higher education should not be included in the group STET but in the corresponding groups of S&T services. The clinical activities carried out within university clinics, which should be regarded as specialized medical care, should also be excluded.

1.3 Scientific and technological services

This is the second main group of "related activities".

Scientific and technological services (STS) can be defined as any activities concerned with scientific research and experimental development and contributing to the generation, dissemination and application of scientific and technical knowledge.

The common denominator of this composite group of scientific activities, which are defined and illustrated below, is the direct or indirect link with R&D, from which they may be distinguished by the fact that they do not have the character of innovation. Therefore any work aiming at establishing new methodologies, procedures and techniques used in these services should be regarded as R&D.

It should be borne in mind that the STS included within the scope of the Recommendation have been chosen because of the importance attached to them by science policy-makers as well as for the statistical feasibility, and that they do not exhaust the whole spectrum of scientific and technological services. Of special interest for this Manual, therefore, is the illustration of how their definitions distinguish them from R&D.

STS may be performed as a secondary activity within an institution with a different principal concern (e.g. R&D, education), or within separate independent institutions set up for this purpose (e.g. institutes of scientific and technological information, statistical offices or institutes, central university libraries, archives, independent documentation centres, museums, botanical and zoological gardens).

This STS group of activities can be classified as follows:

(i) S&T services provided by libraries, archives, information and documentation centres, reference departments, scientific congress centres, data banks and information-processing departments.

This group covers those S&T information and documentation activities whose function is to make information available to the user through the acquisition, storage and systematic arrangement of books, periodicals, graphic and audio-visual materials as well as through the management of scientific data stored on computer.

(ii) S&T services provided by museums of science and/or technology, botanical and zoological gardens and other S&T collections (anthropological, archaeological, geological, etc.).

This category also includes the provision of information and documentation, but in more practical terms because of the nature of the entity which embodies the information.

(iii) Systematic work on the translation and editing of S&T books and periodicals.

This group concerns the national effort in rendering available to the general public foreign scientific publications otherwise not easily readable in the original language. Any activity in translating and editing non-S&T books and periodicals as well as text-books for school and university courses should be excluded.

(iv) Topographical, geological and hydrological surveying; meteorological and seismological observations; surveying of soils and of plants; fish and wildlife resources; routine soil, atmosphere and water testing; the routine checking and monitoring of radioactivity levels.

This group includes the routine systematic collection of data and information in the field of the natural sciences carried out normally by appropriate national services, scientific observatories, national data-collection centres and enterprises.

(v) Prospecting and related activities designed to locate and identify oil and mineral resources.

These activities are dealt with separately from group (iv) only because of their vital importance with respect to energy production. They include any prospection using established methods and techniques, the immediate aim of which is commercial exploitation, whereas any development of new prospecting methods (including the development of new combinations of established techniques) should be assigned to R&D.

(vi) The gathering of information on human, social, economic and cultural phenomena, usually for the purpose of compiling routine statistics, e.g. population censuses; production, distribution and consumption statistics; market studies; social and cultural statistics, etc.

The field of this group of data collection activities is essentially the SSH. The services mentioned above, generally carried out by central statistical offices or other governmental institutions or by enterprises, share the same principles illustrated under (iv) and (v).

(vii) Testing, standardization, metrology and quality control; regular routine work relating to the analysis, checking and testing, by recognized methods, of materials, products, devices and processes, together with the setting up and maintenance of standards and standards of measurement.

These services which are systematic work are normally performed in governmental institutions such as public testing-stations, offices of weights and measures, national bureaux of standards as well as a secondary activity in other scientific institutions. They would include for example, physical, biological or statistical testing and analysis; testing of qualities of soil, of safety equipment, etc.

Routine testing and quality control activities integrated with, or which are part of, industrial production should not be included in this group.

Specific non-routine testing carried out within R&D or other S&T activities should be included with those activities of which it forms a part. Therefore, the testing of prototypes and testing activities in a pilot plant, as long as the primary purpose is non-commercial, should be attributed to R&D.

(viii) Regular routine work on the counselling of clients, other sections of an organization or independent users, designed to help them to make use of scientific, technological and management information.

This activity also includes extension and advisory services organized by the State for farmers and for industry as well as expert reports for the purpose of assisting in the preparation and performance of specific projects, other than R&D projects, and feasibility studies which might be defined as technical investigations of proposed engineering projects using established techniques, in order to provide necessary additional information before deciding on implementation. The normal activities of project planning or engineering offices, however, should not be included in this activity.

(ix) Activities relating to patents and licences.

These activities consist of systematic work of a scientific, legal and administrative nature on patents and licences carried out by public bodies, normally by patent offices. Similar activities carried out by business enterprises should be excluded.

Scientific and technological education and training at broadly the third level (STET), on the one hand, and Scientific and technological services (STS), on the other, are the main activities "related" to R&D and which will be progressively included in the collection of science statistics. Unesco has already embarked on initial studies regarding a methodology for the collection of statistics relating to STET (16) and is currently preparing a provisional guide to the collection of statistics on scientific and technological information and documentation (STID) activities, within the framework of STS.

The transition from the first stage (concerning mainly statistics on R&D) to the second will be accomplished gradually on the basis of the state of progress of national and international experience, so that although this Manual deals explicitly with R&D, some mention has been made here of these "related" activities which do not have the character of innovation.

CHAPTER III

SCIENTIFIC AND TECHNICAL PERSONNEL

1. Definition and scope

The two principal indicators of input in S&T activities are manpower and expenditure. Both of them should be surveyed simultaneously and according to common standards, so as to render the joint analysis meaningful. Of course, if different agencies are in charge of the statistical measurement of manpower and expenditure, it is very important that both statistical institutions co-operate closely with each other.

Definitions and classifications illustrated in this chapter, even though originally developed for manpower engaged in R&D, are equally applicable to the personnel engaged in other S&T activities, provided the necessary adjustments are made.

For example, high level professionals, normally termed scientists and engineers in R&D statistics, may be found under a variety of titles and descriptions, such as research workers, technologists, specialists, professional staff, librarians, museum curators, etc. Similarly, this applies to technicians who may be termed differently in certain STA other than R&D, such as library assistant, computer programmer, investigator, photographer, etc.

1.1 Scientific and technical personnel can be defined as the total number of people participating directly in S&T activities in an institution or unit and, as a rule, paid for their services. This group should include scientists and engineers, technicians and auxiliary personnel, as defined in point 2 below.

To be included in the statistical measurement, the personnel should be directly engaged in, or should provide direct services to, S&T activities and should receive a remuneration for their work.

This implies that all personnel providing only indirect services, such as security, janitorial and maintenance personnel engaged in general house-keeping activities, should be excluded from the measurement. Since, however, their services represent a determining element in the smooth functioning of S&T institutions, their salaries should be included as part of the overhead expenses (Chapter IV, item 3.1.2).

The principle to include only those persons who are remunerated for their S&T work is in accordance with the fact that, on the one hand, only "institutionalized" and "structured" activities should be subject to international comparison and, on the other hand, that this practice ensures consistency between manpower and corresponding expenditure data (labour costs).

1.2 Regarding the scope of statistics on personnel, all residents in the country, both nationals and non-nationals (i.e. expatriates or foreigners), having the necessary requisites described below, should

be considered, with the exclusion of those employed in or by international organizations in the country - both residents and non-residents.

Statistics covering personnel in scientific and technological activities should, in principle, include all persons who have worked in the institutions during the year covered by the survey. However, at the institutional level, a head count is not necessarily representative of levels of effort as some of the personnel may be at an institution for only part of the period covered by the survey, whilst others may be employed at the institution during the whole of the survey period but only engaged in a specific activity on a part-time basis (this is especially true in universities). Again, if the measurement reflects all those employed in the institution at any time during the survey period, their aggregation at the national level would result in double-counting. If one wants to consider employment figures as surrogates for level of activity (R&D or S&T efforts), the use of the full-time equivalent concept can overcome these difficulties (see item 3.3, page 39).

Surveying agencies often make reference to the personnel who are employed simply at a given date indicated in the questionnaire or at the precise moment when the questionnaire is being completed. This is the fixed-date approach. It may be noted that this practice, even if less accurate than the one by one count over a year, has the advantage of being more practical for the respondent. Moreover if, as generally happens, reference is made to a date close to mid-year, it is also statistically reliable because of compensatory effects; however, when it is judged appropriate, the figures obtained through this procedure should be supplemented, even by estimates which could be derived, for example, on the basis of averaging for the year the numbers employed at different points of time during the year. The reason for this is that the personnel figures should be consistent with staff costs data, which necessarily refer to the whole period covered by the survey. /A definition of reference year is provided under item 2 of Chapter IV./

1.3 The personnel of S&T institutions should be classified in a number of ways, some of which concern only the most qualified staff:

- the work they are engaged in combined with their qualifications;
- level of education and field of study;
- occupation;
- number (in full-time and part-time);
- nationality;
- sex;
- age.

The above classifications, which provide for detailed and complete information on the personnel, are described in this chapter even if at the first stage of the extension of S&T statistics (see Recommendation reproduced in Appendix A) only some of them should be used to report data to Unesco.

2. Classification by type of work and qualifications

The basic classification of S&T personnel, which takes into account both formal training or qualification and function, provides three categories, defined as follows.

2.1 Scientists and engineers

Scientists and engineers refer to persons who, working in those capacities, use or create scientific knowledge and engineering and technological principles, i.e. persons with scientific or technological training who are engaged in professional work on S&T activities, high-level administrators and personnel who direct the execution of S&T activities. (In the case of R&D activities, "scientists" are synonymous with researchers and assistant researchers engaged both in the natural sciences and in social sciences and humanities .)

Such personnel should be classified in this category if they have either:

(i) completed education at the third level leading to an academic degree, or

(ii) received third-level non-university education (or training) not leading to an academic degree but nationally recognized as qualifying for a professional career, or

(iii) received training, or acquired professional experience, that is nationally recognized as being equivalent to one of the two preceding types of training (e.g. membership of a professional association or the holding of a professional certificate or licence).

In order to use a terminology equally congenial to the NS and the SSH, particularly with regard to R&D activities, in the category "scientists and engineers" in the above definition the term "researchers and assistant researchers" has also been introduced. Professional titles can vary from country to country and are in relation to the type of S&T activity. Other terms could be librarian, curator, physician, technologist, lawyer, statistician, actuary, et al.

2.2 Technicians

Technicians refer to persons engaged in that capacity in S&T activities who have received vocational or technical training in any branch of knowledge or technology.

Such personnel should be included in this category if they have either:

(i) completed the second stage of second-level education. These studies are in many cases followed by one or two years' specialized technical studies, which may or may not lead to a diploma;

(ii) received at least three years' vocational or technical education (whether leading to a diploma or not) following completion of the first stage of second-level education;

(iii) received on-the-job training (or acquired professional experience) that is nationally recognized as being equivalent to the levels of education defined under (i) or (ii) above.

On the basis of the above classifications which take into account both function and formal training or qualification, persons should be classified as scientists and engineers if they are working in those capacities, even if they do not fulfil the educational requirements for inclusion listed in the definition of scientists and engineers; at the same time persons with a university degree actually occupied as technicians should be classified as technicians.

Typically, technicians participate in S&T activities normally under the supervision of scientists and engineers carrying out tasks such as maintenance and operation of specialized R&D (or S&T) equipment and machinery, preparing materials and equipment and carrying out experiments, tests and analyses; they could be medical assistants, computer programmers, surveyors, draughtsmen or survey interviewers or investigators.

2.3 Auxiliary personnel

Auxiliary personnel refer to persons whose work is directly associated with the performance of S&T activities, i.e. clerical, secretarial and administrative personnel, skilled, semi-skilled and unskilled workers in the various trades and all other supporting personnel.

All personnel providing only indirect services, such as security, janitorial and maintenance personnel engaged in general "housekeeping" activities should be measured separately as a residual group which is not included in the manpower data (although it is considered in the measurement of R&D expenditure).

2.4 It should be pointed out that the categories "scientists and engineers" and "technicians" are defined both by qualification and occupation (as allowance is made for including personnel with an equivalent professional experience or on-the-job training) whereas the category "auxiliary personnel" is defined by the occupational criterion (function) only.

This dual approach is due to the fact that the most qualified staff may be easily identified through their professional ability, detected by the level of education received (a formal qualification) or an equivalent recognition, whereas the auxiliary staff is better definable adopting a criterion of type of occupation or function rather than educational level which may or may not have been achieved.

2.5 It may be noted that the educational qualification approach, if not associated with the concept of working in the appropriate capacity, could be misleading. For this reason, in the above definitions provision is made for persons with incomplete formal training and self-trained persons who have proved their capabilities in scientific and technical work. For example, in countries where the educational system only recently began providing technical training, some technicians may have no formal qualification but according to the Unesco definition could be considered as "technicians".

However, the same principle may have an opposite application: it may happen in fact that holders of academic degrees perform duties of "technicians", for example, in establishing a new programme, such as in computer work, which, once it is standardized will be executed by non-graduates, or simply because a surplus of graduates in his employment makes it economical for the employer to have some technical duties performed by well-trained personnel. In these cases, according to the definition given above (item 2.2), which has an occupational approach as well as an educational approach, the person involved should be included in the category "technicians".

2.6 In the case of R&D activities, high-level administrators or managers, who normally are not directly undertaking R&D but are planning, directing the execution, supervising or otherwise providing direct services to R&D, should be included within the category "scientists and engineers" (and not in the category "Auxiliary personnel"). Also post-graduate or post-doctorate students, who may perform R&D work as part of an academic course of studies or as training should be included in the same category, if possible as a separate sub-group. The examples cited here in respect to R&D activities are, of course, equally applicable with regard to the measurement of other S&T activities.

3. Unit of measure for S&T personnel

Scientific and technical personnel may be measured both by number of persons engaged in S&T activities and in terms of volume of working time devoted to such activities. The two aspects may also be combined.

The nature of the activities under review entails that sometimes personnel are entirely engaged in a given S&T activity and sometimes, due to the close interconnection between various S&T activities and between S&T and other activities (production, distribution), they devote only a part of their working time to the activity in question.

In reporting data on personnel the crucial element is the volume of time devoted to the S&T activity surveyed. To attain this purpose three concepts should be used to measure human resources:

(i) full-time (FT);

(ii) part-time (PT);

(iii) full-time equivalent (FTE).

3.1 Personnel working full-time

Full-time scientific and technical personnel (FT) are defined as those personnel who devote all or almost all their working time to a given scientific and technological activity.

The average amount of working time considered as full-time according to legal regulations or agreements will vary from country to country and, even within a country, among different sectors; however the basis for international comparison would be of the order of 40 hours a week.

For reasons of simplicity overtime should not be reflected in statistical measurement. This practice will lead to some underestimation of the total volume of time devoted to the given S&T activity and will render the data on personnel slightly inconsistent with the relative figures on labour costs which should also include the compensation for overtime. It should be recognized, however, that this distortion, which will probably have a very limited impact on data, also because of compensatory effects, is dictated by necessity since it would be impracticable to evaluate overtime case by case.

The definition of "full-time" given above provides that only personnel who spend the majority of their working time should be considered full-time; in statistical practice, the threshold should be placed around the 90% level. Thus, those staff who devote more than 90% of their working time to a given S&T activity should be classified as full-time personnel.

3.2 Personnel working part-time

Part-time scientific and technical personnel (PT) are defined as those personnel who devote only part of their working time to a given scientific and technological activity.

This implies that the personnel involved may perform at the same time more than one type of S&T activity (R&D, S&T education, S&T services) or other activities (e.g. production, distribution).

Of course if the same person is engaged in more than one type of S&T activity, the above definition should be applied for each of them. For example if a university professor spends 40% of his time on R&D activities and 60% on teaching, he should be accounted for in the measurement of R&D personnel at 40% only.

For reasons of symmetry with the previous definition, only those who devote between 10% and 90% of their working time to a given S&T activity should be included in the category of part-time personnel, whereas staff who spend less than 10% should be excluded altogether.

3.3 Full-time equivalent (FTE)

The concept of full-time equivalent (FTE) is based on the measurement unit representing one person working full-time for a given period, it should be used to convert figures relating to the number of part-time workers into the equivalent number of full-time workers.

Data concerning personnel should normally be calculated in FTE, especially in the case of scientists and engineers and technicians. (For auxiliary personnel full-time equivalent normally equals the number of persons in this category as they do not usually divide their working time.)

The concept of full-time equivalent has been introduced in science statistics as, in the presence of a widespread phenomenon of part-time work (especially in universities), or the fact that some persons may have

had employment in more than one institution during the period under survey, the head count would lead to an overestimation of the human resources devoted to a given S&T activity. The use of full-time equivalent can reduce or resolve this problem.

This concept is based on two components:

(i) actual number of persons working PT,

(ii) percentage of working time devoted by the personnel involved to the given activity.

An example may illustrate the calculation: if out of three scientists in R&D, two work for a quarter of their time and the remaining one spends only one half of his working time on R&D, then the FTE of these three persons would be 0.25+0.25+0.50 = 1 scientist in FTE. It goes without saying that the case of full-time may be considered as a limit case of part-time whereby the percentage equals 100% and therefore one person corresponds to one FTE.

Data on personnel, as for data on expenditure, should refer to a defined period of time which in science statistics is the year. Therefore, if during a year two scientists in R&D work full-time for a period of six months, then the corresponding figure would be one scientist in FTE. It may be noted here that since these FTE data should in principle relate to a year the concepts of FTE and man-year can be regarded as identical (with the afore-going proviso of excluding overtime work (see 3.1 above).

4. Classifications by level of education and field of study

Personnel in the categories "scientists and engineers" and "technicians" should be classified according to the level of education received and the field of study.

It may be observed that these two classifications take into account the formal education acquired, but they neither detect the capacity gained through professional experience and on-the-job training equivalent to formal qualification, nor the fact that personnel with a degree in a field of study may be currently engaged in another field (e.g. chemists working in agricultural sciences, engineers working in medical and health sciences).

4.1 Classification by level of education

The classification by level of education should comprise four groups determined in accordance with ISCED (International Standard Classification of Education) (see Appendix B):

(i) holders of third-level degrees of university type (ISCED:6-7);

(ii) holders of third-level diplomas of non-university type (ISCED:5);

(iii) holders of diplomas at the second level, second stage (ISCED:3);

(iv) other qualifications (ISCED:1,2,9).

Constructing a double-entry table with the two categories of scientific personnel along the rows and in the columns the four groups of level of education (see table 1), one would expect a concentration for scientists and engineers in ISCED levels 6-7 and for technicians in ISCED level 3. Holders of an education at ISCED level 5 will be found either in the first or in the second row, according to national practices. Those placed in the other cells situated to the right of these will be those with other levels of education but having acquired a professional experience equivalent to the normally-required formal education.

TABLE 1

Categories of S&T personnel	ISCED levels			
	6,7	5	3	1,2,9
Scientists and engineers				
Technicians				

4.2 Classification by field of study

The classification by broad field of study in science and technology should be correlated with the following groups of ISCED fields.

Fields of science and technology	Main fields of study in ISCED
Natural sciences	42. Natural science programmes 46. Mathematics and computer science programmes
Engineering and technology	52. Trade, craft and industrial programmes, n.e.c. 54. Engineering programmes 58. Architectural and town-planning programmes 70. Transport and communications programmes
Medical sciences	50. Medical and health programmes
Agricultural sciences	62. Agriculture, forestry and fishery programmes
Social sciences and humanities	14. Teacher training and education science programmes 18. Fine and applied arts programmes 22. Humanities programmes 26. Religion and theology programmes 30. Social and behavioural science programmes 34. Commercial and business administration programmes 38. Law and jurisprudence programmes

Fields of science and technology	Main fields of study in ISCED
	66. Home economics (domestic science) programmes
	84. Programmes in mass communication and documentation
Other fields	01. General programmes
	08. Literacy programmes
	78. Service trades programmes
	89. Other programmes (e.g. military programmes)

The six broad fields of science and technology correspond to regroupings of the twenty-one fields of study in ISCED which may be found in relation to the categories of education (based upon levels). It should be noted, however, that some fields do not exist at every one of the seven ISCED levels, e.g. law and jurisprudence programmes are not found at level categories 2 or 3 while literacy programmes occur only at level category 1.

5. Other classifications

Science policy-making and planning require a rather comprehensive analysis of the human potential engaged in S&T activities. The collection of data on some aspect such as occupation, nationality, age and sex lies within the scope of science statistics, which is to furnish information on the most relevant indicators of the phenomenon under review.

5.1 Classification by occupation

In addition to their classification by formal education or training or function as illustrated in points 2.1 to 2.3 above, scientific and technical manpower could also be classified by occupation. This kind of classification may benefit from a scheme such as ISCO (International Standard Classification of Occupations) (11), which is based upon occupational criteria, principally the kind of work performed in each occupation, irrespective of the organization in which the work is performed or of the educational qualifications of the individuals in the occupations. However, it is to be noted that ISCO does not provide separate classes for S&T workers in all scientific fields; it would therefore be necessary to identify those functions which suit the requirements of science statistics and regroup them according to the three categories of S&T personnel.

At present this cross-classification is not envisaged although some work along these lines is proposed in the long-term development of science and technology statistics.

5.2 Classifications by nationality, age and sex

A number of other specific characteristics of personnel may be analysed with the purpose of gaining better knowledge of the human potential employed in S&T activities.

All the personnel should be classified by sex.

Personnel belonging to the categories "scientists and engineers" and "technicians" should also be classified by :

- nationality (merely showing nationals separately from non-nationals i.e. expatriates or foreigners),

- age, separating them into the following age groups: less than 30, 30-39, 40-49, 50-59, 60 and over.

It may be noted that all such information, which furnishes a rather complete picture of S&T personnel, will be collected gradually, according to the priorities set forth in the Recommendation.

6. Scientific and technical manpower potential

The planning and formulation of science policy requires the knowledge, especially in developing countries, of the total numerical strength of the most qualified human resources, namely the total stock and the number of economically active persons who possess the necessary qualifications to be scientists, engineers and technicians.

6.1 Total stock of qualified manpower

Total stock of qualified manpower comprises the total number of persons with the necessary qualifications for personnel in categories "scientists and engineers" and "technicians", regardless of economic activity (production, S&T activities, the professions, no gainful employment, etc.), age, sex, nationality or other characteristics, present in the domestic territory of a country at a given reference date.

It should be noted that in the definition of total stock (and also in the following definition for economically active qualified manpower), the criterion of inclusion is merely the "necessary qualification" whereas the definition of scientists and engineers and of technicians (see items 2.1 and 2.2) is limited to those who are actually "working in those capacities", i.e. those working as scientists and engineers or as technicians. This limited definition will not produce an inventory of all qualified manpower (i.e. potential scientists, engineers and technicians) in a given country. Frequently, individuals trained in science and engineering or with technical or vocational training are not working in S&T activities for a variety of reasons, varying from unavailability of such positions to a change in interest. They are, however, still part of a reservoir which can be used as a source of personnel for S&T activities.

6.2 Number of economically active qualified manpower

Number of economically active qualified manpower comprises the total number of persons with the necessary qualifications for personnel in categories "scientists and engineers" and "technicians" who are engaged in, or actively seeking work in, some branch of the economy at a given reference date.

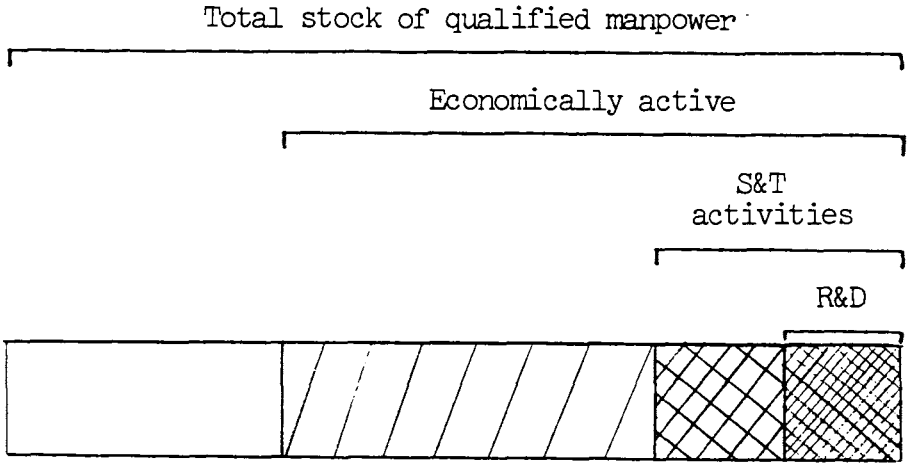
If, for practical reasons, a problem of mutual exclusion arises in the collection of data, the second definition is preferable.

In order to illustrate the difference in coverage of the two definitions, it may be said that the total stock of qualified manpower identifies all persons resident in the country (regardless of their nationality or country of origin) who have the necessary qualification (although for the latter this is not always measurable, see below) - achieved either in the educational system or through professional experience - to work as scientists, engineers and technicians (with the underlying concept of potentiality).

The number of economically active qualified manpower is that part of the total stock which is either employed or actively seeking work (according to the definition nationally used in labour statistics).

In the Recommendation concerning the International Standardization of Statistics on Science and Technology, the terms "Total stock of scientists and engineers and technicians (SET)" and "number of economically active SET" are used to denote, respectively, what we call here "Total stock of qualified manpower" and "number of economically active qualified manpower".

The following scheme illustrates the relationship between these two aggregates and the group of SET actually engaged in S&T activities.



The blank area indicates those persons who, even though possessing the necessary requisites are outside the labour market (e.g. housewives, retired persons); the light shaded area denotes those persons employed in all the branches of the economy (except those occupied in S&T activities) or actively seeking work; the darker areas indicate that part of the total stock actually engaged in S&T activities (some persons working full-time and others part-time) of which a share is devoted to R&D.

The data on the total stock of qualified manpower and on the number of economically active scientists, engineers and technicians cannot be collected by the national survey on S&T activities but will normally be obtained through a periodical population census or through manpower surveys as well as other national sources (registers of professional associations, publications, ad hoc inquiries, special studies, files of employment agencies, etc.). It should be remembered that, since data requested will be derived from the different

sources mentioned above which adopt their own standards and definitions, the arrangement of these data cannot be expected to correspond exactly to the definitions proposed for personnel engaged in S&T activities. Close co-operation between S&T statisticians and the census authorities is therefore essential. If the national concepts differ from those suggested above (for example, concerned only with those employed in the national economy, or not including unemployed persons) and these are followed when reporting information at the international level, this should be specified and noted accordingly.

It will be particularly difficult to identify those "scientists and engineers" who have received training and acquired professional experience equivalent to formal qualification at the third level of education, or those "technicians" who have undergone on-the-job training and acquired professional experience equivalent to formal qualification at the second level of education. The figures from those sources will, in any case, represent estimates which by definition are subject to some margin of error.

CHAPTER IV

FINANCIAL RESOURCES

1. Introduction

In the preceding chapters the elaboration of the various concepts has been treated with more emphasis on the aspect of R&D activities, leaving to a second stage the task of elaborating them in the framework of the STET and of the STS. From the point of view of financial resources, there is basically no reason to emphasize more particularly the R&D aspects, as, insofar as their financing is concerned, there should be no practical difference in the measurement of the financial efforts devoted to each of these S&T activities (R&D, STET, STS). However, it can be remarked that in most countries only the financing of R&D has reached the stage where aggregated data collections have been possible.

In dealing with financial resources devoted to S&T activities, one may refer to two different aggregates:

- financial appropriations (or budget allotment), i.e. to an ex-ante approach;
- actual expenditure, i.e. to an ex-post approach.

Financial appropriations consist of sums of money, reported on budgets, allocated to a scientific or technological activity. They are the formal expression of the will of public and private institutions to spend a certain amount of money for this purpose.

Actual expenditure refers to all payments made by an institution during a given period of time, regardless of the source of funds or of the budget on which the sums were reported.

It happens frequently that the expenditure for a given year does not correspond exactly to what was foreseen, because of changes in sources of funds (e.g. new contracts) and of the gradual spending of sums allotted to S&T activities (e.g. the acquisition of scientific equipment may entail, from the decision to purchase to the payment of the invoice, a procedure which exceeds one year).

It goes without saying that financial appropriations and actual expenditure are two complementary indicators, each stressing some aspects and requiring different treatment and sources of data. It may be remembered that science policy-makers attach, especially for the public sector, a great importance to financial appropriations; however, highest priority is attributed to the real financial effort made by S&T organizations. As a consequence, taking into account the resources available in Member states to be devoted to science statistics and that the extension of S&T statistics is a gradual exercise, this Manual deals with actual expenditure for S&T activities. An exception is constituted by the collection of data on R&D funding classified according to major socio-economic objectives, described in Chapter V, item 4, see page 63.

Regarding the categories and definitions discussed in this chapter, it should be said that, even though they have been developed over the years for use in the statistics on R&D, they are equally applicable to the other scientific and technological activities.

2. Expenditure for S&T activities

Expenditure can be defined as all actual payments made for the performance of S&T activities by a particular unit or institution during the year of reference.

A reference year should be considered as a period of 12 consecutive months to which the statistical data refer. When this period carries over from one calendar year to the next, the year in which the period started is to be taken as the reference year.

With a view to achieving the quantitative measurement of the expenditure for S&T activities of a country, it is necessary to identify which expenditures should be covered by science statistics.

At the national data collection level the problem of double-counting can arise and for this reason a distinction should be made between intramural and extramural expenditure. The following definitions have been elaborated.

2.1 Intramural expenditure can be defined as all payments actually made during a reference year for the performance of a scientific and technological activity within a particular unit, institution or sector of performance, whatever the source or origin of the funds.

2.2 Extramural expenditure can be defined as all payments actually made during a reference year for the performance of a scientific and technological activity outside a particular unit, institution or sector of performance, including payments made outside the national economic territory.

The above distinction is necessary as sometimes a scientific organization commits a part of its funds to other organizations for the performance of S&T activities.

In this case the payment, which may take the form of a contract or of a donation, and can be in cash or in kind (e.g. equipment made available to the performer), should be considered as an extramural expenditure for the former organization (this organization not being, in fact, the "performer") and as an intramural expenditure for the latter (this organization being the actual "performer"), even though the funds have been provided by an outside source (this funding will become apparent in the classification by source of funds - see item 4 below - as reported by the performing institution.

In this perspective expenditure for S&T activities performed outside the paying unit or institution (both within the country and abroad) should be considered as its extramural expenditure.

It is to be recalled that in statistical practice, the compilation of data and the classification of resources devoted to an S&T activity should be made from the "performer's" aspect, so that the extramural expenditure

of the financing institution will be included in (and, consequently, appear as part of) the intramural expenditure of the performing institution which receives the funds. And in this way the problem of double-counting is avoided.

The data on the measurement of expenditure on S&T activities to be reported at the international level should therefore be intramural expenditure.

The sum of the intramural expenditures incurred by all the national S&T institutions leads to a final aggregate called "Total domestic expenditure on S&T activities".

2.3 Total domestic expenditure on S&T activities can be defined as all expenditure made for this purpose in the course of a reference year in institutions and installations established in the national territory, as well as installations physically situated abroad: land or experimental facilities rented or owned abroad and ships, vehicles, aircraft and satellites used by national institutions. Amounts spent on S&T activities carried out by international organizations established in the country in question are excluded from this total.

According to the above definition, which is based on the concept of intramural expenditure, the total domestic expenditure on S&T activities should exclude sums expended directly by international organizations through their own institutions located within the country (of course all the sums given by international organizations to national S&T institutions for the performance of S&T activities within the national S&T institutions should be included in the intramural expenditures reported by these institutions). In the distribution of such expenditures by source of funds, these sums should be classified as "foreign funds" (see item 4.1.3, p. 52); it should also exclude sums expended for mobile and immovable installations physically situated within the country rented or owned by foreign public and private organizations (e.g. oil rigs, launching platforms, etc.). Of course this latter category does not embrace foreign-owned enterprises which, even if their proprietors reside abroad, are legally established in the country.

3. Classification by type of expenditure

Actual intramural expenditure should be structured according to the following categories and subcategories :

- Current intramural expenditure:
  - labour costs
  - other current costs
- Capital intramural expenditure :
  - expenditure of major equipment
  - other capital expenditure.

3.1 Current intramural expenditure comprises all payments made during the reference year for the performance of S&T activities within units, institutions or sectors of performance whatever the source or origin of funds, covering the cost of labour, minor equipment and expendable supplies and other current expenses.

3.1.1 Labour costs comprise wages and salaries, paid in cash or in kind, and all related labour costs, including "fringe benefits" such as bonuses, paid holidays, contributions to pension funds and compulsory social security systems, payroll taxes, etc.

In view of the importance of the category of personnel "scientists and engineers" their labour costs should, as far as possible, be shown separately from the costs of other personnel.

The labour costs for highly qualified personnel dealing with the administration of R&D (normally scientists who in the period concerned are not involved directly in carrying out the research but who work in the setting up of programmes) should be included.

Also included should be the costs for post-graduate students (grants, stipends, etc.) to the extent that they are engaged in research work.

Lacking other reliable parameters, the expenditure for personnel should also be computed according to the concept of "full time equivalence" (Chapter III, item 3.3). Thus the personnel costs should be attributed to the S&T activities according to the percentage of time spent by the person involved in carrying out the activity in question.

Finally, the labour costs for personnel providing only indirect service (such as canteen staff, janitors, etc.) should be excluded and assigned to the subcategory "other current costs" (see below).

3.1.2 Other current costs comprise all other intramural expenditure such as expenditure on office and laboratory supplies, materials, subscriptions to journals, books, rental of buildings, maintenance, computer service, travel and postal services.

This group of costs relates to services, products, materials as well as minor instruments and machinery which may or may not be inventoried, but because of their cost and characteristics of utilization cannot be considered as "major equipment". As is remarked below (item 3.2.1) the demarcation line between "other current costs" and major equipment varies according to national practice (e.g. rental of buildings, subscriptions to journals - which in some countries are considered as capital expenditure). When reporting at the international level, deviations from the recommended definitions should be appropriately indicated.

The above expenditures are often overheads and shares of overheads, i.e. current expenditure which cannot be easily divided up and assigned to the individual S&T units or to the respective categories of activities because of the fact that different S&T activities and non-S&T activities are often located in the same premises (teaching and R&D in the universities, production and R&D in industry, etc.).

In accordance with the principle mentioned above, the labour costs for the personnel providing only indirect services should be included within this subcategory appropriately pro-rated according to the scientific activity under review.

3.2 Capital intramural expenditure comprises all payments made during the reference year for the performance of S&T activities and relating to expenditure on major equipment and other capital expenditure.

For the purpose of international comparison, any provisions for depreciation, whether actual or imputed, should be excluded from international statistics on expenditure. Nevertheless, countries which are in a position to furnish such information may do so separately.

3.2.1 Expenditure on major equipment comprises the purchase of major installations, machinery and equipment. This expenditure reflects the acquisition of goods which normally are inventoried due to the relevance of the expense and of the prolonged use that will be done of them.

The demarcation line between minor equipment, to be included in the sub-category, "other current costs" and major equipment, to be included in "expenditure on major equipment", should be drawn taking into account the relevance of the expenditure, the characteristics of the item and its nature of capital expenditure, e.g. the practice of establishing a monetary limitation is fairly common; another practice takes into account whether the item is consumable within a year or whether it can be considered as permanent.

For instance, the expenditure for a cabinet, an anemograph, a magnetic recorder should be included in "expenditure on major equipment" whereas the cost of a magnifying lens, a stethoscope, a Bunsen burner should be assigned to "other current costs".

A particular case is worth attention; even though payments for the current purchase of books, periodicals and animals shoud be assigned to "other current costs", expenditure for the purchase of complete libraries, large collections of books, periodicals, specimens, etc. should be included under "expenditure on major equipment", especially when made at the time of equipping a new institution.

Even if made at any other time, however, purchases of this type could still be shown under capital expenditure.

3.2.2 Other capital expenditure comprises the purchase of land (for building or for testing purposes) and expenditure on new buildings or large-scale improvements, modifications and repairs to buildings and fixed installations, land-improvement work and other expenditure.

All major changes and improvements to buildings should be included in this group, whereas current repairs and maintenance have to be assigned to "other current costs".

4. Classification by source of funds

The actual intramural expenditures for S&T activities should also be classified according to their origin or source. The sources are usually several and, as their importance changes from country to country, various

types of classifications may be used in order to suit the national or sectoral policy needs. For international reporting of data it is essential, however, that the national classifications ensure that the resulting data can be rearranged into the broad categories defined in the Recommendation.

The following categories of sources of funds, originally adopted by Unesco to be used in the classification of R&D activities, should also be applied, with some minor modifications, to the measurement of financial resources devoted to the other S&T activities.

4.1 Categories of source of funds

4.1.1 Government funds. This category includes funds provided by the central (federal) State or local authorities and originating from the ordinary or extraordinary budget or from extra-budgetary sources. It also covers funds received from public intermediary institutions established and wholly financed by the State.

Besides funds coming from the government and its branches, funds coming from public scientific and technological institutions such as research councils, national libraries, central statistical offices, museums, botanical and zoological gardens, etc., should be included in the "government funds".

4.1.2 Productive enterprise funds and special funds. This category includes funds allocated to S&T activities by institutions classified in the productive sector as productive establishments or enterprises and all sums received from the "Technical and Economic Progress Fund", in countries with a centralized economy, and other similar special funds.

In the case of the productive sector the funds originate from the economic activities of establishments and enterprises (e.g. funds made available from the production of goods and services for sale on the market).

The above category includes also the sums received from the "Technical and Economic Progress Fund" and other similar funds, even if they are disbursed by the various ministries responsible for industry in countries with a centrally-planned economy.

The reason lies in the fact that those Funds were created to supplement the allocation of resources from the state budget - in order to cover the risk involved in particular technological ventures - through funds usually raised by a levy on industrial turnover. In this case the public administration acts as a re-distributing agency of money belonging to industries and therefore, irrespective of the way this money is administered, it should be considered as funds allocated to S&T activities by enterprises.

4.1.3 Foreign funds. This category includes funds received from abroad for national S&T activities, including funds received from international organizations, governments or foreign institutions.

These funds may be acquired within the framework of an aid programme for scientific co-operation between national and foreign S&T institutions, or for the execution of an S&T activity. They include also funds from organizations or companies abroad which have affiliated or parent organizations or companies situated in the domestic territory.

4.1.4 Other funds. This category includes funds that cannot be classified under any of the preceding headings, e.g. "own funds" of establishments in the higher education sector, endowments and gifts.

This last category is essentially a residual category and its main components should be specified as far as possible.

4.2 It may be pointed out that the primary aim of the analysis of intramural expenditure by origin of funds is to find out the original source of funds. This means that, if the funds pass through several (intermediary) organizations, the final performer should indicate, to the extent possible, the original source of funds. This applies particularly in the case of subcontracting (e.g. enterprises frequently subcontract R&D projets financed by the government to other firms; in this case the funds allocated to these projects should be reported as government funds) and in the case of those intermediary organizations mentioned above (4.1.1).

5. Classification by type of R&D activity

The current intramural expenditure for R&D should be broken down according to the categories defined in Chapter II, item 1.1:

- Fundamental research;
- Applied research;
- Experimental development.

The capital expenditure can also be classified according to these categories (some countries follow this practice) but, because of the practical difficulties involved, this analysis is not requested for international comparison.

In doing so, the research projects carried out during the year concerned constitute the basis for this classification.

Each project or, if that is the case, part of it (the same programme may entail more than one type of activity) should be "designated" as being fundamental research, applied research or experimental development and its cost should be calculated.

In statistical practice, whereas it is rather easy for the experts of the field to qualify the type of R&D according to the definitions given in Chapter II, item 1.1, problems arise in the computation of the cost sustained for the execution of a single project.

Of course the simplest case is when an institution was engaged in one type of R&D only - even with various projects: all its intramural expenditure should be assigned to that type of activity. When this is not the case, the cost of each project should be evaluated.

This procedure is often difficult and, apart from those cases - particularly in industry - in which a separate and detailed accounting is taken, there is room for subjective judgement in assessing the cost of an R&D project.

The following guidelines are suggested in reporting, at international level, data on current intramural expenditure by type of R&D activity: the labour costs (which normally represent about one half of the total cost) should be imputed according to the time spent on the projects. In the absence of detailed information, the manpower ratios for the different types of R&D activity should be applied to all other current costs. This procedure is derived from the fact that manpower costs are usually proportional to the other costs: if many people are engaged in a project, it is likely that this project will employ to the same extent the other goods and services at the disposal of the R&D activity.

The practice for estimating the data is acceptable but within limitations and the ratios used should be examined frequently; research projects generally last for a long time and research teams specialized in one type of R&D tend to show a certain inertia in recognizing a change in their type of work, so that there is a danger if respondents continue to apply, for the three types of R&D, the same ratios used for the previous surveys, even though changes have occurred during the years.

This is particularly true of universities where, since specific information is generally lacking, rough estimates are necessarily made by respondents and may remain as such until dramatic changes occur.

CHAPTER V

SECTORAL AND FUNCTIONAL CLASSIFICATIONS

1. Introduction

The basic definitions and classifications of S&T activities and of the two principal indicators of inputs in these activities (manpower and expenditure) have been described in the previous chapters with a view to furnishing a framework to Member countries particularly for their reporting of information to Unesco.

It is clear that quantitative information on a particular scientific and technological activity can be collected, in principle, at different organizational levels depending on the kind of data that are of interest. However, what is of primary interest for science policy makers, and especially for international comparisons, is a global view and not particular aspects which may be usefully investigated through specific enquiries and analyses. For this reason in the present Chapter basic classifications of the data at an aggregated level are discussed.

It may be observed that aggregated classifications for S&T activities may essentially be set up in two ways : either following the general economic classifications or taking primarily into consideration the nature of the activities performed by S&T institutions.

The advantages of the former approach lie in the fact that the collection of data is made within the framework - and even using the same survey - of the economic statistics and therefore the comparison with economic data is immediate.

The major disadvantage of this kind of scheme is that it does not take into account the peculiarities of the activities under review, dealing with them only in respect to the nature of the institutions which carry them out.

A second type of approach takes primarily into account the purpose and the nature of S&T activites ; it therefore fits better to internal analysis of the scientific system. A practical disadvantage of this approach is that it requires a greater amount of work from respondents, who have to elaborate their data according to the guidelines set forth in the classifications.

In conclusion it may be pointed out that the two approaches, which respectively constitute a basis for the correlation between the socio-economic context and the scientific and technological activities and which throw some light on the purpose and the nature of the activities themselves, should be regarded as two facets of the same reality and, of course, may be combined.

1.1 As stated in Chapter I, science statistics is intended to provide as complete statistical information as possible on the situation concerning scientific and technological activities at the national level.

The data should, therefore, cover the whole statistical universe of a given country and include all institutions carrying out S&T activities - with the exclusion of international organizations - operating in the country, as defined below:

> Institutions carrying out S&T activities may be defined as any institutions engaged in S&T activities on a permanent and organized basis. The term institution should be taken as covering a very broad range of entities having legal, financial, economic, social or political status, such as establishments, enterprises, bodies, organizations, institutes, academies, universities, associations, departments, ministries, centres, laboratories, etc.

Having once defined the institutions in which S&T activities are being performed, the problem of identifying the units of classification to which the data refer arises. In fact, often a diversification in S&T activities exists within the institutions (e.g. an enterprise whose main activity is the production of motor vehicles may have R&D establishments working not only in the area of mechanics, but also in plastics, electronic components, metallurgy, etc.). The result will therefore be different whether the data are classified with reference to the single activities (in the previous example, mechanics, plastics, electronic components, metallurgy, etc.) or according to the prevalent objective of the institution (construction of motor vehicles).

In the second alternative a misrepresentation is introduced because of the attribution of all activities to the prevalent one and at the same time a certain amount of information is lost.

1.2 In statistical practice, keeping in mind that data organized in the former way (i.e. according to more specific areas of activities) suit better the needs for science policy formulation, the statistical unit - i.e. the unit to which the data to be collected relate, the unit of classification and observation - has been identified as follows:

> The basic statistical unit selected to measure the performance of S&T activities should be, if possible, an "establishment-type" unit.

The concept of establishment-type unit, which is borrowed from the ISIC classification (10) and is to some extent in contraposition to the concept of enterprise-type unit, serves to indicate that the data should as far as possible refer to the smallest and, in respect of the kind and orientation of the S&T activities performed, the most homogeneous performing unit. This unit must operate, at least to some extent, independently and have separate records available which can provide the data concerning the execution of the activities and the relative human and financial resources. Examples of this type of unit are industrial establishments, research institutes, governmental units and institutes or departments of university.

In more specific operational terms, a unit to be considered as a statistical unit should - irrespective of its legal form and organizational structure - have a certain number of characteristics:

(i) it should have a certain autonomy with respect to management and decision-making;

(ii) it should be placed under the authority or supervision of a director or responsible person;

(iii) it should have a programme of work which may consist of one or more projects or subjects;

(iv) it should have access to a certain amount of financial resources specifically allocated to the work;

(v) it must have a minimum number of personnel. This minimum can be fixed separately for each type of activity;

(vi) and, finally, it should have a stable character.

The different organizational and administrative structures and the varied record-keeping practices of the units engaged in the activities in the three performing sectors defined below have been taken into account in describing the typologies of statistical units to be used in practice in item 2.4, page 60 .

2. Sectors of performance

Sector of performance can be defined as any sector of the national economy comprising a significant number of institutions carrying out S&T activities (as defined in item 1.1) that present a certain degree of homogeneity with respect to the principal function or service provided irrespective of source of funds, the authority to which such institutions are responsible or the category of STA being carried out. According to these criteria, three major sectors of performance can be distinguished: the productive sector, the higher education sector and the general service sector.

The concept of "sector of performance" has been introduced in science statistics in order to identify those areas of the economy in which scientific and technological activities (as described in Chapter II) are being carried out, especially with a view to relating statistical data on S&T activities to data concerning general economic development and national accounts. The sectors of performance represent broad categories of institutions that are to some extent homogeneous as regard function performed or services rendered and that are defined in terms of their principal function, i.e.:

a) scientific and technological activities carried out for the production of goods and services for sale on the market /productive sector/;

b) scientific and technological activities carried out mainly for (providing) education at the third level and for the general advancement of knowledge associated with it / higher education sector/;

c) scientific and technological activities carried out to meet the general collective needs of the community and the collective needs of the members of the community except education at the third level (meeting the collective needs or "general service" includes general economic development, defence, health, welfare, social security, education, culture, etc.) /general service sector/.

It should be borne in mind that the purpose of the Unesco classification is to achieve worldwide comparability of data; this

would therefore preclude a classification criterion according to form of ownership (e.g. private versus governmental or public). Forms of ownership vary considerably from one political-economic system to another (for instance in socialist countries the only category would be "state" or public ; in certain other countries, various mixed institutional forms of ownership or sponsorship can be found). The sectors of performance recommended by UNESCO leave out of consideration these various and incomparable institutional factors and the classification of the institutions is based primarily on the broad notion of societal needs satisfied by these institutions . The three principal sectors distinguished represent three broad types of such needs : those related to the production of goods and services, to higher education, and to the whole community (the latter being in fact a residual category). UNESCO practice has shown that the classification of R&D according to such a criterion is feasible - although it requires, from the national statistical services, a certain extra effort consisting in the regrouping of the original data. This classification is equally applicable to the majority of other scientific and technological activities.

The three sectors have been defined, to the fullest extent possible, in accordance with the definitions of the "System of National Accounts" (8) and the "System of Balances of the National Economy" (9). The definitions of the sectors proposed by UNESCO are as follows:

2.1. Productive sector

Productive sector comprises :
- domestic and foreign industrial and trading enterprises situated within the country which produce and distribute goods and services for sale, and institutions directly serving them with or without contract whatever their form of ownership (public and private). The S&T activities of these enterprises and institutions closely linked to production are known as "S&T activities integrated with production" ;
- governmental, non-governmental and non-profit institutions most or all of whose S&T activities indirectly serve one or more of the categories or classes of activities with a two- or three-digit classification in the ISIC (see Appendix C). The S&T activities of these institutions which are only indirectly linked to production are known as "S&T activities not integrated with production". In countries with a centralized economy, R&D institutes attached to the ministries responsible for the different branches of the national economy should be classified in this category of institutions.

As to the coverage of the productive sector, it should be pointed out that it includes those economic units whose objective is the production and distribution of goods and services for sale (thus, besides private enterprises, government monopolies and nationalized industries, particularly public utilities, transport undertakings, post offices, communications and broadcasting and all other government establishments which function as productive units) as well as the institutions "directly serving them", in the sense in which this term is used in SNA (S&T activities integrated with production); it includes also those institutions (such as industrial and agricultural research institutes

established by government; R&D institutes, in countries with a centralized economy, attached to the ministries responsible for different branches of the national economy; private non-profit institutions) whose activities are, fully or partially, carried out for the benefit of production and distribution (S&T activities not integrated with production).

Due to the importance of the distinction between these two integration levels, in reporting data to Unesco Member states should divide their figures between those activities "integrated" and those "not integrated" with production.

The reason for introducing two "integration levels" in the above definition is to take into account the different structure of the productive sector in countries with different socio-economic systems and also in order to facilitate comparison. The element which characterizes these two levels is that whereas S&T activities integrated with production are carried out within the sphere and in the interest of particular enterprises, S&T activities not integrated with production are performed in institutions, which are not industrial or trading establishments and are not therefore directly involved in the production process, with the aim of benefiting the totality of the enterprises belonging to a category or class of economic activity (two- and three-digit levels of ISIC).

As a general guideline, public and private enterprises engaged in the production and distribution of goods and services for sale and those institutions which are neither wholly nor mainly government financed and controlled which are within an enterprise and are serving the enterprise should be classified as productive sector, integrated S&T; the remaining institutions serving enterprises which are neither wholly nor mainly government financed and controlled (often institutions which are separate legal entities but maintained by fees, donations and contracts from the enterprises) should be classified to the non-integrated S&T activities in the productive sector, together with the S&T (or R&D) units wholly or mainly government controlled and financed but serving 2-or 3-digit ISIC industries.

The following may serve as an additional criterion for the inclusion or exclusion of servicing organizations and institutions in the latter "level" (i.e. non-integrated R&D - or STA).

In so far as government institutes and organizations or individual departments of institutes and organizations are mainly or exclusively serving a specific two- of three-digit group of the economy, they should be classified with this "level". For example the activity of a national "Experimental Station on Leather and Tanning", attached to the Ministry of Industry, should be considered as R&D not integrated with production as it would be classified under ISIC group 3231 "Tanneries and leather finishing" belonging to the major group (three-digit) 323 "Manufacture of leather and products of leather, leather substitutes and fur, except footwear and wearing apparel" (see Appendix C). Of course, where such an organization or institute directly serves two or more branches of economic activity (for example, manufacturing industries, construction, etc.) the scientific and technological activities should be pro-rated between these branches.

All other such institutes or organizations serving a wide group of industries or having a very general and broad field of research or scientific activity serving the community as a whole should be classified with the general service sector (see 2.3, p. 60).

Examples of this kind are the national bureaux of standards and the customs laboratories which, besides their institutional duties of quality control, quite often carry out research on a very large number of products and methodologies of analysis.

Particular difficulties may arise in classifying organizations such as industrial, transport and agricultural R&D institutes which are mostly set up and financed by government and serve both specific two- or three-digit groups of the economy and the community as a whole. Those institutes providing market services should be attributed to the productive sector (non-integrated activities), whereas those providing non-market services would belong to the general service sector. Where the activities of such institutes cannot be assigned properly to the sectors concerned, it is advisable to classify them entirely with the general service sector, particularly if their major activities are in the field of fundamental research.

In the preceding paragraphs and in the definitions relating to the productive sector, the two- or three-digit levels of ISIC are referred to; likewise the single-digit level of ISIC is mentioned with regard to the general service sector (see also p. 60). These ISIC levels have been indicated to provide general guidance only in attributing a specific statistical unit to the appropriate sector of performance. The primary criterion for sectoring remains the principal function or service provided and the references to ISIC levels should be considered as additional, secondary characteristics. ISIC is a classification of kinds of economic activity and its applicability to S&T activities is limited in several respects. This coupled with the problem of attributing the activities of a particular statistical unit (as a whole), can lead to difficulties in the classification of certain research institutes. Their classification is not always immediately obvious or logical and it is left to the reader who is normally the one most cognizant of the specific nature of the principal activity of the unit concerned to determine on the basis of the primary criterion cited above the most appropriate sectoral classification.

2.2 Higher education sector

Higher education sector, comprises:

establishments of education at the third level which require as a minimum condition of admission successful completion of education at the second level or evidence of the attainment of an equivalent level of knowledge, together with research institutes, experimental stations, hospitals and other S&T institutions serving such establishments and directly administered by or associated with them.

This sector includes therefore institutions such as universities, whatever their source of finance, or their legal or economic status, colleges of technology, specialized schools and institutes (agricultural, economics, pedagogical schools, medical schools and teaching hospitals etc.) but excludes institutions of general secondary education (second stage) and of specialized secondary technical education.

2.3 General service sector

General service sector, comprises:

- bodies, departments and establishments subordinate to the central, State (in federal systems), provincial, district or county, municipal, town or village authorities that serve the community as a whole and provide a wide range of services such as administration, maintenance and regulation of public order, public health, culture, social services, promotion of economic growth, welfare and technical progress, etc.;

- institutions such as national scientific research and technology councils, academies of science, professional scientific organizations and other institutions which serve the whole of the community;

- institutions whose S&T activities (including R&D) are carried out for the general benefit of agriculture, industry, transport and communications, building and public works or the public electricity, gas and water services - i.e. activities classified under a single-digit reference in the ISIC.

The main characteristic of the general service sector is that it covers all those institutions which act on behalf of the general collective needs of the community and of members of the community; it includes as well certain S&T activities of public or government organizations and institutions which are carried out as a support to the economic activity - and for this reason they could be considered as S&T activities not integrated with production - but the activities are in fact so general in scope that they cannot be attributed to any two- or three-digit level of ISIC. In this sense, since the productive sector and the higher education sector already include scientific and technological activities of public or government organizations and institutions, the general service sector mainly comprises the residual of these activities. These are often important in volume and relevance.

2.4 Statistical unit in the three sectors of performance

With due regard to the definition of a basic statistical unit as set out in item 1.2, page 55, the following guidelines are suggested for identifying the statistical unit within each of the three sectors of performance of S&T activities:

2.4.1 The statistical unit in the productive sector could be R&D departments and laboratories, reference libraries, documentation centres, etc., belonging to industrial and trading establishments or enterprises; the establishments themselves; enterprises (when their main activity is a S&T activity) or other units of the establishment-type. For S&T activities not integrated with production, the appropriate statistical units would be the institutions which carry out these activities.

2.4.2 In the higher education sector typical statistical units would be university institutes or their equivalents, faculties, departments and colleges; university clinics, experimental stations and research institutes whose S&T activities are associated with educational institutions at the third level.

2.4.3 The typical statistical units of the general service sector are the various types of government institution or body which function separately or are separately identifiable, such as research institutes, testing stations, laboratories, design offices, central offices, departments or divisions of ministries, libraries, archives, museums, documentation centres, etc. Other statistical units in this sector would be institutions, academies, and scientific societies, professional organizations and other institutions that serve the community.

3. Subsectoring by field of activity

For more detailed analysis of scientific and technological activities within a given sector of performance, subsectoral classifications are often used in national practice. The classifications vary according to the sector of performance.

3.1 Classification by branch of economic activity

For institutions belonging to the productive sector (integrated or non-integrated activities) the human and financial resources devoted to S&T activities should be subdivided by branch of economic activity in accordance with the "International Standard Industrial Classification of all Economic Activities" (ISIC). The following industry groupings at single and selected double-digit ISIC levels should be included (see Appendix C):

(i) Agriculture, hunting, forestry and fishing (ISIC:1)

(ii) Mining, and quarrying (extracting industries) (ISIC:2)

(iii) Manufacturing industries (ISIC:3)

- Manufacture of food, beverages and tobacco (ISIC:31)
- Textile, wearing apparel and leather industries (ISIC:32)
- Manufacture of wood and wood products, including furniture (ISIC:33)
- Manufacture of paper and paper products, printing and publishing (ISIC:34)
- Manufacture of chemicals and chemical, petroleum, coal, rubber and plastic products (ISIC:35)
- Manufacture of non-metallic mineral products, except products of petroleum and coal (ISIC:36)
- Basic metal industries (ISIC:37)

- Manufacture of fabricated metal products, machinery and equipment (ISIC:38)

- Other manufacturing industries (ISIC:39)

(iv) Utilities (ISIC:4)

(v) Construction (ISIC:5)

(vi) Transport, storage and communication (ISIC:7)

(vii) Other (ISIC:6,8 and that part of 9 which includes those activities which are not included in the "general service sector" or the "higher education sector".)

3.2 Classification by field of science and technology

In institutions belonging to the higher education sector and to the general service sector the human and financial resources devoted to S&T activities and, in particular, to R&D, should be subdivided by field of science and technology as follows:

(i) Natural sciences, including: astronomy, bacteriology, biochemistry, biology, botany, chemistry, computer sciences, entomology, geology, geophysics, mathematics, meteorology, mineralogy, physical geography, physics, zoology, other allied subjects.

(ii) Engineering and technology, including: engineering proper, such as chemical, civil, electrical and mechanical engineering, and specialized subdivisions of these; forest products; applied sciences such as geodesy, industrial chemistry, etc.; architecture; the science and technology of food production; specialized technologies of inter-disciplinary fields, e.g. systems analysis, metallurgy, mining, textile, technology, other allied subjects.

(iii) Medical sciences, including: anatomy, dentistry, medicine, nursing, obstetrics, optometry, osteopathy, pharmacy, physiotherapy, public health, other allied subjects.

(iv) Agricultural sciences, including: agronomy, animal husbandry, fisheries, forestry, horticulture, veterinary medicine, other allied subjects.

(v) Social science and humanities, comprising:

Group I - Social sciences, including: anthropology (social and cultural) and ethnology, demography, economics, education and training, geography (human, economic and social), law, linguistics (excluding studies of language based on set texts, which should be classified in Group II under "Ancient and modern languages and literature"), management, political sciences, psychology, sociology, organization and methods, miscellaneous social sciences and inter-disciplinary, methodological and historical S&T activities relating to the subjects of this group. Physical anthropology, physical geography and psychophysiology should normally be classified within the natural sciences.

Group II - Humanities, including: arts (history of the arts and art criticism excluding artistic "research" of any kind), letters (ancient and modern languages and literature), philosophy (including the history of science and technology), prehistory and history, together with auxiliary historical disciplines such as archaelogy, numismatics, paleography, etc., religion, other fields and subjects pertaining to the humanities and interdisciplinary, methodological, historical and other S&T activities relating to the subjects in this group.

The above classification overlaps with the classification by field of study (i.e. fields of study corresponding to groups of ISCED fields) illustrated in Chapter III, item 4.2 (with the exclusion of the "other fields") (see page 41).

However, instead of making reference to fields of study, which are of interest when classifying "scientists and engineers" and "technicians", it sets forth the corresponding fields of science and technology - in other words the disciplines - in which S&T activities, and especially R&D, are carried out in institutions belonging to the higher education and general service sectors (universities, colleges of technology; bodies, departments, establishments subordinate to central or local authorities; national research and technology councils, academies of sciences, etc.).

4. Classification by major socio-economic aims or objectives

The classification of data on national activities in R&D by socio-economic objectives is based on the ultimate aim or purpose for which these activities are carried out and shows the broad pattern of national efforts in these activities. Data classified by these objectives should provide a very useful tool in the formulation of national policy.

It may be emphasized that, in order to avoid confusion, the distinction between objective and function should be made. In fact it frequently happens that an institution whose primary function is to provide services in a certain area, supports S&T activities in other areas. Therefore if, for example, a Ministry of Health gives a research contract to study a certain aspect of air pollution, the funds should be classified under objective (x) "Protection of the environment" of the following classification and not under objective (viii) "Development of health services", as the primary objective of the research is the study of an environmental problem.

All civil R&D should be classified in major aims (i) to (xii) whilst all R&D consistent with the definition of defence should be reported separately under that specific major aim (xiii). So that, if a Ministry of Defence commits one of its research establishments to the study of a new type of paint with particular characteristics of resilience to corrosion, the funds should be attributed to objective (iv) "Promotion of industrial development" and not to objective (xiii) "Defence".

In developing the following classification, the experience of the Nordsforsk (3) and of the European Economic Communities (2) in their analyses of government R&D budgets was of much benefit and special attention was paid to the OECD guidelines (1) for classifying national

R&D expenditure by objectives. The scheme for classification does not follow an institutional or strictly sectoral scheme but is based exclusively on objectives. This classification should be used to obtain summary information on the broad pattern of national funding (ex-ante) or expenditure (ex-post) (see Chapter IV, item 1) financed from public funds and, if possible, from all other sources of funds. The scheme shown below has been developed by Unesco on an experimental basis; it is also of evolutionary character and changes will be introduced over time to reflect the changes in objectives of funds.

It is clear that the thirteen main aims listed below are not intended to give an exhaustive list of what type of R&D should be included in each one of them, but rather a few guidelines for classification. Obviously there will be cases where more than one way of classifying a given project is possible. Having in mind that the aim of this classification is to give the most accurate reflection of the purposes of the funder, if there is a difference between the aim of the funder and that of the performer, the interest of the financer (funder) should be considered paramount.

(i) Exploration and assessment of the earth, the seas and the atmosphere

This heading covers R&D activities primarily related to the exploration and assessment of the earth's crust and mantle, the seas, oceans and the atmosphere and their administration, economics, policy and planning. It does not include studies on soils for agricultural purposes, R&D on oceanography serving the fishing industry nor R&D concerning the economic exploitation of sources of raw materials, fuel and energy. The activities included in this group are undertaken with a view toward economic exploitation of results, thus excluding fundamental investigation in meteorology, geology, hydrology, etc., which is included under (xi) "General advancement of knowledge".

(ii) Civil space

This heading covers all civil R&D concerning space (programmes undertaken for military purposes should be included under (xiii) "Defence" below). It includes, among others, R&D on launch vehicles and spacecrafts and their propulsion and control; on ground facilities (launch bases, guidance, telemeasure and telecommand); on satellites, interplanetary probes; stratospheric balloons; sounding rockets. The use of space vehicles for communication, meteorology, navigation, earth resources surveying, etc., should be assigned to the appropriate objective.

(iii) Development of agriculture, forestry and fishing

This heading covers two categories of R&D activities, the first related to aspects of food products, and the second concerned with non-food agricultural products and forestry. Under the first are included R&D on the production, storage and distribution of food, e.g. livestock production and improvement of species, veterinary medicine, crop production and agronomy, R&D on agricultural machinery and agricultural chemicals, R&D on the processing of food and beverages, their storage and distribution, fisheries and their related technologies, and the administration, economics, policy and planning of agriculture

and food production. The second category, development of non-food agricultural products and forestry, covers all R&D activities on non-food agricultural products such as wool, skins, tobacco, cotton and other fibres, and on forestry and related technology.

(iv) Promotion of industrial development

This major aim relates to all R&D activities contributing to the development and improvement of the manufacturing and non-fuel mining industries and construction. It includes R&D on the administration, economics, policy and planning of industrial development, on the production of textiles, wearing apparel and leather, wood and paper products, chemicals including petro-chemicals, rubber and plastics, basic metals, fabricated metal products, machinery and equipment including transport vehicles, non-metallic products, mining other than fuels. It does not include industrial R&D performed in support of other objectives such as development of agriculture and food production, transport and communications, exploration of space, urban and rural planning and defence.

(v) Production, conservation and distribution of energy

This heading covers all R&D activities relating to the production, supply, conservation and distribution of all forms of energy (including nuclear) and the administration, economics, policy and planning of energy; it includes the mining of solid fuels and related technology, petroleum and gas production as well as non-conventional energy sources (solar, wind) and small energy sources.

(vi) Development of transport and communication

This group relates to the transportation systems and networks and systems of communication, covering land, air and water transport, radio and television, telephone and other communications including satellites as well as R&D on the administration, economics, policy and planning of transport and communication networks. It includes auxiliary services such as electronic traffic aids and radar stations but excludes engines, motors and means of transportation such as vehicles, ships and planes which are included in the aim "Promotion of industrial development".

(vii) Development of education services

This major aim includes R&D activities concerning the administration, economics, policy and planning of education services at all levels. Formal education as well as out-of-school in-service and other forms of adult education and training are included. R&D on both conventional and new technical

devices and teaching methods such as programmed instruction, television and other audio-visual techniques should also be considered in this group.

(viii) Development of health services

This heading concerns all R&D activities directed to the protection and improvement of human health. It includes R&D on medical care (including surgery and obstetrics), disease prevention, nutrition and food hygiene, on the impact on health of the environment, including labour medicine, on pharmaceutical products, vaccines and prosthetics as well as health administration, economics, policy and planning.

(ix) Social development and socio-economic services

This group relates to R&D activities concerning the administration, economics, policy and planning of social development and socio-economic services; it includes political organization, law and order, social security, culture, recreation and leisure, consumer protection, the improvement of working conditions, labour relations, manpower and migration, international relations including the maintenance of peace, international courts, treaties and other social services. Also included are R&D activities on economic organization, money and banking, insurance, etc. This major aim also includes R&D activities concerning urban and rural planning such as domestic housing, sanitary services and other community services involved in the improvement of human settlements.

(x) Protection of the environment

This major aim covers all aspects of the "protection" of the environment - the maintenance of the purity of the atmosphere, water and soil, the control of noise, environmental models and statistics and the regulation, economics, policy and planning relative to the environment. It excludes R&D on the environmental impact on health which should be included under (viii) above and the environmental impact on human settlements which should be included under (ix) above. Also excluded is R&D designed to prevent pollution by specific economic activities, which should be included with the relevant activities.

(xi) General advancement of knowledge

This heading includes all R&D of very general orientation which cannot be classified in one of the other major aims but contributes to the general advancement of knowledge in the social as well as the natural sciences. It consists of fundamental and applied research which science councils, institutes of academies of sciences and universities undertake in the context of their broad vocation. It includes R&D on the administration, economics, policy and planning of R&D itself.

(xii) Other aims (civil)

This item includes all other civil R&D undertaken with a specified aim which does not fall under any of the above headings. It would include for example, the improvement of information systems, computer science (hardware and software) but exclude expenditure on the gathering of data. Another example would be R&D in favour of the wholesale and retail trade, restaurants and hotels.

(xiii) Defence

This major aim includes nuclear, space and other R&D undertaken for military purposes. Sums spent on civil research by military institutions should, as far as possible, be distributed among the major civil objectives to which they may relate.

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APPENDIX A

Recommendation concerning the International Standardization of Statistics on Science and Technology

adopted by the General Conference at its twentieth session
Paris, 27 November 1978

The General Conference of the United Nations Educational, Scientific and Cultural Organization, meeting in Paris from 24 October to 28 November 1978, at its twentieth session,

Considering that, by virtue of Article IV, paragraph 4 of the Constitution, it is for the Organization to draw up and adopt instruments for the international regulation of questions falling within its competence,

Considering that Article VIII of the Constitution provides, inter alia, that each Member State shall report to the Organization, at intervals and in a manner to be determined by the General Conference, on its laws, regulations and statistics relating to educational, scientific and cultural life and institutions,

Convinced that it is highly desirable for the national authorities responsible for collecting and communicating statistics relating to science and technology to be guided by certain standards in the matter of definitions, classifications and presentation, in order to improve the international comparability of such statistics,

Recognizing that the efforts made by Member States to develop science and technology will contribute to strengthening peace and security in the world,

Convinced that co-operation in this field would also advance economic and social progress,

Having before it, as item 34 of the agenda of the session, proposals concerning the international standardization of statistics relating to science and technology,

Having decided at its nineteeth session that this question should be made the subject of an international regulation, to take the form of a recommendation to Member States within the meaning of Article IV, paragraph 4, of the Constitution,

Adopts the present recommendation this 27th day of November 1978.

The General Conference recommends that Member States should apply the following provisions concerning international standardization of statistics relating to science and technology, by taking whatever legislative measures or other steps may be required, in conformity with the constitutional practice of each State, to give effect, within their respective territories, to the standards and principles formulated in this recommendation.

The General Conference recommends that Member States bring this recommendation to the attention of authorities and services responsible for collecting and communicating statistics relating to science and technology.

The General Conference recommends that Member States forward to it, by the dates and in the form which it shall prescribe, reports concerning action taken by them upon this recommendation.

1. SCOPE AND DEFINITIONS

Scope

1. This recommendation relates to statistics designed to provide standardized information in each Member State on certain scientific and technological (S&T) activities, and particularly on research and experimental development (R&D). These statistics should cover all national institutions that perform or finance such activities.

Definitions

2. In compiling the statistics covered by this recommendation, the following definitions should be used :

2.1 Scientific and technological activities (STA): systematic activities which are closely concerned with the generation, advancement, dissemination, and application of scientific and technical knowledge in all fields of science and technology. These include such activities as R&D, scientific and technical education and training (STET), and the scientific and technological services (STS), defined in paragraphs (a) to (c) below.

(a) Research and Experimental Development : any systematic and creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications. In most fields several categories may be distinguished :

(aa) Scientific research activities : any systematic and creative work aimed at increasing the stock of scientific knowledge and applying it in practice.

- Scientific research activities in the natural sciences, technology, and the medical and agricultural sciences : Any systematic and creative activities designed to ascertain the links between, and the nature of, natural phenomena, to generate knowledge of the laws of nature and to contribute to the practical application of this knowledge of laws, forces and substances.

- Scientific research activities in the social sciences and humanities : Any systematic and creative activity aimed at increasing or improving knowledge of man, culture and society, including use of such knowledge for the solution of social and human problems.

In most fields of science, research may be classified as either fundamental or applied :

(i) Fundamental research : experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular or specific application or use in view.

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

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

(b) S&T education and training (STET) at broadly the third level : all activities comprising specialized non-university higher education and training, higher education and training leading to a university degree, post-graduate and further training, and organized lifelong training for scientists and engineers. These activities correspond broadly to ISCED levels 5, 6 and 7.

(c) Scientific and technological services (STS) :activities concerned with research and experimental development and contributing to the generation, dissemination and application of scientific and technical knowledge.

(i) S&T services provided by libraries, archives, information and documentation centres, reference departments, scientific congress centres, data banks and information-processing departments.

(ii) S&T services provided by museums of science and/or technology, botanical and zoological gardens and other S&T collections (anthropological, archaeological, geological, etc.).

(iii) Systematic work on the translation and editing of S&T books and periodicals (with the exception of textbooks for school and university courses).

(iv) Topographical, geological and hydrological surveying; routine astronomical, meteorological and seismological observations ; surveying of soils and of plants, fish and wildlife resources ; routine soil, atmosphere and water testing ; the routine checking and monitoring of radioactivity levels.

(v) Prospecting and related activities designed to locate and identify oil and mineral resources .

(vi) The gathering of information on human, social, economic and cultural phenomena, usually for the purpose of compiling routine statistics, e.g. population censuses; production, distribution and consumption statistics ; market studies ; social and cultural statistics, etc.

(vii) Testing, standardization, metrology and quality control : regular routine work on the analysis, checking and testing, by recognized methods, of materials, products, devices and processes, together with the setting up and maintenance of standards and standards of measurement.

(viii) Regular routine work on the counselling of clients, other sections of an organization or independent users, designed to help them to make use of scientific, technological and management information. This activity also includes extension and advisory services organized by the State for farmers and for industry but does not include the normal activities of project planning or engineering offices.

(ix) Activities relating to patents and licences : systematic work of a scientific, legal and administrative nature on patents and licences carried out by public bodies.

2.2 Scientific and technical personnel : the total number of people participating directly in S&T activities in an institution or unit and, as a rule, paid for their services. This group should include scientists and engineers, and technicians (SET) and auxiliary personnel, as defined in paragraph 4 (a) below.

(a) Full-time scientific and technical personnel (FT) : personnel who devote almost all their working time to S&T activities.

(b) Part-time scientific and technical personnel (PT) : personnel whose working time is shared between S&T and other activities.

(c) Full-time equivalent (FTE) : measurement unit representing one person working full-time for a given period; this unit is used to convert figures relating to the number of part-time workers into the equivalent number of full-time workers. Data concerning personnel should normally be calculated in FTE, especially in the case of scientists and engineers and of technicians.

2.3 Reference year : period of 12 consecutive months to which the statistical data relate. When this period carries over from one calendar year to the next, the year in which the period started is to be taken as the reference year.

2.4 Annual expenditure : funds actually expended during the reference year for the performance of S&T activities.

(a) Intramural expenditure : all payments actually made during a reference year for the performance of S&T activites within a given unit, institution or sector of performance.

(b) Extramural expenditure : all payments actually made during a reference year for the performance of S&T activities outside a particular unit, institution or sector of performance, including payments made outside the national economic territory.

(c) Total domestic expenditure on S&T activites : all expenditure made for this purpose in the course of a reference year in institutions and installations established in the national territory, as well as installations physically situated abroad: land or experimental facilities rented or owned abroad and ships, vehicles, aircraft and satellites used by national institutions. Amounts spent on S&T activities carried out by international organizations established in the country in question are excluded from this total.

2.5 Institutions carrying out S&T activities : any institution engaged in S&T activities on a permanent and organized basis. The term "institution" should be taken as covering a very broad range of entities having legal, financial, economic, social or political status, such as establishments, enterprises, bodies, organizations, institutes, academies, associations, departments, ministries, centres, laboratories, etc.

2.6 Sector of performance : sector of the national economy comprising a significant number of institutions carrying out S&T activities (as defined in paragraph 2.5) that present a certain degree of homogeneity with respect to the principal function or service provided irrespective of source of funds, the authority to which such institutions are responsible or the category of STA being carried out. According to these criteria, three major sectors of performance can be distinguished : the productive sector, the higher education sector and the general service sector.

2.7 Fields of activity : branches of economic activity and fields of science and technology in which R&D and other S&T activities are carried out.

2.8 Categories of activities : specific types of endeavours that comprise S&T activities such as R&D, S&T education and training (STET), STS, described in paragraphs 2.1(a), 2.1(b) and 2.1 (c).

II. CLASSIFICATION OF DATA

3. The human and financial resources devoted to S&T activities should be classified :

(a) By category and subcategory of such activities :

(i) Research and experimental development.

(ii) S&T education and training at broadly the third level (STET).

(iii) Scientific and technological services (as listed in 2.1 (c) (i) to (ix)).

(b) By sector of performance :

(i) Productive sector comprising :

domestic and foreign industrial and trading enterprises situated within the country which produce and distribute goods and services for sale, and institutions directly serving them with or without contract, whatever their form of ownership (public and private). The S&T activities of these enterprises and institutions closely linked to production are known as "S&T activities integrated with production";

governmental, non-governmental and non-profit institutions most or all of whose S&T activities indirectly serve one or more of the categories or classes of activities with a two- or three-digit classification in the ISIC. The S&T activities of these institutions which are only indirectly linked to production are known as "S&T activities not integrated with production". In countries with a centralized economy, R&D institutes attached to the ministries responsible for the different branches of the national economy should be classified in this category of institutions.

(ii) Higher education sector, comprising :

establishments of education at the third level which require as a minimum condition of admission successful completion of education at the second level or evidence of the attainment of an equivalent level of knowledge, together with research institutes, experimental stations, hospitals and other S&T institutions serving such establishments and directly administered by or associated with them.

(iii) General service sector, comprising :

bodies, departments and establishments subordinate to the central, State (in federal systems), provincial, district or county, municipal, town or village authorities that serve the community as a whole and provide a wide range of services such as administration, maintenance and regulation of public order, public health, culture, social services, promotion of economic growth, welfare and technical progress, etc.; institutions such as national scientific research and technology councils, academies of sciences, professional scientific organizations and other institutions which serve the whole of the community ;

institutions whose S&T activities (including R&D) are carried out for the general benefit of agriculture, industry, transport and communications, building and public works or the public electricity, gas and water services - i.e. activities classified under a single-digit reference in the ISIC.

(c) By fields of science and technology in which institutions belonging to the higher education and general service sectors carry out S&T activities and , in particular, R&D :

(i) Natural sciences, including : astronomy, bacteriology, biochemistry, biology, botany, chemistry, computer sciences, entomology, geology, geophysics, mathematics, metecrology, mineralogy, physical geography, physics, zoology, other allied subjects.

(ii) Engineering and technology, including : engineering proper, such as chemical, civil, electrical and mechanical engineering, and specialized subdivisions of these; forest products; applied sciences such as geodesy, industrial chemistry, etc.; architecture; the science and technology of food production; specialized technologies or interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology, other allied subjects.

(iii) Medical sciences, including : anatomy, dentistry, medicine, nursing, obstetrics, optometry, osteopathy, pharmacy, physiotherapy, public health, other allied subjects.

(iv) Agricultural sciences, including : agronomy, animal husbandry, fisheries, forestry, horticulture, veterinary medicine, other allied subjects.

(v) Social sciences and humanities, comprising :

Group I - Social sciences, including :

anthropology (social and cultural) and ethnology, demography, economics, education and training, geography (human, economic and social), law, linguistics (excluding language studies based on set texts, which should be classified in Group II under "Ancient and modern languages and literature"), management, political sciences, psychology, sociology, organization 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.

Group II - Humanities, including :

arts (history of the arts and art criticism, excluding artistic "research" of any kind), languages (ancient and modern languages and literature), philosophy (including the history of science and technology), prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, etc., religion, other fields and subjects pertaining to the humanities and interdisciplinary, methodological, historical and other S&T activities relating to the subjects in this group.

(d) By branch of economic activity for institutions belonging to the productive sector, in accordance with the "International Standard Industrial Classification of all Economic Activities"(ISIC). Specific industry groupings at single and selected double digit ISIC levels from the following major divisions should be included:

(i) Agriculture, forestry, hunting and fishing (ISIC:1).

(ii) Extracting industries (ISIC:2).

(iii) Manufacturing industries (ISIC:3).

(iv) Construction (ISIC:5).

(v) Transport, storage and communication (ISIC:7).

(vi) Other (ISIC: 4,6,8 and part of 9).

4. The personnel of S&T institutions should also be classified :

(a) By the work they are engaged in and their qualifications :

(aa) Scientists and engineers, comprising persons working in those capacities, i.e. as persons with scientific or technical training who are engaged in professional work on S&T activities, administrators and other high-level personnel who direct the execution of S&T activities.

Such personnel should be classified in this category if they have either :

(i) completed education at the third level leading to an academic degree, or

(ii) received third-level non-university education (or training) not leading to an academic degree but nationally recognized as qualifying for a professional career, or

(iii) received training, or acquired professional experience, that is nationally recognized as being equivalent to one of the two preceding types of training (e.g. membership of a professional association or the holding of a professional certificate or licence).

(bb) Technicians, comprising persons engaged in that capacity in S&T activities who have received vocational or technical training in any branch of knowledge or technology, in accordance with the following criteria :

(i) that they have completed the second stage of second-level education. These studies are in many cases followed by one or two years' specialized technical studies, which may or may not lead to a diploma ;

(ii) that they have received three or four years' vocational or technical education (whether leading to a diploma or not)

following completion of the first stage of second-level education ;

(iii) that they have received on-the-job training (or acquired professional experience) that is nationally recognized as being equivalent to the levels of education defined under (i)or (ii) above.

(cc) Auxiliary personnel, comprising persons whose work is directly associated with the performance of S&T activities, i.e. clerical, secretarial and administrative personnel, skilled, semi-skilled and unskilled workers in the various trades and all other auxiliary personnel.

(b) By level of education and by field of study, determined in accordance with ISCED (International Standard Classification of Education), for classifying personnel in the "aa" and "bb" categories.

(i) By level of education:

(aa) Holders of third-level degrees of university type (ISCED: 6-7).

(bb) Holders of third-level diplomas of non-university type (ISCED:5).

(cc) Holders of diplomas at the second level, second stage (ISCED: 3).

(dd) Other qualifications (ISCED. 1, 2, 9).

(ii) By field of study :

Fields of science and technology should be correlated with the classification of fields of study in ISCED, as follows :

Fields of science and technology	Main fields of study in ISCED
Natural sciences	42. Natural science programmes
	46. Mathematics and computer science programmes
Engineering and technology	52. Trade, craft and industrial programmes, (n.e.c.)
	54. Engineering programmes
	58. Architectural and town-planning programmes
	70. Transport and communications programmes

Fields of science and technology	Main fields of study in ISCED
Medical sciences	50. Medical and health programmes
Agricultural sciences	62. Agriculture, forestry and fishery programmes
Social sciences and humanities	14. Teacher training and education science programmes
	18. Fine and applied arts programmes
	22. Humanities programmes
	26. Religion and theology programmes
	30. Social and behavioural science programmes
	34. Commercial and business administration programmes
	38. Law and jurisprudence programmes
	66. Home economics (domestic science) programmes
	84. Programmes in mass communication and documentation
Other fields	01. General programmes
	08. Literacy programmes
	78. Service trades programmes
	89. Other programmes

(c) By occupation in accordance with the ISCO (ILO-1968).

(d) By number (in FT and PT) for personnel in category (aa).

(e) By nationality, for personnel in categories (aa) and (bb) (merely showing nationals separately from non-nationals).

(f) By sex, for personnel in categories (aa), (bb) and (cc).

(g) By age, for personnel in categories (aa) and (bb), separating them into the following age groups ; for category (aa): less than 30,

30-39, 40-49, 50-59, 60 and over; for category (bb): less than 30, 30-39, 40-49, 50-59, 60 and over.

5. Each type of national S&T human resources, i.e. scientists and engineers and technicians, should be assessed in accordance with the following two criteria; if only one is to be used, criterion (b) is preferable.

(a) Total stock of SET, comprising the total number of persons with the necessary qualifications for personnel in categories (aa) and (bb), regardless of economic activity (production, S&T activities, the professions, no gainful employment, etc.), age, sex, nationality or other characteristics.

(b) Number of economically active SET, comprising the total number of persons with the necessary qualifications for personnel in categories (aa) and (bb) who are engaged in, or actively seeking work in, some branch of the economy at a given reference date.

6. Intramural expenditure on S&T activities should be classified:

(a) By type of expenditure:

(i) Current intramural expenditure, comprising all payments made during the reference year for the performance of S&T activities within units, institutions or sectors of performance, whatever the source or origin of funds, covering the cost of labour, minor equipment and expendable supplies and other current expenses, i.e.:

- labour costs, comprising wages and salaries, paid in cash or in kind, and all related labour costs, including "fringe benefits" such as bonuses, paid holidays, contributions to pension funds and compulsory social security systems, payroll taxes, etc. As far as possible, the cost of personnel in category (aa) should be shown separately from the cost of other personnel;

- other current costs, comprising all other current intramural expenditure such as expenditures on office and laboratory supplies, materials, subscriptions to journals, books, rental of buildings, maintenance, computer services, travel and postal services.

(ii) Intramural capital expenditure, comprising all payments made during the reference year for the performance of S&T activities and relating to expenditure on major equipment and other capital expenditure. All reserves for depreciation, whether actual or imputed, should be excluded from international statistics on expenditure. Nevertheless, countries that are in a position to furnish such information may do so if they wish. This expenditure comprises:

- expenditure on major equipment, comprising the purchase of major installations, machinery and equipment. Expenditure on the purchase of complete libraries, large collections of books, periodicals, specimens, etc. should be included under this heading, especially when made at the time of equipping a new institution. Even if made at any other time, however, purchases of this type could still be shown under capital expenditure;

- other capital expenditure, comprising the purchase of land (for building or for testing purposes) and animals (where the unit cost or quantity purchased make it appropriate to include the expenditure in this category) and expenditure on new buildings or large-scale improvements, modifications and repairs to buildings and fixed installations, land-improvement work and other expenditure.

(b) By source of funds:

(i) Government funds. This category should include funds provided by the central (federal) State or local authorities and originating from the ordinary or extraordinary budget or from extra-budgetary sources. It also covers funds received from public intermediary institutions established and wholly financed by the State.

(ii) Productive enterprise funds and special funds. This category should include funds allocated to S&T activities by institutions classified in the productive sector as productive establishments or enterprises and all sums received from the "Technical and Economic Progress Fund", in countries with a centralized economy, and other similar funds.

(iii) Foreign funds. This category should include funds received from abroad for national S&T activities, including funds received from international organizations, foreign governments or institutions.

(iv) Other funds. This category should include funds that cannot be classified under any of the preceding headings, e.g. "own funds" of establishments in the higher education sector, endowments and gifts.

(c) By category, for expenditure on R&D:

(i) Fundamental research.

(ii) Applied research.

(iii) Experimental development.

7. National activities in R&D and STS should be classified by major socio-economic aims or objectives as listed below, on the basis of funding (ex-ante) or expenditure (ex-post) financed from public funds and, if possible, from all other sources of funds:

(i) Exploration and assessment of the earth, the seas and the atmosphere.

(ii) Civil space.

(iii) Development of agriculture, forestry and fishing.

(iv) Promotion of industrial development.

(v) Production, conservation and distribution of energy.

(vi) Development of transport and communication.

(vii) Development of education services.

(viii) Development of health services.

(ix) Social development and socio-economic services.

(x) Protection of the environment.

(xi) Other aims.

(xii) Defence.

8. Basic statistical units: If possible, the basic statistical unit selected to measure the performance of S&T activities should be an establishment-type unit; for example, industrial establishments, research institutes, governmental units and institutes or departments of universities.

III. PRESENTATION OF STATISTICAL DATA

9. The statistics covered by this recommendation should be presented in accordance with the definitions and classifications set out therein.

Levels of detail

10. In view of the fact that the statistical systems of Member States are not all the same stage of development, the data should be presented at two levels of detail or complexity depending on the information available in Member States.

(a) First level of detail : a limited quantity of basic information that is indispensable for establishing international comparisons and that should, if possible, be compiled by all Member States.

(b) Second level of detail : fuller statistical data, which not all Member States are able to provide but which, taken as a whole, could constitute a guide for those that wish to improve and enlarge their natural statistical systems.

Periodicity

11. The basic international statistics should be updated biennially. It would be desirable for Member States that can do so to update certain data annually so that variations in their R&D effort can be seen. Figures for the stock of SET and/or number of economically active SET should be compiled twice during each ten-year period.

Stages for the extension of S&T statistics

12. The compilation of international S&T statistics should be developed in two successive stages, the transition from the first stage to the second being accomplished gradually on the basis of the state of progress of national and international experience. The first stage should cover a period of at least five years starting from the time the General Conference adopts this recommendation. The second stage should be regarded as being of an experimental nature.

(a) First stage: during this stage, i.e. during the years immediately following the adoption of this recommendation, international statistics should cover only R&D activities in all sectors of performance, together with the stock of SET and/or the economically active SET. If, of the last two,

only one is collected it should preferably be the latter one.

(b) Second stage: Before going on to the second stage, it would be advisable for Member States to ascertain through the Unesco Secretariat that a sufficiently large number of them are in a position, on the basis of international experience and their own work, to extend statistical observation to the STS and Scientific and Technological Education and Training at broadly the third level (STET) involved in this stage.

During this stage, the international statistics should be extended to cover STS and STET carried out in institutions in which R&D activities are performed and should be shown either in consolidated form or by STET and by type of STS, depending on the country's capabilities. First an evaluation should be made of STS and STET in all sectors of performance, with the exception of integrated units in the productive sector. Subsequently, the international statistics relating to STS and STET should be progressively extended to the integrated units in the productive sector and to institutions in all sectors of performance that do not carry out R&D but provide STS and STET in an institutionalized and structured manner. These statistics should be broken down by STET and by type of STS.

13. The information furnished by the statistics of science and technology should be presented with the periodicity and level of detail shown below;

FIRST STAGE

Periodicity (if other than biennial)	Level of detail	Indicators
		(a) Stock and/or economically active SET
*	1	1. Number of SET by sex, nationality and occupation
*	2	2. Number of S&E by field of qualification
		(b) R&D activities
		(i) R&D personnel
Annual	1	1. Personnel by category (S&E, T, auxiliaries)
	2	2. S&E by field of qualification
Annual	1	3. Personnel by sector of performance

* Twice during each ten-year period.

Periodicity (if other than biennial)	Level of detail	Indicators
	2	4. S&E (in FT and PT) by field of qualification; and by sector of performance and field of activity
	2	5. SET by category and nationality
	2	6. SET by sex and age
		(ii) Intramural expenditure on R&D
Annual	1	1. Total expenditure by sector of performance
	2	2. Total and current expenditure by sector of performance
	2	3. Current and capital expenditure, in detail, by sector of performance
	2	4. Current expenditure by type of R&D, sector of performance and field of activity
	2	5. Current expenditure on S&E personnel by sector of performance
		(iii) Financing of intramural R&D expenditure
Annual	1	1. Total expenditure by source of funds
Annual	2	2. Total and current expenditure by source of funds and sector of performance
	2	3. Total expenditure by source of funds, sector of performance and field of activity.
		(c) Other classifications relating to R&D
		(i) Major socio-economic aims
	2	1. Funding (ex-ante) or expenditure (ex-post) financed from public funds, by major socio-economic aim

Periodicity (if other than biennial)	Level of detail	Indicators
	2	2. Funding (ex-ante) or expenditure (ex-post) financed from all sources, by major socio-economic aim.
		SECOND STAGE
		(a) STS in R&D institutions (with the exception of R&D units integrated of the productive sector)
		(i) STS personnel
	1	1. Personnel by category (S&E, T, auxiliaries)
	1	2. Personnel by sector of performance
	2	3. Personnel by sector of performance and field of activity
	2	4. Personnel by type of STS
	2	5. S&E (in FT and PT) by field of qualification; and by sector of performance and field of activity
	2	6. SET by sex, age and nationality
		(ii) Intramural expenditure on STS
	1	1. Total expenditure by sector of performance
	2	2. Current and capital expenditure by sector of performance
	2	3. Total and current expenditure by sector of performance and type of STS
	2	4. Current expenditure by type of STS, sector of performance and field of activity
	2	5. Current and capital expenditure, in detail, by sector of performance
		(iii) Financing of intramural expenditure on STS
	1	1. Total expenditure by source of funds.

Periodicity (if other than biennial)	Level of detail	Indicators
	2	2. Total and current expenditure by source of funds and sector of performance
	2	3. Total expenditure by source of funds, sector of performance and field of activity.
		(b) Other classifications relating to STS
		(i) Major socio-economic aims
	2	1. Funding (ex-ante) or expenditure (ex-post) financed from public funds by major socio-economic aim
	2	2. Funding (ex-ante) or expenditure (ex-post) financed from all sources by major socio-economic aim

IV. LONG-TERM DEVELOPMENT OF SCIENCE AND TECHNOLOGY STATISTICS

14. In order to set themselves goals to aim at in the gradual development of science and technology statistics, Member States should further certain statistical work already under way which should provide a better understanding of present problems in this field of statistics and help to resolve them. Their efforts should be concentrated on the following items, though these are not set out in any intended order of priority:

(a) Development of co-ordination between science and technology statistics and economic and social statistics, and especially with national accounting systems including the Material Product System.

(b) Development of classifications for financial resources devoted to R&D, in terms of appropriations and expenditure (ex-ante and ex-post analyses), by main national socio-economic aims.

(c) Indicators for the "production" or "output" of S&T activities, especially R&D.

(d) Indicators of the statistical and accounting aspects of technology transfer processes.

(e) Preparation of specific price indexes and exchange rates to serve as suitable deflators for expenditure on S&T activities, and especially on R&D.

(f) Measurement and classification of S&T equipment and installations for R&D activities.

(g) Studies of the effects of fiscal systems on expenditure for S&T activities.

(h) Classification of S&T personnel by occupation and professional status.

APPENDIX B

International Standard Classification of Education (ISCED)

(Extracted from International Standard Classification of Education, Abridged edition, UNESCO, Paris, 1975 (ED/31E/CONFINTED.35/Ref.8)

ISCED Levels

0 Education preceding the first level, where it is provided, usually begins at age three, four, or five (sometimes earlier) and lasts from one to three years.

1 Education at the first level usually begins, therefore, at age 5, 6 or 7 and lasts for about five or six years.

2 Education at the second level, first stage, begins at about age 11 or 12 and lasts for about three years.

3 Education at the second level, second stage, begins at about age 14 or 15 and lasts for about three years.

5 Education at the third level, first stage, of the type that leads to an award not equivalent to a first university degree begins at about age 17 or 18 and lasts for about three years. Thus, at about age 20 or 21, students who have progressed through the school system to complete these programmes are usually ready to enter employment.

6 Education at the third level, first stage, of the type that leads to a first university degree or equivalent, also begins at about age 17 or 18 and lasts for about four years. Thus, students who have progressed through the school system to complete their first degree are usually ready for employment or for post-graduate study at about age 21 or 22.

7 Education at the third level, second stage, of the type that leads to a post-graduate university degree or equivalent, includes all education beyond level 6.

9 Education not definable by level.

Description of ISCED levels

0 Education preceding the first level

The initial stages of organized instruction as defined for purposes of ISCED. The educational programmes included here therefore do not include play groups, day nurseries, crèches, child-care centres, or similar organizations that have no sustained educational purpose. The age of entry to education preceding the first level varies in different countries and in areas within some countries. The upper age limit in this

level category depends in each case on the usual age for entry into primary education.

Programmes at this level place little emphasis on literacy or general education, the activities being directed mainly toward the children becoming accustomed to group activities such as singing, dancing, participation in rhythm groups and group games to promote healthy and socially desirable habits. Also stressed is the development of skills in handling colouring, moulding, lettering and similar materials as well as simple tools. The programmes are designed primarily to introduce very young children to anticipated school-type environment, i.e. to provide a bridge between a home and school atmosphere.

1. Education at the first level

The "core" at this level consists of education provided for children in all countries, the customary or legal age of entrance being not younger than five years or older than seven years. This level then covers five or six years of full-time schooling. Programmes are designed to give the students a sound basic education in reading, writing and arithmetic along with an elementary understanding of other subjects such as national history, geography, natural science, social science, art and music, and in some cases religious instruction is featured, especially in programmes run by religious organizations. The programmes are rarely specialized by subject, but are usually organized on a unit- or project basis. In a few countries, education at this level is divided into two stages, usually a first stage of four years and a second stage of two years, which may be combined with the first stage of the second level.

2. Education at the second level, first stage

The "core" at this level consists of education continuing the basic programmes constituting the first level but usually on a more subject-oriented pattern. Some small beginnings of specialization may be seen at this level with some students having the opportunity to direct their attention more particularly to certain types of subject, e.g. commercial or technical subjects. This level consists of three or four years of full-time schooling. Programmes are composed of the subjects mentioned uner level 1 with a broader approach to mathematics, more attention to literature and composition in the mother tongue, other modern languages, and a beginning at specialization in some natural sciences such as chemistry, botany and physical geography. In many countries this level of education is carried on in the same institutions as levels 1 and 0, in some it occurs in "secondary schools" along with level 3, while in some cases separate institutions are provided for approximately the 6th to the 9th year of schooling.

In addition to the above for the core, this level covers a wide variety of programmes consisting of subject matter usually having a specific vocational emphasis. The common feature of all these programmes is their entrance requirement, i.e. a minimum of first-level education (some five to six years of schooling) completed or demonstrable ability to handle the programme through a combination of basic education of something less than five years and vocational experience.

3. Education at the second level, Second stage

The "core" at this level consists of education for those who have completed the second level, first stage. General education is still an important constituent, but separate subject presentation and more specialization are found at this level. Many students will have moved over to particular sets of programmes such as commercial, trade or technical, while others following the general programmes will be given more leeway in their choice of subject courses. This level consists of three or four years of full-time education.

Additional choice of subjects at this level may include such subjects as physics, biology and geology; classics; some social science; and the fine arts. The general programmes are often designed to provide the subject-matter credits required for university entrance or to prepare students for examinations of the university-entrance type.

In addition to the above for the "core", this level covers an even wider variety of programmes than those at the first stage, consisting of subject matter mainly having a specific vocational emphasis. The educational programmes included here are those requiring at least the equivalent of some eight years' full-time education for admission or a combination of basic education and vocational experience that demonstrates ability to handle subject matter of that educational level.

5. Education at the third level, first stage, of the type that leads to an award not equivalent to a first university degree

The core at this level consists of education for those who have completed requisite programmes at the second level, second stage, and who continue their education in a type of programme that generally does not lead to the awarding of a university degree. Typically in these programmes, less time and attention are paid to the theoretical, general and scientific principles of the subjects studied, attention being concentrated more on application to particular vocations.

The core programmes at this level tend to parallel those for which university degrees are granted in terms of subject-matter categories, but are usually shorter and more "practical" in orientation. Programmes of equivalent level to be associated with this core are of very great variety in most countries, and are provided through many organizations of very different types. The programmes are typically specialized in subject-matter; many are part-time; evening courses are common. Refresher courses and general-interest courses are important segments of this level of education.

The unifying criterion for all these programmes is the prerequisite that enrollees have completed the second stage of second-level education or have at least some education at that level plus appropriate vocational experience to indicate ability to handle the subject matter. In other words the subject matter is such that its mastery requires the equivalent of full second-level education.

The range of subjects is very wide, as indicated by the detailed categories in ISCED. To avoid a long listing, it is sufficient to point out that the level of instruction is aimed at developing highly skilled

technicians, teachers, artists, office staff, transport personnel, production supervisors, journalists, police and fire protection staff, and the like.

6. Education at the third level, first stage, of the type that leads to a first university degree or equivalent

The core at this level consists of programmes of education for those who have completed requisite programmes at the second level, second stage, and who choose to continue their education in a type of programme that is generally provided by a university. Typically, much time is spent on the historical aspects of the subjects taught, while practical skills, though often given some prominence, have a lower priority. The importance of research is stressed by preparing students for participation in original work. These programmes require a minimum of four years' full-time study, many requiring five or six years, and a few seven years. The earlier years (usually the first or the first two) are sometimes provided in local colleges or in secondary schools, but these programmes are distinguishable from others in that they are recognized by a university as the equivalent of the corresponding university programme when a student transfers to the university.

A great variety of subject-matter programmes is offered at this level, the university being organized by subject into "departments", "faculties" or "schools" under such headings as Agriculture; Arts (Humanities, Letters); Education; Engineering; Fine Arts; Law; Business Administration (Commerce); Medicine; Pharmacy; Natural Science; Social Science; Theology (Religion). Students choose a programme within one faculty but the programme will often contain some courses given in another faculty or faculties. In some cases also, the same programme, often with somewhat different emphasis, is given in more than one faculty, e.g. pharmacology in Natural Science and in Medicine; plant pathology in Agriculture and in Natural Science; marketing in Social Science (Economics) and in Business Administration.

The term "first university degree" requires clear definition for ISCED purposes. It includes, of course, programmes leading to the usual first degrees such as bachelor of arts, bachelor of science, diplôme, etc.; as well as first professional degrees like those of bachelor of law, bachelor of medicine (in some countries), and others that are frequently taken as first degrees after three, four or five years of study following a non-degree programme of pre-professional study, i.e. a total of as many as seven years in all, e.g. doctor of medicine (in some countries). Similarly, programmes designed for the simultaneous conferring of two degrees (e.g. B.A. and B. Comm. or B.A. and L.l.b.) are classed as at this level.

7. Education at the third level, second stage, of the type that leads to a post-graduate university degree or equivalent

The core at this level consists of programmes of education for those who have completed requisite programmes at the third level, first stage, of a type that leads to a first university degree, and who choose to continue their education toward a higher degree or equivalent award.

These are programmes of high-level professional education and those involving independent research of a high order. In almost all cases students follow programmes in the same subject field as for their first degrees, but of a more specialized character, the study and research being concentrated on one or two sub-dividions of the major subject. The theoretical and philosophical aspects of the subjects studied are emphasized even more at this level than for the first university degree. Subject-matter fields within which the higher specialization takes place are the same at this level as in the one immediately preceding, and programmes are usually of one to four years' duration.

Programmes included in this category are of two types; one is mainly an extension of the classroom-laboratory-seminar type of learning characteristic of category 6 and leading usually to a higher degree such as a master's degree or a higher professional qualification such as a specialist qualification in medicine; the other consists mainly of original research, usually of a largely independent nature, resulting in a dissertation worthy of publication and culminating in a degree or other award of the highest level (usually a doctorate).

Degrees and equivalent diplomas or other certificates are usually awarded after completion of a series of examinations and often after the presentation and defence of a thesis. These higher degrees and awards take various forms and have different titles from country to country, some of them being master of arts, master of science, diplôme d'études supérieures, doctorates of various kinds. These are not given as equivalents, but merely as examples.

9. Education not definable by level

This category includes educational programmes that cannot be defined by level and that are therefore not included in any of the categories numbered 0 to 7, i.e. no particular definable prior education is required to enable students to undertake them. Because the programmes cannot be defined by level it is clear that their subject-matter content is organized and presented in a non-theoretical "general interest" manner, with minimal reference to scientific principle or historical perspective. Thus, the programmes may be useful to students having wide variety of educational experience and perhaps in some cases no prior formal education.

The content of this category can be described only in a negative sense, i.e. programmes that cannot be fitted into any of the other categories. Thus it is a residual and care must be taken to avoid making it a receptacle for all cases that are difficult to classify by level. If it were to become such a receptacle, not only would it be too large and heterogenous itself for useful analysis, but the value of the data on all other levels would be affected adversely.

APPENDIX C

CORRESPONDENCE BETWEEN UNESCO GROUPS OF BRANCHES OF ECONOMIC ACTIVITY AND ISIC (1).

UNESCO Groups (Branches of economic activity)	I.S.I.C. Number			Major Division (One-digit) Division (Two-digits) Major Group (Three-digits)
	One-Digit	Two-Digits	Three-Digits	
1. Agriculture, forestry, hunting, fishing	1			Agriculture, hunting, forestry and fishing
		11		Agriculture and hunting
			111-112	Agriculture and livestock production and agricultural services
			113	Hunting, trapping and game propagation
		12	121-122	Forestry and logging
		13	130	Fishing
2. Extracting industries	2			Mining and quarrying
		21	210	Coal mining
		22	220	Crude petroleum and natural gas production
		23	230	Metal ore mining
		29	290	Other mining
3. Manufacturing industries	3			Manufacturing
		31		Manufacture of food, beverages and tobacco
			311-312	Food manufacturing
			313	Beverage industries
			314	Tobacco manufactures
		32		Textile, wearing apparel and leather industries
			321	Manufacture of textiles

UNESCO Groups (Branches of economic activity)	I.S.I.C.			
	Number			Major Division (One-digit) Division (Two-digits) Major Group (Three-digits)
	One-Digit	Two-Digits	Three-Digits	
			322	Manufacture of wearing apparel, except footwear
			323	Manufacture of leather and products of leather, leather substitutes and fur, except footwear and wearing apparel
			324	Manufacture of footwear, except vulcanized or moulded rubber or plastic footwear.
		33		Manufacture of wood and wood products, including furniture
			331	Manufacture of wood and cork products, except furniture
			332	Manufacture of furniture and fixtures, except primarily of metal
		34		Manufacture of paper and paper products, printing and publishing
			341	Manufacture of paper and paper products
			342	Printing, publishing and allied industries
		35		Manufacture of chemicals and chemical petroleum, coal, rubber and plastic products
			351-352	Manufacture of industrial chemicals and other chemical products
			353-354	Petroleum refineries and manufacture of miscellaneous products of petroleum and coal

1. Indexes to the International Standard Industrial Classification of All Economic Activities (I.S.I.C.) United Nations, New York, 1971 (Statistical Papers, Series M, no.4, Rev.2 Add.1).

UNESCO Groups (Branches of economic activity)	I.S.I.C. Number			Major Division (One-digit) Division (Two-digits) Major Group (Three-digits)
	One-digit	Two-digits	Three-digits	
			355-356	Manufacture of rubber products and plastic products not elsewhere classified
		36	361-369	Manufacture of non-metallic mineral products, except products of petroleum and coal
		37	371-372	Basic metal industries
		38		Manufacture of fabricated metal products, machinery and equipment
			381	Manufacture of fabricated metal products, except machinery and equipment
			382	Manufacture of machinery, except electrical
			383	Manufacture of electrical machinery, apparatus, appliances and supplies
			384	Manufacture of transport equipment
			385	Manufacture of professional and scientific and measuring and controlling equipment not elsewhere classified, and of photographic and optical goods
		39	390	Other manufacturing industries
4. Utilities	4			Electricity, gas and water
		41	410	Electricity, gas and steam
		42	420	Water works and supply
5. Construction	5	50	500	Construction

UNESCO Groups (Branches of economic activity)	I.S.I.C. Number			Major Division (One-digit) Division (Two-digits) Major Group (Three-digits)
	One-digit	Two-digits	Three-digits	
6. Transport and communication	7			Transport, storage and communication
		71		Transport and storage
			711-719	Transport-land, water, air and services allied to transport
		72	720	Communication
7. Other	6			Wholesale and retail trade and restaurants and hotels
		61	610	Wholesale trade
		62	620	Retail trade
		63	631-632	Restaurants and hotels
	8			Financing, insurance, real estate and business services
		81	810	Financial institutions
		82	820	Insurance
		83		Real estate and business services
			831	Real estate
			832	Business services except machinery and equipment rental and leasing
			833	Machinery and equipment rental and leasing
	Part of 9			Community, social and personal services
		92	920	Sanitary and similar services
		Part of 93		Social and related community services

UNESCO Groups (Branches of economic activity	I.S.I.C. Number			
	One-digit	Two-digits	Three-digits	Major Division (One-digit) Division (Two-digits) Major Group (Three-digits)
			933	Medical, dental, other health; veterinary services
			935	Business, professional and labour associations
			939	Other social and related community services
		Part of 94		Recreational and cultural services
			941	Motion picture and other entertainment services
			949	Amusement and recreational services not elsewhere classified
		95	951-959	Personal and household services (services generally involving the care of the person or his apparel)
	0		000	Activities not adequately defined

APPENDIX D

A comparison of the concepts presented in the Manual with the corresponding concepts used by OECD in the "Frascati Manual" 1980 (1)

This Appendix is especially intended for the Unesco Member States which also report to OECD; at the same time it will also be of interest for other Member States using the OECD basic concepts in their national R&D surveys. The Appendix concerns more specifically R&D (rather than STA). The Unesco concepts are set out in tabular form and presented in the same order as in the Manual with the chapter and section references for ease of identification; alongside are the equivalent or corresponding OECD concepts, suitably adjusted with the references to the OECD "Frascati Manual" indicated in brackets (FM § ...). Where necessary, the comparisons are accompanied by explanatory remarks and a few illustrative examples.

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category	
II	Research and experimental development			
II.1.1		Research and experimental development	Research and experimental development	(FM § 43)
II.1.1.1		Scientific research activities	No such corresponding broad category	
II.1.1.1.1		- Fundamental research	Basic research	(FM § 132)
II.1.1.1.2		- Applied research	Applied research	(FM § 135)
II.1.1.2		Experimental development	Experimental development	(FM § 138)

Remarks: The basic definitions of R&D and the subcategories of R&D are practically the same in both manuals. It may be noted that in both the Unesco and OECD concepts defence R&D is included.

(1) OECD. The Measurement of Scientific and Technical Activities. Proposed Standard Practice for Surveys of Research and Experimental Development. "Frascati Manual", 1980. Paris, 1981.

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category	
III	R&D personnel	The R&D personnel should include: - persons working directly on R&D - persons providing direct services to R&D (managers, administrators, secretarial and clerical staff).	Same coverage	(FM section 5.2)
		Remarks: Persons providing indirect services to R&D should be excluded from the measurement of R&D personnel according to both manuals. The labour costs of such persons should, however, be included as overhead in other current costs. Personnel employed by international organizations should be excluded. The Unesco Manual states explicitly that all residents in a country, nationals as well as non-nationals, should be included in the measurement. No corresponding statement is included in the Frascati Manual. In practice, however, the coverage is the same.		
III.2	Classification by type of work and qualification			
III.2.1		Scientists and engineers (i.e. researchers and assistant researchers)	Researchers (RSE)	(FM § 184)
III.2.2		Technicians	Technicians and equivalent staff	(FM § 188)
III.2.3		Auxiliary personnel	Other supporting staff	(FM § 190)
		Remarks: The concepts are defined differently in the Unesco and OECD Manuals. The Unesco definitions are based on a mixed criterion, taking into account both formal training or qualification and function. The OECD Manual contains definitions for R&D personnel which correspond specifically to two different breakdowns, one by occupation (function), the other by level of formal qualification. Insofar as for Unesco the occupational criteria dominate, the former concept for OECD and Unesco's concept can be considered as corresponding. These definitions, however, may be interpreted differently, an example being the case of Japan where their concept of assistant research workers is interpreted by Unesco as included in scientists and		

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category	
III.2.3 (cont.)	engineers and by OECD in their category technicians and equivalent staff. Both the Unesco and OECD Manuals give consideration to high-level administrators or managers not directly undertaking R&D but in fact providing direct services to R&D, as well as to post-graduate or post-doctorate students engaged on R&D, classifying them similarly as researchers. (Unesco Manual, III.2.6, FM §§ 185, 187).			
III.3	Unit of measure for R&D personnel			
III.3.1		Full-time personnel	No corresponding measure	
III.3.2		Part-time personnel	No corresponding measure	
III.3.3		Full-time equivalent	Full-time equivalent	(FM § 177)
	Remarks: Full-time equivalent can according to OECD be measured:			
	1) In person-years (measurement of the volume of work).			(FM § 178)
	2) As FTE on a fixed date (with adjustements for seasonal variations).			(FM § 181)
	The Unesco Recommendation does not amplify the concept of FTE although the Manual provides some explanatory remarks, both on the calculation of FTE and on alternative measurements.			
III.4	Classification by level of education and field of study			
III.4.1		Level of education	Levels of education	
		Third level degrees of university type (ISCED 6-7)	University level degrees (ISCED 6-7)	(FM § 193)
		Third level diplomas of non-university type (ISCED 5)	Other post-secondary diplomas (ISCED 5)	(FM § 194)

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category	
		Diplomas at the second level, second stage (ISCED 3)	Diplomas of secondary education (ISCED 3)	(FM § 196)
		Other qualifications (ISCED 1, 2, 9)	Other qualifications (ISCED 1, 2, 9)	(FM § 198)

Remarks: Both classifications are based on ISCED, the only differences being semantic, with Unesco terminology corresponding more closely to that of ISCED. According to Unesco practice, a comparison of the classification by type of work and qualification and the classification by level of education would show that most of the persons with third level degrees of university type are occupied as "scientists and engineers". However, those mainly performing assisting functions should be found in the technicians group. Some of the holders of third level diplomas of non-university type may be performing the same functions in R&D as scientists and engineers with third level degrees of university type. These would therefore be classified as scientists and engineers. The others, mainly performing assisting functions, will be classified as technicians. Holders of diplomas at the second level, second stage will normally be classified as technicians. Some countries may interpret the concept "scientist and engineer" purely in terms of level of education according to Unesco standards, thus including in the category "scientists and engineers" all persons with diplomas at ISCED levels 6 and 7 as well as persons with ISCED level 5 diplomas which are nationally recognized as qualifying for the profession of scientist or engineer. Those persons with other ISCED level 5 diplomas would be regarded as technicians.

III.4.2		Fields of study	No corresponding classification is recommended	

Remarks: OECD is not currently concerned with the field of qualification ; it, however, mentions the field of study as a possible supplementary classification for researchers and technicians and equivalent staff (FM § 203).

III.5	Other classifications			
III.5.1		Classification by occupation according to ISCO (suggested as a possible classification in the long-term development of science statistics)	Classification by occupation is treated only with regard to "function of personnel"	(FM § 183)

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category	
III.5.1 (cont.)				
		Remarks: The Frascati Manual states that ISCO may be adapted to suit some aspects of R&D surveys, and suggests a list of ISCO classes as reference for the classification of R&D personnel with regard to "function" - researchers, technicians and equivalent staff and other supporting staff.		
III.5.2		Classifications by nationality, age and sex	Classifications by sex, age, length of service, etc. mentioned	(FM § 203)
		Remarks: The Unesco Manual sets out the types of classification which bring out other specific characteristics of the different categories of S&T (or R&D) personnel which could be collected. OECD mentions theirs as possible supplementary classifications for researchers (or holders of university-level degrees).		
III.6	Scientific and technical manpower potential			
III.6.1		Total stock of qualified manpower	No corresponding concept in the Frascati Manual	
III.6.2		Number of economically active qualified manpower	No corresponding concept in the Frascati Manual	
		Remarks: On an experimental basis OECD collects data on the total stock of scientific and technical manpower. Data is collected either in terms of formal qualification or in terms of occupation.		
IV.2	Expenditure for R&D activities			
		Reference year	Not defined as a concept but mentioned in practice	(FM § 169)
		Remarks: The Unesco Manual specifies that if the period of 12 consecutive months carries over from one calendar year to the next, the year in which the period started is to be taken as the reference year. The Frascati Manual only refers to measurement		

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category	
IV.2 cont.)	on an annual basis without further precision ("in terms of some twelve-month period"); however in OECD practice, fiscal years should be considered as the year where they mainly fall.			
IV.2.1		Intramural expenditure	Intramural expenditure	(FM §§ 20, 206)
	Remarks: Both organizations recommend that the measurement of R&D expenditure should include only intramural expenditure at the institutional level, in order to avoid double-counting when aggregating at the national data collection level.			
IV.2.2		Extramural expenditure	Extramural expenditure	
	Remarks: This measurement is mentioned, but not defined in the Frascati Manual.			
IV.2.3		Total domestic expenditure on R&D	GERD plus R&D expenditure in installations physically situated abroad but used by national institutions	FM § 236)
			or	
			GNERD plus R&D financed from abroad but performed by the country	(FM § 238)
	Remarks: OECD distinguishes two separate concepts for measuring national totals of R&D expenditures; GERD (gross domestic expenditure in R&D) is the total intramural expenditure for R&D performed on the national territory, during a given period, regardless of the origin of the funds (GERD includes funds from abroad but excludes national funds sent abroad), whilst GNERD (gross national expenditure on R&D) is the total R&D expenditure financed by institutions of a country during a given period (GNERD excludes funds from abroad, but includes national funds destined for R&D performed abroad).			

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category	
IV.2.3 (cont.)				
		An example for Finland which illustrates the difference in the Unesco and OECD concepts is the Finnish Institute in Rome which performs R&D on Roman culture. This Institute is financed and controlled from Finland. The expenditure by this Institute for such R&D activity will be included in total domestic expenditure on R&D (Unesco category), but according to the Frascati Manual it would be excluded from GERD. In practice, however, when the R&D activities of such institutions are part of "integrated programmes", OECD assimilates such units with "testing grounds abroad, etc." (FM § 124); OECD would therefore accept the inclusion of the Institute in the Finnish GERD. There is therefore, in practice, no problem in establishing a correspondence between the concepts.		
		Both the Unesco and OECD concepts should exclude expenditure spent abroad as part of development aid.		
IV.3	Classification by type of expenditure			
IV.3.1.1		Labour costs	Labour cost of R&D personnel	(FM § 209)
IV.3.1.2		Other current costs	Other current costs	(FM § 212)
IV.3.2.1		Expenditure on major equipment	Expenditure on instruments and equipment	(FM § 216)
IV.3.2.2		Other capital expenditure	Expenditure on land and buildings	(FM § 215)
		Remarks: The definitions for all these concepts correspond. Both Unesco and OECD suggest that labour costs may be further subdivided by category of personnel. Both Manuals state that depreciation should be excluded from the measurement.		
IV.4	Classification by source of funds			
IV.4.1.1		Government	Government sector plus Public GUF (General University Funds)	

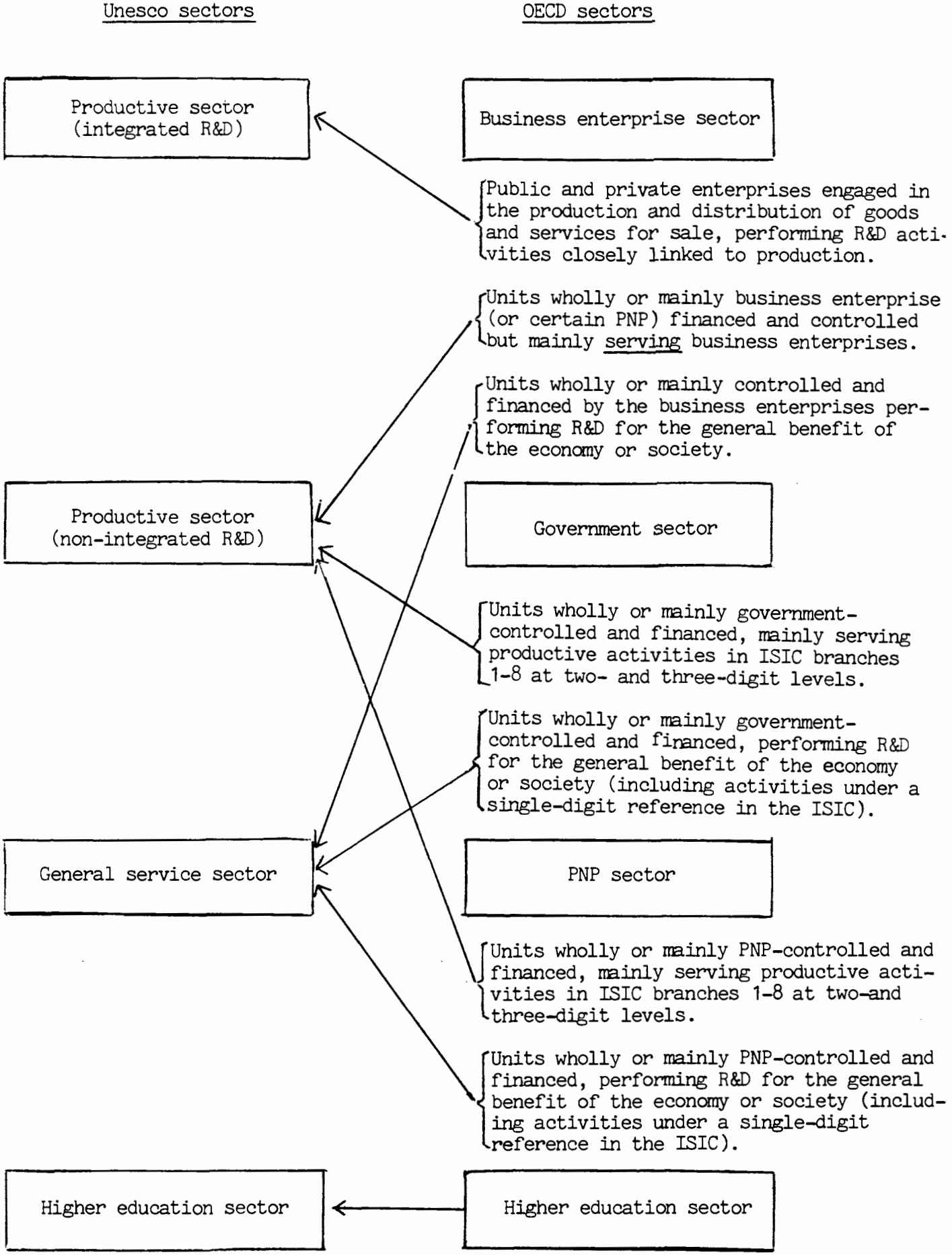
Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category
IV.4.1.2		Productive enterprise	Business enterprise sector
IV.4.1.3		Foreign	Abroad
IV.4.1.4		Other	Private non-profit (PNP) sector plus Higher education sector (excluding Public GUF)

Remarks: Both manuals recommend that data should, if possible, be credited by the performers of the R&D to the original source of funds, and intermediary organizations should not be taken into account. This explains why, for Unesco, clearly Public GUF should be included under Government funds but that "own funds" of establishments in the Higher education sector should be included under "Other" funds. The OECD methodology uses four identical sectors both for performance and for funding of R&D plus one extra ("from abroad") for funding. (FM, section 5.3.3).

V.1.2	Basic statistical unit	An establishment type unit if possible	No specific recommendation. Refers, in practice, in most cases to an enterprise type unit
V.2	Classification by sector of performance		

Remarks: The coverage of the Unesco and OECD higher education sectors is identical. The other sectors of performance are quite differently defined and are not directly comparable. For Unesco, the main criterion for the institutional classification by sectors is that of "function performed - or services rendered", whilst for OECD it is that of "finance" and "control". The following diagrams show the correspondence between the OECD sectors of performance and those of Unesco.

Relation between Unesco and OECD sectors of performance



PRINCIPLES FOR A THEORETICAL CONCORDANCE BETWEEN UNESCO AND OECD R&D DATA, BY SECTORS OF PERFORMANCE

Theoretically, Unesco and OECD R&D data may be aligned as follows:

UNESCO \ OECD	Business Enterprise sector	Government sector	Private Non-Profit sector	Higher Education sector	Total
Productive sector (integrated R&D)	Public and private enterprises engaged in the production and distribution of goods and services for sale, performing R&D activities closely linked to production.	No units	No units	No units	Total integrated R&D in Unesco Productive sector
Productive sector (non-integrated R&D)	Units wholly or mainly business enterprise financed and controlled, mainly serving enterprises such as co-operative and other commercial, engineering, architectural and technical services, research and scientific institutions/ firms n.e.c. (including some "PNP institutions and associations" serving enterprises - see FM §§ 87, 90).	Units wholly or mainly government controlled and financed, mainly serving productive activities in ISIC branches 1-8 at two- and three-digit levels.	Units wholly or mainly PNP controlled and financed, mainly serving productive activities in ISIC branches 1-8 at two- and three-digit levels.	No units	Total non-integrated R&D in Unesco Productive sector
General service sector	Units wholly or mainly controlled and financed by the business enterprises performing R&D for the general benefit of the economy or society (probably very few units).	Units wholly or mainly government controlled and financed, performing R&D for the general benefit of the economy or society (includes most of ISIC 9).	Units wholly or mainly PNP controlled and financed, performing R&D for the general benefit of the economy or society (i.e. all OECD PNP sector less units in the box above).	No units	Total Unesco General service sector
Higher education sector	No units	No units	No units	Identical	Total Unesco Higher education sector
TOTAL	Total OECD Business Enterprise sector	Total OECD Government sector	Total OECD Private Non-Profit sector	Total OECD Higher Education sector	GRAND TOTAL

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category
V.3	Classification by field of activity		
V.3.1		Productive sector (integrated and non-integrated R&D) Classification by branch of economic activity.	Business enterprise sector (FM § 91 For an institutional analysis in OECD surveys of this sector, a detailed industrial classification based on ISIC categories is proposed
		Agriculture, hunting, forestry and fishing (ISIC 1)	Agriculture (ISIC 1)
		Mining and quarrying (extracting industries) (ISIC 2)	Mining (ISIC 2)
		Manufacturing industries (ISIC 3)	Manufacturing industries (ISIC 3) broken down by - Electrical machinery - Electronic equipment and components - Chemicals - Drugs - Petroleum refining - Aerospace - Motor vehicles - Ships - Other transport equipment - Ferrous metals - Non-ferrous metals - Fabricated metal products - Instruments - Office and computing machinery - Machinery n.e.c.

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category
V.3.1 (cont.)			- Food, drink and tobacco - Textiles, footwear and leather - Rubber and plastic products - Stone, clay and glass - Paper and printing - Wood, cork and furniture - Other manufacturing
		Utilities (ISIC 4)	Utilities (ISIC 4)
		Construction (ISIC 5)	Construction (ISIC 5)
		Transport, storage and communication (ISIC 7)	Transport, storage and communication (ISIC 7)
		Other (ISIC 6,8 and that part of 9 not included in the Higher education and the General service sectors)	- Scientific and engineering services (ISIC 8324, 9320) - Other (ISIC 6, 8 n.e.c., 9 n.e.c.)
V.3.2		Higher education and General service sectors Classification by field of science and technology	OECD no longer recommends a specific classification for the Government sector (FM § 103). A classification by field of science and technology compatible with the Unesco fields is recommended for the OECD Higher education and PNP sectors (FM §§ 113, 119)
V.4	Classification by major socio-economic aims or objectives		
		Exploration and assessment of the earth, the seas and the atmosphere	Exploration and exploitation of the earth and atmosphere (FM § 342) minus - fundamental investigation in meteorology, geology and hydrology plus - R&D on satellites for meteorology and earth resources surveying

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category	

Remarks: According to the Unesco Manual, fundamental investigation in meteorology, geology and hydrology, etc. should be included under "General advancement of knowledge". In the OECD classification, R&D on satellites for meteorology, etc., are to be included under "Civil space", so that, when reporting to Unesco, in order to arrive at the category "Exploration and assessment of the earth, the seas and the atmosphere", data for fundamental investigation in meteorology, geology and hydrology, etc. should be deducted from the OECD class "Exploration and exploitation of the earth and atmosphere", whilst data for R&D on satellites for meteorology, etc. should be added, having been extracted from the OECD class "Civil space".

	Civil space	Civil space	(FM § 344)
		minus - the use of space vehicles for communication, meteorology, navigation, earth resources surveying, etc. (*)	

Remarks: In order to be aligned to the Unesco definition, these above-mentioned activities (*) need to be extracted from the OECD concept and should be assigned to the appropriate Unesco aim.

	Development of agriculture, forestry and fishing	Development of agriculture, forestry and fishing	(FM § 334)
		plus - food processing and packaging industries - veterinary medicine	

Remarks: Veterinary medicine is not mentioned in the Frascati Manual, but Unesco specifies its inclusion in this category. In the OECD classification food processing and packaging industries are found under "Promotion of industrial development".

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category	
V.4 (cont.)				
		Promotion of industrial development	Promotion of industrial development minus - food processing and packaging industries - R&D on banking, insurance and other commercial services - R&D on pharmaceuticals	(FM § 335)

Remarks: In order to arrive at the Unesco category, information for the following activities needs to be extracted from the OECD class and included under other Unesco classes as follows:

food processing and packaging industries to:	"Development of agriculture, forestry and fishing"
R&D on banking, insurance and other commercial services to:	"Social development and socio-economic services"
R&D on pharmaceuticals to:	"Development of health services".

Production, conservation and distribution of energy	Production and rational use of energy	(FM § 336)
Development of transport and communication	Transport and telecommunication plus - R&D on satellites for telecommunication purposes	(FM § 337)

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category
V.4 (cont.)	Remarks: In the OECD classification, R&D on satellites for telecommunication purposes would be under "Civil space".		
		Development of education services	There is no such separate objective in the OECD classification
	Remarks: For OECD this objective would seem to be included in the objective "social development and services" (FM § 341); it should therefore be extracted and shown separately.		
		Development of health services	Health (excl. pollution) (FM § 340) plus - R&D on pharmaceuticals - Environmental impact on health
	Remarks: In the OECD classification, R&D on pharmaceuticals is included under "Promotion of industrial development" and the environmental impact on health under "Protection of the environment". These activities must therefore be added to the OECD class "Health" in order to arrive at the Unesco category "Development of health services".		
		Social development and socio-economic services	Social development and services (FM § 341) minus - development of education services plus - urban and rural planning, including environmental impact on human settlement - R&D on banking, insurance and other commercial services

Unesco Manual reference	Main concept	Unesco terminology/ category	OECD terminology/ category
V.4 (cont.)	Remarks: The development of education services is a specific major aim in the Unesco classification and should therefore be shown separately. "Urban and rural planning" is a separate objective in the OECD classification (FM § 338). In the OECD classification, R&D on banking, insurance, etc., is included under "Promotion of industrial development" and must therefore be subtracted from that class and added to the OECD class "Social development and services".		
		Protection of the environment	Protection of the environment (FM § 339) minus - environmental impact on health - environmental impact on human settlement
	Remarks: For Unesco classification, the environmental impacts on human settlement and health should be respectively included under "Social development and socio-economic services" and "Development of health services".		
		General advancement of knowledge	General advancement of knowledge (FM § 343) plus - fundamental investigation in meteorology, geology and hydrology, etc.
	Remarks: In the OECD classification, fundamental investigation in meteorology, geology and hydrology, etc., would be included under "Exploration and exploitation of the earth and atmosphere".		
		Other aims	No separate objective in the OECD classification
		Defence	Defence (FM § 345)

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APPENDIX E

A comparison of the concepts presented in the Manual with corresponding concepts used in the CMEA system (1)

This Appendix is primarily intended for the guidance of the Unesco Member States wich also report to the CMEA; it will, however, also be useful for other Member States interested in comparing their national R&D concepts with those recommended for use by the Member countries of CMEA. As in the case with the major part of the Unesco Manual, so also this Appendix is primarily concerned with R&D. The concepts are set out and compared in tabular form and presented in the same order as in the Manual with the chapter and section references for ease of identification.

Manual reference	Main concept	Unesco terminology/ category	CMEA terminology/ category
II	Research and experimental development		
II.1.1		Research and experimental development	Research and experimental and designing activities (REDA)
II.1.1.1		Scientific research activities	No such corresponding broad category
II.1.1.1.1		Fundamental research	Fundamental research
II.1.1.1.2		Applied research	Applied research
II.1.1.2		Experimental development	Experimental and designing works

Remarks: The basic definitions of R&D and the subcategories of R&D are practically the same in both manuals; however, whilst Unesco specifically mentions that the practice is to include defence R&D in the statistical measurement, no such statement appears in the CMEA document, as it is not an activity which is measured separately (although such activity could be deduced as being included in "other national economic sectors").

(1) Based on the main indicators of the volume and structure of research and experimental and designing activities as set out in "Statistics on Science", Basic Methodological Concepts on Statistics, Vol. II, Moscow, CMEA, 1980, pp. 356-383 and Main Indicators of the Volume and Structure of Research and Experimental and Designing Activities of the CMEA Countries, Moscow, CMEA, 1974.

Manual reference	Main concept	Unesco terminology/ category	CMEA terminology/ category
III	Scientific and technical personnel		No direct corresponding concept
	R&D personnel	The R&D personnel (A) should include: - persons working directly on R&D - persons providing direct services to R&D (Managers, administrators, secretarial and clerical staff)	There is no correspondence as such although it could be assimilated to the total number of persons employed in REDA organizations (B) minus those persons not directly engaged in R&D activities e.g. in institutions of higher learning, and those not providing direct services to such activities (n.b. those providing direct services to R&D should be included) (C) /i.e. A = B - C/

Remarks: For Unesco, persons providing indirect services to R&D should be excluded from the measurement of R&D personnel. This applies in some cases to some CMEA measurements. The labour costs of such persons should, however, be included as overhead in other current costs which would seem to be the case for CMEA which includes all "outlays for maintenance". The Unesco Manual states explicitly that all residents in a country, nationals as well as non-nationals, should be included in the measurement. Personnel employed by international organizations should be excluded. No corresponding statement is included in the CMEA document. If in applying the CMEA methodology, it is not possible to extract the specific group of persons under consideration the information should be suitably foot-noted.

III.2	Classification by type of work and qualification		
III.2.1		Scientists and engineers (i.e. researchers and assistant researchers)	Researcher or research worker (in certain sectors of the economy the term scientific worker may be used) /N.B. Those persons possessing the appropriate qualifications providing direct services to R&D (e.g. research administrators/managers) should be included/

Manual reference	Main concept	Unesco terminology/ category	CMEA terminology/ category
III.2.2		Technicians	No corresponding measurement
III.2.3		Auxiliary personnel	No corresponding measurement

Remarks: The concepts for R&D scientists and engineers (Unesco) and research workers (CMEA) would seem to correspond, both taking into account formal training or qualification and function. However, in actual measurement, there may be some difference as Unesco includes those persons providing direct services to R&D which would not appear to be the case for "research workers" (CMEA). In addition, in CMEA measurement not all scientific workers in the higher education sector for example may necessarily be undertaking research activities. As regards technicians and auxiliary personnel, for CMEA those providing direct services to R&D are not accounted for separately, although those persons with a secondary specialized education (thus for Unesco qualifying to be considered as technicians) employed in RED institutions are measured.

III.3	Unit of measure for R&D personnel		
III.3.1		Full-time personnel	No corresponding measurement
III.3.2		Part-time personnel	No corresponding measurement
III.3.3		Full-time equivalent	No corresponding measurement

Remarks: The CMEA concept does not make any distinction between full-time and part-time activities in R&D. The CMEA measurement of research workers would correspond to the Unesco measurement "full-time plus part-time" and if this data is provided it should be appropriately footnoted. In order to achieve international comparisons of the volume of real time devoted to R&D, an attempt should be made to apply some conversion rates particularly in the case of scientific workers in the higher education sector who devote an important amount of their time to activities other than R&D.

Manual reference	Main concept	Unesco terminology/ Category	CMEA terminology/ category
III.4	Classification by level of education and field of study		
III.4.1		Level of education	Levels of education
		Third level degrees of university type (ISCED 6-7)	Higher education (with or without learned titles)
		Third level diplomas of non-university type (ISCED 5)	Diplomas of special secondary education including from professional technical schools "technicum"
		Diplomas at the second level second stage (ISCED 3)	Diplomas of general secondary education (ISCED 3)
		Other qualifications (ISCED 1, 2, 9)	No corresponding category

Remarks: It may be noted that this theoretical correspondence is not applicable in reality as i) diplomas of special secondary education in the CMEA system do not necessarily correspond to ISCED level 5 and ii) data concerning diploma-holders of general secondary education ISCED level 3 are not collected in connection with S&T statistics in the CMEA system.

III.4.2		Fields of study	No corresponding classification (CMEA is not concerned with the field of qualification)

Remarks: CMEA measures research workers each year according to branch of science of their present activity (every five years it is specifically concerned with those with a scientific degree, distinguishing between doctors and candidates of science). It may be noted that the fields of science (of current activity) correspond to those specified by Unesco as field of science or technology under field of activity (chapter V, item 3.2). In the absence of a distribution of research workers by scientific field of qualification, their distribution by field of current activity could be considered as an approximation.

III.5	Other classifications		
III.5.1		Classification by occupation according to ISCO (suggested as a possible classification in the long-term development of science statistics)	No complete corresponding classification as classification by occupation is treated only with regard to personnel in universities and institutions of higher learning

Manual reference	Main concept	Unesco terminology/ category	CMEA terminology/ category
III.5.1 (cont.)		Remarks: This correspondence can only be applied in part, for the relevant sector (higher education), as CMEA only measures the occupation of teaching staff at universities and institutions of higher education distinguishing separately from those in the national economy, those engaged in research, showing professors, docents, others.	
III.5.2		Classification by nationality, age and sex	Classification by age and sex
		Remarks: Unesco proposes this classification for scientists and engineers and for technicians whilst CMEA only uses this classification for research workers, irrespective of nationality, so that any data provided on this basis should be suitably footnoted.	
III.6	Scientific and technical manpower potential		
III.6.1		Total stock of qualified manpower	No corresponding concept in the CMEA document
III.6.2		Number of economically active qualified manpower	Number of specialists employed in the national economy
		Remarks: The Unesco concept of economically active qualified manpower covers the relevant persons engaged in or actively seeking work at a given reference date (and therefore includes those persons temporarily registered as unemployed). The CMEA concept measures those "employed". However, a priori there is no unemployment in the CMEA countries, so that these two measurements can be considered as comparable. For the different levels of scientific and technological manpower potential, see the correspondence keys under III.4.1 above. Note: The term "specialist" as mentioned here for CMEA is to be interpreted as meaning those persons with a higher education and with secondary specialized education; the corresponding data for ISCED levels 5-7 will be found in the statistics under item "labour and wages".	

Manual reference	Main concept	Unesco terminology/ category	CMEA terminology/ category
IV.2	Expenditure for R&D activities		
		Reference year	Not defined as a concept but mentioned in practice

Remarks: The Unesco Manual specifies that if the period of 12 consecutive months carries over from one calendar year to the next, the year in which the period started is to be taken as the reference year. The CMEA document specifies those measurements to be done on an annual basis; for persons and institutions the measurement is taken at the end of the year under review whilst expenditures should relate to the year under review. In practice one could consider the measurements as corresponding.

IV.2.1		Intramural expenditure	Intramural expenditure

Remarks: The Unesco Manual recommends that the measurement of R&D expenditure should include only intramural expenditure at the institutional level, in order to avoid double-counting when aggregating at the national data collection level. CMEA specifies that only "real" expenditures for R&D should be measured irrespective of source of funds, so that double-counting should be avoided when aggregating at the national data collection level.

IV.2.2		Extramural expenditure	Not specified
IV.2.3		Total domestic expenditure on R&D	No specific category indicated

Remarks: See remarks to IV.2.1. For CMEA the national aggregate of "real" expenditures would correspond to IV.2.3 though there is no such definition. The Unesco concept excludes expenditure spent abroad as a part of development aid.

IV.3	Classification by type of expenditure		
IV.3.1		Current expenditure	Current expenditures
IV.3.1.1		- Labour costs	- Wages and salaries
IV.3.1.2		- Other current costs	- Material inputs minus depreciation
IV.3.2		Capital expenditure	Capital investments
IV.3.2.1		- Expenditure on major equipment	- Expenditure on equipment, tools

Manual reference	Main concept	Unesco terminology/ category	CMEA terminology/ category
IV.3.2.2		- Other capital expenditure	- Expenditure on construction and erection activities

Remarks: The definitions for all these concepts correspond, the only difference being that Unesco proposes that depreciation be excluded from the measurement, whilst in the CMEA document the concept of "material inputs" includes depreciation of fixed assets and other outlays. The problem with "labour costs" is that for Unesco, these expenditures should relate only to personnel engaged in R&D (expenditures for personnel providing only indirect services for R&D should be excluded and in fact included under "other current costs") and should be computed according to the concept of full-time equivalence (please see para. IV.3.1.1, p. 49) whilst for CMEA "wages and salaries" covers all personnel employed in the RED organizations and units. If the Unesco concepts cannot be adhered to, this should be explained in a footnote.

IV.4	Classification by source of funds		
IV.4.1.1		Government	State budget
IV.4.1.2		Productive enterprise and special funds	Other
IV.4.1.3		Foreign	
IV.4.1.4		Other	

Remarks: The Unesco Manual recommends that data should be given, if possible, according to the original source of funds, not taking intermediary organizations into account. CMEA proposes only two categories, State budget and other funds. If data are available separately for Technical and economic progress fund, these should be reported under productive enterprise and special funds.

V.1.2	Basic statistical unit	An establishment-type unit if possible	No specific concept is proposed; Member countries are free to define their units in keeping with the national peculiarities of organized research and the accounting system. In many cases this would correspond to an enterprise-type unit.

Manual reference	Main concept	Unesco terminology/ category	CMEA terminology/ category
V.2	Classification by sector of performance		
	Remarks: The CMEA scheme does not suggest a breakdown by sector of performance, but distinguishes the different economic sectors; following the MPS, the breakdown is activities within the sphere of material production and the non-material sphere. Grossly, the "sphere of material production" (including in particular the independent research institutes of the branch ministries) corresponds to the productive sector whilst the "non-material sphere" (with one exception) corresponds to the higher education and general service sectors. These activities can relatively easily be rearranged to correspond essentially to the Unesco classification by sector of performance as follows:		
V.2.1		Productive sector	All independent and non-independent RED units active in one of the following branches of the national economy: - industry - construction - agriculture - forestry - transport - communication - trade, material and technical supplies and procurements plus other activities in the sphere of material production (including e.g. independent research institutes of the branch ministries) - finance, credit and insurance (from the non-material sphere)
		- Integrated R&D	Non-independent RED units in independent and non-independent industrial enterprises
		- Non-integrated R&D	- Independent research units of the various branch ministries (i.e. those classified under "science and scientific services")

Manual reference	Main concept	Unesco terminology/ category	CMEA terminology/ category
V.2.1 (cont.)			
			- Non-independent research units whose main activity is only indirectly linked to production (i.e. those classified under "other national economic sectors" in the material sphere)
V.2.2		Higher education sector	- Universities and institutes of higher learning ("Vuzy")
V.2.3		General service sector	- Health protection, social security and physical culture
			- Education, culture and arts minus the universities and institutes of higher learning (see above)
			- Academies of sciences
			- Other non-independent (government) activities in the non-material sphere minus finance, credit and insurance

Remarks: Whilst the aggregated data for the productive sector would seem to correspond to data measured in the CMEA scheme, the subdivision corresponding to integrated and to non-integrated R&D categories would seem more problematical as the independent science research institutes and other establishments concerned are included under the CMEA economic branch "science and scientific services" and, other than Academy of sciences, are not measured separately, and not classified by economic sectors.

Manual reference	Main concept	Unesco terminology/ category	CMEA terminology/ category
V.3	Classification by field of activity		

Remarks: As has been explained above the CMEA scheme does not suggest a sectorial breakdown. The national data are broken down into economic branches and within these branches by fields of science and technology so that there is no close correspondence although an approximation may be obtained by a regrouping and adjustment of the data. The information provided should be suitably footnoted regarding the coverage or the exclusion of some data.

V.3.1		Productive sector (classification by branch of economic activity)	No direct correspondence

Remarks: For Unesco, the classification by branch of economic activity is used in both the subgroups: R&D activities integrated with production and R&D activities not integrated with production. In the CMEA scheme, all RED activities are classified by economic branches but some activities which for Unesco should be broken down into industry groups are grouped under the economic branch "science and scientific services" for CMEA. Thus only a partial correspondence can be established.

The number of research workers in RED organizations and expenditure for REDA can be classified as follows:

Unesco scheme	CMEA scheme
Agriculture, hunting, forestry, fishing (ISIC 1)	- Agriculture - Forestry
Mining and quarrying (extracting industries) (ISIC 2) Manufacturing industries (ISIC 3) Utilities (ISIC 4)	- Industry
Construction (ISIC 5)	- Construction
Transport, storage, communications (ISIC 7)	- Transport - Communication

Manual reference	Main concept	Unesco terminology/ category	CMEA terminology/ category
V.3.1 (cont.)		Other (ISIC 6, 8 and part of 9)	- Trade, material and technical supplies and procurements - Finance, credit and insurance

These groupings could be considered as broadly corresponding to integrated R&D activities, as the higher education sector, the general service sector and the independent research units of the branch ministries are not included.

A slightly different CMEA classification could be used for non-independent RED units in industrial enterprises, but the data could only be shown for the Unesco groups ISIC 2, 3 and 4.

V.3.2		Higher education and General service sectors Classification by field of science and technology	A correspondence is possible as the fields of science are similar

Remarks: In the CMEA scheme, the number of research workers in RED organizations are measured within the national economic sectors by branches of science. These branches of science - natural sciences, engineering sciences, medical sciences, agricultural sciences and social sciences (and humanities) can be considered as closely corresponding. This breakdown can be obtained directly for the areas corresponding to the Unesco Higher education sector (see V.2.2); however, for the General service sector, some arithmetical adjustments will be necessary to arrive at aggregated data (see V.2.3).

V.4	Classification by major socio-economic aims or objectives		No corresponding classification

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INDEX

This index does not claim to be exhaustive. It has been prepared with the purpose of facilitating the task of the layman when referring to the Manual and thus the comprehension of statistics on scientific and technological activities, and more particularly those on R&D.

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