CHAPTER 1

AIM AND SCOPE OF THE MANUAL

1.1 A preliminary word to the user of R&D data

1. This Manual has been written by and for the national experts in Member countries who collect and issue – *inter alia* – national R&D data, and who submit responses to OECD R&D surveys with the aid of the Secretariat of the OECD Economic Analysis and Statistics Division. Although maximum use is made of examples from Chapter 2 onwards, the Manual is still a rather technical document and is intended mainly as a reference work.

2. Chapter 1 is addressed principally to non-experts. It both provides a summary of the coverage and contents of the Manual, designed to help them to use the body of the text, and also indicates why certain types of data are, or are not, collected, what problems of comparability they pose, and what can be said about their accuracy.

1.2 Coverage of the Manual and the uses of R&D statistics

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

4. Over the years, input statistics have proved to be valuable indicators, as various national and international reports show. The OECD reports on science and technology indicators (OECD, 1984; OECD, 1986; OECD, 1989*c)* and the Science and Technology Policy Review and Outlook series, *(e.g* OECD, 1992*c),* provide useful measures of the scale and direction of R&D in various countries, sectors, industries, scientific fields and other categories of classification. Administrations concerned with economic growth and productivity rely on R&D statistics as one possible type of indicator of technological change. Advisors concerned not only with science policy, but also industrial policy, and even general economic and social policies use them extensively. R&D statistics are now an essential background element in many government programmes and provide an important tool for evaluating them.

5. However, R&D statistics are not enough. It has become increasingly clear that such data need to be examined within a conceptual framework that relates them both to other types of resources and to the desired outcomes of the R&D activities concerned. This link may be made, for example, via the innovation process (see Section 1.5.3 below) or within the broader framework of "intangible investment", which covers not only R&D and related S&T activities but also expenditures on software, training, organisation, etc. Similarly, R&D personnel data need to be viewed as part of a model of the training and use of scientific and technical personnel. It is also of interest to analyse R&D data in conjunction with other economic variables, such as value added and investment data. The Manual is not based on a unique model of the S&T system and how that system meshes with the economy and society; its aim is to produce statistics that can be used to calculate indicators for use in various models.

6. The Manual has two parts. The first consists of eight chapters which present recommendations and guidelines on the collection and interpretation of established R&D data. While all Member countries may not be able to comply with the recommendations as stated, it is accepted that these are the standards to which all should aspire. In a number of cases suggestions are offered for dealing with certain aspects of R&D; they are not recommended for all Member countries, but can be used at the discretion of national authorities. Such suggestions are printed in italics.

7. The second part consists of 13 annexes which interpret and expand upon the basic principles outlined in the main text. These annexes should be used operationally, but do not necessarily reflect an up-to-date interpretation of the subject. Since the annexes may be discussed by national experts on S&T indicators periodically and may be updated, augmented or deleted before the next complete revision of this Manual, users are cautioned to ensure that they have the most up-to-date version of an annex, preferably by consulting the OECD Secretariat.

1.3 The relationship between the Frascati Manual and other international standards

8. R&D is carried out throughout the economy but has certain special characteristics that distinguish it from the larger family of scientific activities and from the economic activities of which it is a part. From the outset it was intended that the OECD should establish a set of guidelines on the measurement of scientific and technological activities. For many years the Frascati Manual was the only manual available, but there are now two more, with others in preparation (see Table 1.1).

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

10. Because of the need to place R&D in a wider context, both conceptually and in terms of databases, United Nations classifications are used as far as possible, *e.g.* System of National Accounts – SNA (UN, 1968b; CEC *et al.*, 1994); International Standard Industrial Classification – ISIC (UN, 1968a; UN, 1990); International Standard Classification of Occupations – ISCO (ILO, 1968; ILO, 1990); and International Standard Classification of Education – ISCED (UNESCO, 1976). However, it has proved necessary in some cases to deviate from these international norms in order to obtain internationally comparable R&D statistics. Furthermore, wherever possible, the Manual draws on the experience of regional organisations within the OECD area, notably NORDFORSK (and later the Nordic Industrial Fund) and the European Community (EC).

Table 1.1. **OECD methodological manuals**

Type of data	Title
A. The "Frascati Family"	The Measurement of Scientific and Technological Activities Series
R&D	*Proposed Standard Practice for Surveys of Research and Experimental Development ("Frascati Manual")*
	R&D Statistics and Output Measurement in the Higher Education Sector. "Frascati Manual Supplement" (OECD, 1989c)
Technology balance of payments	Manual for the Measurement and Interpretation of Technology Balance of Payments Data (OECD, 1990)[1]
Innovation	"OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data – Oslo Manual" (OECD, I992b)
Patents	Using Patent Data as Science and Technology Indicators
S&T personnel	The Measurement of Human Resources Devoted to Science and Technology[1,2]
High-Technology	Measurement of High-. Medium- and Low-technology Products and Sectors [1,3]
Bibliometrics	Recommendations for the Use of Indicators Derived from Statistical Studies of Scientific and Technical Literature ("Bibliometrics")[1,3]
B. Other Relevant OECD Statistical Frameworks	
Education statistics	Methods and Statistical Needs for Educational Planning (OECD, 1967)
Education indicators	*Handbook for International Educational Planning (OECD, forthcoming)*
Training statistics	Proposed Best Practice for Surveys of Training[3]

1. Dealing mainly with problems of classifying and interpreting existing information.
2. In preparation.
3. Planned.

11. The references to R&D in such classifications are relatively recent and are generally based on the Frascati Manual as the established international statistical framework.

1.4 R&D input and output

12. The term "R&D statistics" covers a wide range of possible statistical series measuring the resources devoted to stages of R&D activity and the results of that activity. This Manual is devoted to measuring R&D "inputs". However, we are more interested in R&D because of the new knowledge and inventions that result from it than in the activity itself.

13. The need to place R&D analysis and thus statistics in a wider context has been noted above. There are also a number of more direct ways of measuring R&D output. Unfortunately, while indicators of R&D output to complement input statistics are clearly needed, they are far more difficult to define and collect. A substantial amount of methodological work was required before any international standard practice could be recommended. A manual on the technology balance of payments has been issued (OECD, 1990a), one on the use of patents as science and technology indicators is being finalised, and guidelines are currently foreseen on bibliometrics and on the analysis of trade data in terms of the "technology intensity" of the products or industries concerned (see Table 1.1). These manuals differ from the present one in that they pay more attention to problems of interpretation; the data concerned are not specially collected for the purpose of S&T analysis but are extracted from existing sources and rearranged for this purpose (for further details, see Annex 2).

1.5 R&D and related activities

1.5.1 Research and experimental development (R&D)

14. The Manual deals only with the measurement of research and experimental development (comprising basic research, applied research, and experimental development). A full definition will be found in Chapter 2.

15. R&D is an activity related to a number of others with a scientific and technological base. Although these other activities are often very closely linked to R&D through flows of information and in terms of operations, institutions, and personnel, they must be excluded when measuring R&D. R&D and these related activities may be considered under two headings: the family of scientific and technological activities (STA) and the process of scientific and technological innovation.

1.5.2 Scientific and technological activities (STA)

16. The concept of STA was developed by UNESCO. According to its "Recommendation Concerning the International Standardisation of Statistics on Science and Technology" (UNESCO, 1978), scientific and technological activities comprise:

‘‘...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)..."

17. R&D (defined by UNESCO and the OECD on the same lines) has, thus, to be distinguished both from STET and SIS. The STET covers:

"...all activities comprising specialised non-university higher education and training, higher education and training leading to a university degree, postgraduate and further training, and organised lifelong training for scientists and engineers. These activities correspond broadly to ISCED levels *5,* 6 and 7."

18. The STS are defined as "...activities concerned with research and experimental development and contributing to the generation, dissemination and application of scientific and technical knowledge". The STS are divided by UNESCO into nine subclasses for the purposes of surveying; they can be summarised as follows:

- S&T activities of libraries, etc.;
- S&T activities of museums, etc.;
- translation, editing, etc., of S&T literature;
- surveying (geological, hydrological, etc.);
- prospecting;
- data collection on socio-economic phenomena;
- testing, standardisation, and quality control, etc.;

- client counselling, including public agricultural and industrial advisory services, etc.;

- patent and licence activities by public bodies.

19. A large part of Chapter 2 of the Manual deals with the definitions and conventions to be applied to distinguish R&D which is being measured from STET and from the STS, which are not. As the specific UNESCO definitions of individual STS are not always suitable for this narrower purpose, a slightly different subdivision is used in Chapter 2 of the present Manual.

1.5.3 R&D and scientific and technological innovation

20. Scientific and technological innovation may be considered as the transformation of an idea into a new or improved product introduced on the market, into a new or improved operational process used in industry and commerce, or into a new approach to a social service. The word "innovation" can have different meanings in different contexts and the one chosen will depend on the particular objectives of measurement or analysis. So far, international norms for data collection proposed in the Oslo Manual (OECD, 1992b) have only been developed for technological innovation which is defined as follows:

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

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

21. Besides R&D, six fields of innovative activities may often be distinguished in the innovation process (Stead, 1976; and OECD, 1992*b):*

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

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

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

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

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

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

22. Furthermore, in the case of innovations based on government R&D programmes, there may be a significant **demonstration** stage in the process. "A demonstration is a project involving an innovation operated at or near full scale in a realistic environment for the purpose of: *i)* formulating national policy or *ii)* promoting the use of innovation" (Glennan *et al.*, 1978). It should be noted that the data collected and published by the International Energy Agency at the OECD cover research, development and demonstration ("R, D and D") (OECD, 1993b).

23. Possibly the greatest source of error in measuring R&D lies in the difficulty of locating the cut-off point between experimental development and the related activities required during the realisation of an innovation. Errors at this point are particularly significant because, though many innovations may require costly R&D, the costs of preparing the invention for production are often higher still. Section 2.3.4 of Chapter 2 is devoted to guidelines and conventions designed to deal with these problems and gives examples. It provides new guidelines on this borderline in the case of the development of computer software and large-scale projects, notably defence. Supplementary guidance for the treatment of large-scale projects is given in Annex 12, where examples are given to distinguish between R&D and preproduction development.

1.5.4 R&D administration and other supporting activities

24. In order to actually carry out the R&D activities described above, the funds must be provided and the project and its finance must be managed. The R&D funding activities of policy agencies such as ministries of science and technology or research councils are not themselves R&D. In the case of the in-house management of R&D projects and their finance a distinction is made between direct support for R&D by persons such as R&D managers closely associated with individual projects, who are included in both the personnel and expenditure series, and persons such as financial directors whose support is indirect or auxiliary, who are included in the expenditure series only as an element of overheads. Auxiliary support by catering or transport services are also included in overheads. These distinctions are discussed further in Chapters 2, *5* and 6.

1.6 Natural sciences and engineering (NSE) and social sciences and humanities (SSH)

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

26. The first two versions of the Manual covered only the natural sciences and engineering. The social sciences and humanities were incorporated in the third edition (OECD 1976), adopted in 1974. Although the Manual recommends standard practices, it is understood that, for various reasons, some deviations may still have to be accepted for the SSH. Experience in different Member countries has not been the same: some find surveys can cover all sciences in all sectors equally, others find common procedures are not always appropriate. For example, few countries collect data on SSH R&D in industrial firms.

27. The special problems of measuring SSH R&D are raised as they occur in the various chapters of the Manual.

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

1.7.1 R&D personnel

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

30. R&D personnel data, narrower in coverage than most expenditure series, are not affected in the same way by differences in currency values. There are, however, problems for reducing such data to full-time equivalent (FTE) or person-years on R&D (see Section 5.3). It is recommended that data should also be collected in terms of physical persons ("headcount") so that they can be used in overall models and databases on S&T personnel.

31. A wide variety of personnel is needed in the national R&D effort: from the Nobel prize-winner to the winner's secretary, from the designer of space experiments to the breeder of laboratory animals. Because of the range of skills and education required, it is essential to classify R&D personnel into categories.

32. Two systems are now used by OECD Member countries to classify persons engaged in R&D. Section 5.4 of the Manual contains definitions for both a classification by occupation [linked as far as possible to the International Standard Classification of Occupation – ISCO (ILO, 1990)] and a classification by level of formal qualification [based entirely on the International Standard Classification of Education – ISCED (UNESCO, 1976)]. While it would be desirable to have data based on both approaches, most Member countries use only one of the two. As data are available by occupation for the majority of OECD countries, the fact that there are still a few which collect only qualification data for some or all sectors means that serious problems of international comparability remain. It might be argued that in an efficient system there should be no major difference between the two approaches – that all those employed as researchers, for example, would have university degrees and that all university graduates working on R&D would be employed as researchers. In practice, this is not entirely true. For example, a number of mature researchers do not have university level qualifications, though they do have other post-secondary qualifications or equivalent experience. Conversely, an increasing number of young university graduates are employed not as researchers but as high-level technicians or as support staff.

1.7.2 R&D expenditures

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

expenditures. Depreciation costs are excluded. Further details of the coverage and content of R&D expenditures are given in Chapter 6 of the Manual (see Section 6.2).

34. R&D is an activity for which there are significant transfers of resources among units, organisations, and sectors, especially between government and other performers. It is important for science policy advisors and analysts to know who finances R&D and who performs it. Chapter 6 deals with ways of tracing the flow of R&D funds. It is stressed that such flows should be based on the reply of the performer of the R&D and not on that of the source of funds (see Section 6.3). Guidelines are suggested for the treatment of public general university funds (GUE), *i.e.* that part of university research which is financed from the general grant from ministries of education, which is destined for both education and research. Such flows may represent up to 90 per cent of all university research and an important share of all public support for R&D.

35. The main disadvantage of R&D input series expressed in monetary terms is that they are affected by differences in price levels between countries and over time. It can be shown that current exchange rates often do not reflect the balance of R&D prices between countries and that in times of high inflation general price indices do not accurately reflect trends in the cost of performing R&D. The Manual recommends the use of purchasing power parities (PPP) and the implicit GDP price index for use with R&D statistics, although it is recognised that they reflect the opportunity cost of the resources devoted to R&D rather than the "real" amounts involved. Methods of developing special R&D deflators and R&D exchange rates are discussed in Annex 10.

1.7.3 R&D facilities

36. Indicators of facilities available for R&D may be envisaged but are seldom collected and are not discussed in the Manual. Standardised equipment, library facilities, laboratory space, journal subscriptions, and standardised computer time would all be possible measures.

1.7.4 National R&D efforts

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

38. Science and technology activities are becoming increasingly internationalised. The role of multinational enterprises is growing as is the level of R&D co-operation between government agencies, both formally via international organisations such as the European Community (EC) or the European Centre for Nuclear Research (CERN) or informally via multilateral and bilateral agreements. Researchers are becoming even more internationally mobile. The present version of the Manual attempts to take the need for relevant R&D data into consideration.

1.8 Classification systems for R&D

39. In order to understand R&D activity and its role, one must examine it both in terms of the organisations performing and funding R&D (institutional classification) and in terms of the nature of the R&D programmes themselves (functional distributions).

40. It is usual to use institutional basic classifications in national (and international) R&D surveys, as they facilitate the survey process, and combine them with functional distributions in order to obtain a fuller understanding of the situation described by the statistics.

1.8.1 Institutional classifications

41. In the institutional approach, interest is focused on the characteristic properties of the performing or funding institutions. All units are classified according to their principal (economic) activity. In this approach, all of the R&D resources of the statistical unit are allocated to one class or subclass. The advantage of this approach is that R&D data are generally collected within the same framework as regular economic statistics; this simplifies surveying and facilitates comparisons between R&D and other economic data. The main disadvantage is that it does not exactly describe the R&D activities of the unit, which may not always be directly related to its "official" activity.

42. Chapter 3 of the Manual deals with the institutional classifications used. In order to ensure maximum comparability with regular economic or social statistics, these are, as far as possible, based on existing United Nations classifications. The main institutional classification of national R&D efforts is by sector. Five sectors are identified: business enterprise, government, private non-profit (PNP), higher education, and abroad. Subclassifications are given for three of the four national sectors (business enterprise, PNP, and higher education) and additional institutional classifications, designed to reveal international differences in sectoring, are suggested.

1.8.2 Functional distributions

43. In the functional approach, discussed in Chapter 4, interest is focused on the character of the R&D itself. The nature of the R&D activities performed by the unit is examined, and the activities are broken down in various ways to show their distribution by type of activity, product field, objective, detailed field of science, etc. Thus, the functional approach provides data which are more detailed and, since international differences in institutional patterns have less influence, theoretically more internationally comparable than those resulting from institutional classification. It is, however, sometimes difficult to apply in practice. This is particularly true for the analysis by type of activity (basic research, applied research, and experimental development) which is, on the one hand, of undoubted science policy interest but, on the other hand, is based on an oversimplified model of the workings of the scientific and technological system and also contains an important element of subjective assessment by the respondent. This question is further discussed in Section 4.2.3.

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

of R&D expenditure within the overall picture of national R&D effort. Defence R&D is further discussed in Annex 12.

45. A particular effort has been made in this version of the Manual to provide norms for the measurement of environment-related R&D.

46. It should be noted that although these functional distributions are more detailed than the institutional classifications, they are still not detailed enough to be of use to one significant class of potential users of R&D data, *i.e.* the person interested in only one very specific subitem such as a subfield of science or a product field (holography or computer controls for machine tools). It has already been noted that this Manual is essentially designed to measure national R&D efforts and to categorise them in various ways. Except for special inventories of specific fields, few individual Member countries have been able to push subcategorisation to such a detailed level, and it is doubtful that such detail would be obtainable at the OECD level.

47. Furthermore, it is difficult to establish norms for categories of interest to national governments when reviewing the type of research funded from public monies when they can have various policy connotations. One area which has received considerable attention is that of strategic research. This is generally taken to mean research that a nation sees as a priority for the strategic development of its research base and ultimately its economy. Strategic research is not to be confused with what are called the strategic objectives of the business sector. Nor should it be confused with that of strategic technologies, on which discussions are taking place in the context of defining “rules of the game” for governments that subsidise so-called strategic industries or technologies. Such industries and technologies are characterised by: high dependence on a strong technology base and vigorous research efforts; considerable strategic significance for governments; long lead-times from basic research to industrial application; competitive pressure of new product and process introductions; high risks and large capital investments; high degree of international co-operation and competition in R&D, production and world-wide marketing. Understanding of what is and is not strategic varies between Member countries. Nevertheless, in recognition of the policy importance of strategic research in some Member countries, there is some reference to its identification in Chapter 4 of the Manual.

1.9 R&D surveys, reliability of data and international comparability

48. While a certain amount of R&D data can be derived from published sources, there is no substitute for a special R&D survey, and most of the text of the Manual is drafted on the assumption that such surveys will be made of at least all the major national performers of R&D. Nevertheless, it may be necessary for both respondents and surveying agencies to make estimates, and this question is discussed at length in Chapter 7.

49. It is hard to generalise about how far such estimates are necessary or how far they affect the reliability of the data, as the situation will vary from country to country. Nevertheless, it is generally the case that “subjective” estimation by respondents is probably greatest for the breakdown between basic research, applied research, and experimental development, while the use of “rule of thumb” estimation by survey agencies is probably greatest for R&D in the higher education sector. As a consequence, these data should be treated with circumspection. A special supplement to the 1980 version of the Manual gives further guidance on this topic (OECD, 1989*c).*

50. Even if national surveys provide R&D data which are reasonably accurate and relevant to national users’ needs, they may not be internationally comparable. This may simply be because national definitions or classifications clearly deviate from international norms. Such cases are generally

documented in footnotes. The situation is more complex when the national situation does not correspond to the international norms. This is often true for sector analysis, where for administrative reasons, apparently similar institutions fall into different sectors in different countries. Again, national perception of these norms may be different, notably for type of activity analysis and for the analysis of R&D personnel by occupation. Such differences are impossible to quantify.

1.10 Government budget appropriations or outlays for R&D (GBAORD)

51. The term "budgetary appropriations for R&D" in this Manual is a general term used to describe government allocations to R&D and should not be interpreted as a direct reference to any national government's budgetary practice.

52. All the above-mentioned problems occur to a marked degree in the analysis of government R&D budgets by socio-economic objectives. On the other hand, such data are often available much earlier than the results of retrospective R&D surveys and are framed in categories of particular interest to policy makers.

53. This topic is discussed separately (Chapter 8) because, although the general definitions in Chapter 2 apply to GBAORD, the specifications in the following chapters, which are essentially designed for performer-based reporting, often do not.

54. This type of analysis essentially seeks to ascertain government intentions or objectives when committing money to R&D. R&D funding is thus defined by the funder (including public GUF) and may be both forecast (forward budgets) or retrospective (final budget or out-turn). Whereas R&D statistics proper are collected by means of especially designed surveys, government R&D funding data generally have to be derived at some stage or another from national budgets which have their own standard national methods and terminology. Although the links between survey and GBAORD data have improved in recent years, the resulting analysis will always be a balance between what is desirable from the R&D point of view and what is available from the budget or allied sources.

55. The aim of classifying GBAORD by socio-economic objective is to assist government science and technology policy formulation. Consequently, the categories have to be broad, and the series are intended to reflect the amount of resources devoted to each primary purpose (defence, industrial development, etc.). Governments in OECD countries generally pursue science policies and thus distribute their R&D funds in ways which match, to a large extent, the 11 broad categories used by the OECD. Nevertheless, the fit is never perfect and always reflects the policy intentions of a given programme rather than its precise contents. Because of this and because of methodological constraints on the way they are compiled, the strict level of international comparability is probably lower for GBAORD data than for most of the other series discussed in the Manual.

1.11 A final word to the user of R&D data

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

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

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

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

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

CHAPTER 2

BASIC DEFINITIONS AND CONVENTIONS

2.1 Research and experimental development (R&D)

57.

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

58. R&D is a term covering three activities: basic research, applied research, and experimental development (described in detail in Chapter 4). **Basic research** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. **Applied research** is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. **Experimental development** is systematic work, drawing on existing knowledge gained from research and/or practical experience, that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

2.2 Activities to be excluded from R&D

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

60. These activities will be discussed here under four headings:

- education and training (Section 2.2.1);
- other related scientific and technological activities (Section 2.2.2);
- other industrial activities (Section 2.2.3);
- administration and other supporting activities (Section 2.2.4).

61. The definitions here are practical and designed solely to exclude these activities from R&D. They are thus slightly different from the broader concepts of scientific and technical education and training (STET), scientific and technological services (STS) and innovation” discussed in Chapter 1.

2.2.1 Education and training

62. All education and training of personnel in the natural sciences, engineering, medicine, agriculture, the social sciences, and the humanities in universities and special institutions of higher and

post-secondary education should be excluded. However research by postgraduate students carried out at universities should be counted, wherever possible, as a part of R&D (see also Section 2.3.2.2).

2.2.2 Other related scientific and technological activities

63. The following activities should be excluded from R&D except where carried out solely or primarily for the purposes of an R&D project (see also examples in Section 2.3.1).

2.2.2.1 Scientific and technical information services

64. The specialised activities of:

– collecting		– scientific and technical
– coding		Personnel
– recording		– bibliographic services
– classifying	by	– patent services
– disseminating		– scientific and technical
– translating		information extension and
– analysing		advisory services
– evaluating		– scientific conferences

except where conducted solely or primarily for the purpose of R&D support *(e.g* the preparation of the original report of R&D findings should be included in R&D).

2.2.2.2 General purpose data collection

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

2.2.2.3 Testing and standardisation

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

2.2.2.4 *Feasibility studies*

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

2.2.2.5 *Specialised medical care*

68. Refers to routine investigation and normal application of specialised medical knowledge. There may, however, be an element of R&D in what is usually called “advanced medical care”, carried out, for example, in university hospitals (see Section 2.3.2.4).

2.2.2.6 *Patent and licence work*

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

2.2.2.7 *Policy-related studies*

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

2.2.2.8 *Routine software development*

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

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

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

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

2.2.3 Other industrial activities

73. These can be considered under two, to some extent overlapping, headings.

2.2.3.1 Industrial innovation not elsewhere classified

74. All those scientific, technical, commercial, and financial steps, other than R&D, necessary for the successful development and marketing of a manufactured product and the commercial use of the processes and equipment (Stead, 1976; OECD, 1992*b).*

2.2.3.2 Production and related technical activities

75. Industrial production and preproduction and distribution of goods and services and the various allied technical services in the business enterprise sector and in the economy at large, together with allied activities using the disciplines of the social sciences such as market research.

2.2.4 Administration and other supporting activities

76. This category has two components.

2.2.4.1 Purely R&D financing activities

77. The raising, management and distribution of R&D funds to performers by ministries, research agencies, foundations, or charities is not R&D. This is in line with the instructions in the latest version of ISIC (UN, 1990).

2.2.4.2 Indirect supporting activities

78. This covers a number of activities which are not themselves R&D but which provide support for R&D. By convention, R&D personnel data cover R&D proper and exclude the indirect support activities, whereas an allowance for them is included in R&D expenditure of performers under overheads. Typical example are transportation, storage, cleaning, repair, maintenance, and security activities. Administration and clerical activities undertaken exclusively for R&D, such as the activities of central finance and personnel departments, also come under this heading.

2.3 The boundaries of R&D

2.3.1 The basic criterion

79. The basic criterion for distinguishing R&D from related activities is the presence in R&D of an appreciable element of novelty and the resolution of scientific and/or technological uncertainty, *i.e.* when the solution to a problem is not readily apparent to someone familiar with the basic stock of commonly used knowledge and techniques in the area concerned. (Supplementary criteria are suggested in Chapter 7; see Section 7.5.3.)

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

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

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

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

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

e) The Manual has gone a long way towards solving this problem by including in the definition of R&D "knowledge of man, culture and society" (para. *57).* The concept of novelty should still be the underlying criterion for defining the boundaries between R&D and related (routine) scientific activities. Such related activities can only be included in R&D if they are undertaken as an integral part of a specific research project or undertaken for the benefit of a specific research project. Therefore, there are a number of areas in which social scientists bring established methodologies and facts of the social sciences to bear on a particular problem that cannot be classified as research. The following are examples of work which might fall into this category but are not R&D: interpretative commentary on the probable economic effects of a change in the tax structure, using existing economic data;

forecasting future changes arising from an altered demographical structure in the patterns of the demand for social services within a given area; operations research (OR) as a contribution to decision making, *e.g.* planning the optimal distribution system for a factory; the use of standard techniques in applied psychology to select and classify industrial and military personnel, students, etc., and to test children with reading or other disabilities.

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

2.3.2 Problems at the borderline between R&D and education and training

2.3.2.1 General approach

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

82. Because the results of research feed into teaching, and because information and experience gained in teaching can often result in an input to research, it is difficult to define where the education and training activities of higher education staff and their students end and R&D activities begin, and *vice versa.* R&D is an activity whose elements of novelty distinguish it from routine teaching and other work-related activities (para. 79). There is, however, a problem in deciding whether or not to consider as R&D those scientific activities which are the by-products of educational or training activities.

83. This dilemma exists for a number of cases which are considered below:

- postgraduate students and their activities;
- supervision of students by university staff;
- specialised health care;
- personal education of academic staff (own reading).

2.3.2.2 The case of postgraduate studies

84. In some OECD countries, the “postgraduate student” is not a usual national category. In these cases, the R&D activity of such persons is probably included with that of other part-time teaching staff or technicians (see para 282). This means that identifying their R&D is not a special problem.

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

86. Parts of the *curricula* for postgraduate studies (ISCED level 7) are highly structured, involving, for instance, study schemes, set courses, compulsory laboratory work, etc. Here, the teacher is

disseminating education and training in research methods. Typical activities for students under this heading are attending compulsory courses, studying literature on the subject concerned, learning research methodology, etc. These activities do not fulfil the criterion of novelty specified in the definition of R&D.

87. In addition, in order to obtain a final qualification at postgraduate level (ISCED 7), students are also expected to prove their competence by undertaking a relatively independent study or project and by presenting its results. As a general rule, these studies contain the elements of novelty required for R&D projects. Such activities of students should, therefore, be attributed to R&D, and any supervision by the teacher should also be considered as R&D. In addition to R&D performed within the framework of courses of postgraduate education, it is possible for both teachers and students to be engaged in other R&D projects.

88. In addition, students at this level are often attached to or directly employed by the establishment concerned and have contracts or are bound by a similar engagement which oblige them to do some teaching at lower levels or to perform other activities, such as advanced medical care, while allowing them to continue their studies and to do research.

89. The borderlines between R&D and education at ISCED level 7 are illustrated in Table 2.1 which, together with much of the above text, is based on the relevant Nordic Manual (NORDFORSK, 1986). The more practical problems of applying these concepts are dealt with in Chapter *5* (see Section *5.2.2.2).*

Table 2.1. Borderline between R&D and education and training at ISCED level 7

	Education and training at level 7	R&D	
Teachers	1. Teaching students at level 7 2. Training students a level 7 in R&D methodology, laboratory work, etc.	3. Supervision of R&D projects required for student qualification at level 7 4. Supervision of other R&D projects and performance of own R&D projects	5. Teaching at levels lower than 7 6. Other activities
Postgraduate students	1. Course work for formal qualification including independent study, laboratory work, etc.	2. Performing and writing up R&D projects required for formal qualification 3. Any other R&D activities	4. Teaching at levels lower than 7 5. Other activities

2.3.2.3 Supervision of students

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

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

2.3.2.4 Specialised health care

92. In university hospitals where, in addition to the primary activity of health care, the training of medical students is of major importance, the activities of teaching, R&D, and advanced as well as routine medical care are frequently very closely linked. "Specialised medical care" is an activity which normally is to be excluded from R&D (see Section 2.2.2.5). However, there may be an element of R&D in what is usually called "advanced medical care", carried out, for example, in university hospitals. It is difficult for university doctors and their assistants to define that part of their overall activities which is exclusively

R&D. If, however, time and money spent on routine medical care are included in the R&D statistics, there will be an overestimate of R&D resources in the medical sciences.

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

2.3.2.5 Personal education of academic staff

94. This activity covers time spent on activities such as professional continued learning ("own reading"), attendance at conferences and seminars, etc.

95. In distinguishing R&D from other related activities, the question is often raised as to whether "own reading" should be included as part of R&D activities. It is certainly part of the general professional development of research staff and, in the long term, the knowledge and experience gained will be incorporated into the researcher's thinking, if not into the actual implementation, of R&D. "Own reading", in fact, constitutes a cumulative process, and when the information gained from such activities is translated into research activity, it will then be measured as R&D.

96. Only personal education carried out specifically for a research project should be considered as an R&D activity.

2.3.3 Problems at the borderline between R&D and other related scientific and technological activities

2.3.3.1 General approach

97. Difficulties in separating R&D from other scientific and technological activities are caused by the performance of several activities at the same institution. In survey practice, the identification of the R&D portion is facilitated by using rules of thumb for making distinctions. Two such rules are:

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

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

98. The following examples illustrate the use of such rules of thumb:

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

These criteria apply only where it is necessary to exclude the activities of an institution or a department in their entirety. Where more detailed accounting methods are used, it may be possible to impute part of the costs of the excluded activities to R&D overheads. Whereas the preparation of scientific and technical publications is, generally speaking, excluded, the preparation of the original report of research findings should be included in R&D.

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

c) General purpose data collection is particularly important to social science research, since without it many aspects of this research would not be feasible. However, unless it is collected primarily for research purposes, it should not be classified as a research activity. On the other hand, the larger statistical institutes may carry out some R&D *(e.g.* on survey methods, sampling methodologies, and small area statistical estimates). Whenever possible, such R&D should be identified and appropriate estimates included with the main R&D sectoral data.

2.3.3.2 Specific cases

99. In certain cases the theoretical criteria for distinguishing between R&D and related scientific and technological activities are particularly difficult to apply. Space exploration, mining and prospecting, the development of social systems, and software development are four areas involving large amounts of resources, and any variations in the way they are treated will have important effects on the international comparability of the resulting R&D data. Large-scale projects also pose problems for the definition of their R&D; they are discussed in Section 2.3.4.2.3. The following conventions apply in the four areas mentioned.

2.3.3.2.1 Space exploration

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

2.3.3.2.2 Mining and prospecting

101. Mining and prospecting sometimes cause problems due to a linguistic confusion between research for new or substantially improved resources (food, energy, etc.) and the search for existing reserves of natural resources, a confusion which blurs the distinction between R&D and surveying and prospecting. In theory, in order to establish accurate R&D data, the following activities should be identified, measured, and summed:

a) the development of new surveying methods and techniques;

b) surveying undertaken as an integral part of a research project on geological phenomena;

c) research on geological phenomena *per se,* undertaken as a subsidiary part of surveying and prospecting programmes.

102. In practice, the third presents a number of problems. It is difficult to frame a precise definition that would be meaningful for respondents to national surveys. The sums involved are probably relatively small in practice, but a misreading by respondents might lead to large amounts of "search" resources being counted as R&D. For this reason, only the following activities should be included in R&D:

- the development of new or substantially improved methods and equipment for data acquisition and for the processing and study of the data collected and for the interpretation of these data;

- surveying undertaken as an integral part of an R&D project on geological phenomena *per se,* including data acquisition, processing, and interpretation undertaken for primarily scientific purposes.

103. It follows that the surveying and prospecting activities of commercial companies will be almost entirely excluded from R&D. For example, the sinking of exploratory wells to evaluate the resources of a deposit should be considered as scientific and technological services.

2.3.3.2.3 The development of social systems

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

2.3.3.2.4 Software development

105. For a software development project to be classified as R&D, its completion must be dependent on the development of a scientific and/or technological advance, and the aim of the project must be resolution of a scientific and/or technological uncertainty on a systematic basis.

106. In addition to software which is part of an overall R&D project, research and development associated with software as an end-product should also be classified as R&D.

107. Software development, by its nature, makes identifying its R&D component, if any. It is an integral part of many projects which of themselves have no elements of R&D. The software development component of such projects, however, may be classified as R&D if an advance occurs in the area of computer software. Advances in software are normally incremental rather than revolutionary. Therefore, an upgrade, addition or change to an existing programme or system may be classified as R&D if it embodies

scientific and/or technological advances which result in an increase in the stock of knowledge. Use of software for a new application or purpose, however, does not by itself constitute an advance.

108. A scientific and/or technological advance in software may be achieved even if a project is not completed. This situation arises because a failure can increase knowledge of the technology of computer software by showing that a particular approach will not succeed within the limits of the business environment. Alternatively, the project's objectives may not be achieved once all of the planned approaches have been exhausted.

109. Advances in other fields resulting from a software project have no effect on whether an advance in computer software has occurred.

110. See Annex 4 for an elaboration of these points.

2.3.4 Problems on the borderline between R&D and other industrial activities

(see also Table 2.2)

2.3.4.1 General approach

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

Table 2.2**. Some borderline cases between R&D and other industrial activities**

Item	Treatment	Remarks
Prototypes	Include in R&D	As long as the primary objective is to make further improvements
Pilot plant	Include in R&D	As long as the primary purpose is R&D
Industrial design and drawing	Divide	Include design required during R&D. Exclude design for production process
Industrial engineering and tooling-up	Divide	Include "feedback" R&D and tooling-up industrial engineering associated with development of new products and new processes. Exclude for production processes
Trial production	Divide	Include if production implies full-scale testing and subsequent further design and engineering. Exclude all other associated activities
After-sales service and trouble-shooting	Exclude	Except "feedback" R&D
Patent and licence work	Exclude	All administrative and legal work connected with patents and licences (except patent work directly connected with R&D projects)
Routine tests	Exclude	Even if undertaken by R&D staff
Data collection	Exclude	Except when an integral part of R&D

Public inspection control, enforcement of standards, regulations	Exclude	

112. Experimental development is defined as "systematic work, drawing on existing knowledge gained from research and/or practical experience that is directed to producing new materials, products or devices; to installing new processes, systems and services; or to improving substantially those already produced or installed" (para. 233). It is difficult to define precisely the cut-off point between experimental development and preproduction developments, such as producing user demonstration models and testing, and production that is applicable to all industrial situations. It would be necessary to establish a series of conventions or criteria by type of industry. The basic rule originally laid down by the US National Science Foundation (NSF) provides a practical basis for the exercise of judgement in difficult cases. Slightly expanded, it states:

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

113. Despite this elaboration, definitions can be difficult to apply in individual industries. It may not be clear when there is an appreciable element of novelty in R&D, or when a product/process is substantially set.

2.3.4.2 Specific cases

114. Some common problem areas are described below.

2.3.4.2.1 Prototypes

115. A prototype is an original model constructed to include all the technical characteristics and performances of the new product. For example, if a pump for corrosive liquids is being developed, several prototypes are needed for accelerated life tests with different chemicals. A feedback loop exists so that if the prototype tests are not successful, the results can be used for further development of the pump.

116. Applying the NSF criterion, the design, construction and testing of prototypes normally falls within the scope of R&D. This applies whether only one or several prototypes are made and whether they are made consecutively or simultaneously. But when any necessary modifications to the prototype(s) have been made and testing has been satisfactorily completed, the boundary of R&D has been reached. The construction of several copies of a prototype to meet a temporary commercial, military or medical need after successful testing of the original, even if undertaken by R&D staff, is not part of R&D.

2.3.4.2.2 Pilot plants

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

- evaluating hypotheses;

- writing new product formulae;
- establishing new finished product specifications;
- designing special equipment and structures required by a new process;
- preparing operating instructions or manuals on the process.

118. But if, as soon as this experimental phase is over, a pilot plant switches to operating as a normal commercial production unit, the activity can no longer be considered R&D even though it may still be described as a "pilot plant". As long as the primary purpose in operating a pilot plant is non-commercial, it makes no difference in principle if part or all of the output happens to be sold. Receipts from this source should not be deducted from the cost of R&D activity. However, as soon as the pilot plant begins to operate as a normal production unit, the effect is more or less the same as the sale of a pilot plant.

2.3.4.2.3 Large-scale projects and costly "pilot plants"

119. Large-scale projects, of which defence and aerospace are the most significant types, usually cover a spectrum of activity from experimental to preproduction development. In such circumstances, the funding and/or performing organisation often cannot distinguish between the R&D and other elements of expenditure. This distinction between R&D and non-R&D expenditures is particularly important in countries where a large proportion of government R&D expenditure is directed to defence. Annex 12 provides supplementary guidelines on this question.

120. It is very important to look closely at the nature of very costly pilot plants or prototypes, such as the first of a new line of nuclear power stations or of ice-breakers. They may be constructed almost entirely from existing materials and using existing technology, and they are often built for simultaneous use for R&D and for providing the primary service concerned (power generation or ice breaking). The construction of such plants and prototypes should not be wholly credited to R&D. For further details see Chapter 6 (Section 6.2.3).

2.3.4.2.4 Trial production

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

122. For example, if a new product is to be assembled by automatic welding, the process of optimising the settings on the welding equipment in order to achieve maximum production speed and efficiency would not count as R&D (even if joint-strength requirements have to be met).

2.3.4.2.*5* Trouble-shooting

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

2.3.4.2.6 "Feedback" R&D

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

2.3.4.2.7 Industrial design

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

126. For example, if an engineering product which incorporates machined, heat-treated, and/or electroplated components has been developed, the drawing up and documenting of the requirements for surface smoothness, heat treatment procedures, or electroplating process requirements, whether incorporated on the drawings or as separate specification sheets, are considered to be R&D.

2.3.4.2.8 Tooling up and industrial engineering

127. In the majority of cases the tooling-up and industrial engineering phases of any project are considered to be part of the production process.

128. Three phases of tooling up can be identified:

a) the first-time use of components (including the use of components resulting from R&D efforts);

b) the initial tooling of equipment for mass production;

c) installing equipment linked with the growth of mass production.

129. However, if the tooling-up process results in further R&D work, such as developments in the production machinery and tools, changes to the production and quality control procedures, or the development of new methods and standards, then these activities are classified as R&D.

130. For example, a vehicle or subassembly is made up of the integration of a number of different components, the technologies of which are well known. This integration of all the parts, components, and subassemblies in the development of a new model of a vehicle is normally taken for granted. However, if problems arise in this integration process, and R&D is required to achieve the desired result and produce an acceptable product, those activities associated with the tooling-up process are classified as R&D.

131. As another example, if prototypes are made by bolted or welded fabrication, final production will be a complex casting or forging process. The work involved in designing and optimising the dies, or the

feeding systems for the casting, or in establishing radiographic inspection procedures and defect acceptance levels, is considered R&D.

132. “Feedback” R&D resulting from the tooling-up phase should be defined as R&D.

2.3.5 R&D administration and indirect support activities

133. The R&D activities described above are supported by a number of other activities. The practice in R&D statistics is that the personnel data should cover only R&D proper whereas the expenditure data should cover the full cost of R&D, including the indirect support activities which are treated as overheads (see Section 2.2.4.2).

134. Some activities, such as the provision of library or computer services are R&D proper if they are intended exclusively for R&D, but indirect supporting activities if they are provided by central departments for both R&D and non-R&D uses (see Section 2.3.3.1). The same argument applies in the case of management, administration and clerical activities. When these contribute directly to R&D projects and are undertaken exclusively for R&D, then they are part of R&D proper and included in R&D personnel. Typical examples are the R&D manager who plans and supervises the scientific and technical aspects of the project or the word-processor who produces the interim and final result of the project. It remains a moot point whether the bookkeeping associated with a specific R&D project is direct (R&D proper) or indirect (ancillary) activity. By convention it is R&D proper rather than an indirect support activity if it is carried out in close proximity to the R&D (see also Table 5.1 and Section 5.1).

CHAPTER 3

INSTITUTIONAL CLASSIFICATIONS

3.1 The approach

135. The institutional approach focuses on the characteristic properties of the performing or funding institutions, and all the R&D resources of the unit are classified to one class or subclass according to the unit's principal activity.

3.2 The reporting unit and the statistical unit

3.2.1 The reporting unit

136. The reporting unit (referred to in earlier versions of the Manual as the unit surveyed) is the entity from which the recommended items of data are collected. These will vary from sector to sector and from country to country, depending on institutional structures, the legal situation affecting data collection, tradition, national priorities, and survey resources. In some countries, data may be collected from scientific units; in others, it may be gathered only at a higher level of institutional aggregation. **The Manual can make no recommendation to Member countries concerning the reporting unit.** However, whenever Member countries provide statistics for international comparisons, the reporting units should be specified.

3.2.2 The statistical unit

137. The statistical unit (referred to in earlier versions of the Manual as the unit classified) is the entity for which the required statistics are compiled. It may be an **observation unit** on which information is received and statistics are compiled or an **analytical unit** which statisticians create by splitting or combining observation units with the help of estimations or imputations in order to supply more detailed and/or homogeneous data than would otherwise be possible.

138. So far as possible, the statistical unit should be uniform, within sectors, for all countries. In practice, however, this goal is never completely achieved. One reason is that structures are different and names are different (or misleadingly similar). Another is the interaction with the reporting unit. If the reporting unit is larger than the statistical unit (for example, when the survey is undertaken by contracting firms who are requested to make separate returns for each establishment or by contracting institutes who are requested to respond at project level), there may be problems for distributing the data into the appropriate classification units. Various units will be recommended in the sections which follow. Where necessary, further references are given to the definitions of international standard classifications.

3.3 Sectors

3.3.1 Reasons for sectoring

139. In order to facilitate the collection of data, the description of institutional flows of R&D funds, and the analysis and interpretation of R&D data, the statistical unit(s) classified should be grouped into sectors of the economy, following as closely as possible existing standard classifications of economic activities. This offers a number of important practical advantages:

a) Different questionnaires and survey methods can be used for each sector to take into account the different "mixes" of activities, the different accounting systems, or the different response possibilities of the organisations.

b) When measuring expenditure, the sectoral approach offers the most reliable way of building up national aggregates.

c) Sectoring offers a framework for the analysis of flows of funds between the R&D funding and performing agencies.

d) Since each sector has its own characteristics and its own blend of R&D, this classification also throws some light on differences in the level and direction of R&D in different countries.

e) Insofar as the sectors chosen are based on the framework of an existing standard classification, it may be possible to relate R&D to other statistical series, thus facilitating the interpretation of the role of R&D in economic development and the formulation of science policy.

f) The institutions of the various sectors are sensitive to differing government policy initiatives.

3.3.2 Choice of sectors

140. The System of National Accounts (SNA) (UN, *1968b)* stated that "in any national accounting system transactors are necessarily grouped ... but they need not be grouped in the same way in all parts of the system and, indeed, it is not desirable that they should be". The following definitions are based largely on the SNA (UN, *1968b;* CEC *et al.,* 1994), with the difference that higher education has been established as a separate sector and households have, by convention, been merged with the private non-profit sector. Here, as in the SNA, non-profit institutions (NPIs) have been distributed between sectors.

141. Five sectors are identified and discussed below:

- business enterprise (see Section 3.4);
- government (see Section 3.5);
- private non-profit – PNP (see Section 3.6);
- higher education (see Section 3.7);
- abroad (see Section 3.8).

These are, in turn, divided into subsectors appropriate to each sector.

3.3.3 Problems of sectoring

142. In view of the diverse ways in which most contemporary institutions have developed, the definitions of the sectors that follow cannot be logically precise because, like the SNA from which they are partly drawn, they are based on a combination of sometimes conflicting criteria such as function, aim, economic behaviour, sources of funds, and legal status.

143. Thus, it will not always be clear in which sector a given institute should be classified, and an arbitrary decision may have to be made. Institutions may lie on the borderline between two sectors; or even if the conceptual distinction is clear, established legal and administrative affiliations or political considerations may prevent the application of this conceptual distinction in practice.

144. When two countries classify institutions with the same or similar functions in different sectors, the survey results will not be completely internationally comparable. Such divergences are unavoidable, as R&D surveys are primarily undertaken to serve national purposes. For international surveys, however, data should be collected and submitted in as much detail as possible in order to leave room for rearrangement for international comparisons. This is a reason for the "other institutional subclassifications" included for each sector. (See Annex 6 for a decision tree on the classification of units to sectors.)

3.4 Business enterprise sector

3.4.1 Coverage

145. The business enterprise sector includes:

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

146. The core of the sector is made up of **private enterprises** (corporations or quasi-corporations) whether or not they distribute profit. Among these enterprises may be found some firms for which R&D is the main activity (commercial R&D institutes and laboratories). Any private enterprises producing higher education services should be included in the higher education sector.

147. In addition, this sector includes **public enterprises** (public corporations and quasi-corporations owned by government units) mainly engaged in market production and sale of the kind of goods and services which are often produced by private enterprises, although, as a matter of policy, the price set for these may be less than the full cost of production. In order to qualify as market production in this context, the charges should be related to the amount (quality and quantity) of the goods and services furnished, the decision to purchase them should be voluntary, and the price charged should have a significant effect on the quantities supplied and demanded. Any public enterprises producing higher education services should be included in the higher education sector.

148. This sector also includes **non-profit institutions** (NPIs) who are market producers of goods and services other than higher education. These are of two kinds.

149. The first are NPIs whose main activity is the production of goods and services for sale at prices designed to recover most or all their costs. Such research institutes, clinics, hospitals, medical practitioners in private, fee-paying practices, etc., may be able to raise additional funds in the form of donations or own assets generating property income which allow them to charge below average cost.

150. The second are NPIs serving business. These are typically created and managed by associations of businesses whose services they are designed to promote, such as chambers of commerce, and agricultural, manufacturing or trade associations. Their activities are usually financed by contributions or subscriptions from the businesses concerned which provide “institutional” support for their R&D. However, any NPIs carrying out similar functions but controlled or mainly financed by government – for example if they depend for their existence on a block grant from government – should be included in the government sector.

151. Finally, this sector includes units associated with the higher education and government sectors whose main purpose is development of and contribution to the business enterprise sector. The criterion for the classification of the unit is the sector it mainly serves and not co-operation related to projects or use of equipment or of personnel belonging to or used by higher education or government sector institutions.

3.4.2 The principal sector subclassification

3.4.2.1 The classification list

152. For international comparisons of R&D statistics, units in the business enterprise sector are classified into a number of significant industry groups and subgroups by the International Standard Industrial Classification (ISIC) (UN, 1968*a*; UN, 1990). Table 3.1 shows a rearrangement of ISIC Rev. 3 (UN, 1990) which is suitable for such comparisons, and Annex 13 the version currently used by the OECD for its surveys.

3.4.2.2 The statistical unit

153. R&D by business enterprises may be organised in a number of ways. Core R&D may be carried out in units attached to establishments or in central units serving several establishments of an enterprise. In some cases, separate legal entities may be established to provide R&D services for one or more related legal entities. *Ad hoc* R&D, on the other hand, is usually carried out in an operational department of a business, such as the design, quality or production department

154. The choice of the statistical unit(s) must be determined by the nature of the information normally collected. This is described in detail in Chapter 6, but it can be stated here that one of the most fundamental questions concerns the sources of funds for R&D. This will generally concern the legal entity that controls the performance of R&D rather than the smaller units that actually carry out the work. The R&D unit may have to prepare a budget and record its costs, but only the central administration of the company may know where the money to cover the expenditures actually came from. Contracts and taxation must involve a legal entity.

155. This enterprise-type unit is, therefore, recommended as the **reporting unit** and, with exceptions, as **the statistical unit** in the business enterprise sector. In most cases the legal entity defined in paragraphs 78 and 79 of the ISIC Rev. 3 (UN, 1990) is the appropriate unit.

156. When an enterprise is heterogeneous with regard to its economic activities and carries out significant amounts of R&D for several kinds of activity units, the R&D activity should be subdivided if the necessary information can be obtained. In some countries, this is done by division into statistical units corresponding to economic units within the enterprise. In others, the R&D activity might be broken down according to data on the products and processes involved.

157. Within a group of enterprises, it is desirable to obtain separate returns in respect of each of the legal units for which records are kept. Where such records are not kept by the enterprise, the data could be compiled for analytical units created by the statisticians.

3.4.2.3 Criteria for classification

3.4.2.3.1 Firms

158. The principal activity classification of these statistical units should be determined by “the class of the ISIC in which the principal activity, or range of activities, of the unit is included” [see ISIC Rev. 3, para. 114 (UN, 1990)].

159. According to ISIC, this principal activity should be determined by reference to the value added of the goods sold or the services rendered by the activities. If this is not possible, the principal activity can be determined either on the basis of the gross output of the goods sold or services rendered by each activity, or by the number of persons assigned to them [see ISIC Rev. 3, para. 115 (UN, 1990)].

Table 3.1 **International Standard Industrial Classification arranged for the purposes of R&D statistics**

Title	ISIC Rev. 3 ISIC Rev 3 Division/Group/Class[3]	NACE Rev. I NACE Rev.1 Division/Group/Class[4]
Agriculture[1]	**01, 02, 05**	**01, 02, 05**
Mining[1]	**10, 11, 12, 13, 14**	**10, 11, 12, 13, 14**
Manufacturing[1]	**15-37**	**15-37**
"Food, beverages and tobacco"[1]	15±16	15+ 16
Food products and beverages	15	15
Tobacco products>	16	16
"Textiles, fur and leather"[1]	17+18+19	17+18+19
Textiles	17	17
Wearing apparel and fur	18	18
Leather products and footwear	19	19
"Wood, paper, printing, publishing"[1]	20+21+22	20+21+22
Wood and cork (not furniture)	20	20
Pulp, paper and paper products	21	21
Publishing, printing and reproduction of recorded media	22	22
"Coke, petroleum, nuclear fuel, chemicals and products, rubber and plastics"	23 + 24 + 25	23 + 24 + 25
Coke, refined petroleum products and nuclear fuel	23	23
Coke and nuclear fuel	23 (less 232)	23 (less 23.2)
Petroleum products[1] (**but** Rev.2 includes coke products,231)	232	23.2
Chemicals and chemicals products	24	24
Chemicals and chemicals products (less pharmaceuticals)	24 (less 2423)	24 (less 24.4)
Pharmaceuticals	2423	24.4
Rubber and plastics products	25	25
Non-metallic mineral products ("Stone, clay and glass")	26	26
Basic metals	27	27
Basic metals, ferrous	271 and 2731	27.1.27.3 + 27.51/52
Basic metals, non ferrous	272 and 2732	27.4 +27.53/54
Fabricated metal products, machinery and equipment, instruments and transport"	28-35	28-35
Fabricated metal products	28	28
Machinery, n.e.c.	29	29
Engines and turbines, except aircraft, vehicle and cycle	*2911*	*29.11*
Special purpose machinery	*292*	*29.3+ 29.4 + 29.5 + 29.6*
Machine-tools	*2922*	*29.4*
Weapons and ammunition	*2927*	*29.6*
Office, accounting and computing machinery	*30*	*3(1*
Electrical machinery	*31*	*31*
Electrical motors, generators and transformers	*311*	*31.1*
Electricity distribution and control apparatus (includes semi—conductors)	*312*	*31.2*
Insulated wire and cable (includes optic fibre cables)	*313*	*31.3*
Accumulators, primary cells and primary batteries	*314*	*31.4*

Electric lamps and lighting equipment	*315*	*31.5*
Other electrical equipment n.e.c.	*319*	*31.6*
Electronic equipment (radio, TV and communications)	32	32
Electronic valves, tubes and components	*321*	*32.1*
TV, radio transmitters and line apparatus	*322*	*32.2*
- TV and radio receivers, sound and video goods	*323*	*32.3*
Medical, precision and optical instruments, watches and clocks (instruments)[1]	33	33
Medical appliances, instruments and control equipment.	*331*	*33.1 + 33.2 + 33.3*
Optical instruments and photographic equipment	*332*	*33.4*
Watches and clocks	*333*	*33.5*
Motor vehicles[1]	34	34
Other transport equipment[1] (in Rev. 2, less 351 and 353)	35	35
Ships[1]	351	35.1
Railway and tramway locomotives and rolling stock	*352*	*35.2*
Aerospace[1]	353	35.3
Transport equipment, n.e.c.	*359*	*35.5*
Furniture; Other manufacturing, n.e.c.	36	36
Furniture	*361*	*36.1*
Other manufacturing	*369*	*36.5*
Recycling	*37*	*37*
Utilities	**40,41**	**40,41**
Construction [1]	**45**	**45**
“Service sector”	**50-99**	**50-99**
Wholesale, retail trade and motor vehicle repair	**50,51,52**	**50,51,52**
Hotels and restaurants	**55**	**55**
Transport, storage and communications	**60,61,62,63,64**	**60,61,62,63,64**
Financial intermediation (includes insurance)	**65,66,67**	**65,66,67**
Real estate, renting and business activities	**70,71,72,73,74**	**70,71,72,73,74**
Computer and related activities	72	*72*
Software consultancy and supply	*722*	*72.2*
Research and development	*73*	*73*
Other business activities	*74*	*74*
Architectural, engineering and other technical activities	*742*	*74.2*
Community, social and personal service activities, etc.[2]	**75-99**	**75-99**
Grand total	**01-99**	**01-99**

1. Heading in present ISIC Rev. 2 International statistical year industry list.
2. Activities carried out in these industries by the business enterprise sector only. Figures are obviously expected to be negligible: the heading is included as an aide-memoire.
3. UN, 1986*b*.
4. EUROSTAT, 1990.
The version of this classification used in OECD surveys, which also includes references to ISIC Rev. 2 (UN, 1968*a*), is reproduced as Annex 13.
Note: Indented texts in italics are industries identified by analysts as potentially useful for their work.
n.e.c.: Not elsewhere classified.

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160. To conform as far as possible to the ISIC principles, outlined in paragraph 159**,** the R&D statistical units in the business enterprise sector should be linked with the division in the family of industries that benefits directly from their R&D. In most cases, this will be determined by the principal activity classification of the R&D statistical units.

3.4.2.3.2 R&D units serving enterprises

161. When the R&D is carried out in a legal entity specialising in research and development, that unit will be classified in research and services for enterprises [ISIC Rev. 3, para. 73 (UN, 1990)]. It is therefore desirable for the purpose of R&D analysis to identify for it an additional classification reflecting the division(s) in the family of industries which benefit from its R&D activities. This may be based on activity or product data obtained in R&D surveys.

3.4.3 Other institutional subclassifications

3.4.3.1 Type of institution

162. The nature of the R&D performed by an entity in the business enterprise sector often reflects the type of entity, and it would be useful if R&D data reflected these differences. In particular, the evolving nature of the business sector both within countries and on a global scale requires subdivision both of private and public enterprises.

163. If private enterprises are broken down between nationally and multinationally owned enterprises, some trends in the internationalisation of industry can be examined. Public enterprises, on the other hand, would benefit from an identification of how much of their R&D effort is carried out in conjunction with institutions that are classified in the business enterprise sector but are at the border of the higher education and government sectors.

164. It is recommended, therefore, that if possible the following classification by type of institution be used:

– private enterprises:

– • national;

– • multinational (at least 50 per cent foreign ownership of capital);

– public enterprises:

– • units associated with the higher education sector;

– • units associated with the government sector;

– • all other public enterprises;

– other research and co-operative institutes.

165. Public enterprises are distinguished from private enterprises on the basis of control. The SNA (UN, 1968b, para. 5.55) makes the following recommendation:

> "Because of the many forms in which government may exercise control over enterprises, it is difficult to describe the means of influencing the management of an enterprise which, in all cases, indicate who effectively controls a given enterprise. The important consideration in determining whether the public authorities are in control is: do they exercise an effective influence in all the main aspects of management; not merely such influence as is derived from the use of their regulatory powers of a general kind."

3.4.3.2 Size of institution

166. The extent and nature of the R&D programmes of entities in the business enterprise sector are normally affected by the size of the entity. Two size classifications are possible: one based on revenue or other financial items, and one based on employment. Employment is preferable since it is a less ambiguous measure; *e.g.* total revenue including investment income, operating revenue, sales, turnover, extra-enterprise sales might all be used for the financial classification. Since this classification is based on the assumption of the likelihood of some sort of relationship between size of enterprise and resources available for R&D, non-commercial institutions should be separated from commercial enterprises, as their high ratios of R&D inputs to size are not comparable to ratios for enterprises whose R&D is auxiliary. For the same reason, enterprises and institutes whose primary activity is R&D should be separated from other commercial enterprises. It seems best, therefore, to confine this classification to statistical units in the manufacturing industries (and possibly even to commercial enterprises only).

167. The following size groups (according to number of employees) are recommended:

Under 100

100-499

500-999

1 000-4 999

5 000-9 999

10 000 and above.

3.5 **Government sector**

3.5.1 Coverage

168. The government sector is composed of:

– all departments, offices and other bodies which furnish but normally do not sell to the community those common services, other than higher education, which cannot otherwise be conveniently and economically provided and administer the state and the economic and social policy of the community. (Public enterprises are included in the business enterprise sector.

– NPIs controlled and mainly financed by government.

169. According to the SNA definition (UN, 1968*b;* CEC *et al.,* 1994) of "producers of government services" (with the exception of publicly controlled institutes of higher education), this sector should include all bodies, departments and establishments of government – central, state or provincial, district or county, municipal, town or village –that engage in a wide range of activities, such as: administration; defence and regulation of public order; health, education, cultural, recreational, and other social services; promotion of economic growth and welfare; and technological development. The legislature, the executive, departments, establishments, and other bodies of government should be included, irrespective of their treatment in the actual government accounts. It is immaterial whether they are accounted for in ordinary or extraordinary budgets, or in extra-budgetary funds.

170. This sector also includes non-market NPIs controlled and mainly financed by government, other than those administered by higher education units. With the latter exception, all non-market NPIs controlled and financed by government are included in the government sector irrespective of the types of institutional units that mainly benefit from their activities. Control is the ability to determine the general policy or programme of the NPI by having the right to appoint the officers managing the NPI. These research institutes and foundations are mainly financed by block grants from government and frequently the sums for this "institutional support" are published in government reports or budgets.

171. Units associated with the higher education sector mainly serving the government sector should also be included in this sector.

3.5.2 The principal sector subclassification

3.5.2.1 The classification list

172. The standard international classification for use within the government sector is that shown in SNA (UN, 1968b) Table 5 3 ("Classification of the purposes of government" – COFOG) (UN, 1980) (see Table 4 of 11). Unfortunately, it is not considered appropriate for the classification of R&D activities. In preparing this revision of the Manual, experts considered the appropriateness of using ISIC Rev. 3 (UN, 1990) fields of science and socio-economic objectives classification systems to classify R&D activities at subsector level. No agreement was reached as to the most appropriate system; therefore, no recommendation is being made. (See Table 4 1 and Sections 4 5 1 and 4 6 1 for recommendations for functional distributions.)

3.5.2.2 The statistical unit

173. ISIC Rev 3 (UN, 1990), paragraph 51, recommends that when data are combined with those collected from legal business entities, the statistical unit should be similar to the legal business entity.

3.5.2.3 Criterion for classification

174. In the absence of a recognised classification list, no recommendations can be made at this time.

3.5.3 Other institutional subclassifications

175. The following classifications are mainly designed to reveal differences among countries in the coverage of the government sector, usually resulting from variations in institutional arrangements.

3.5.3.1 Level of government

176. Statistical units should be classified into three categories, according to the level of government involved:

- central and federal government units;
- local and municipal government units;
- provincial and state government units;
- units at the border of the higher education sector (borderline institutions).

3.5.3.2 Type of institution

177. When there are important groups of units at the borderline between government and other sectors *(e.g.* units administered or controlled by government but situated at, or otherwise associated with, higher education units; or units serving industry but financed and controlled by government), it is desirable to identify them separately when reporting to international organisations. (For this particular classification, the statistical unit may be an establishment-type rather than an enterprise-type unit.) Where R&D in public service hospitals is included in this sector, it is also useful to declare it separately. A useful distinction may also be made between units for which R&D is the principal economic activity (Division 73, ISIC Rev. 3) and the rest.

3.6 Private non-profit sector

3.6.1 Coverage

178. The coverage of this sector – in line with revised SNA (CEC *et al.*, 1994) – has been reduced substantially since the last revision of this Manual and now includes:

- non-market, private non-profit institutions serving households (*i.e.* the general public);
- private individuals or households.

179. As a source of funds, this sector covers R&D financed by NPIs serving households (NPSH). These provide individual or collective services to households without charge or at prices that are not economically significant. Such NPIs may be created by associations of persons to provide goods or more often services primarily for the benefit of members themselves or for general philanthropic purposes. Their activities may be financed by regular membership subscription or dues or by donations in cash or in kind from the general public, corporations, or government. They include NPIs such as professional or learned societies, charities, relief or aid agencies, trades unions, consumers' associations, etc. By convention, this sector includes any funds contributed directly to R&D by households.

180. As a sector of performance, PNP includes non-market units controlled and mainly financed by NPIs serving households, notably professional and learned societies and charities, other than those providing higher education services or administered by units of higher education. However, R&D foundations managed by NPSH but which have more than 50 per cent of their running costs covered by a block grant from government should be included in the latter sector.

181. By convention, this sector also covers the residual R&D activities of the general public (households). The role of the latter in the performance of R&D is very small. The market activities of unincorporated enterprises owned by households, *i.e.* consultants undertaking R&D projects for another unit at an economically significant price, should be included in the business enterprise sector in line with National Accounts conventions (unless the project is undertaken using staff and facilities in another sector – see below). Obtaining data on such consultants may be difficult because the R&D activities of individuals are not captured in business enterprise R&D surveys. Hence the PNP sector should include only R&D undertaken by non-market, unincorporated enterprises owned by households, *i.e.* individuals financed by their own resources or by "uneconomic" grants.

182. Furthermore, where grants and contracts are formally placed with individuals who are primarily employed in another sector, such as, grants made directly to a university professor, unless such persons undertake the R&D concerned entirely on their own time without any use of their employing unit's staff and facilities, then they should be included for the purposes of R&D statistics with the latter. Similarly, postgraduate students in receipt of research grants should be included in the higher education sector. It follows that there only remains in this sector R&D performed by individuals exclusively on their own time and with their own facilities and at their own expense or supported by an uneconomic grant.

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

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

3.6.2 The principal sector subclassification

3.6.21 The classification list

184. Statistical units in the private non-profit sector are classified into the six major fields of science and technology suggested in the UNESCO "Recommendation Concerning the International Standardisation of Statistics on Science and Technology" (UNESCO, 1978). These fields are:

- natural sciences;
- engineering and technology;
- medical sciences;
- agricultural sciences;
- social sciences;
- humanities.

185. The major fields of science, together with examples of their subfields, are **defined by component fields** as given in Table 3.2.

186. While the major fields of science and technology are clearly defined, the degree of disaggregation within each component field is to be left open to each country.

3.6.2.2 The statistical unit

187. According to the SNA (UN, 1968*b;* **CEC** *et al.,* 1994), the legal entity is the recommended statistical unit for this sector. In some cases a smaller statistical unit may be appropriate (see below).

3.6.2.3 Criterion for classification

188. When a private non-profit institution is active in more than one field of science, the reporting unit should be broken down into statistical units and classified in one or more of the six science fields listed in paragraph 184 so that the breakdown by fields best describes the nature and composition of activities performed or funded by the institution in percentage terms. For example, an institute for medical sciences may be the reporting unit, but it may have two statistical units: medical sciences (70 per cent) and natural sciences (30 per cent).

3.6.3 Other institutional subclassifications

189. The role of this sector in R&D is very small. Therefore, no further breakdown is proposed (see also Table 4 of Annex 11).

3.7 Higher education sector

3.7.1 Coverage

190. This sector is composed of:

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

Table 3.2. **Fields of science and technology**

1.	**NATURAL SCIENCES**
1.1	Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified with the engineering fields)]
1.2	Physical sciences (astronomy and space sciences, physics, other allied subjects)
1.3	Chemical sciences (chemistry, other allied subjects)
1.4	Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)
1.5	Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)
2.	**ENGINEERING AND TECHNOLOGY**
2.1	Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)
2.1	Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]
2.3	Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, *e.g.* systems analysis, metallurgy, mining, textile technology, other allied subjects)
3.	**MEDICAL SCIENCES**
3.1	Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)
3.2	Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)
3.3	Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)
4.	**AGRICULTURAL SCIENCES**
4.1	Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)
4.2	Veterinary medicine
5.	**SOCIAL SCIENCES**
5.1	Psychology
5.2	Economics
5.3	Educational sciences (education and training and other allied subjects)
5.4	Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary, methodological and historical S&T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences]
6.	**HUMANITIES**
6.1	History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)
6.2	Languages and literature (ancient and modem languages and literatures)
6.3	Other humanities [philosophy (including the history of science and technology), arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic “research” of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S&T activities relating to the subjects in this group]

191. This sector is not a SNA sector. It has been separately identified by the OECD (and by UNESCO) because of the important role played by universities and similar institutions in the performance of R&D.

192. The above definition describes the general coverage of the sector. However, it is difficult to provide clear guidelines which ensure internationally comparable reporting of data because it is not backed by SNA. As it is based on mixed criteria, it is particularly susceptible to varying interpretation resulting from national policy preoccupations and definitions of the sector.

193. The core of the sector in all countries is made up of universities and colleges of technology. Where treatment does vary, it does so with respect to other institutes of post-secondary education and above all to several types of institutes that are linked to universities and colleges. The main borderline problems are considered below:

- post-secondary education;
- university hospitals and clinics;
- borderline research institutions.

3.7.1.1 Post-secondary education

194. The sector includes all establishments whose **primary activity** is to provide post-secondary (third level) education regardless of their legal status. They may be corporations, quasi-corporations belonging to a government unit, market NPIs or NPIs controlled and mainly financed by government or by NPSHs. As noted above, the core is made up of universities and colleges of technology. The number of units in the sector has grown as new universities and specialised post-secondary educational institutions have been set up and secondary level units, some of which may supply education services at both secondary and post-secondary level, have been upgraded. If such units supply post-secondary education as a primary activity, they are always part of the higher education sector. If their primary activity is the provision of secondary level education or in-house training they should be allocated by sector in line with the other general rules (market or non-market production, sector of control and institutional funding, etc.). If, however, their post-secondary activities can be identified separately, they may be judged under the "associated" rule (see below).

3.7.1.2 University hospitals and clinics

195. Inclusion of university hospitals and clinics in the higher education sector is justified both because they are post-secondary educational institutions (teaching hospitals) and because they are research units "associated with" higher education institutions *(e.g.* advanced medical care in clinics at universities).

196. Academic medical research is traditionally funded from many sources: out of the institutions' general "block grant" (GUF); from the institution's "own funds"; directly or indirectly (via a medical research council, for instance) from government funds or from private funds.

197. Where all or nearly all activities in the hospital/medical institution have a teaching/training component, the entire institution should be included as part of the higher education sector. If, on the other hand, only a few of the clinics/departments within a hospital/medical institution have a higher education component, **only** these teaching/ training clinics/departments should be classified as part of the higher education sector. All other non-teaching/training clinics/departments should, as a general rule, be included

in the appropriate sector (corporations, quasi-corporations belonging to a government unit, and market NPIs in the business enterprise sector; NPIs controlled and mainly financed by government in the government sector, NPIs controlled and mainly financed by NPSHs in the PNP sector). Care must be taken to avoid double-counting of R&D activities between the various sectors concerned.

3.7.1.3 Borderline research institutions

198. Traditionally universities have been major centres of research, and when countries have wished to expand their R&D in specific fields, they have frequently been considered appropriate locations for setting up new institutes and units. Most such institutions are principally government-financed and may even be mission-oriented research units; others are financed by private non-profit sector funds and latterly by the business enterprise sector.

199. A particular case arises when special funds are used to set up and finance mainly basic research managed by agencies which not only pay grants to universities proper, but also have their "own" research institutes, which may or may not be situated on university campuses.

200. One factor which determines the classification of such research institutions is the purpose for which the research is being carried out. If it is predominantly to serve government's needs, countries may decide to classify the institution as part of the government sector. This is the case of "mission-oriented" R&D institutions financed from the budget of their sponsoring ministry or department. Alternatively, if the R&D is basic in nature and adds to the general body of knowledge in a country, then some Member countries may have opted to classify the institutions as part of the higher education sector, regardless of its teaching/training activities.

201. A higher education unit may have "links" with other research institutions not directly concerned with teaching or other non-R&D functions. One example might be the mobility of personnel between the higher education units and the research institution concerned (or *vice versa),* and another the sharing of equipment facilities between institutions classified in different sectors.

202. Furthermore, in some countries, such borderline institutions may have a private legal status and carry out contract research for other sectors, or may be government financed research institutions. It is difficult to decide, in such cases, whether the links between the units are strong enough to justify including the "external" unit in the higher education sector.

203. A more recent development concerns the "science parks" situated at or near universities and colleges which host a range of manufacturing, service, and R&D institutions. It is recommended that, for science parks and other borderline institutions, physical location and use of common resources with the higher education sector should not be used as a classification criterion for the institutions associated with them, except when individuals, such as postgraduate students or fellows financed by direct grants or their own resources, perform R&D using higher education facilities are not actually on the university payroll (or that of any other sector, see Section 3.6.1).

204. Units administered by post-secondary teaching units (including teaching hospitals) as defined above, which are not primarily market producers of R&D, should be included in the higher education sector. The same applies if they are mainly financed from university block grants. If they are primarily market producers of R&D, they should be included in the business enterprise sector despite any links with higher education units; this is particularly relevant for science parks.

205. In the case of science parks also, any units controlled and mainly financed by government should be included in the government sector, while those controlled and mainly financed by the private non-profit sector should be included in the private non-profit sector.

206. In the case of classic associated "research institutes", it is not possible to give more definite instructions; further detailed discussion will be found in the supplement to the 1980 Frascati Manual (OECD, 1989*c*).

207. It is recommended that R&D expenditure and personnel of all institutes at the borderline with the higher education sector be reported separately.

3.7.2 The principal sector subclassification

3.7.2.1 The classification list

208. Statistical units in the higher education sector, like those in the private non-profit sector, are classified into six major fields of science and technology as follows:

- natural sciences;
- engineering and technology;
- medical sciences;
- agricultural sciences;
- social sciences;
- humanities.

209. The major fields of science, together with examples of their subfields, are **defined by component fields** as given in Table 3.2.

210. While the major fields of science and technology are clearly defined, the degree of disaggregation within each component may be left to the discretion of each country.

3.7.2.2 The statistical unit

211. Since the enterprise-type unit would almost invariably be involved in more than one of the six major fields of science and technology, a smaller statistical unit is necessary. An establishment-type unit is, therefore, recommended: the smallest homogeneous unit predominantly involved in only one of the six fields and for which a complete (or almost complete) set of factor input data can be obtained. Depending on the size of the institution and national terminology, the statistical unit could be a research institute, a "centre", a department, a faculty, a hospital, or a college.

3.7.2.3 Criterion for classification

212. The statistical unit should be classified in the field of science or technology which seems to describe most accurately its principal activity as reflected, for example, by the occupations of most of the unit's professional staff. Where R&D data for this sector are estimates made by the surveying authority, supplementary criteria, such as the institutional location of the unit, may have to be used. Depending on the size and character of the unit, a breakdown by several fields of science, with corresponding percentages, should be used. For example, a reporting unit in an institute for social sciences may have two statistical units: social sciences (70 per cent) and humanities (30 per cent).

3.7.3 Other institutional subclassifications

213. *For some countries, it may be interesting, for the purposes of international comparison, to know the breakdown between public and private universities and between universities proper and other post-secondary institutions.*

214. Statistical units should therefore be classified by the most appropriate type of main activity:

- teaching units *(e.g.* faculty or departments):
- • public;
- • private;
- research institutes or centres;
- borderline institutions;
- clinics, health centres, or university hospitals;
- other units at the borderline of the higher education sector not elsewhere classified.

3.8 Abroad

3.8.1 Coverage

215. This sector consists of:

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

3.8.2 The principal sector subclassification

216. The principal sector subclassifications are essentially designed to classify all the R&D activities of a performing unit. However, “Abroad” occurs in R&D surveys only as a source of funds for R&D performed by statistical units already classified in one of the four national sectors or as a destination for their extramural R&D expenditures. Thus, as it occurs only as a subitem of the R&D resources of a statistical unit, the choice of a standard subclassification does not arise.

3.8.3 Other institutional subclassifications

217. The sector may be divided into the four sectors used for domestic R&D, plus a fifth: international organisations. The recommended classification is, therefore:

- business enterprise;
- other national governments;
- private non-profit;
- higher education;
- international organisations.

218. *When financial flows for R&D between national and foreign business enterprise sectors are significant, they may usefully be subdivided among*:

- – *subsidiary or associated companies;*
- – *joint ventures;*
- – *other business enterprise companies.*

3.8.4 Geographic area of origin or destination of funds

219. It may also be interesting to break down flows of funds to and from abroad by geographical area as follows:

- European Community (EC);
- other European countries;
- United States and Canada;
- Japan;
- other OECD countries;
- international organisations.

CHAPTER 4

FUNCTIONAL DISTRIBUTION

4.1 The approach

220. In the functional approach, the nature of the R&D activity of the performing unit, rather than its principal (economic) activity, is examined. The R&D resources of the performing unit are distributed to one or more functional classes on the basis of the characteristics of the R&D itself, usually examined at the project level but sometimes in even greater detail. The survey approaches described in this Chapter are thus unique to the field of R&D statistics. Although functional distributions are quite appropriate for personnel data in theory, they are generally confined to R&D expenditure.

221. The existing standard nomenclatures used in institutional classifications may also be used for functional distributions *(e.g.* field of science). However, much nomenclature is used only for functional distributions *(e.g.* type of activity). In most cases, statistics on R&D distributed by function are already classified by institution. For example, R&D is almost always classified by sector and subsector prior to its functional distribution. In fact, most functional distributions are not appropriate for all sectors (see Table 4.1).

4.2 Type of activity

4.2.1 Use of distribution by type of activity

222. The breakdown by type of activity is currently recommended for use in all four national sectors of performance. It is usually easier to apply to R&D in the natural sciences and engineering (NSE) than in the social sciences and humanities (SSH). For the purposes of international comparison, the breakdown should be based on current expenditures only. It may be applied at project level, but some R&D projects may have to be subdivided among activities.

Table 4.1. Utility of functional distributions listed in Chapter 4

BREAKDOWN BY		Business enterprise	Government	PNP	Higher education
TYPE OF ACTIVITY	Expenditure	Recommended for current expenditure	Recommended for current expenditure	Recommended for current expenditure	Recommended for current expenditure
	Personnel	Unlikely	Unlikely	Unlikely	Unlikely
PRODUCT FIELD	Expenditure	Recommended	Unlikely	Unlikely	Unlikely
	Personnel	Possible	Unlikely	Unlikely	Unlikely
PRODUCT AND PROCESS R&D	Expenditure	Recommended	Possible	Unlikely	Unlikely
	Personnel	Unlikely	Unlikely	Unlikely	Unlikely
DETAILED FIELD OF SCIENCE	Expenditure	Unlikely	Recommended	Recommended	Recommended
	Personnel	Unlikely	Possible	Possible	Possible

SOCIO-ECONOMIC OBJECTiVE	Expenditure	Recommended for selected objectives only	Possible	Possible	Possible
	Personnel	Unlikely	Possible	Possible	Unlikely

4.2.2 The distribution list

223. Three types of R&D may be distinguished:

- basic (or fundamental) research (see Section 4.2.2.1);

- applied research (see Section 4.2.2.2);

- experimental development (see Section 4.2.2.3).

4.2.2 1Basic research

224.

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

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

226. Basic research is usually undertaken by scientists who may set their own goals and to a large extent organise their own work. However, in some instances, basic research may be oriented or directed towards some broad fields of general interest. Such research is sometimes called "oriented basic research".

227. Such oriented basic research may be distinguished from pure basic research as follows:

- ***Pure basic research** which is carried out for the advancement of knowledge, without working for long-term economic or social benefits and with no positive efforts being made to apply the results to practical problems or to transfer the results to sectors responsible for its application.*

- ***Oriented basic research** which is carried out with the expectation that it will produce a broad base of knowledge likely to form the background to the solution of recognised or expected current or future problems or possibilities.*

228. It is recognised that such a subdivision of basic research may not be applicable to all OECD countries or to the social sciences and humanities. Nevertheless, the separate identification of oriented basic research may provide some assistance towards the identification of strategic research.

4.2.2.2 Applied research

229.

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

230. Applied research is undertaken either to determine possible uses for the findings of basic research or to determine new methods or ways of achieving some specific and predetermined objectives. It involves considering the available knowledge and its extension in order to solve particular problems. In the business enterprise sector, the distinction between basic and applied research will often be marked by the creation of a new project to explore promising results of a basic research programme.

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

232. While it is recognised that an element of applied research can be described as strategic research, the lack of an agreed approach to its separate identification in Member countries prevents a recommendation at this stage.

4.2.2.3 Experimental development

233.

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

234. In the social sciences, experimental development may be defined as the process of translating knowledge gained through research into operational programmes, including demonstration projects undertaken for testing and evaluation purposes. The category has little or no meaning for the humanities.

4.2.3 Criteria for distinguishing between types of activity

235. There are many conceptual and operational problems associated with these categories which, as defined, may be considered archetypal. They seem to imply a sequence and a separation which rarely exist in reality. The three types of activity may sometimes be carried out in the same centre by essentially the same staff. Moreover, there may be movement in both directions. When an R&D project is at the applied research/development stage, for example, some funds may have to be spent on additional experimental or theoretical work to acquire new knowledge of the underlying foundations of the relevant phenomena before further progress can be made. Furthermore, some research projects may genuinely straddle more than one category. For instance, study of the variables affecting the educational attainment of children drawn from different social and ethnic groups may simultaneously involve both basic and applied research.

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

4.2.3.1 Examples from the natural sciences and engineering

237.

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

b) The study of a crystal's absorption of electromagnetic radiation in order to obtain information on its electron band structure is basic research. The study of the absorption of electromagnetic radiation by this material under varying conditions (for instance temperature, impurities, concentration, etc.) in order to obtain some given properties of radiation detection (sensitivity, rapidity, etc.) is applied research. The preparation of a device using this material in order to obtain better detectors of radiation than those already existing (in the considered spectral range) is experimental development.

c) The determination of the amino acid sequence of an antibody molecule is basic research. Such investigations undertaken in an effort to distinguish between antibodies of various diseases is applied research. Experimental development then consists of devising a method for synthesising the antibody for a particular disease, on the basis of knowledge of its structure, and clinically testing the effectiveness of the synthesised antibody on patients who have agreed to accept experimental advanced treatment.

4.2.3.2 Examples from the social sciences and humanities

238.

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

b) Analysis of the environmental determinants of learning ability is basic research. Analysis of the environmental determinants of learning ability for the purpose of evaluating education programmes designed to compensate for environmental handicaps is applied research. The development of means of determining which educational programme to use for particular classes of children is experimental development.

c) The study of a hitherto unknown language to establish its structure and grammar is basic research. Analysis of regional or other variations in the use of a language to determine the influence of geographical or social variables on the development of a language is applied research. No meaningful examples of experimental development have been found in the humanities.

(See Annex *5* for an elaboration of these definitions.)

4.2.3.3 Examples from software development

239.

a) Basic research. Pure basic research includes the development of software for algebraic manipulations and numerical analysis. Oriented basic research includes investigation into the formalisation of human speech and of specific tasks *(e.g.* work in the field of man/machine communication using direct speech input and output, research into basic algorithms for possible information processing applications, and investigation into the possibility of formalising programming procedures).

b) Applied research includes investigation into the application of information processing in new fields or in new ways *(e.g.* developing a new programming language, new operating systems, programme generators, etc.) and investigation into the application of information processing to develop such tools as geographical information and expert systems.

c) Experimental development is the development of new applications software, substantial improvements to operating systems and application programmes, etc.

4.3 Product fields

4.3.1 Use of distribution by product fields

240. For the present, the distribution of R&D by product fields is confined to the business enterprise sector. It could also be applied to other sectors, but then the distribution list suggested in the next section would have to be modified to account for the different orientation of R&D carried out in non-commercial institutions.

241. Product field analysis focuses on the actual industrial orientation of the R&D carried out by institutions in the business enterprise sector. R&D data are thus distributed to categories which are more comparable internationally and which permit more detailed analysis. For example, R&D expenditures by product field are better for comparison with commodity and production statistics than are the unmodified institutionally classified data.

242. In theory, basic research, at least unoriented basic research, cannot be assigned to product fields. In practice, the basic research carried out by a firm is generally oriented towards some field that interests the firm because of commercial applications. Since the product fields identified in the next section are very broad, a firm should be able to assign even its basic research to a field that effectively describes its orientation. It is recommended, therefore, that all three types of activity be considered in the product field distribution. R&D undertaken in the expectation that it will be applied to processes rather than products should be included.

243. At this time, it is recommended that only current intramural expenditures be considered for international comparisons. This recommendation is made because a number of Member countries are unable to include capital expenditures whereas those who can do so are, on the whole, able to report current expenditures separately from capital expenditures for the purpose of international comparison. The classification should be applied at project level.

4.3.2 The distribution list

244. The list recommended depends on the reason for the distribution, *i.e.* the intended use of the statistics. Trade data are classified by the national equivalent of the Standard International Trade Classification (SITC) (UN, 1986b); industrial output data are classified by the national equivalent of the International Standard Industrial Classification (ISIC) (UN, 1990). At present, both comparisons with industrial output data and with trade data are popular with analysts. For reasons of symmetry with the institutional classification for the business enterprise sector, the same distribution list has been adopted (see Table 3.1).

4.3.3 Criteria for distribution

245. Two criteria for distributing R&D by product field are feasible. In one case, the allocation should take the **nature** of the product into consideration. In the other, the distribution is based on the **use** of the product in terms of the enterprise's economic activities. At present no recommendation is possible since most Member countries lack experience in this area. It is hoped that a recommendation can be made in the next revision of the Manual.

4.3.31 Nature of product

246. When applying the "nature of product" criterion, the R&D input is distributed according to the type of product being developed.

247. The guidelines formerly used by the National Science Foundation to survey applied research and experimental development in industry are good examples of operational criteria:

> "Costs should be entered in the field or product group in which the research and development project was carried on, regardless of the classification of the field of manufacturing in which the results are to be used. For example, research on an electric component for a farm machine should be reported as research on electrical machinery. Also, research on refractory bricks to be used by the steel industry should be reported as research on stone, clay, glass and concrete products rather than primary ferrous metals, whether performed in the steel industry or the stone, clay, glass and concrete industry."

(National Science Foundation, 1983)

248. These guidelines should pose few problems for most R&D projects on product development. R&D on processes may be more difficult to deal with. If the results of the R&D will clearly be embodied in materials or equipment, then the guidelines should be applied to those products. If not, then the process should be allocated to the product it is destined to produce. Furthermore, for enterprises engaged in broad R&D programmes, rather detailed records or consultations with R&D personnel are needed in order to provide complete estimates.

249. The advantage of this approach is that as any enterprise in any industry carrying out R&D on a given product should select the same product field, no matter the expected use of the product, both interfirm and, especially, international data should therefore be comparable. The main disadvantage is that R&D on products assembled from a wide range of components, such as aircraft, may be underestimated.

4.3.3.2 Use of product

250. The "use of product" criterion is applied in order to distribute an enterprise's R&D among the economic activities that are supported by its R&D programme. The R&D is therefore distributed according to the relation of the product (or process) underdevelopment (see para. 160) to the enterprise's industrial activities.

251. The R&D of an enterprise active in only one industry would be assigned to the product field characteristic of that industry, except when R&D is being carried out on a product or process in order to enable the enterprise to enter a new industry.

252. When an enterprise is active in more than one industry, then the use of the product must be considered. For example 1992), the R&D carried out on very large-scale integrated circuits (VLSI) could be distributed in several ways:

a) for an enterprise active only in the semiconductor industry, this is R&D for electronic components and accessories;

b) for an enterprise active only in the computer industry, this is R&D for office, computing and accounting machines;

c) for an enterprise active in the semiconductor and computer industries, the use of the VLSI will determine the choice of product field:

d) if the VLSI is sold separately, the product field should be electronic components and accessories;

e) if the VLSI is included in computers sold by the enterprise, the product field should be office, computing and accounting machinery.

253. The "use of product" approach is intended to provide R&D data as comparable as possible with other economic statistics, particularly value added. It is, therefore, particularly useful when dealing with enterprises active in more than one industry.

254. In theory, the data derived from a functional analysis by use of product should be exactly the same as that of the institutional breakdown by industry if the R&D by enterprises active in more than one industry has been subdivided into several institutional units. In practice, the functional classification, which applies only to current expenditures, will be more detailed and should distribute the activities of many firms over several product fields, as adjustments will only be made in the institutional classification for the most significant multi-product firms.

4.4 Product and process R&D

4.4.1 Utilisation

255. This section deals with the distinction between product and process R&D as contained in the total R&D activities of business enterprises. Respondents to surveys have difficulty distinguishing between the two elements of R&D and the definitions given here are intended to be guidelines to assist respondents in allocating their R&D effort across the two activities. [For a more detailed discussion of the roles of product and process innovation, see the Oslo Manual, especially Chapter 4 (OECD, 1992b).]

4.4.2 Product R&D

256. Product R&D can be of a type which results in a product whose intended use, performance characteristics, attributes, design properties, added services or use of materials and components differs significantly from previously manufactured products. Such innovations can involve radically new technologies, or can be based on combining existing technologies in new uses. For example, the first microprocessor or video cassette recorders were product innovations of the radical type. The first portable cassette player, which combined existing tape and mini-headphone techniques, was a product innovation of the second type. In each case, the overall product had not existed before. Product R&D can also be incremental leading to the significant enhancement or upgrading of an existing product. First, a simple product may be improved (in terms of improved performance or lower cost) through use of higher performance components or materials. Second, a complex product which consists of a number of integrated technical subsystems may be improved by partial changes to one of the subsystems. Incremental product innovations may have both major and minor effects on the firm. The substitution of plastics for metals in kitchen equipment or furniture is an example of the first kind of incremental product innovation. The introduction of ABS braking or other subsystem improvements in cars is an example of the second kind of incremental product innovation.

4.4.3 Process R&D

257. Process development leads to the adoption of new or significantly improved production methods. These methods may involve changes in equipment or production organisation or both. The methods may be intended to produce new or improved products, which cannot be produced using conventional plants or production methods or to increase the production efficiency of existing products.

4.5 Detailed fields of science and technology

4.5.1 Use of distribution by detailed fields of science and technology

258. The distribution by detailed fields of science and technology differs from the major field classification described in Chapter 3 (see Sections 3.6.2; 3.7.2) in three ways. First, the R&D itself is examined, rather than the main activity of the performing unit; second, the resources are usually distributed at the project level within each performing unit; and, third, as its title suggests, a much more detailed list of fields should be used. Such a distribution is most easily applied in the higher education and private non-profit sectors. Sometimes the units surveyed in the government sector may also be able to break down their R&D activities by detailed field of science, but this has very rarely been attempted in the business enterprise sector.

259. It is recommended as a classification for all R&D carried out by units in the higher education, government and private non-profit sectors.

4.5.2 The distribution list

260. Unfortunately, no up-to-date detailed standard international classification of fields of science and technology, suitable for the functional distribution of R&D activities, is available. Therefore it is

recommended that the major fields of science and technology described in Table 3.2 be adopted as the functional fields of a science classification system.

4.5.3 The criteria for distribution

261. Resources should be allocated to the various fields of science and technology on the basis of the focus of R&D activities measured in terms of expenditure or of the occupational field in which R&D personnel actually work, usually at project level. Where appropriate, *e.g.* in the case of projects with a multidisciplinary character, a breakdown of resources by several fields of science and technology should be made.

4.6 Socio-economic objectives

4.6.1 Use of distribution by socio-economic objectives

262. This section deals with the functional analysis of the primary socio-economic objectives of intramural R&D as reported retrospectively by the performer. This approach should not be confused with the analysis by socio-economic objectives of government budget appropriations or outlays for R&D, which is treated in Chapter 8 (which deals with the objectives of total intended government R&D expenditure – intramural and extramural – as reported by the funder, often on the basis of budget data).

263. Performer-based reporting of the socio-economic objectives of R&D is most easily applied in the government and private non-profit sectors (or in a general “institutes” survey), although individual countries have applied it in the higher education sector and even for selected objectives in the business enterprise sector. It should be applied to total intramural expenditures for total NSE plus SSH R&D.

264. Over half of the OECD countries make a detailed breakdown of R&D expenditures in one or more sectors by socio-economic objectives, and some also use this distribution for R&D personnel data. Others, however, have not attempted this approach.

4.6.2 Minimum recommended breakdown

265. Although a general recommendation on the utility of detailed analysis by socio economic objectives cannot be made, it is suggested that Member countries make efforts to collect performer reported data in all sectors for two priority objectives:

- defence;
- control and care of the environment.

4.6.2.1 Defence R&D

266. Defence includes all R&D programmes undertaken primarily for defence reasons, regardless of their content or whether they have secondary civil applications. Thus, the criterion is not the nature of the product or subject (or who is funding the programme) but the objective. The objective of defence R&D is the creation or enhancement of techniques or equipment for use by national, overseas or multinational armed forces. For example, defence R&D includes nuclear and space R&D undertaken for defence

purposes. It does not, however, include civil R&D financed by ministries of defence, for instance on meteorology or telecommunications. It also includes enterprise-financed R&D whose main applications are in the defence area.

267. At first sight, the definition of defence R&D according to objective appears relatively straightforward. However, exactly the same R&D programme could have either a civil or a defence objective. An example is the Canadian research on cold-weather clothing intended for military use; because of its potential for civil applications, this programme could have been, or could become, civil.

268. Where there is pressure to "spin off' defence R&D to civil uses, or *vice versa*, the blurring of the objectives can become substantial. In such cases, only the organisation funding the R&D may be able to decide on its objective – and thus its classification as either defence or civil R&D (see also paras. 449-450).

269. The financing of defence R&D is becoming increasingly internationalised and privatised, and all sources of funds should be included. For countries with major defence R&D efforts, a breakdown by source of funds can be informative.

4.6.2.2 Control and care of the environment

270. In recent years, policy makers' attention has focused on all aspects of environmental activity, and environmentally related R&D is no exception. International definitions of the environment are currently under review and this Manual has adopted an approach that is in line with current thinking in this area. To identify both the R&D designed to prevent pollution in those activities that might cause it and R&D on the causes, diffusion, conversion of pollution and its effects on people and the environment, it is recommended that this heading be split into two components:

- the prevention of pollution;
- the detection and treatment of pollution.

4.6.3 The distribution list

271. The same distribution list is suggested as for government R&D funding in Chapter 8, that is:

1. Development of agriculture, forestry and fishing
2. Promotion of industrial development
3. Production and rational use of energy
4. Development of the infrastructure
   - 4.1 Transport and telecommunications
   - 4.2 Urban and rural planning
5. Monitoring and protection of the environment
   - 5.1 Prevention of pollution

– 5.2 Identification and treatment of pollution

6. Health (excluding pollution)

7. Social development and services

8. Exploration and exploitation of the Earth and the atmosphere

9. General advancement of knowledge

– 9.1 Advancement of research

10. Civil space

11. Defence.

4.6.4 The criteria for distribution

272. R&D should be distributed according to the primary objective of the project. As in the case of product field analysis, there are two approaches to distribution. One may look at the project content itself (similar to the "nature of product" approach) or at the end or purpose which the project is intended to serve (similar to the "use of product" approach). As this type of functional distribution is as yet not very widespread, it is not possible to give any recommendation as to which approach should be used for performer-based analysis by socio-economic objective.

273. Note that when this type of analysis is attempted in the higher education sector, "General university funds – GUF" (see Section 6.3.3.3) should be distributed among objectives and not be grouped under "Advancement of research".

CHAPTER 5

MEASUREMENT OF PERSONNEL DEVOTED TO R&D

5.1 General introduction

274. Personnel data measure the amount of resources going directly to R&D activities. Expenditure data measure the total cost of carrying out the R&D concerned, including that of indirect support (ancillary) activities.

275. The theoretical distinction between R&D and indirect support (ancillary) activities was already discussed in Chapter 2. In practice, it is useful to introduce additional criteria based on the location of the activity in the organisation concerned and its relation to the R&D-performing unit, considered as an establishment-type unit that may differ from the statistical unit. It should be noted that the treatment of ancillary staff in this Manual differs from that recommended in the System of National Accounts (SNA).

276. It is recognised that in the actual compilation of R&D data it may be difficult to isolate the R&D activities of ancillary staff from those of other R&D staff, but, in theory, the following activities are included in personnel and expenditure data if carried out in the R&D unit:

a) performing the scientific and technological work for the project (setting up and carrying out experiments or surveys, building prototypes, etc.);

b) planning and managing R&D projects, especially their S&T aspects;

c) preparing the interim and final reports of R&D projects, especially R&D aspects;

d) providing direct in-house services for R&D, ***e.g.*** computing or library and documentation work;

e) providing support for the administration of the financial and personnel aspects of R&D projects.

277. The following are service or indirect support (ancillary) activities to be excluded from the personnel data but to be included in the expenditure data as overheads:

a) specific services to R&D provided by central computer departments and libraries;

b) the services of central finance and personnel departments;

c) security, cleaning, maintenance, canteens, etc.

Table 5.1. **R&D and indirect support activities**

	Treatment in R&D survey	Location in the institution carrying out the R&D		Categories	Activities in each category
R&D activities	In R&D personnel and in R&D labour costs	In the R&D performing unit	R&D laboratories (formal R&D) plus other technical units (informal R&D)	Direct R&D	Carry out experiments, build prototypes, etc.
				Specific information, acquisition and treatment	Drafting, typing and reproducing R&D reports, in-house libraries, etc.
				Specific R&D management	Planning and managing S&T aspects of R&D project
				Specific administrative support	Bookkeeping, personnel administration
Indirect support activities	Not in R&D personnel or in R&D labour costs but in ''other current costs'' as ''overheads''	Elsewhere in the performing institution (firm, agency, university etc.) (or contracted out)	Central finane or personnel services	Central administration	R&D share of finance, personnel and general operations
			S&T-related support services	Direct centralised support activities	R&D share of support provided by computer departments, libraries, etc.
			Other ancillary services	Indirect centralised support services	Security, clearning maintenance, canteen, etc.
Not involvd in performance	Excluded	Outside the performing institution n.e.c.	Regional and national authorities, international agencies, charities, etc.		Collection and distribution of R&D funds

278. Note that the activities identified above as indirect support activities should also be included in overhead expenditures if they are purchased or hired from outside suppliers (See also Table 5.1).

5.2 Initial coverage of R&D personnel

5.2.1 Definition

279.

> All persons employed directly on R&D should be counted, as well as those providing direct services such as R&D managers, administrators, and clerical staff.

280. Those providing an indirect service, such as canteen and security staff, should be excluded, even though their wages and salaries are included as an overhead cost in the measurement of expenditure.

5.2.2 Cases needing specific guidelines

5.2.2.1 Treatment of administrative staff

281. In vertically integrated bodies with both an R&D funding and an R&D performing function, it may be difficult to decide at what levels administrators are actually directly employed on R&D (and thus included here and in labour costs), at what levels they are providing a service to R&D (included in overheads), and at which point both they and expenditures on their services should be wholly excluded from R&D data.

5.2.2.2 Treatment of postgraduate students

282. In those countries where postgraduates are not a recognised category of S&T personnel, they are probably included in part-time teaching staff or technicians. This means that as part of the overall calculation of higher education R&D personnel and expenditures – either by survey or through coefficients – their R&D full-time equivalent levels, their R&D costs, and their sources of R&D funds are measured as for staff employed by the higher education institution.

283. The difficulties of establishing the borderline between the R&D and education and training activities of postgraduates (and of their teachers) in countries where they are a recognised group were discussed in general terms in Chapter 2 (Section 2.3.2.2).

284. The aim here is to present guidelines on which categories of postgraduate students it is both theoretically sound and practically possible to include in R&D personnel (and hence expenditure) series.

285. As noted in Chapter 2, students at this level are often attached to or directly employed by the establishment concerned and have contracts, or are bound by similar engagements, which oblige them to do some teaching at lower levels or to perform other activities such as advanced medical care while allowing them to continue their studies and do research.

286. A first distinction can be made according to the level of studies. According to the International Standard Classification of Education (ISCED) (UNESCO, 1976), programmes at postgraduate level (ISCED 7) 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). This category (7) could be subdivided into two "level" categories *(e.g.* 7 and 8) on the above basis because the two kinds of programmes are so different in content and method."

287. Postgraduate students on "taught" courses can probably be safely excluded from R&D estimates in most countries, whereas those on "research-based" courses should be included as far as possible. However, it may be necessary, for practical reasons, to further reduce coverage to those students for whom the corresponding R&D expenditures can be estimated. Given the varying ways in which higher postgraduate studies are organised and financed in Member countries, it is not possible to give any very precise recommendations. The practice of including the full-time equivalence of all students who have attained level 7 of the ISCED classification system in the R&D statistics (together with the corresponding financial data) should, if possible, be adopted by Member countries. R&D activities of postgraduate students funded from scholarships or grants not awarded for R&D purposes or from personal resources should, however, be excluded, at least until further notice (see also Section 6.2.2.1.1).

5.3 Measurement

5.3.1 Introduction

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

- identifying which types of personnel should be initially included (see Section 5.2);
- measuring their number;
- measuring their R&D activities in full-time equivalent (person-years) (see Section 5.3.3).

5.3.2 Headcount data

5.3.2.1 Reasons for the approach

289. Data on the total number of persons who are mainly or partially employed on R&D allow links to be made with other series of data, for example education or employment data or the results of population censuses. This is particularly important when examining the role of R&D employment in total stocks and flows of scientific and technological personnel.

290. Headcount data are also the most appropriate measure for collecting additional information about R&D personnel, such as their age, gender, or national origin.

291. While data series measuring the number of R&D staff in this sector, and notably researchers, have many important uses, they are not a substitute for a series based on the number of full-time equivalent staff. The latter is a true measure of the volume of R&D and should be maintained by all Member countries for international comparisons.

5.3.2.2 Possible approaches and options

292. Persons working less than 10 per cent of their time on R&D may be excluded. The headcount data could usefully be divided between persons:

- working full-time on R&D (90 per cent or more);
- working mainly on R&D (50-90 per cent of time);
- working part-time on R&D (less than 50 per cent of time).

293. Various options are available for reporting headcount numbers:

- number of persons engaged in R&D at a given date (for instance, end of period);
- total number of persons engaged in R&D during the (calendar) year;
- average number of persons engaged in R&D during the (calendar) year.

294. Insofar as possible, the approach adopted for measuring headcount data for R&D personnel should be similar to that/those used for collecting other statistical headcount series (employment, education) with which the R&D series are likely to be compared.

5.3.3 Full-time equivalence (FTE) data

5.3.3.1 Reasons for the approach

295. R&D may be the primary function of some persons *(e.g.* workers in an R&D laboratory) or it may be a secondary function *(e.g.* members of a design and testing establishment). It may also be a significant part-time activity *(e.g.* university teachers or postgraduate students). To count only persons employed in R&D establishments would result in an underestimate of the effort devoted to R&D; to do a headcount of everyone spending some time on R&D would lead to an overestimate. The number of persons engaged in R&D should, therefore, be expressed in full-time equivalents (FTE).

5.3.3.2 Measurement in person-years

296. One FTE may be thought of as one person-year. Thus, a person who normally spends 30 per cent of his or her time on R&D and the rest on other activities (such as teaching, university administration, and student counselling) should be considered as 0.3 FTE. Similarly, if a full-time R&D worker was employed at an R&D unit for only six months, this results in an FTE of 0.5**.** Since the normal working day (period) may differ from sector to sector and even from institution to institution, it is impossible to express FTE in person-hours.

297. Theoretically, the reduction to FTE should be made for all R&D personnel initially included. In practice, it may be acceptable to count all persons spending more than 90 per cent of their time on R&D *(e.g.* most persons in R&D laboratories) as one FTE and, correspondingly, to completely exclude all persons spending less than 10 per cent of their time on R&D.

298. Personnel should be measured as the person-years expended on R&D over the same period as the expenditure series.

5.3.3.3 ETE on a fixed date

299. In some case it may be more practical to survey the FEE of R&D personnel as of a specific date. If, however, there are significant seasonal variations in R&D employment *(e.g.* temporary staff hired by governments at the end of the university teaching year), allowance should be made for these variations in order to permit comparison with data based on FTE during a period. Where the fixed-date approach is used and data is collected annually for the first or last day of the expenditure period, it is recommended that two-year moving averages should be used for comparisons with R&D expenditure data.

5.3.4 Specific problems in the higher education sector

5.3.4.1 General

300. The method used to measure R&D personnel should cover all categories of personnel defined as directly contributing to R&D activities in the sector, *i.e.* those actively involved in R&D and those supporting it.

301. There are two interrelated problems for the measurement of R&D personnel:

- definition of the working time;
- calculation of full-time equivalence (FEE).

5.3.4.2 Definition of working time

302. The one aspect of an academic teacher/researcher’s workload that is usually well-defined (although not necessarily internationally comparable) is the number of his/her teaching hours in the academic year. Absolute working time varies according to a number of factors, such as:

- the number of teaching hours in a week;
- the demands that examinations and student supervision make on teachers’ time;
- administrative duties, which vary according to the time of year;
- the nature of R&D activities and the deadlines imposed for publication and/or presentation of results;
- the vacation periods of students.

303. There is thus great flexibility in the working pattern of staff, a flexibility which has been highlighted in recent time-budget studies, where it has been found that much of their professional activity – notably R&D – is carried on outside "normal working hours" and frequently outside the higher education institution itself.

5.3.4.3 Calculation of full-time equivalence

304. Much attention has been devoted to defining "normal" working time, particularly since respondents in time-budget surveys frequently report much longer working time than most similar categories of civil servants. The normal measure used to define the personnel input to R&D is that of full-time equivalence (FEE), recommended because the use of a "headcount" approach to the staff who usually devote part of their working time to R&D would seriously inflate the figures for personnel inputs.

305. On this basis, therefore, calculation of full-time equivalent R&D personnel must be based on total working time. Accordingly, no person can represent more than one full-time equivalent in any year and hence cannot perform more than one FTE on R&D.

306. In carrying out surveys, the definition of R&D and its inclusions, *i.e.* "normal time" and "overtime", are very important if the respondent is to report accurately his/her volume of R&D. The method of time-budget survey will have a bearing on the accuracy of full-time equivalence calculations (see Annex 3). If the survey is based on the distribution of working hours during a specific week, it is relatively easy to take into account R&D work done outside "normal office hours". If the respondent must evaluate the time spent on R&D during the whole year, it is more difficult to give correct weight to R&D work (as well as to other work-related activities) done outside "normal" hours. Also, the time of year at which a time-budget survey is carried out may have a direct bearing on the calculation of the full-time equivalence.

5.4 **Categories of R&D personnel**

5.4.1 Introduction

307. Two approaches are used by OECD Member countries for classifying R&D personnel: one by occupation, the other by level of formal qualification. While both are perfectly logical and linked to two different United Nations classifications – the International Standard Classification of Occupations (ISCO) (ILO, 1968; ILO, 1990) and the International Standard Classification of Education (ISCED) (UNESCO, 1976) – this divergence poses problems of international comparability.

308. Both approaches have advantages and disadvantages. Occupation series reflect the present use of resources and thus are more useful for purely R&D analysis. Furthermore, they are probably easier for employers to provide. Qualification series are important, however, for broader analysis, for example for setting up total personnel databases and for forecasting needs and supplies of highly qualified S&T personnel, but they suffer from problems of international comparability due to the differences in levels and structures of national educational systems.

309. The Manual therefore contains definitions for both a classification by occupation and a classification by level of formal qualification.

5.4.2 Classification by occupation

5.4.2.1 Introduction

310. The standard international classification in this field is the International Standard Classification of Occupation (ISCO) (110, 1968; 110, 1990). The main definitions of occupations which follow are especially designed for R&D surveys. However, they can also be described in terms of ISCO-88 (110, 1990) as shown in Annex 7.

5.4.2.2 Researchers *(RSE)*

311.

> – Researchers are professionals engaged in the conception or creation of new knowledge, products processes, methods, and systems, and in the management of the projects concerned.

312. Researchers are all persons in ISCO-88 Major Group 2 "Professional Occupations" plus "Research and Development Department Managers" (ISCO-88 1237). By convention, any members of the Armed Forces with similar skills performing R&D should also be included in this category.

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

314. Professional titles may vary from institution to institution, from sector to sector, and from country to country.

315. Postgraduate students engaged in R&D should be considered as researchers, and should be reported separately. Where they are not a separate category (see Section 2.3.2.2) and are treated as employed as technicians as well as researchers, this may cause inconsistencies in the researcher series.

5.4.2.3 Technicians and equivalent staff

316.

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

317. Technicians and equivalent staff are persons in ISCO-88 Major Group 3 "Technicians and Associate Professionals", notably in Sub-major 31 "Physical and Engineering Science Associate Professionals" and 32 "Life Science and Health Associate Professionals" plus "Statistical, Mathematical and Related Associate Professionals" (ISCO-88, 3434). Any members of the Armed Forces working on similar tasks should be included in this category.

318. Their tasks include:

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

5.4.2.4 Other supporting staff

319.

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

320. Other R&D supporting staff will be found essentially in ISCO-88 Major Groups 4 "Clerks", 6 "Skilled Agricultural and Fishery Workers", and 8 "Plant and Machine Operators and Assemblers".

321. Included under this heading are all managers and administrators dealing mainly with financial and personnel matters and general administration, insofar as their activities are a direct service to R&D. They will mainly be found in ISCO-88 Major Group 2 and Minor Group 343 "Administrative Associate Professionals" (except 3434).

5.4.3 Classification by level of formal qualification

5.4.3.1 Introduction

322. The International Standard Classification of Education (ISCED) (UNESCO, 1976) provides the basis for classifying R&D personnel by formal qualification. Five classes are recommended for the purposes of R&D statistics. They are defined exclusively by level of education, regardless of the field in which personnel are qualified.

5.4.3.2 Holders of university PhD level degrees (ISCED level 7 upper part)

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

5.4.3.3 Holders of basic university degrees below the PhD level (ISCED level 7 lower part and level 6)

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

5.4.3.4 Holders of other post-secondary diplomas (ISCED level 5)

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

5.4.3.5 Holders of diplomas of secondary education (ISCED level 3 and below)

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

5.4.3.6 Other qualifications

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

5.5 National aggregates

328. The recommended aggregate is for total person-years spent in the performance of R&D on national territory for a given 12-month period. This should be broken down by sector and by occupation and/or formal qualification as shown in Tables *5.2.a* and Table *5.2.b.* The other institutional classifications (and sometimes the functional distributions) are applied within this framework.

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

5.6 Cross-classification between occupation and qualification

330. Both systems have their strengths and their weaknesses when used to classify R&D personnel. However, since each is associated with a body of useful related statistics (employment by occupation, educational statistics by qualification) it is desirable to classify R&D personnel by both occupation and qualification. It is recommended, further more, that perhaps every five years or every third OECD international R&D survey, data be collected for a cross-classification between occupation and qualification on a headcount basis, as shown in Table 5.3.

Table 5.2a Total national R&D personnel (in FTE) by sector and by occupation

Occupation	Sector				
	Business enterprise	Private non-profit	Government	Higher education	Total
Researchers					
Technicians and equivalent staff					
Other supporting staff					
Total					

Table 5.2b Total national R&D personnel (in FTE) by sector and by level of qualification

Qualification	Sector				
	Business enterprise	Private non-profit	Government	Higher education	Total
Holders of:					
University degrees					
PhDs					
Other					
Other post-secondary diplomas (ISCED 5)					
Secondary diplomas (ISCED 3)					
Other qualifications					
Total					

331. There will normally be a general correspondence between researchers and university graduates, in that most researchers will have university level diplomas though a few will have lower qualifications supplemented by experience on the job. However, the correspondence is more tenuous for the other occupation categories. It is increasingly common to find university graduates with national science and engineering (NSE) degrees employed as technicians. Similarly, other supporting staff may hold diplomas at all levels (e.g. financial directors with university degrees in accountancy, senior secretaries with ISCED level 5 diplomas, etc.) A cross-classification such as the one suggested above is useful for any attempt to understand another country's R&D personnel statistics, to evaluate the international comparability of these statistics, or, indeed, for discussing trends in a country's own R&D labour force.

Table 5.3. R&D personnel classified by occupation and by formal qualification (Headcount)

	Occupation			
Qualification	Researchers (RSE)	Technicians and equivalent staff	Other supporting staff	Total
Holders of:				
University degrees				
PhDs				
Others				
Other post-secondary diplomas (ISCED 5)				
Secondary diplomas (ISCED 3)				
Other qualifications				
Total				

5.7 Other personnel classifications

332. In order to understand more about the R&D labour force and how it fits in the wider pattern of total scientific and technical personnel, it is also useful to collect the following types of data on a headcount basis:

- researchers (or holders of university-level degrees) by field of highest qualification;
- technicians (or holders of post-secondary degrees and diplomas) by field of highest qualification;
- researchers (or holders of university-level degrees) by age, gender, national origin, length of service, etc.

CHAPTER 6

MEASUREMENT OF EXPENDITURES DEVOTED TO R&D

6.1 Introduction

333. Expenditures on R&D may be spent within the statistical unit (intramural) or outside it (extramural). The full procedures for measuring these expenditures are:

a) to identify the intramural expenditure on R&D performed by each statistical unit;

b) to identify the sources of funds for these intramural R&D expenditures as reported by the performer;

c) to identify the extramural R&D expenditures of each statistical unit;

d) to aggregate the data, by sectors of performance and sources of funds, in order to derive significant national totals. Other classifications and distributions are then compiled within this framework.

334. Nevertheless, it is the first two stages which are essential and which generally suffice for stage *d).* R&D expenditure data should be compiled on the basis of performers reports of intramural expenditures. The collection of extramural expenditures is, however, also desirable as a supplementary source.

6.2 Intramural expenditures

6.2.1 Definition

335.

> Intramural expenditures are all expenditures for R&D performed within a statistical unit or sector of the economy, whatever the source of funds.

336. Expenditures made outside the statistical unit or sector but in support of intramural R&D (*e.g.* purchase of supplies for R&D) are included. Both current and capital expenditures are included. (See Annex 4 for guidelines on the classification of R&D expenditures in the software area.)

6.2.2 Current expenditures

337. Current expenditures are composed of labour costs and other current costs (see also Section 6.2.3.3).

6.2.2.1 Labour costs of R&D personnel

338. These comprise annual wages and salaries and all associated costs or fringe benefits such as bonus payments, holiday pay, contributions to pension funds and other social security payments, payroll taxes, etc. The labour costs of persons providing indirect services and which are not included in the

personnel data (such as security and maintenance personnel or the staff of central libraries, computer departments, or head offices) should be excluded and included in other current costs.

339. Labour costs are almost always the largest component of current expenditure. Member countries may find it useful to collect or otherwise secure labour costs by personnel element ***(e.g.*** researchers, technicians and equivalent staff, other supporting staff, etc.). These extra classifications will be particularly helpful in the construction of cost indices for R&D expenditures.

6.2.2.1.1 Labour costs of postgraduate students engaged in R&D

340. Calculation of the salary element for postgraduate students poses a problem in most countries. Only those postgraduate students who are on universities' payrolls (as research assistants, for instance), and/or in receipt of external funds for R&D (such as research scholarships) should be included in the statistics. Very often, the monies they receive are lower than the "market value" of their work. Frequently, such students supplement their low R&D income with monies from non-R&D activities or from personal resources. The measure of R&D labour costs should, at least in theory, include these personal funds.

341. There may be a temptation to inflate R&D labour costs to take account of the difference between the "market value" mentioned above and the amounts actually spent in order to derive a "true" value of their R&D activities. This is, however, a questionable approach.

342. Only the actual "salaries"/stipends and similar expenditures associated with postgraduate students should be reported in the R&D statistics and accordingly no inflated values should be derived.

6.2.2.2 Other current costs

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

6.2.2.3 Indirectly paid current costs

344. R&D activities may incur costs that are often not paid by the sector itself but are borne by institutions classified in other sectors of the economy, usually the government sector. Two examples are discussed in the following sections.

6.2.2.3.1 Rents for research facilities

345. In many countries, responsibility for "housing" public institutions (including universities, etc.) is undertaken by a central agency which is most likely to be included in the government sector in R&D surveys and whose accounts would not reflect the functional breakdown between R&D and "other"

activities. This may apply to the administration of ongoing accommodation and temporary arrangements concerning premises and equipment. This is particularly relevant for the higher education sector.

346. In some cases, such facilities are available to institutions free of charge, or are not accounted for in the institutions' books. If a realistic cost of R&D is to be assessed, all fees/rents, etc., associated with R&D should be included in expenditure data. Where the fee or rent is charged to a unit within a sector, this is easily done. If, however, there is no such charge, it might still be desirable, for reasons of international comparability, to include a notional amount which represents an actual payment known to have been made between agencies in different sectors. This might be, for example, an estimated "market value", to be included in "other current costs". Care must be taken to avoid "double-counting" of costs between the suppliers and the recipients of these services.

347. Provided actual payments are made (even if not necessarily revealed by the R&D surveys), an adjustment – to account, for instance, for the estimated market value of the facilities concerned – should be made by the national authorities in their data series. It should be classified as "other current cost" in the receiving sector and should be subtracted, as appropriate, from the accounts of the other donating sectors concerned. If no actual provisions and/or payments exist, no such adjustments should be made.

6.2.2.3.2 Social security costs and pensions for R&D personnel

348. Labour costs of R&D personnel "comprise annual wages and salaries and all associated costs or fringe benefits such as bonus payments, holiday pay, contributions to pension funds and other social security payments, payroll taxes, etc." (para. 338).

349. While there is no ambiguity as to whether pension and other social security payments should be included in R&D cost data, the problem is that identification of such funds is extremely difficult in a sector such as higher education, where R&D is not readily identifiable as a separate area of activity. This problem is compounded by the complexity of national health, social security, retirement, and other systems.

350. Where there is an actual provision for social security and/or pensions for R&D personnel, such amounts should be included in R&D labour costs. These provisions need not necessarily be visible in the bookkeeping accounts of cost to the sector concerned but may often involve transactions within or between sectors. Care should be taken to avoid double-counting of such expenditure.

6.2.2.4 Value Added Tax (VAT)

351. Data on R&D expenditure on both a provider and funder basis should be at factor cost. This means excluding VAT and similar sales taxes from the measured cost of the R&D and specifically of R&D financed by government (for the treatment of subsidies, see Section 6.3.2). Not only will this aid in making valid international comparisons, but it will also assist countries' internal analyses, for example when looking at the opportunity cost of funds devoted to R&D or when deriving ratios using national income and government expenditure statistics, which generally exclude VAT.

352. In the case of the business enterprise sector, this should present very few problems since separate recording of VAT input costs is part of standard accounting procedures and is reclaimable if offset against any VAT charged on outputs. In the case of the government sector, VAT on input costs may generally be reclaimable, and therefore separately identifiable.

353. More difficulties may arise in the higher education and private non-profit sectors where VAT included in goods and services purchased as part of an R&D project may not be reclaimable and will

therefore be regarded by the respondents as a legitimate part of their expenditures. Countries should make every effort to exclude VAT from expenditure figures for these sectors, making an adjustment centrally if necessary. It is recommended, therefore, that the figures returned to the OECD should be exclusive of VAT.

6.2.2.5 Exclusion of depreciation

354. All depreciation provisions for building, plant, and equipment, whether real or imputed, should be excluded from the measurement of intramural expenditures. This approach is proposed for three reasons:

a) If depreciation (an allowance to finance the replacement of existing assets) were included in current expenditures, then the addition of capital expenditures would result in double-counting.

b) The actual sums set aside for depreciation are useless for purposes of international comparison because of differences in tax laws.

c) In the government sector, no provision is normally made for depreciation of fixed assets. Consequently, even within a country, comparisons between sectors cannot be made unless depreciation provisions are excluded, and aggregates for a national series cannot be compiled unless the sector totals are put on a comparable basis.

6.2.3 Capital expenditures

355. Capital expenditures are the annual gross expenditures on fixed assets used in the R&D programmes of statistical units. They should be reported in full for the period when they took place and should not be registered as an element of depreciation (see para. 354).
They are composed of expenditures on:

- land and buildings;
- instruments and equipment.

6.2.3.1 Land and buildings

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

357. The R&D share of the costs for new buildings is often difficult to quantify and many countries ignore this element of R&D expenditure (in the higher education sector), or at best estimate it, based on scheduled use (see Section 6.2.3.4).

358. Purchase of new research equipment is often included in the cost of new buildings, without being separately identifiable. This can result, in some years, in an underestimation of the “instruments and equipment” component in total capital R&D expenditures.

359. Countries should maintain a consistent methodology with regard to these costs.

6.2.3.2 Instruments and equipment

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

6.2.3.3 Conventions for distinguishing between current and capital items

361. In measuring actual capital expenditure, small tools and instruments and minor improvements to existing buildings will normally be excluded, as in most accounting systems these items are usually carried on current expenditure accounts. The boundary between “minor” and “major” items varies slightly among countries according to taxation practices and among different firms and organisations in the same country according to accounting practices. But these differences are rarely significant, and it is neither necessary nor practical to insist on any rigid standard for this purpose. Thus, national conventions will govern allocations to current or to capital expenditures. Nevertheless, in those countries where expenditures on very expensive prototypes *(e.g.* aircraft) or equipment with a limited life *(e.g.* launching rockets) are considered current expenditures, such conventions should always be made explicit.

6.2.3.4 Identifying the R&D content of capital expenditures

362. Occasionally, the R&D term of a fixed asset may be known at the time of acquisition. In this case, only a portion of the cost should be attributed to R&D capital expenditures. Similarly, when a fixed asset will be used for more than one activity and neither the R&D nor the non-R&D activities predominate *(e.g.* computers and associated facilities; laboratories used for R&D, testing, and quality control), the costs should be prorated between R&D and other activities. In the first case, the R&D share could be based on R&D term compared to the expected life of the asset. In the second case, the proportion could be based on numbers of R&D personnel using the facility, compared to total personnel, or on administrative calculations already made *(e.g.* the R&D budget may be charged a certain portion of the capital cost; a certain proportion of time or floor space may be assigned to R&D).

6.2.3.5 Sale of R&D capital goods

363. The sale or transfer of fixed assets originally acquired for R&D creates a problem. The disposal of such assets could be considered as a disinvestment in R&D. However, no adjustment to recorded capital expenditures should be made. The statistical unit’s capital R&D expenditures should not be reduced accordingly, either currently or retrospectively (for the years in which the capital costs were recorded). Current revisions can cause anomalies such as negative intramural R&D expenditures. Retrospective revisions are difficult and confusing.

6.2.3.6 Libraries

364. Another case worthy of attention is that of libraries. Even though payments for the current purchase of books, periodicals, and annuals should be assigned to “other current costs”, expenditure for the purchase of complete libraries, large collections of books, periodicals, specimens, etc., should be included in the data reported to UNESCO under expenditure on major equipment”, especially when made at the time of equipping a new institution (see Section 3.2.1 of UNESCO, 1984c).

365. Each country should adopt the UNESCO approach in reporting data to the OECD. If this is not possible, a consistent methodology should be maintained with regard to the classification of the above costs, thus making it possible to observe changes in the pattern of such expenditure.

6.3 Sources of funds

6.3.1 Methods of measurement

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

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

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

367. The first of these approaches is strongly recommended.

6.3.2 Criteria for identifying flows of R&D funds

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

- there must be a direct transfer of resources;

- this transfer must be both intended and used for the performance of R&D.

6.3.2.1 Direct transfer

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

370. Resources may be transferred in a number of ways, not all of which may be considered direct.

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

372. Two categories of such government funds may be identified:

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

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

373. It is recommended that, if possible, both categories of transfer of government R&D funds be identified in the R&D data of the business enterprise sector. If possible, a similar breakdown should be made for government funds going to the higher education sector.

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

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

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

6.3.2.2 Transfer both intended and used for R&D

377. In many R&D transfers this criterion can be taken for granted. There are instances, however, where its application can clarify the situation (particularly where there is a difference between the performer's and the funder's report):

a) In one case, a unit gives funds to another in return for equipment or services needed for its own R&D. If the provision of this equipment or these services does not require the second unit to carry out R&D, it cannot report that it performed R&D funded by the first unit. For example, a government laboratory buys standard equipment or uses an outside computer to perform calculations required for an R&D project. The equipment supplier or the computer service firm carry out no R&D themselves and would report no R&D funded by the government. These expenditures should be considered by the government laboratory, for R&D statistics, to be intramural capital and intramural other current costs, respectively.

b) In a second case, there are transfers of funds which are loosely described by the source as "development contracts" for "prototypes", but no R&D is performed by the funder and very little by the recipient. For example, the government places a contract with an industrial firm to "develop" a "prototype" civil aircraft for a specific use *(e.g.* treatment of oil slicks). The aircraft is largely constructed by the performer using existing materials and existing technology, and R&D is only needed to meet the new specifications. Only this portion of the contract should be reported by the performer as R&D financed by the government sector, even though the funder's accounts may suggest at first sight that the entire contract was for R&D.

c) In a third case, one unit receives money from another and uses it for R&D although the funds were not paid out for that purpose. For example, a research institute may finance some of its work through receipts from royalties and profits from the sales of goods and services. Although these funds are received from other units and other sectors, they should not be considered as transfers for R&D but as coming from the "retained receipts" of the performing unit itself, as the purchasers of the institute's goods and services did not intend to transfer funds for R&D.

6.3.3 Identifying the sources of flows of R&D funds

378. Performers are usually asked to distribute their intramural expenditures between funds of the performing unit (own funds), funds from other units in the same sector or subsector, and from other sectors and subsectors. They can usually do so relatively easily, but there are one or two problem areas.

6.3.3.1 Influence of the type of the statistical unit

379. The amount of transferred funds reported will be affected by the type of statistical unit on which the data are based. This particularly concerns flows between organisations within the same sector. For instance, government departments may well charge one another for the performance of R&D, but this will usually be considered as intramural to the government sector. Similarly, a business enterprise may, for accounting reasons, charge for the R&D done by one of its establishments for another, but consider the work to be intramural as far as the enterprise is concerned. The decision on where to draw the boundary is an arbitrary one, and the important point again is to comment fully in any published tables.

6.3.3.2 Subcontracting and intermediaries

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

6.3.3.3 Public general university funds (GUF)

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

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

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

c) The general grant they receive from the Ministry of Education or from the corresponding provincial or local authorities in support of their overall research/teaching activities. This case gives rise to a conflict between the principle of tracing the original source and that of using the performer's report and also to some disagreement about how the criterion concerning the intentions of the funder (para. 377) should be applied. In the first approach one argues that, as government is the original source and has intended at least part of the funds concerned to be devoted to R&D, the R&D content of these public general university funds should be credited to government as a source of funds. Using the second approach, one argues that it is within universities that the decisions are taken to commit money to R&D out of a pool which contains both “own funds” as narrowly defined in *b)* and public general university funds; therefore, the sums concerned should be credited to higher education as a source of funds. While no recommendation can be made for national practice, government-financed GUF should be credited to the public sector as a source of funds for the purposes of international comparisons. For clarity, publicly financed GERD is divided into two sub-categories:

– direct government funds;

– GUF.

382. In line with the findings of a study by a group of experts, the following procedures should be adopted:

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

b) monies from the higher education “block grant” should be classified as GUF, and other monies generated by the sector should be considered as “own funds”;

c) adjustments related to “other current costs” to account for real or imputed payments of rents, etc., should be debited to direct government funds.

6.4 Extramural expenditures

383. Data on the extramural R&D expenditures of statistical units are a useful supplement to the information collected on intramural expenditures. These extramural expenditure data are essential for providing statistics on R&D performed abroad but financed by domestic institutions. They may also be helpful to those analysing the flows of funds reported by performers, particularly if there are gaps in the survey coverage.

384. The concept of “techno-globalism” is a rapidly evolving one in the context of the increasingly world-wide organisation of R&D. As the focus of R&D data is necessarily on the individual country, it is very difficult to track international flows of R&D funds. In the future, more use should be made of analysis of extramural R&D funds to address this problem. The internationalisation of R&D activities mainly affects the business enterprise sector, and it is therefore recommended that analysis of business enterprise extramural R&D expenditure be done according to the institutional subclassification described in the sector “Abroad” (paras. 217-219), with the following subclassification system:

– subsidiary or associated company;

– joint ventures;

– other business enterprise company located abroad;

– foreign government;

– EC;

– international organisations;

– other.

6.5 National totals

6.5.1 Gross domestic expenditure on R&D (GERD)

385.

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

386. It includes R&D performed within a country and funded from abroad but excludes payments made abroad for R&D. GERD is constructed by adding together the intramural expenditures of the four performing sectors. It is often displayed as a matrix of performing and funding sectors (see Table 6.1). The GERD and GERD matrix are fundamental to the international comparison of R&D expenditures. They also provide the accounting system within which the institutional classifications and functional distributions may be applied.

387. It would be useful to have separate tables for defence and civil GERD, in order to map how treads in these areas affect the level and structure of total GERD. This is particularly true for those countries with significant defence R&D programmes.

6.5.2 Gross national expenditure on R&D (GNERD)

388. The GNERD is an optional supplementary aggregate which comprises total expenditure on R&D financed by institutions of a country during a given period. It includes R&D performed abroad but financed by national institutions or residents; it excludes R&D performed within a country but funded from abroad. It is constructed by adding the domestically financed intramural expenditures of each performing sector and the R&D performed abroad but financed by domestic funding sectors (see Table 6.2).

Table 6.1. **Gross domestic expenditure on R&D (GERD)**

Funding sector	Business enterprise	Private non-profit	Government	Higher education	Total
Business enterprise					Total financed by the business enterprise sector
Private non-profit					Total financed by the PNP sector
Government					Total financed by the government sector
Public GUF					Total financed by public GUF
Higher education					Total financed by the higher education sector
Abroad - Foreign enterprises • subsidiaries or associated • joint venture • other - Foreign government - European Union - International organisations - Other					Total financed by abroad
Total	Total performed in the business enterprise sector	Total performed in the PNP sector	Total performed in the government sector	Total performed in the higher education sector	GERD

Table 6.2. **Gross national expenditure on R&D (GNERD)**

Funding Sector	Sector of performance									Total
	National territory				Abroad					
					Business enterprise					
	Business enterprise	Private non-profit	Government	Higher education	Subsidiaries	Joint ventures	EU	International organisations	Other	
Business enterprise										Total financed by the business enterprise sector
Private non-profit										Total financed by the PNP sector
Government										Total financed by the government sector
Public GUF										Total financed by Public GUF
Higher education										Total financed by the higher education sector
Total	Total nationally financed performed in the business enterprise sector	Total nationally financed performed in the PNP sector	Total nationally financed performed n the government sector	Total nationally financed in the higher education sector	Nationally financed performed abroad					GNERD

389. To allow the identification of R&D activities of international organisations, the “Abroad” sector should have as a subcategory “International Organisations” as recommended in the institutional subclassification (see Section 3.8.3).

CHAPTER7

SURVEY PROCEDURES

7.1 Surveys and estimates

390. Although the preparation of statistics on R&D will require both survey data and estimations, there is no satisfactory substitute for a special survey. While a certain amount of information about recent trends in R&D resources can be obtained from published materials, such as annual reports of science councils or major R&D performing institutions, these data can give only an approximate measure of R&D efforts. Not only will the concepts of R&D used by various organisations often differ from the definition given in this Manual, they may also change over time. It is also extremely difficult to secure all data for the same time period and to avoid double-counting when tracking down flows of funds from financial statements. However, for various reasons (such as the lack of satisfactory records, the cost of statistical surveys, and the need to restrict statistical demands on respondents), surveys cannot always provide all the information required.

391. Estimates are a necessary supplement to surveys (respondents are often required to make estimates in order to provide the requested "survey" information). Based on relationships derived from survey data, incomplete information may be used to provide adequate aggregate trends or totals without requiring a costly survey. Indeed, the R&D inputs of one major sector, higher education, are very often partially or wholly estimated. In all cases, when statistics are released, full information on the sources and generation of the statistics should be provided.

7.2 Core and marginal R&D resources

392. R&D has two elements: R&D carried out in formal R&D departments and R&D of an informal nature carried out in units for which it is not the main activity. In theory, surveys should identify and measure all financial and personnel resources devoted to all R&D activities. It is recognised that in practice it may not be possible to survey all R&D activities and that it may be necessary to make a distinction between "significant" R&D activities which are surveyed regularly and "marginal" ones which are too small and/or dispersed to be included in R&D surveys.

393.

> It is recommended that significant R&D should include all units where at least one full-time equivalent (FTE) is worked on R&D per year.

394. This is mainly a problem in the business enterprise sector where it may be difficult and costly to break out all the *ad hoc* R&D of small companies. It may also be a problem in other sectors, *e.g.* local government or teaching establishments at ISCED level 5.

395. Efforts should be made via other sources *(e.g.* innovation surveys) to establish estimates for units with even smaller R&D efforts. However, such small amounts of R&D should only be included if the R&D is undertaken on a basis consistent with the definition of R&D in paragraph 57.

7.3 Questions for inclusion in surveys

396. At a minimum, questions included in surveys should make it possible to transmit a fully completed OECD international R&D survey questionnaire to the OECD. There are also, however, other areas of interest which surveying agencies may wish to cover. The Oslo Manual on innovation statistics (OECD, 1992b) outlines in detail some R&D-specific questions which may be included in innovation surveys if they are not covered in national R&D surveys. There are also some other topics included in the Oslo Manual which may be of interest to those carrying out R&D surveys, but which are not dealt with in this Manual, *e.g.* objectives of innovation, factors assisting or hampering innovation, and the impact of innovation. Such topics are equally appropriate for R&D surveys should the authorities wish to include them. These questions are especially relevant to the business enterprise sector, and readers are directed to the Oslo Manual (OECD, 1992b) for their detailed specifications.

7.4 Identifying survey respondents

397. The identification and selection of survey respondents will depend on the institutions, the statistical framework, and the relevant statutes of Member countries. Only in a few Member countries is it possible for the surveying agency to make an exhaustive survey of R&D performers and funders. Generally, the extent of the survey is limited by many constraints. For example, the number of respondents may have to be restricted to keep costs down; an R&D survey may have to be taken in conjunction with another survey with acceptable but not ideal respondents; surveys of some groups may require the participation of other agencies with different data needs and hence different questions for respondents.

398. It is not possible to make detailed recommendations on survey methods that would be relevant to all Member countries, as the size and structure of national R&D capacities vary widely. The following suggestions are made for the four sectors identified in Chapter 3, although it is recognised that some countries use a different system of sectoring for surveying and for reporting the data. Thus, some countries undertake three surveys of firms, institutes, and higher education teaching establishments and then redistribute the institutes between the four standard sectors of performance.

7.4.1 Business enterprise sector

399. There are at least two feasible approaches for establishing the survey population of the business enterprise sector. One is to survey a sample drawn from the entire sector, choosing the sample on the basis of the company data available, such as employees and sales, by industry and region. The other is to try to survey only firms supporting R&D. In this case, more information is required to select the firms, and several Member countries obtain this information by making an exhaustive "postcard survey" at regular intervals (say five years) in order to identify the maximum number of potential R&D performers or funders who can then be contacted for a full survey.

400. Sources of useful information include lists of firms receiving governments grants and contracts for R&D, lists of firms reporting R&D activities in innovation surveys, directories of R&D laboratories, members of industrial research associations, employers of very highly qualified personnel, and lists of firms claiming tax deductions for R&D.

7.4.2 Government sector

401. Identifying those federal or central government units who are likely to be performing or funding R&D in the natural sciences and engineering (NSE) is usually relatively easy, but the task may be more

difficult in the case of provincial or local government agencies, and/or in the case of the social sciences (typically, respondents will not be active in both the NSE and the social sciences and humanities – SSH). In general, in this sector, potential respondents either have concentrations of scientists and engineers with higher degrees or have a mandate for the financial support of R&D in other sectors.

7.4.3 Private non-profit sector

402. There are typically relatively few institutions in the private non-profit sector that perform or fund R&D. However, in many countries this sector is also statistically undercovered, especially where PNP institutes are dealt with separately rather than within a wider "institute sector" survey. If an adequate list is not available from other sources *(e.g.* directories, income tax exemption lists), it can probably be compiled by asking a number of researchers and research administrators in other sectors to identify private nonprofit institutions known to support R&D.

7.4.4 Higher education sector

403. Institutions are readily identified in the higher education sector since there is already a considerable amount of information published by universities, ministries of education. etc. The problem of identification arises if the statistical unit chosen is a component of a university: the smaller the unit or the more there are in an institution, the greater the problem of identification. It is often desirable, when components of a university are surveyed, to have the central administration co-ordinate the response. In this way, some omissions may be detected. The university may also effectively do the first-stage editing of returns and may also, as first-stage collector, improve response rates.

7.5 Working with correspondents

7.5.1 Encouraging co-operation

404. In many cases, R&D performers are also users of R&D statistics. They should, therefore, appreciate the need to co-operate fully with a survey agency. Unfortunately, the respondent actually supplying the data to the surveying agency may have little or no interest in the final statistics and in the case of larger institutions, the reporting unit *(i.e.* the R&D performer) may even have little control over the data supplied. In some institutions, such as government departments or universities, it may be possible to survey through liaison officers from user units. The institution itself thereby seems to be requiring the data: at least there is some tacit approval of the survey. Alternatively, if initial contacts are at a sufficiently high level or are centralised, user and respondent units may be brought together. The survey agency must be able to demonstrate the usefulness of the data to respondents and should attempt to ensure that the resulting statistics are made available to respondents.

405. In other cases respondents have no use for the statistics derived from their data. It may occasionally be possible to work with or through trade associations or other groups with which these respondents are professionally associated. Besides better response, such co-operation may result in surveys tailored to the interests of these groups and in questionnaires designed to use the normal records and concepts of the groups. However, such tailoring must not result in data incompatible with those collected elsewhere.

406. In all cases a good questionnaire is essential: a minimum of clear and logical questions with the best possible definitions, examples, and layout. It is highly recommended to test draft questionnaires on a sample of respondents.

407. The extent to which follow-up procedures are used will depend on the level and quality of response, the number of units surveyed, and the resources available to the surveying authority. It is rarely feasible to make personal contact with all the units surveyed. One possibility is to plan a follow-up programme for each enquiry, aiming to visit all the main units over a given period. Another is to limit the follow-up and to check a few organisations very thoroughly. This does not, of course, preclude making personal contact with respondents who require guidance or who submit unsatisfactory returns.

408. Almost all respondents will have to make some estimates. Not only is the activity of R&D complex in itself but it is inextricably linked to a number of other activities. Furthermore, an institution's R&D may not be satisfactorily reflected either in its organisation or in its records and accounts.

409. R&D is not just what R&D laboratories and research institutes do. It is both less and more than this, since very few of the surveyed institutions have only one activity. The measurement of R&D inputs may be carried out in three stages:

- identification of all specialised R&D units and the measurement of their total activity;
- estimation of the non-R&D portions of their activity and subtraction of these estimates from the totals;
- estimation of the inputs used for R&D in other units and addition of these estimates to the totals.

410. In practice, minor deviations from the strict R&D definition may be overlooked in order to better utilise existing records or to otherwise ease the burden on respondents. In some cases, particularly in the higher education sector, it may be necessary to resort to very crude ratios to estimate R&D inputs.

7.5.3 Operational criteria

411. Operational criteria must be developed which are suitable for the sector being surveyed. Thus, on questionnaires intended for the business enterprise sector it would be appropriate to give guidance for distinguishing between R&D and preproduction, but a government questionnaire might concentrate on the difference between R&D and data collection and information. Government units may need criteria for distinguishing between contracts to industry for goods and services required for intramural R&D and those awarded for industrial R&D. Criteria with the same intent but different wording may be useful in the business enterprise surveys. Nor should differences within a sector be overlooked. For example, operational definitions and examples appropriate for the oil and gas industry are probably not really suitable for the electrical products industry. In discussion with respondents, general supplementary criteria are often useful. Examples are given in Table 7.1.

412. During R&D surveys respondents may have great practical difficulties in applying the theoretical distinctions made in earlier chapters to the wide range of projects in progress in their organisation. As surveying agencies are not always in a position to check the responses they receive and are usually obliged to accept them as given, it is of utmost importance that they provide the institutions surveyed with very clear explanations and guidance to complement the formal definitions in order to ensure uniformity.

Table 7.1. Supplementary criteria for separating R&D from related scientific, technological and industrial activities

1.	A. What are the objectives of the project?
2.	B. What is new or innovative about this project?
3.	• Is it seeking previously undiscovered phenomena, structures or relationships?
4.	• Does it apply knowledge or techniques in a new way?
5.	• Is there a significant chance that it will result in new (extended or deeper) understanding of, phenomena, relationships or manipulative principles of interest to more than one organisation?
6.	• Are the results expected to be patentable?
7.	C. What staff are working on the project?
8.	D. What methods are being used?
9.	E. Under what programme is the project being funded?
10.	F. How general are the findings or results of the project likely to be?
11.	G. Does the project fall more naturally into one of the other scientific, technological or industrial activities?

413. There are four important tools available to achieve this objective:

a) explanatory notes;

b) hypothetical examples;

c) guidance to individual respondents;

d) documentation on treatment of different cases.

For obvious reasons, this Manual deals exclusively with *a)* and *b).* However, formal definitions and theoretical distinctions have to be complemented with information of types *c)* and *d).* In order to secure consistency in the guidance given by surveying agencies, it is essential to develop documentation on how difficult borderline cases have been solved. This documentation can also serve as a valuable source of examples for *b)* and could help countries to develop more uniform classification practices.

7.6 The surveying agency

7.6.1 Responsibilities to respondents

414. Respondents are asked to spend time on a task which, in many cases, is of no direct benefit to them; they may even see completing a questionnaire on R&D as a waste of time and money. The surveying agency has the responsibility to help contributors to appreciate the potential uses of the data and to be alert to respondents' possible requirements for R&D statistics. It has the further responsibility to respect confidential data and ensure that users are aware of respondents' concerns. In the design of surveys, it should also consider the need to minimise the burden on respondents.

7.6.2 Editing procedures

415. Besides the normal editing of questionnaires based on historical and arithmetic checks, the surveying agency must often edit for transaction consistency. The reports on a transaction made by the financing organisation and the performer are likely to differ because of different reference periods, bookkeeping practices, methods of estimation, and interpretations of concepts. A government agency may report funding action during its fiscal year while a firm under contract may report funds spent during a

similar but not identical 12-month period. The financing organisation may consider the whole of the contract to be experimental development whereas the performer correctly reports only that portion of the work which involves novelty.

416. There are thus sources of errors on both sides, but, as a rule, the performer is in a much better position to make the estimates and adjustments. There are other practical reasons for relying primarily on performers' reports of the sources of funds for intramural expenditures rather than on funders' reports of extramural expenditure. Insofar as they finance some R&D with their own funds, performers must be surveyed anyway. The intramural expenditures may be linked to the R&D personnel for the same institutions. The risk of double-counting is minimised since a given sum of R&D money cannot be spent by more than one performer at a time. In addition, foreign sources of funds cannot be surveyed.

7.6.3 Estimations

7.6.3.1 Non-respondents

417. Generally, the surveying agency will have to estimate for important non-respondents using past returns, the reports of others who have transactions with them for R&D, or the reports of comparable institutions. Here, extramural expenditure data may be useful: for example, a performer's records may not permit R&D contracts to be readily identified or a recipient of substantial R&D funding may not participate in the survey. Sometimes, subsectors, or even whole sectors, may have to be estimated to create the national totals for selected years. Extrapolation from benchmark surveys, using some related series as a trend indicator, is a common way of making such estimates. Given the subjective nature of even the most conscientiously reported data, surveying agencies should not hesitate to make estimates to supplement survey data. The models or methods used to make estimates should, however, always be given with the results of the survey.

7.6.3.2 The higher education sector

418. The higher education sector generally requires large-scale estimations. The distinction between R&D, teaching, and other activities is not always obvious in theory (see Section 2.3.2) let alone in practice, especially in the case of postgraduate studies (see Section 2.3.2.2). It is an expensive and complex matter to undertake a full survey of R&D activities in this sector and may only be possible at rather long intervals. In order to prevent this vital sector from being omitted in the intermediary years it is often necessary for the survey agency to make estimates based on ratios derived from time-budget studies or other sources.

419. An additional complication arises from the fact that only some university R&D projects are financed by contracts, grants, or other earmarked funds. Others are supported, normally without any administrative record, by public general university funds (GUF) (e.g. the cost of the unsponsored research carried out by a faculty member might involve a portion of the teacher's salary, the cost of supplies used, computer costs, library and general university overheads). The total cost of R&D could be estimated using personnel ratios and various types of university expenditure data. The difference between this estimate and sponsored R&D funds is the contribution of general university funds. For some purposes it may be sufficient to consider these as the universities' own funds, the residual costs of R&D being considered as paid by the higher education sector. For the purposes of international comparison, it is desirable to show the original source of funds from the general university budget used to support R&D, particularly in the case of public GUF. In this case, the original sources of the general university funds must be prorated and the ratios applied to the residual R&D cost estimates.

7.6.4 Reporting to the OECD and to other international agencies

420. Authorities carry out R&D surveys to obtain data relevant to national concerns, which are collected within the framework of national institutional arrangements. Discrepancies between national practices and international norms in this or other manuals are inevitable. Nevertheless, every effort to reduce the impact of such discrepancies should be made when reporting these data to the OECD or to other international organisations, by making adjustments or estimates even if this means that R&D data in international sources will differ from those in national documents. If national authorities are unwilling to make such adjustments on their own responsibility, they might aid the relevant secretariats to make informed estimates. Where such adjustments cannot be made, full technical notes should be submitted to the international organisation concerned. Discrepancies are generally of two kinds:

a) explicit differences in approach between national R&D surveys and that recommended in this Manual;

b) “implicit” differences between the standard national economic or educational classifications used in countries’ surveys and the corresponding international classifications recommended in this Manual.

It is important to identify and report both kinds of discrepancy.

421. Furthermore, it should be recognised that some classifications recommended in this Manual are not designed to give data that are interesting in their own right at national level or even at international level but rather to yield information that throws light on the international comparability of data (notably, the classifications by type of institution in Chapter 3) or is useful for making further calculations (*e.g.* type-of-cost data are necessary for calculating R&D deflators, see Annex 8). These results are very valuable to the Secretariat even though they may be of little immediate interest to national authorities.

CHAPTER 8

GOVERNMENT BUDGET APPROPRIATIONS OR OUTLAYS FOR R&D BY SOCIO-ECONOMIC OBJECTIVES

8.1 Introduction

422. There are two ways of measuring how much governments spend on R&D. The first and most accurate is to hold surveys of the units which actually carry out R&D (firms, institutes, universities, etc.) in order to identify the amount actually spent on R&D over the previous year and the share which was financed by government. The sum of the R&D spending in a national territory (see Table 6.1) is known as "government-financed gross domestic expenditure on R&D (GERD)".

423. Unfortunately, owing to the time it takes to carry out such surveys and process their results, such "government-financed GERD" data do not become available until several years after the R&D has been carried out. Furthermore, the R&D performing units responding to the surveys are sometimes unable to report on where their particular grant or contract fits into the government's overall S&T policy.

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

425. In the previous edition of the Manual, the budget-based series were described as "public R&D funding" in order to distinguish them from the "government-financed GERD" data drawn from retrospective surveys. However, it became evident that readers continued to confuse the two series, and the budget-based data are now officially referred to as "government budget appropriations or outlays for R&D" (GBAORD). The use of the term "budgetary appropriations for R&D" in this Manual is intended to be a general term to describe government allocations to R&D and should not be interpreted as a direct reference to any national government's budgetary practice.

8.2 Relationship with other international standards

426. As far as possible the definitions and distributions discussed in this Chapter are compatible with the methodologies developed by the Eurostat in their NABS system (Eurostat, 1975; Eurostat, 1986; Eurostat, forthcoming) and by NORDFORSK Nordic Industrial Fund (NORDFORSK, 1975).

8.3 Sources of data on the socio-economic objectives of GBAORD

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

8.4 Coverage of R&D

8.4.1 Basic definition

428. The basic definition is the one given at the beginning of Chapter 2 (see Section 2.1). Basic research, applied research, and experimental development are all included but are not identified separately.

8.4.2 Fields of science and technology

429.

The analysis covers NSE and SSH without making any distinction between the two.

8.4.3 Identifying R&D

430. As far as possible all the guidelines and conventions for distinguishing R&D from non-R&D activities listed in Chapter 2 should be applied. Particular care should be taken to check the real R&D content of budget items officially described as "development contracts" or as "purchase of prototypes" as discussed in Chapters 2 and 6 (see Section 2.3.4, Section 6.3.2 and Annex 12).

8.5 Definition of government

431. According to Chapter 3, "government" should cover central (or federal), provincial (or state) and local government (see Section 3.5). For the purposes of GBAORD, however, it is recommended that:

a) central or federal government should always be included;

b) provincial or state government should be included where its contribution is significant;

c) local government funds *(i.e.* those raised by local taxes) should be excluded.

8.6 Coverage of government budget appropriations and outlays

8.6.1 Intramural and extramural expenditures

432.

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

8.6.2 Funding and performer-based reporting

433. R&D expenditures can be reported either by the agency that provided the money (funding) or the agency that actually performs the R&D. In general, the Manual recommends the second approach, which is

used in the standard tables in the OECD surveys. However, the first approach is preferred for the GBAORD series.

434.

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

8.6.3 Budgetary and extra-budgetary funds

435.

GBAORD clearly includes all outlays to be met from taxation.

436. A problem arises with money spent on R&D by government but financed from other sources. In some countries this may be included in the government budget, on the grounds that the agency concerned needs government permission to spend it (gross approach). In others it may be excluded and only newly voted money included (net approach). When dealing with these "extra-budgetary" sources, a distinction should be made between:

– contracts or grants from other sectors for the performance of R&D by government establishments;

– other extra-budgetary funds such as the retained receipts of government laboratories, receipts from levies, etc.

8.6.3.1 Receipts for R&D performed for other sectors

437.

Such payment should always be credited to the sector of origin and should not be included in GBAORD.

8.6.3.2 Other extra-budgetary funds

438. No guidelines can be suggested, but their treatment should always be made explicit in accompanying notes.

8.6.4 Direct and indirect funding

8.6.4.1 Treatment of public general university funds (GUF)

439. It is a matter of discussion whether or not such funds should be credited to government as a source of funds in standard R&D surveys. Nevertheless,

GBAORD includes public general university funds (GUF)

8.6.4.2 Loans and indirect funding of industrial R&D

440. As far as possible, the instructions in Chapter 6 regarding both loans and indirect funding apply (see Section 6.3.2.1). Thus, loans that may be forgiven should be included in GBAORD, but loans that are to be repaid and indirect support of industrial R&D via tax rebates, etc., should in principle be excluded. Nevertheless, when such indirect support programmes are undertaken as part of an integrated R&D policy (for example, when the sources are documented and are included in interministerial discussions of a science budget), they may be included in GBAORD. However, indirect funding should always be declared separately so that it can be excluded when making certain international comparisons.

8.6.5 Type of expenditures

8.6.5.1 General coverage

441.

GBAORD includes both current and capital expenditure.

8.6.5.2 Money carried forward

442. In some countries it is budgetary practice to carry forward large sums from one year to another, sometimes including them in sums voted in successive years.

443.

Data should be reported for a single year and any double-counting for money carried forward should be excluded.

8.6.6 Stages of government R&D appropriations and outlays

444. A number of efforts have been made to establish exhaustive typologies of all the stages of GBAORD, from projections through to final outlays. In practice, however, the point at which it is both meaningful and practical to measure GBAORD varies from one country to another.

445. For this reason no detailed recommendations can be made for OECD surveys. Nevertheless, it is suggested that:

- Data for the current and coming years should be based on initial intentions, *i.e.* the data should reflect the amount the government intends to devote to R&D. Such data become obsolete once the year is completed and are therefore not generally suitable for stocking in time series.
- Data for past years should be based on final measures of GBAORD ranging from final intentions as reflected in the definitive budget to final outlays. National authorities should choose a measure that can be meaningfully stocked as a time series.

8.7 Distribution by socio-economic objectives

8.7.1 The criteria for distribution

8.7.1.1 Purpose or content

446. Two approaches to distribution are possible:

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

447. The difference between the two is illustrated by the following example:

- A research project on the effects of various chemicals, which could be used as weapons, on human body functions. The purpose is "defence" but the general content is "human health".

- A research project to develop fuel cells to provide power in remote forest locations, financed by the Ministry of Agriculture. The purpose is "agriculture, forestry and fishing" but the R&D content is "energy".

Other examples will be found under the objective "Promotion of industrial development" (see Section 8.7.4.2).

448.

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

8.7.1.2 Primary and secondary objectives

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

8.7.1.3 Identifying primary objectives

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

> *c)* Direct derivation: A project which owes its existence solely to the technical needs of another programme is directly derived from the said programme and should be classified with it.
>
> *d)* Indirect spin-off: Where the results of R&D undertaken for one purpose are subsequently reworked to give an application relevant to another objective, this is indirect spin-off and should be credited to the objective to which the subsequent R&D is oriented.

8.7.2 The unit distributed (statistical unit)

451. The allocation of R&D appropriations or outlays to socio-economic objectives should be made at the level that permits the most accurate reflection of the funder's purposes. The actual reporting level chosen (and thus the statistical unit distributed) will depend on the practical possibilities of a particular situation and on the method of planning, organising and executing research programmes.

8.7.3 The distribution

8.7.3.1 Introduction

452. The distribution list consists of 11 categories of objectives which have been drawn up primarily for use in the analysis of GBAORD. In general, they are broad categories into which all Member countries can fit their budget R&D categories, and, with three exceptions, there are no subcategories. The list is evolutionary in that it will change over time to reflect changes in the concerns of governments. The descriptive text for each category of objectives is indicative rather than complete. In order to assist the Secretariat's analytical work and to make it possible to provide more complete listings of the scope of the individual objectives, Member countries should report their objectives by major subcategories, especially those relevant to policy.

453. This distribution scheme draws heavily on the lists of NORDFORSK (Nordic Industrial Fund) and the European Communities (EC) (Tables 8.1 and 8.2 give keys between their lists and the OECD categories). In general, it reflects the overall purposes for which funds have been committed to R&D programmes rather than the fields of science involved.

8.7.4 The list of socio-economic objectives

8.7.4.1 Development of agriculture, forestry and fishing

454. This group covers all R&D primarily intended to develop and support these activities [ISIC Rev. 3, Division 1, 2, *5* (UN, 1990)], including, for example, relevant work on chemicals and mechanisation. It excludes R&D for the food processing and packaging industries which should be included in the objective described in Section 8.7.4.2 below.

8.7.4.2 Promotion of industrial development

455. This group includes R&D programmes whose primary objective is to support the development of industry. The core of this class will consist of R&D programmes in favour of manufacturing industry (ISIC Rev. 3, Divisions 15-37). However, it also contains R&D for the construction industry (ISIC Rev. 3, Division 45); wholesale and retail trade, restaurants, and hotels (ISIC Rev. 3, Divisions 50-52 and 55); banking, insurance, and other commercial services (ISIC Rev. 3, Divisions 65-67 and 70-74); or industry in general. It does not include R&D performed by industry (principally financed from public funds) in support of other objectives – for example in the fields of space, defence, transportation and telecommunications – although these obviously have an important secondary effect on the development of the industries concerned. If R&D is supported for a communal project, it should be excluded from this class and included under the relevant objective. For example, the development of a new type of rolling stock as part of a reorganisation of the nation's railways should be classified under "transport".

Redevelopment of similar rolling stock in view of export sales belongs under the present heading. Similarly, R&D in support of tourism as a cultural activity should be included under the objective described in Section 8.7.4.7, but R&D mainly intended to improve the commercial prospects of the hotel and tourism industry should be included here (see also Section 8.7.5).

Table 8.1. Standard key between OECD and EU (NABS 1993) GBAORD objectives

OECD categories	NABS categories
1. Development of agriculture, forestry and fishing	6. Agricultural production and technology
2. Promotion of industrial development technology	7. Industrial production and technology
3. Production and rational use of energy	5. Production, distribution and rational utilisation of industry
4. Development of the infrastructure	2. Infrastructure and general planning of land use
4.1 Transport and telecommunications	*2.4 Transport systems* *2.5 Telecommunication systems*
4.2 Urban and rural planning	*2. n.e.c. = general infrastructure and land planning research, construction and planning of buildings, water supplies, infrastructure R&D n.e.c.*
5. Control and care of the environment	
5.1 The prevention of pollution	*(Included in objective concerned)*
5.2 Identification and treatment of pollution	3*. Control of environmental pollution*
6.Health (excluding pollution)	4. Protection and improvement of human health
7. Social development and services	8. Social structures and relationships
8. Exploration and exploitation of Earth and atmosphere	1. Exploration and exploitation of the Earth
9.	General advancement of knowledge
9.1 Advancement of research	*11. Non-oriented research*
9.2 General university funds	*10. Research financed from general university funds*
10. Civil space	9. Exploration and exploitation of space
11. Defence	13. Defence
12. Not specified	12. Other civil research

Source: EUROSTAT (1993), *Research and Development: Annual Statistics 1993*.

8.7.4.3 Production and rational use of energy

456. This section covers all R&D activities aimed at the supply, production, conservation, and distribution of all forms of energy, except R&D on means of propulsion for vehicles and rockets. R&D on water as a source of energy should be included. R&D on nuclear energy should be included but reported separately. Those countries where all nuclear R&D is funded through an integrated national programme which cannot be subdivided should report the total sum giving as many details as possible on the non-energy R&D projects included (see also Section 8.7.5.4).

Table 8.2. Standard key between OECD and NORDFORSK GBAORD objectives

OECD categories	NORDFORSK categories
1. Development of agriculture, forestry an Fishing	1. Agriculture, forestry and fishery
2. Promotion of industrial development and technology	2. Mining, trade and industry, Building and capital investments services
3. Production and rational use of energy	3. Production and distribution of energy
4. Development of the infrastructure	
4.1 Transport and telecommunications	*4. Transport and telecommunications*
4.2 Urban and rural planning	*5. Living conditions and physical planning*
5. Control and care of the environment	6. Combatting pollution and protecting nature
5.1 The prevention of pollution	*(Included mainly in objective concerned)*
5.2 Identification and treatment of pollution	*6. Combatting pollution, etc.*
6. Health (excluding pollution)	7. Preventing and combatting disease
7. Social development and services	8. Social conditions
	9. Culture, mass media and leisure
	10. Education

	11. Working conditions
	12. Economic planning and public administration
8. Exploration and exploitation of the Earth and atmosphere	13. Exploration and exploitation of the Earth and atmosphere
9. General advancement of knowledge	14. General advancement of science
9. 1 Advancement of research	***Not separately specified***
9. 2 General university funds	***Not separately specified***
10. Civil space	15. Space research
11. Defence	16. Defence

Source: NORDFORSK (1976*), Statlige udgifter til forskning og udviklings – arbejde i de nordiske land 1975. En budgetanalyse.*

8.7.4.4 Development of the infrastructure

457. This group is made of two subcategories:

8.7.4.4.1 Transport and telecommunications

458. This includes:

- R&D directed towards better and safer transportation systems, including traffic safety (except when an integral part of urban and rural planning);

- R&D on all telecommunication services (except satellites), as well as R&D on the planning and organisation of networks.

8.7.4.4.2. Urban and rural planning

459. This includes R&D referring to the total planning of urban and rural areas, better housing, and improvements to the community environment *(e.g.* siting of hospitals, sound insulation, etc.). The intention here is the integrated planning that attempts to co-ordinate various elements and create a "total environment".

8.7.4.5 Control and care of the environment

460. This group covers R&D directed towards an "undestroyed" physical environment. It covers pollution in or due to: air, water, soil and substrata, noise, solid waste disposal, and radiation.

461. It has two components, the prevention of pollution and the identification and treatment of pollution.

8.7.4.5.1 The prevention of pollution

462. This concerns R&D designed to prevent pollution in those activities that might cause it.

8.7.4.5.2 Identification and treatment of pollution

463. This concerns R&D on the causes, diffusion, and remediation of pollution and its effects on people and the environment.

8.7.4.6 Health (excluding pollution)

464. This category covers R&D programmes directed towards the protection and improvement of human health. It includes R&D on food hygiene and nutrition; radiation used for medical purposes; biochemical engineering; medical information; rationalisation of treatment and pharmacology (including the testing of medicines and the breeding of laboratory animals for scientific purposes); as well as research relating to epidemiology, prevention of industrial diseases, and drug addiction.

8.7.4.7 Social development and services

465. R&D related to social and cultural problems includes, for example, social security, social services, social relations, culture, recreation and leisure, law and order, consumer protection, working conditions, labour relations, personnel development, public administration, national economy, peace, and other international objectives. This group should be subclassified in as much detail as possible using whatever classification respondents think relevant.

8.7.4.8 Exploration and exploitation of the Earth and atmosphere

466. This heading covers exploration and exploitation of the Earth's crust and mantle, seas, oceans, and atmosphere. It does not include the study of pollution, the study of soils for agricultural purposes, or fishing. It includes R&D on meteorology (except when conducted by satellite).

8.7.4.9 General advancement of knowledge

467. This group covers all R&D which contributes to the general advancement of knowledge and cannot be attributed to a specific objective. It has two components, advancement of research and general university funds (GUF).

8.7.4.9.1 Advancement of research

468. This covers all those appropriations or outlays which are earmarked for R&D but which cannot be attributed to an objective. A supplementary breakdown by field of science may be useful.

8.7.4.9.2 General university funds (GUF)

469. When reporting GBAORD by "purpose", this class should include, by convention, all R&D financed from general purpose grants from ministries of education, although in some countries many of these programmes may be relevant to other objectives. This convention has been adopted because of the problems of obtaining suitable data and thus of comparability. Member countries should provide the most detailed breakdown possible of the "contents" of this class by field of science and technology and, where they are able to do so, by objectives.

8.7.4.10 Civil space

470. This class covers all civil R&D concerning space (also see Section *8.7.3.5.1).*

8.7.4.11 Defence

471. Defence includes all R&D programmes undertaken primarily for defence reasons regardless of their content or whether they have secondary civil applications. It includes nuclear and space R&D undertaken for defence purposes. It does not include civil R&D financed by ministries of defence, for instance on meteorology or telecommunications.

8.7.5 Principal areas of difficulty

472. The OECD distribution as it stands is, broadly speaking, an amalgam of the EC NABS (Eurostat, 1975; Eurostat, 1986) and the NORDFORSK (Nordic Industrial Fund) (NORDFORSK, 1975) classifications. As such it does not have a truly logical structure. Furthermore, the results of the many OECD surveys for which it has been used have shown that it contains some overlapping and one or two gaps. Also, some objectives are not relevant in a number of Member countries.

8.7.5.1 Civil space

473. Civil space R&D is not a purpose in its own right for most OECD countries, as such R&D is usually undertaken for another purpose, such as advancement of knowledge (astronomy) or for specified applications *(e.g.* telecommunication satellites). Nevertheless, it has been maintained in the list for the time being as it cannot be deleted without greatly altering the distribution amongst the other objectives to which it would be reallocated for the few OECD countries that do have major space programmes.

8.7.5.2 Mining

474. A specific problem occurs with the treatment of mining and prospecting. The current OECD distribution list does not include any mention of mining or prospecting. Both NORDFORSK and NABS agree that R&D related to prospecting should be included in “Exploration and Exploitation of Earth and Atmosphere”. However, they part company on mining. According to the NORDFORSK classification, all R&D in favour of the mining industry should be included in “Industrial Development” whereas according to NABS, fuel mining and extraction belong in “Energy” but mining of non-energy minerals belongs in “Industrial Development”. When reporting to the OECD, “independent” Member countries *(i.e.* those who do not use either NORDFORSK or NABS) have tended to include most or all mining R&D in “Exploration and Exploitation of Earth and Atmosphere”. Until such time as full agreement can be reached on this point, it is most important that the treatment of mining R&D should be mentioned specifically.

8.7.5.3 Construction

475. A further difference occurs with respect to construction. Logically, if one is applying main purpose analysis with the aid of the “derivation” convention (see Section 8.7.1.3), then construction R&D programmes should be broken down according to their main aim (missile silos in “Defence”, hospitals in “Health”, agricultural buildings in “Agriculture”, etc., and R&D in favour of the building industry in “Industrial Development”). This would leave a residual problem of where to classify construction R&D not

elsewhere classified (n.e.c.) However, NABS has chosen a different approach and stated that construction R&D should not be considered as derived except in the case of "defence" and "space" programmes. According to NABS, R&D on construction materials belongs in "Industrial Development", but general construction R&D is included in "Urban and Rural Planning" whereas according to NORDFORSK, construction R&D is included in "Industrial Development". The treatment of construction R&D also appears to vary in the "independent" countries. Here again, it is most important that the approach used should be specified.

8.7.5.4 Production and rational use of energy

476. The series and data collected and issued by the OECD Directorate for Science, Technology and Industry for GBAORD for the objective "Production and Rational Use of Energy", as defined in Section 8.7.4.3, should not be confused with the special series collected and issued by the International Energy Agency of the OECD (IEA) which covers energy research, development and demonstration expenditures or "RD&D" (OECD, 1 993*b).* A definition of the latter concept will be found in Chapter 1 (see para. 22).

8.8 Main differences between GBAORD and GERD data

477. Users of the GBAORD often discover and have difficulty in understanding differences between the sums reported as:

- Total GBAORD and government-financed GERD.
- GBAORD for a given objective and total R&D expenditure on the same objectives as discussed in Section 4.6. These variations in the sums reported spring from differences in the specifications of the data.

8.8.1 General differences

478. In principle both series should be established on the basis of the same definition of R&D, should cover R&D in both NSF and SSH, and both current and capital expenditures.

479. They differ in two main respects. First, government-financed GERD and GERD objectives data are based on the reports of R&D performers, whereas GBAORD is based on that of the funder. Secondly, the GERD-based series cover only R&D performed on national territory, whereas GBAORD also includes payments to foreign performers, including international organisations.

480. Differences may also occur because the periods covered are different (calendar and fiscal years), because the money is finally spent by the performer in a later year than the one in which it was committed by the funder, and because the performer may have a different and more accurate idea of the R&D content of the project concerned.

8.8.2 GBAORD and government-financed GERD

481. In addition to the general differences, government-financed GERD should include R&D financed by central (or federal), provincial (or state), and local government, whereas GBAORD excludes local government and sometimes also provincial government.

8.8.3 GBAORD and GERD by socio-economic objectives

482. GBAORD covers only R&D financed by government (including abroad), whereas GERD covers all sources of funds on national territory.

483. The performer's appreciation of the objectives of the project concerned may differ significantly from that of the funder, notably for R&D funded from block grants such as GUF, which should be distributed by objective in the GERD approach.

ANNEX 1

BRIEF HISTORY AND ORIGINS OF THE PRESENT MANUAL AND OF R&D METHODOLOGICAL WORK BY OTHER INTERNATIONAL BODIES

Origins

1. Encouraged by the rapid growth of the amount of national resources devoted to research and experimental development (R&D), most OECD Member countries began to collect statistical data in this field around 1960. They followed the pioneering efforts of a small number of countries, including the United States, Japan, Canada, the United Kingdom, the Netherlands, and France. However, countries encountered theoretical difficulties when starting R&D surveys, and differences in scope, methods, and concepts made international comparisons difficult. An increasing need was felt for some attempt at standardisation of the kind undertaken for economic statistics.

2. The OECD's interest in this question dates back to the existence of the Organisation for European Economic Co-operation (OEEC). In 1957, the Committee for Applied Research of the European Productivity Agency of the OPEC began to convene meetings of experts from Member countries to discuss methodological problems. As a result, an *Ad Hoc* Group of Experts was set up, under the auspices of the Committee for Applied Research, to study surveys of research and development expenditure. The Technical Secretary of the Group, Dr. J.C. Gerritsen, prepared two detailed studies on the definitions and methods employed to measure R&D in the government sector of the United Kingdom and France and later of the United States and Canada. Other members of the Group circulated papers describing the methods and results of surveys in their own countries.

First edition

3. When the Directorate for Scientific Affairs took over the work of the European Productivity Agency in 1961, the time was ripe for specific proposals for standardisation. At a meeting in February 1962, the *Ad Hoc* Group decided to convene a study conference on the technical problems of measuring R&D. In preparation, the Directorate for Scientific Affairs appointed a consultant, Mr. C. Freeman, to prepare a draft document, which was circulated to Member countries in the autumn of 1962 and revised in the light of their comments. The "Proposed Standard Practice for Surveys of Research and Development" (OECD, 1963) was discussed, revised and accepted by experts from the OECD Member countries at the conference, which was held in Frascati, Italy, in June 1963.

4. Later in 1963, the OECD Directorate for Scientific Affairs invited the United Kingdom's National Institute for Economic and Social Research to undertake an experimental comparison of research efforts in five western European countries (Belgium, Prance, Germany, the Netherlands, and the United Kingdom), the United States, and the USSR. The Institute study, though based on statistics from surveys undertaken before the international standards had been decided on, also tested the first draft definitions.

The report (Freeman and Young, 1965) concluded that the available statistical information left a great deal to be desired. The main improvements suggested were:

a) a more rigorous conceptual separation of research and experimental development and "related scientific activities";

b) careful studies in the higher education sector to estimate the proportion of time devoted to research by teaching staff and postgraduate students;

c) a more detailed breakdown of R&D manpower and expenditure data to permit, *inter alia*, a more exact calculation of research exchange rates;

d) a more systematic measurement of expenditure flows between R&D sectors;

e) more data on the flow of technological payments and of international migration of scientific personnel.

5. In 1964, following the acceptance of the Frascati Manual by the Member countries, the OECD launched the International Statistical Year (ISY) on Research and Experimental Development. Member countries returned data for the year 1963 or 1964. Seventeen countries took part, many of them conducting special surveys and enquiries for the first time (OECD, 1968).

Second edition

6. Following the publication of the Statistical Year findings, the OECD Committee for Science Policy requested the Secretariat to prepare a revision of the Frascati Manual in the light of the experience gained. An outline of the suggestions was circulated to Member countries in March 1968. A draft revision, incorporating most of these suggestions, was examined at the meeting of national experts held in Frascati in December 1968. During this revision, particular attention was paid to making the Manual conform, as far as possible, to existing United Nations' international standards such as the System of National Accounts (SNA) and the International Standard Industrial Classification (ISIC). A revised draft was examined by a small group of experts in July 1969, and a revised version of the Manual was published in September 1970 (OECD, 1970).

Third edition

7. The second revision of the Manual was influenced by two series of events. First, by 1973, Member countries had participated in four ISY surveys and the accuracy and comparability of the data had benefited greatly from this continued experience. National survey techniques had also greatly improved. Secondly, in 1972 the OECD Committee for Scientific and Technological Policy (CSTP) set up the first *Ad Hoc* Review Group on R&D Statistics under the chairmanship of Mr. Silver (United Kingdom) to advise it and the Secretariat on how to make optimal use, over the short term, of the restricted resources available for R&D statistics at the OECD while taking account of Member countries' priorities. Member countries were asked to draw up an inventory of their needs, and nearly all responded. In addition to giving absolute priority to a continuation of the ISY surveys, they made a number of recommendations touching on methodology, notably concerning the need for closer contacts between the OECD and other international organisations.

8. As a result, the third edition of the Frascati Manual went more deeply into subjects already treated and examined certain new ones. Its scope was expanded to cover research in the social sciences and

humanities, and greater stress was placed on "functional" classifications, notably the distribution of R&D by "objectives". A draft of this version was discussed at a meeting of experts held at the OECD in December 1973, and the final text was adopted in December 1974 (OECD, 1976).

Fourth edition

9. The national experts recommended undertaking only an intermediate revision exercise, with no significant changes in key concepts and classifications. The main stress was to be placed on improving drafting and layout. However, a number of revisions were made to reflect: recommendations made by the second *Ad Hoc* Review Group on R&D Statistics, which met in 1976 under the chairmanship of Mr. J. Mullin (Canada); the experience gained by the OECD Secretariat from its international surveys and analytical reports; and suggestions from the national experts on R&D statistics. Revision proposals were presented at the annual meeting of national experts in December 1978. A small *Ad Hoc* Group of Experts met at the OECD Secretariat in July 1979 for more detailed discussions of a draft prepared by a consultant to the Secretariat. A revised version incorporating the Group's and the Secretariat's suggestions was discussed in December 1979, and the text was finally adopted in autumn 1980 (OECD, 1981).

The higher education supplement

10. The higher education sector does not appear in the System of National Accounts (SNA) adopted by the United Nations and the OECD. It was introduced by the OECD and UNESCO early in their collection of R&D statistics because of policy-makers' interest in the role of universities and other third-level colleges and institutions in national research efforts. Despite this interest, there are significant problems associated with the collection of accurate data for this sector, and they were discussed at the seminar on S&T indicators in this sector held at the OECD in June 985. The experts felt that, while the Manual gave general guidance, it sometimes gave insufficient practical advice, and at their annual meeting in December 1985, the Group of National Experts on Science and Technology Indicators (NESTI) agreed to prepare a supplement to the Frascati Manual to address these problems and to make recommendations on improving future survey practice. A first draft was discussed in December 1986; and the amended text was then adopted by NESTI, and, subject some final adjustments, recommended for derestriction in December 1987 (OECD, 1 *989c).* Certain of its recommendations are also relevant to other sectors of performance. This supplement remains valid although many of its recommendations have been integrated into the fifth edition of the Manual

Fifth edition

11. By the late 1980s, it was clear that the Frascati Manual guidelines needed to be revised to Incorporate the changes in policy priorities and obtain the data needed to inform the policy-making process. Many issues were involved, notably developments in the S&T system and our understanding of it. Some of these issues emerged in the OECD's Technology-Economy Programme – TEP *(e.g.* internationalisation, software, transfer sciences, etc.); others included data on environmental R&D; analytical needs for R&D data that can be integrated with other economic and industrial series; and the revisions of the international standards and classifications applied to R&D statistics in the Manual.

12. In consequence, the Italian authorities volunteered to organise an expert conference to discuss a series of proposals for revisions to the Frascati Manual. It took place at the headquarters of the Consiglio Nazionale delle Ricerche in Rome from 30 September to 4 October 1991. It was hosted by the Italian Ministry for the Universities and Scientific Research, was organised jointly by the Italian authorities and the OECD, and was attended by experts from OECD Member countries, the European Commission, and

observers from the former Czech and Slovak Federal Republic (CSFR), Hungary, Poland, and the former Soviet Union, plus UNESCO and Indonesia.

13. Following the conference, a draft revised version of the Manual incorporating much of the text of the supplement on higher education was formally discussed by NESTI at their April 1992 meeting. After further revision by a small editorial group in the light of their recommendations, the draft was adopted early in 1993.

Efforts of other international organisations

14. The problems of comparing R&D data, collected in different countries with varying institutional patterns and traditions in education and research, have been considered by other international organisations as well as by the OECD.

UNESCO (United Nations Educational, Scientific and Cultural Organization)

15. The UNESCO Division of Statistics has since 1965 organised the systematic collection, analysis, publication and standardisation of data concerning science and technology (S&T), and more especially, R&D. The first experimental questionnaires were circulated to member states in 1966, and standardised periodical surveys were established in 1969. From information obtained mainly through statistical surveys conducted world-wide since 1970 on qualified human resources and R&D personnel and expenditure, a database has been built up, and covers at present some 100 countries and territories. These data have been published regularly in the *UNESCO Statistical Yearbook* (UNESCO, annual*b*), the *UNESCO Statistical Digest* (UNESCO, annual*a*) and the *United Nations Statistical Yearbook* (UN, annual); they are also used for special reports and analyses.

16. The methodology used in the surveys was progressively developed with the aid of national specialists from throughout the world and was discussed at length during missions and at meetings convened by UNESCO. The aim is to collect information on scientific and technological activities (STA) in a form that allows for maximum international comparability. Following methodological studies in 1975 and 1976, the UNESCO Secretariat drew up, with the assistance of external specialists, a draft recommendation for consideration by a meeting of governmental experts in 1978. The experts took into consideration the need for international standards that could be applied to all member states, both those with advanced S&T statistical systems and those whose systems are still being developed. Although designed to provide standardised information on S&T activities, the proposal concentrated on R&D. However, it proposed a gradual extension of the statistics beyond R&D.

17. The "Recommendation Concerning the International Standardisation of Statistics on Science and Technology" was adopted by the UNESCO General Conference at its twentieth session in 1978 (UNESCO, 1978). Two successive stages were proposed at the international level: the first, over a period of at least five years after the adoption of the "Recommendation", was to cover R&D only in all sectors of performance, together with stock and/or economically active qualified personnel; during the second stage, statistics were to be extended to cover scientific and technological services (STS) and S&T education and training at broadly the third level (scientific and technical education and training – STET). In 1984, UNESCO published a manual (UNESCO, 1984b) on these international standards and issued a revised "Guide to S&T Statistics" (UNESCO, 1984a), for use by its member states. Throughout this work, UNESCO took account of the experience acquired by other intergovernmental organisations such as the OECD, the former CMEA (Council for Mutual Economic Assistance), and the OAS (Organization of American States). Co-operation was also promoted through a Joint Working Group of UNESCO and BCE

(United Nations Economic Commission for Europe), which studied ways to improve and develop S&T statistics at meetings held in 1969, 1972, 1976 and 1981.

18. Since 1976, UNESCO has also made efforts to develop a methodology for data collection on scientific and technological information and documentation (STID); this work resulted in the publication of a provisional STID Guide in 1984 (UNESCO, 1984*b*). Work on the establishment of a methodology for collecting statistics on STET was initiated in 1981. UNESCO's current activities include, *inter alia,* case studies in various regions of the world to determine the present state of S&T statistics, problems encountered in the implementation-of the Recommendation, and the needs for new S&T indicators.

EUROSTAT (Statistical Office of the European Communities)

19. The European Community's Working Party on R&D and Innovation Statistics, with its secretariat in Eurostat, draws up annual reports on the public financing of R&D in member states and on the R&D appropriations of the Community institutions. The report provides time series on the final R&D budgets as well as provisional budget appropriations for the current year. Data are collected through an annual survey of each member state and processed so that they can be presented in comparable form (Eurostat, annual). They are broken down by principal socio-economic objectives of the research, in accordance with the 1983 version of the nomenclature for the analysis and comparison of scientific programmes and budgets (NABS) (Eurostat, 1986).

20. The predecessor to the Working Party, the statistical subcommittee on R&D statistics set up by the Scientific and Technical Research Committees (CREST), was entrusted in 1978 with extending coverage beyond public sector R&D data in all the member states. This broadened coverage, together with various related developments, is expected to provide the foundation for a statistical information processing system covering all aspects of research and development.

NORDFORSK/Nordic Industrial Fund

21. Since 1968 the Nordic countries have collaborated, co-ordinating their work in the area of R&D statistics. Until 1987 the co-operation was organised by NORDFORSK (the Nordic Co-operative Organisation for Applied Research) which set up a special committee on R&D statistics. During this period, various working groups discussed a number of problems related to the production and analysis of R&D statistics, mainly with reference to inter-nordic data comparability. In 1974, the Committee published a "Nordic Manual" in the Nordic languages, which was a detailed supplement to the Frascati Manual (NORDFORSK, 1974). Selected chapters have been translated into English and have been presented by NORDFORSK at various meetings of experts at the OECD. In 1978, the Committee started work on budget analysis and relevant guidelines were published in the Nordic languages (NORDFORSK, 1983). Then, in 1986 a short report was published on work on improved guidelines in the higher education sector (NORDFORSK, 1986).

22. In 1987 NORDFORSK merged with Nordic Industrial Fund which took over responsibility for the Committee. As in the NORDFORSK period, the Committee accords high priority to developing R&D statistics in the Nordic countries. Among other topics, the need for projection data and a methodology for establishing such data has been discussed. Most recently, the Committee, renamed the Nordic Group for Development of Science and Technology Indicators, has put more effort into the problems of measuring and evaluating the results of R&D; both producers and users of S&T indicators are members of the group.

23. In 1990 the Nordic Industrial Fund set up a special working group for innovation studies which launched and made a major contribution to the development of guidelines in this area. These were adopted and published by the OECD in 1992 as the Oslo Manual (OECD, 1992*b).*

Acknowledgements

24. Neither the original version of this Manual nor the revised editions could have been completed without the active collaboration of R&D statisticians in all OECD Member countries and in international organisations, notably UNESCO, BC, and NORDFORSK/the Nordic Industrial Fund. Particular debts of gratitude are due to the National Science Foundation which pioneered the systematic measurement of R&D.

25. Among those who must be mentioned in connection with the first edition of the Manual are the late Dr. J. Perlman, Professor C. Freeman, and the French Délégation génerale à la recherche scientifique et technique (DGRST).

26. The late H.E. Bishop chaired the 1968 Frascati meeting, and Mr. H. Stead (Statistics Canada), Mr. P. Slors (Netherlands Central Bureau of Statistics), and Dr. D. Murphy (Irish National Science Council) also made major contributions to the second edition.

27. Among those who helped to prepare the third version, thanks are due to the late K. Sanow (National Science Foundation), Mr. J. Mitchell (Office of Fair Trading, United Kingdom), and Mr. K. Perry (United Kingdom Central Statistical Office), and to Mrs. K. Arnow (National Institutes of Health, United States), Chairman of the 1973 meeting of experts, as well as to the chairmen of special topics, Mr. T. Berglund (Swedish Central Statistical Office), Mr. J. Sevin (DGRST) and Dr. F. Snapper (Netherlands Ministry of Education and Science).

28. The fourth edition owed a great deal to the work of Mr. H. Stead (Statistics Canada). Chairing the various expert meetings involved were Mr. G. Dean (Central Statistical Office, United Kingdom) in 1978 and Mr. C. Falk (National Science Foundation, United States) in 1979.

29. The Higher Education Supplement was prepared by Ms. A. FitzGerald [EOLAS (Irish Science and Technology Agency), Ireland]. The section on time-budget studies drew heavily on work by Mr. Mikael Akerblom (Central Statistical Office of Finland). The 1985 Conference onS&T Indicators for the Higher Education Sector was chaired by Mr. T. Berglund (Statistics Sweden).

30. The present fifth edition was largely prepared by Ms. A. FitzGerald (BOLAS) on the basis of work by a large number of national experts. Particular thanks are due to Mr. T. Berglund (Statistics Sweden), Mr. J. Bonfim (Junta Nacional de Investigaçao Cientifica e Tecnologica, Portugal), Ms. M. Haworth (Department of Trade and Industry, United Kingdom, Mr. A. Holbrook (Industry, Science and Technology Canada, Canada), Mr. J.-F. Minder (ministère de la Recherche et de Ia Technologie, France), Prof. F. Niwa (National Institute of Science and Technology Policy, Japan), Dr. Erika Rost (Bundesministerium fur Forschung und Technologie, Germany), Mr. P. Turnbull (Central Statistical Office, United Kingdom), and Mrs. K. Wille-Maus (Norges allmennvitenskaplige forskningrad, Norway). Mr. G. Sirilli (Consiglio nazionale delle richerche, Italy) was Chairman of the Group of National Experts on Science and Technology Indicators during this period and also organised the Rome Conference.

ANNEX 2

OTHER SCIENCE AND TECHNOLOGY INDICATORS

Introduction

1. As discussed in Chapter 1, it has become increasingly clear that R&D statistics alone do not suffice to describe the range of inputs and outcomes associated with scientific and technological development. [See, for example, *Output Measurement in Science and Technology: Essays in Honor of Yvan Fabian* (Freeman, 1987).]

2. The OECD, recognising the need to facilitate the development of indicators other than those associated with R&D, has in train the preparation of a series of non-R&D methodological manuals (see Chapter 1, Table 1.1). These manuals are intended to be complementary and, in time, to provide guidelines for the collection and interpretation of data describing the full spectrum of scientific and technological activities.

3. This annex outlines seven series of such indicators – for which manuals are prepared, in preparation, or planned. Its purpose is to provide users and producers of R&D statistics a context for setting R&D indicators within the framework of the overall S&T system. It also outlines the sources and availability of data in each area. It describes the situation as of end 1993.

Patent statistics

Coverage

4. A patent is a right granted by a government to an inventor in exchange for the publication of the invention; it entitles the inventor to prevent any third party from using the invention in any way, for an agreed period.

5. Patent data cover applications and grants classified by field of technology. International applications series distinguish four subcategories: *a)* patents taken out by residents of a country in that country; *b)* patents taken out in a country by non-residents of that country; *c)* total patents registered in the country or naming it; *d)* patents taken out outside a country by its residents. Data on patents granted only distinguish between patents awarded to residents and to non-residents.

6. For international comparison, statistics on applications are somewhat easier to use than statistics on grants because of the delay that patent requests undergo in certain countries, notably because of the lack of resources in the national offices.

7. Patent descriptions also contain much technological information unavailable elsewhere and therefore constitute a significant complement to the traditional sources of information for measuring diffusion of technological/scientific information (see section on bibliometrics).

Use of patent statistics

8. When constructed, patent indicators use data collected by national and international patent agencies to identify changes in the structure and evolution of inventive activities in countries, industries, companies, and technologies by mapping changes in technology dependency, diffusion, and penetration.

Availability

9. National and international patent offices are the main sources of raw data. The OECD assembles, stocks and publishes total applications data for its Member countries for the four categories identified above in *Main Science and Technology Indicators* (OECD, biannual) and *Basic Science and Technology Statistics* (OECD, 1993*a*) and in the associated diskettes and tapes. It also holds a base of patents applied for in the United States broken down by the country of residence of applicants, by industrial product field, and by field of technology.

International guidelines

10. The growing role of international patent organisations is contributing to greater comparability between the patent data available for individual countries, although these are still affected by special characteristics of patents. At the time of writing, a set of guidelines for the use and interpretation of patent data as indicators of S&T prepared for the OECD was being finalised after discussion by national experts. The manual is expected to be adopted and issued in 1994.

The technology balance of payments (TBP)

Coverage

11. The TBP registers the international flow of industrial property and know-how.

12. The following operations should be **included** in the TBP: patents (purchase, sales); licenses for patents; know-how (not patented); models and designs; trademarks (including franchising); technical services; finance of industrial R&D outside national territory.

13. The following, however, should be **excluded:** commercial, financial, managerial and legal assistance; advertising, insurance, transport; films, recordings, material covered by copyright; design; software.

Use of TBP statistics

14. When constructed, TBP indicators measure the international diffusion of disembodied technology by reporting all intangible transactions relating to trade in technical knowledge and in services with a technology content between partners in different countries.

15. The international comparability of national TBP indicators is improving progressively as national practices are changed to match the guidelines of the new manual.

Availability

16. National TBP data may be collected by means of special surveys but more often are assembled from existing records kept by central banks, exchange control authorities, etc.

17. The OECD has assembled a data base of "macro" TBP data for most of its Member countries covering total transactions (receipts and payments) by partner country back to 1970. Data for periods since the late 1980s are published in *Main Science and Technology Indicators* (OECD, biannual) and *Basic Science and Technology Statistics* (OECD, I 993a) and in the associated diskettes and tapes. In 1991 a new international database for detailed TBP series (broken down by industry, type of operation, and geographical area) starting with Japan, Germany, Italy and Sweden, was created at the OECD. In parallel, detailed data based on national practices and classifications have been assembled and updated for about ten countries.

International guidelines

18. The OECD issued the "Proposed Standard Method of Compiling and Interpreting Technology Balance of Payments Data – TBP Manual" in 1990 (OECD, 1990*a*). It is the second in the series of OECD manuals on science and technology indicators.

Bibliometrics

Coverage

19. Bibliometrics is the generic term for data about publications. Originally, work was limited to collecting data on numbers of scientific articles and publications, classified by authors and/or by institutions, fields of science, country, etc., in order to construct simple "productivity" indicators for academic research. Subsequently, more sophisticated and multidimensional techniques based on citations in articles (and more recently also in patents) were developed. The resulting citation indexes and co-citation analyses are used both to obtain-more sensitive measures of research quality and to trace the development of fields of science and of networks.

Use of bibliometric statistics

20. Bibliometric analysis use data on numbers and authors of scientific publications and on articles and the citations therein (and in patents) to measure the "output" of individuals/research teams, institutions, and countries, to identify national and international networks, and to map the development of new (multi-disciplinary) fields of science and technology.

Availability

21. Most bibliometric data come from commercial companies or professional societies. The main general source is the Science Citation Index (SCI) set of databases created by the Institute for Scientific Information (United States) on which are based several major bases of science indicators developed by Computer Horizons, Inc. (for the National Science Foundation). Other specialised bases are Medline (United States) and Excerpta Medica (the Netherlands) for medical bibliometrics, and Chemical Abstracts (United States).

22. A number of other international and/or national databases, frequently interlinked, are currently being developed. The OECD currently has neither plans, resources, nor competence to undertake basic data collection, although bibliometric data are regularly used in its analytical reports.

International guidelines

23. Bibliometric methods have essentially been developed by university groups and by private consultancy firms. At the time of writing there are no official international guidelines for the collection of such data or for their use as science and technology indicators. In 1989-90 the OECD commissioned a report on the "state of the art" in bibliometrics which might constitute a basis for a future OECD manual on the use and interpretation of bibliometric indicators. It may be prepared and issued in co-operation with the European Commission (European Network on S&T Indicators of the MONITOR-SPEAR Programme).

High-technology products and industries

Coverage

24. Two main approaches have been used to date, by **industry**, where OECD work (drawing on earlier studies by the US Department of Commerce) has been the basis for most exercises in individual countries, and by **product.**

- In the **industry** approach, used by the OECD, the main criterion used in the past has been R&D expenditures as a percentage of the production, turnover or value added of the industry concerned. Industries were divided into three categories, "high", "medium" and "low" R&D intensity (OECD, 1986). Further work will allow industries to be divided up according to their "technology content", taking into consideration not only direct investment in R&D but the indirect acquisition of its domestic results incorporated in intermediate consumption and capital goods, as well as in results of foreign R&D incorporated in imported goods. All these technology inputs must be estimated econometrically using input-output matrices.

- The **product** approach has the advantage of allowing more detailed analysis and identification of the technology content of products and hence a weeding out of mature products manufactured by otherwise R&D-intensive industries. This approach requires the use of detailed R&D data by product field.

Use of high-technology products and industry statistics

25. When constructed, these indicators measure the technology content of the goods produced and exported by a given industry and country with a view to explaining their competitive and trade performance in "high-tech" markets. These markets are characterised by rapid growth in world demand and oligopolistic structures, they offer higher than average trade returns, and they affect the evolution of the whole structure of industry.

26. Indicators on trade in high-tech products/industries were originally designed as measures of the "output" or "impact" of R&D; they are now seen as having a wider use in the analysis of competitiveness and globalisation.

Availability

27. To date the OECD has favoured the industry approach. Using an OECD trade database classified by ISIC, a series of import-export ratios for the main R&D-intensive industries has been set up and published twice a year in *Main Science and Technology Indicators* (OECD, biannual) and in the associated diskette. Series for trade by high, medium and low R&D-intensive industries are analysed in *Industrial Policy in OECD Countries: Annual Review* (OECD, annual*a*) and summarised in *OECD in Figures* (OECD, annual*c*). In addition to the other improvements mentioned above, a new trade base by product offering greater analytical possibilities became available at the OECD in 1992.

International guidelines

28. At the time of writing there are no officially approved international standards for identifying high-tech industries and products, although the OECD intends to prepare a manual dealing with both the industry and product approaches; a workshop on this topic was held in 1993.

Innovation statistics

Coverage

29. **Technological innovations** comprise new products and processes and significant technological changes of products and processes. An innovation has been **implemented** if it has been introduced on the market (product innovation).

- **Major product innovation** describes a product whose intended use, performance characteristics, attributes, design properties or use of materials and components differ significantly compared with previously manufactured products. Such innovations can involve radically new technologies or can be based on combining existing technologies in new uses.

- **–Incremental product innovation** concerns an existing product whose performance has been significantly enhanced or upgraded. This again can take two forms. A simple product may be improved (in terms of improved performance or lower cost) through use of higher performance components or materials, or a complex product which consists of a number of integrated technical subsystems may be improved by partial changes to one of the subsystems.

- **Process innovation** is the adoption of new, significantly improved production methods. These methods may involve changes in equipment or production organisation, or both. The methods may be intended to produce new or improved products that cannot be produced using conventional plants or production methods or to increase the production efficiency of existing products.

Use of innovation statistics

30. Innovation indicators measure aspects of the industrial innovation process and the resources devoted to innovation activities. They also provide qualitative and quantitative information on the factors enhancing or hindering innovation, on the impact of innovation, on the performance of the enterprise and on the diffusion of innovation.

Availability

31. National data on innovation activities are generally collected by means of surveys addressed to industrial firms. Over half of the OECD Member countries have organised such surveys, and it is on their experience that the Oslo Manual is based.

32. It is also possible to collect data on the number and nature of actual innovations. Such information can be obtained by special surveys or assembled from other sources such as the technical press.

33. The first set of internationally comparable series of data was collected under the auspices of the Nordic Industrial Fund. The OECD contributed to the preparation of a list of questions proposed for inclusion in harmonised surveys during the launching by the Commission of the European Communities (CEC) of a community survey based on the Oslo Manual. This survey is currently drawing to a close in the EC countries and in many other OECD countries, which have adapted the list of questions to meet their national needs.

International guidelines

34. The "OECD Proposed Guidelines for Collecting and Interpreting Innovation Data – Oslo Manual" (OECD, 1992*b*), prepared jointly by the OECD and the Nordic Fund for Industrial Development (Nordisk Industrifond, Oslo) in 1990, was officially adopted by the OECD as the third in the "Frascati" family of manuals.

Measuring the use of advanced manufacturing technology (AMT)

Coverage

35. Advanced manufacturing technology is defined as computer-controlled or micro-electronics-based equipment used in the design, manufacture or handling of a product. Typical applications include computer-aided design (CAD), computer-aided engineering (CAE), flexible machining centres, robots, automated guided vehicles, and automated storage and retrieval systems. These may be linked by communications systems (factory local area networks) into integrated flexible manufacturing systems (FMS) and ultimately into an overall automated factory or computer-integrated manufacturing system (CIM).

Use of AMT-usage statistics

36. AMT-usage statistics measure the extent of use of different kinds of manufacturing technology, including the patterns of diffusion and the effects of use (disadvantages, difficulties, constraints, and barriers to wider use) as well as skills and training and employment issues.

Availability

37. National data have been collected through special surveys of manufacturing firms. About half of the OECD Member countries have carried out surveys, and their comparability has improved due to the use of common survey questions.

38. A list of key survey questions was published in *Government Policies and the Diffusion of Micro-electronics* (OECD, 1989*a*). These questions covered the applications of micro-electronics in processes where they are used for monitoring and controlling purposes as well as in products. The OECD has been playing a clearing-house role in this area, regularly reviewing and exchanging information on surveys that have been carried out or are under way, and promoting greater comparability between national surveys. The diffusion and use of manufacturing technology was reviewed in *Managing Manpower for Advanced Manufacturing Technology* (OECD, 1991*b*).

39. So far detailed international comparisons of the use of AMT have been made in France, Germany, and the United Kingdom, and subsequently in Canada and the United States. Other countries have made more limited comparisons.

International guidelines

40. The OECD has followed and encouraged these comparisons. A supplement to the Oslo Manual dealing with advanced manufacturing technology (AMT) surveys is currently planned.

Human resources for science and technology (HRST)

Coverage

41. The Frascati Manual only discusses the measurement of R&D personnel. The concept of HRST is much wider and covers, depending on the purpose of the exercise, categories of higher personnel engaged in all scientific and technological activities and some others.

42. HRST may be defined in terms of qualifications or current employment. In the first case, the appropriate classification is the International Standard Classification of Education (ISCED) (UNESCO, 1976) and, in the second, the International Standard Classification of Occupations (ISCO) (ILO, 1968; ILO, 1990). HRST may cover only persons with university qualifications/ professional occupations or also include those with other post-secondary qualifications and technical jobs. A combination of criteria and levels is needed if supply and demand issues are to be analysed correctly.

43. An ideal database should cover total national stocks of HRST personnel at given points in time, broken down by employment status and by sector and type of employment, and the intervening inflows (mainly educational output and immigration) and outflows (mainly retirement and emigration). Both stocks and flows should be broken down by field of science and technology, age and gender and possibly also national or ethnic origins.

Use of HRST data

44. Co-ordinated sets of data on HRST can (when linked to demographic statistics) be used to review the current and possible future supply, use and demand (at home and abroad) for science and engineering personnel, with a view to evaluating the consequences for future research and industrial performance, planning education and training, measuring the diffusion of knowledge incorporated in human resources, and assessing the roles of women (and minorities) in science and technology activities.

Availability

45. While a few very small OECD countries are able to maintain complete nominal registers of all S&T graduates and their whereabouts, databases on HRST have to be built up in most countries from several sources, notably education statistics (numbers of teachers and graduates), employment statistics, and population censuses, supplemented by special surveys.

46. UNESCO collects and publishes data annually on total national stocks of scientific and technical personnel in its statistical yearbook (UNESCO, annual *b*). The OECD hopes to build a more sophisticated database and set of indicators.

International guidelines

47. A draft manual of international standards for measuring stocks and flows of HRST was discussed at major meetings in autumn 1992 and 1993. It is expected that it will be adopted and issued in 1994.

ANNEX 3

ISSUES OF SPECIFIC RELEVANCE TO THE HIGHER EDUCATION SECTOR

Introduction

1. This annex deals with a number of issues in the broad field of R&D statistics, as they concern the higher education sector:

- time-budget surveys;
- use of coefficients to estimate R&D expenditure and personnel;
- use of central administration data when establishing R&D data;
- accounting for R&D expenditures by sources of funds.

2. These topics are presented under four separate and independent headings for easy reference. In consequence, some are treated several times in different contexts. Readers are also referred to the general guidelines on survey procedures in Chapter 7.

Topic 1: Time-budget surveys in the higher education sector

General

3. Various kinds of time-budget surveys are used in Member countries to establish a base for identifying the R&D share of total university activities and to serve as a tool for calculating and estimating corresponding personnel and expenditures data.

4. Caution must be exercised when using time-budget surveys in higher education surveys. Staff in institutions of higher education combine research with a range of other duties, such as teaching, administration, and supervision. It can therefore be difficult for respondents to identify unambiguously that part of their time (working or otherwise) that is devoted exclusively to R&D, and respondents may have to make many estimations when compiling this information. The following sections outline several survey methods that may help minimise some of the problems raised by such estimations.

Resources required

5. Time-budget studies require surveys for which questionnaires are sent to personnel employed in the higher education sector, either to individuals or to heads of university departments, for example.

6. All surveys involving questionnaires require adequate resources in terms of time and money, and surveys of the higher education sector are no different. A considerable amount of time must be devoted to even a relatively small survey of from 300 to 400 people. This is due, among other things, to the irregular distribution of the workload of academic staff in higher education institutions. They may receive the questionnaire at a time when they are fully occupied. Time-budget survey questionnaires should be completed by the person to whom they are addressed; they cannot usually be passed to an assistant or secretary for completion. Thus, these surveys normally require intensive follow-up (reminders) before the survey is completed. Results of such surveys are, therefore, usually from 12 to 18 months out of date when they are released.

7. The costs involved in such surveys may also be high, once postage, travel, and computer analyses for the planning and carrying out of the survey are taken into account.

Possible methods

8. When choosing the most appropriate survey method, the following factors have to be considered:

- the resources available to the producers of statistics;
- the desired level of quality of the statistics;
- the burden that can reasonably be laid on university administrations and individual respondents;
- special features of the country.

9. Two methods for time-budget studies can be distinguished:

a) those based on researchers' own evaluation of the distribution of their working time;

b) those based on estimates by the heads of university departments or institutes.

Methods based on respondents' own evaluation of the distribution of their working time

10. These methods can be divided according to the period covered by the survey:

- surveys on the distribution of working time during the whole year;
- surveys on the distribution of working time during one or several specified weeks;
- surveys on the distribution of working time during the whole year by means of partial special C 'rolling") surveys of a specific sample of the population every week during the year.

Surveys on the distribution of working time during the whole year

11. In this type of survey, questionnaires can be sent to all individual staff members or to a representative sample, to researchers only, or to the heads of academic departments. The survey may cover the entire higher education sector or a representative institutional sample. Respondents are asked to estimate the allocation of their working time over a whole year across a list of various categories of work-related activities. In recent surveys undertaken by Member countries, the number of activities has varied from the two categories of "research" and "other", to as many as 15 categories covering all aspects of a working year. It is recognised that respondents may find it difficult to recall their pattern of work and to reply accurately to the questionnaire.

12. The following is an example of a use-of-time classification but, depending on the institutions examined, other activities may well be suggested:

- undergraduate time;
- postgraduate course-work time;
- postgraduate research time;
- personal research time;
- administration;
- unallocable internal time;
- external professional time.

13. This type of survey depends on the respondents' recall of their work practices over an entire year. It can be difficult to carry out, particularly if respondents are answering on behalf of colleagues, other academic staff, technicians, or support staff.

14. Such questionnaires frequently also include questions on more general topics such as respondents' educational background, age, sex, hindrances to R&D, membership on committees, etc.

Surveys on the distribution of working time during one or several specified weeks

15. Questionnaires may be sent to all staff in third-level institutions, to heads of academic departments, or to researchers only. In the latter two cases, the respondents may be asked to reply on behalf of other (R&D) personnel associated with them. The questionnaire is a diary in which the respondents mark, according to the list presented, the activity that best represents the use of each half-hour of each day.

16. Staff members included in the survey may be asked to maintain diaries for three short periods of the academic year, such as:

- a normal teaching week;
- a vacation week that falls outside a personal holiday period;
- an examination period week.

Surveys by means of partial special surveys every week during the year

17. It is assumed to be very difficult for academic staff to give accurate detailed information on how they spend their time when the questionnaire covers more than one week. A method has therefore been developed, which uses partial surveys taken of a "rolling" sample of respondents for one week to estimate the time allocation pattern for the whole year. Sampling consists of choosing individuals out of the total population to be surveyed and assigning one or several particular survey week(s) to each person chosen in order to cover the whole year. This information is then used to calculate/estimate the corresponding R&D personnel and expenditures series.

18. This pattern is expressed in "time-spending coefficients". The time-spending coefficient for R&D, for example, is calculated by adding up all hours spent on R&D, divided by the total of all hours worked.

19. The method involves the following broad steps prior to sending out the questionnaires:

- defining the survey population;
- drawing a sample from the population if no full survey is made;
- assigning one (or several) survey week(s) to each person included in the survey.

20. Countries take various approaches for acquiring information in this type of survey. Sometimes, respondents are asked to indicate the number of hours spent on various activities over the entire week; sometimes they are asked to reply for each day of the week.

21. Again, countries give different options to their respondents, but the general principle is always to list all possible work-related activities and ask respondents to identify how much time they spend on them (in absolute or relative terms).

22. General information of the kind referred to in paragraph 14 may also be collected as part of the survey.

Methods based on estimates by heads of university institutions

23. It is usually not possible to gather full information on R&D activities in the higher education sector without obtaining data from the university institutes. In most countries, R&D statistics for the higher education sector are based on a combination of information obtained at central administrative and institute level and information supplied by individual respondents. The questionnaires addressed to the institutes often contain questions on certain types of expenditures and other total resources available and the estimated R&D share of these resources.

24. Several countries have found it convenient to include questions on time budgets at a more aggregate level in a questionnaire addressed to the university institutes, rather than make time-budget studies concerning individual researchers. This method is certainly cheaper than those described above and puts a less heavy burden on respondents. In this case, the questionnaires are usually addressed to the head of the institute, who is assumed to have the knowledge of ongoing activities necessary to supply sufficiently accurate estimates. However, consultations with individual staff members are often necessary in order to prepare the best estimates possible.

Treatment of R&D borderline activities

25. Respondents in time-budget surveys need clear instructions if accurate and comparable results are to be obtained. Therefore, the surveyor must state very clearly which activities should be included in the R&D reported and which should not. Clear definitions must be given in the guidelines when respondents are asked to distribute their own activities. The recommendations given in Chapter 2 of the Manual should be followed for such guidelines.

Response rates

26. Methods based on estimates obtained from the university institutes put virtually no burden on the individual researcher (or other categories of respondents) but a modest one on the university institute itself. The diary exercises make rather heavy demands on the academic staff members but none on the university institute. The burden on the individual respondent is smaller in surveys when he or she only has to indicate the distribution of time over the whole year.

27. Response rates are generally rather low for diary exercises covering one or several weeks. They are usually higher when respondents reply for the whole year. On the other hand, response rates are often close to 100 per cent for surveys addressed to the university institutes.

Using time-budget survey results to derive R&D cost and funding series

28. The aim of the time-budget studies described above is to obtain a base for distributing total university resources among research, teaching and other activities (including administration). These studies are therefore only the first step in establishing the R&D statistics. More or less sophisticated time-budget studies are used to derive coefficients, by means of which the R&D shares of total personnel and expenditure resources can be calculated and broken down into more detailed categories. Some countries use the results of time-budget studies more directly than those that mainly draw their R&D data from other sources (see also Topics 2 and 3 below).

29. To establish the R&D statistics for the higher education sector it is often necessary to estimate:

a) the sector's total available resources, both personnel and financial;

b) full-time equivalents for total R&D personnel, and/or for various categories of R&D staff;

c) the corresponding R&D expenditure by type of cost;

d) the corresponding R&D expenditure by source of funds.

Total resources

30. Calculations of R&D resources are based on data on total available resources by applying the R&D coefficients derived from time-budget studies or other sources. These total data, principally general university funds (GUF), may be derived from several sources:

- university accounts;
- administrative records;

- additional breakdowns made by the central administrations of the universities on the basis of general accounts and registers;

- surveys addressed to the university institutes;

- other statistical systems (statistics on public servants, general wage statistics, etc.).

31. Countries gain access to sufficiently detailed data on total resources *(e.g.* broken down by field of science) in different ways. Differences among universities within a given country may also cause variations in countries' ability to supply sufficiently detailed data to the OECD.

Full-time equivalence

32. The results of time-budget studies are used to derive countries' R&D full-time equivalents from data on total staff. Total R&D full-time equivalents can in theory be defined in at least two different ways:

- the total amount of work done on R&D by one person in one year;

- the total number of full-time R&D positions held by one person in one year, salary being the criterion: if a person receives one full-time salary and one 30 per cent salary, he or she is included as 1.3 full-time equivalents (see Chapter *5*, para. 305).

Type of costs

33. According to Sections 6.2.2 and 6.2.3 of this Manual, R&D expenditures should be broken down by current and capital expenditures, which in turn consist of labour and other current costs on the one hand, and instruments/equipment costs and land/buildings costs, on the other.

34. If no data are directly available for each of these R&D components, an estimate must be made on the basis of information on total expenditure.

35. **Labour costs** (*i.e.* salaries and related social costs) usually represent some two-thirds to three-quarters of total R&D expenditure in the higher education sector. Information on total labour costs is usually available or calculated on the basis of one or several of the following data sources:

- point on the salary scale for each researcher, technician or other member of the staff, and the scale itself;

- labour costs by category of personnel and institute;

- labour costs by category of personnel, institute, field of science, or department.

36. The coefficients derived from the time-budget studies are used directly at an appropriate level (individual, institute, department, university) to estimate the R&D share of total labour costs; if necessary, adjustments should be made to take account of various kinds of associated social security or retirement scheme costs.

37. Information on **other current costs** is usually available by institute and often concerns resources at the disposal of the institutes themselves for the purchase of items such as documents, minor equipment,

etc. The institutes are usually asked to estimate the R&D share of these costs on the basis of intended use. The part that is not available by institute (overhead costs, such as water, electricity, rents, maintenance, general administration, etc.) has to be distributed among the institutional units concerned. One method is to use the same distribution coefficients as for labour costs. The R&D shares may also be determined on the basis of conventions or on institutes' own opinions.

38. Information on total investment in **instruments and equipment** is usually available at the level of the institution. In many surveys, the R&D shares are estimated by the institutes according to the intended use of the equipment. Time-budget coefficients are probably of less use for estimating the R&D shares of instruments and equipment than for estimating various types of current expenditure. The R&D share of investments in instruments and equipment may also be based on conventions or on institutes' opinions, as for certain types of other current expenditure discussed above.

39. Information on total investments in **land and buildings** is usually available only at the level of the institute or the university. Time-budget coefficients are seldom used to estimate the R&D shares of these costs. Here again, the R&D data are often estimated on the basis of the intended use of the facilities.

40. From the above, it may be concluded that the time-budget coefficients offer the only way to estimate the R&D share of labour costs, play a significant role in estimating R&D shares of other current costs, but are of minor importance in calculating R&D investments in instruments and equipment or in land and buildings.

Sources of funds

41. Time-budget studies and other methods used to identify the R&D share of universities'total activities usually only concern general university funds (GUF), which constitute the major part of higher education R&D (HERD). University R&D projects are also financed from other sources, such as the university's "own" funds (including retained receipts) and outside funds, from other government departments, private non-profit institutions, research councils, and increasingly from industry, as well as from abroad.

42. Some of these external funds (especially funds from foundations and research councils) are not always fully included in the central accounting records of the universities. Some research contracts may in fact go directly to the university institute or individual professors. To obtain as broad coverage as possible, data on institutes' external funds have in some cases to be taken from funders' accounts (although this goes against the Manual's principle of performer-based reporting) (see Chapter 6, paras. 334 and 366-367) or should, at least, be "double-checked" with such information. Funder-based data usually give only expenditures, and the problem of acquiring the corresponding R&D personnel data is therefore a tricky one.

Topic 2: Use of coefficients to estimate R&D expenditure and personnel in the higher education sector

General

43. While surveys are the most systematic and accurate way of collecting research information, they are not always suited to the resources and/or needs of individual countries. They require a great deal of time and money and can make very heavy demands on the resources of producers of statistics. Large

countries, in particular, may find it difficult to carry out detailed R&D surveys, given their many higher education institutions and researchers.

44. In addition, the formulation of education and research policy in some countries may not require information at the level of detail available from time-budget surveys.

45. Therefore, alternative data collection methods are required to accommodate resource constraints and meet information needs. The most common alternative used in Member countries is the derivation and use of research coefficients.

Definition of research coefficients

46. Research coefficients are fractions or proportions applied to statistics describing the total resources of the higher education sector. They are derived in a number of ways, ranging from informed guesses to sophisticated models. Whatever the method used, they are a useful alternative to the more costly large-scale surveys of researchers and/or higher education institutions.

47. The accuracy of the coefficients depends on the quality of the judgement applied to their calculation; the accuracy of the resultant estimates depends on the quality of the data to which they are applied and the detail available for both data and coefficients.

Derivation of research coefficients

48. Coefficients should be prepared to match the level of detail available for the data and needed for the statistics. They may be derived in several ways, depending on the information available to the responsible statistical unit. It is essential that experienced and knowledgeable persons participate in the work.

49. A variety of relevant information will normally be available. For example, time-budget studies (as described in Topic 1) may have been carried out for part or all of the sector. Employment contracts may specify time allowed for some activities; the job descriptions of some categories of employee may provide useful input. Some institutions may have established full or partial coefficients for their own planning or evaluations; countries with similar education systems may have derived relevant coefficients.

50. Time coefficients derived for calculating overall R&D activity can sometimes be validated by comparisons with the results of time-budget surveys of other countries with similar higher education structures. Senior education staff should be asked to comment both on the coefficients chosen and on the statistics resulting from their use.

51. The use of models to derive research coefficients is a relatively new activity which results from the increased computerisation of information on the higher education sector. Different models are drawn up by applying different coefficients to weighted or unweighted higher education data.

52. For example, teaching weights and R&D ratios can be applied to total teacher and expenditure data. The most appropriate weighting system can be derived by comparing the R&D results based on the output of R&D models with the situation as it is known to exist.

Information requirements

53. To comply fully with the data requirements of the OECD international R&D surveys, respondents must supply the following information on the total resources of the entire higher education sector (as defined in Chapter 3, para. 170).

Financial data

54. This information falls into two broad categories: *i*) breakdown by sources of funds for the higher education sector; and *ii)* the associated type-of-cost breakdown.

55. Funding information requirements are:

- total general university funds (GUF) financed by government sources for the overall operation of institutions in the sector;
- other general funding of the sector, identified by source of funds;
- direct research funds paid to/received by the sector, identified by source of funds.

56. The costs need to be identified and broken down by detailed labour and other current and capital components.

R&D personnel data

57. Total higher education personnel should be identified under the following occupations/ grades:

- academic staff by grade;
- technicians;
- full-time researchers/research assistants;
- –postgraduate students supported by external research funds;
- other support staff either within the (research) unit/department or in the institution/sector as a whole.

58. In addition, the same personnel should be classified according to the discipline in which they teach and/or undertake research.

Application of R&D coefficients

59. The level of detail at which the coefficients are derived and at which sectoral information is available determines the detail and accuracy of the statistics. With the availability of spreadsheet and other computer programmes, it is both possible and useful to treat the application of R&D coefficients as a modelling exercise.

60. The main advantage of such models lies in their flexibility; they can include all aspects of the sector, such as part-time and full-time teachers, different salary scales, and the length of teaching terms as opposed to periods of student vacation. Another advantage is that the derivation of time coefficients and the calculation of R&D costs and funding can be combined in one exercise rather than be treated as several steps in a long iterative process. In addition, the agency preparing the R&D series can easily alter coefficients and assess the effects of modifications.

61. Research coefficients can be expected to vary according to the teaching or research discipline, the occupational category of the personnel directly involved in R&D, and the type of institution in which the activity is being performed. At the greatest level of detail, coefficients can be applied to the financial and personnel data of individual institutions. When this is possible, coefficients may be modified to reflect the different R&D positions of the institutions, for example, those of small liberal arts colleges, of technical universities, and of major teaching and research universities.

62. Coefficients are typically applied in stages:

- R&D coefficients applied to different categories of staff, if possible by discipline and institution, yield the FTE personnel estimates;

- these personnel estimates, converted to coefficients themselves, may be applied to financial data to provide R&D expenditure estimates.

Reporting data to the OECD

63. When reporting data to the OECD, the Member countries are encouraged to supply the total expenditure and personnel data on which the R&D data are based, together with the actual coefficients used.

Summary

64. Increased computerisation of higher education statistics provides increased opportunities for developing models of higher education R&D activity. In the future, this will probably result in greater use of research coefficients to estimate R&D statistics.

65. The results of time-budget surveys in other Member countries can also be used as a basis of model-building and for checking the validity of results obtained using coefficients.

66. Future developments in this area should aim to be as objective as possible and should rely less and less on the subjective assessment of optimum coefficients by researchers, thus minimising any inherent bias in the data.

Topic 3: Use of central administration data as a source when establishing R&D data for the higher education sector

General

67. The role of central administrations varies from country to country and from level to level– nationally at the Ministry of Education, regionally, locally, or within the higher education institute itself.

Regardless of location, such centres usually have a vast quantity of information resulting from their administrative activities.

68. The producer of R&D statistics whose data is based on R&D coefficients is always seeking ways to improve the accuracy of the statistics, while those carrying out time-budget surveys are always trying to lower the response burden of respondents. The information held by central administrations, while generally not specifically related to R&D, is a useful source of overall data from which R&D data can be extracted using either estimated coefficients of R&D or R&D coefficients drawn from time-budget surveys.

Availability of information

69. The information held by central administrations in their files varies according to the function of the particular administration. Ministries of Education may have very broad overall information, while the finance officers of higher education institutions may have income and expenditure information associated even with individual researchers and other staff.

70. Information making it possible to identify disciplines/fields of science separately may require information at the researcher level within a large institution carrying out research in many disciplines or at the level of the institution if its R&D is confined to a single field of science.

71. R&D statisticians need information on two main categories – financial and personnel.

Financial information

- •*Costs associated with R&D*

72. Information needs on R&D costs follow the data requirements of the OECD international R&D survey questionnaire:

- labour costs;
- other current costs;
- instrument and equipment costs;
- land and buildings costs.

73. In particular, producers of R&D statistics often find it difficult to ascertain the cost of land and buildings associated with R&D activity. The accounts of central administrations are a useful source of information in this regard, but the problem of determining how much of that cost is attributable to future R&D activity remains.

74. Cost information is usually available for total activity within the higher education sector at a level of disaggregation consistent with the functions of the administration.

- •*Sources of R&D funds*

75. Central administrations usually have information on the overall disbursement of general university funds (GUF) to individual institutions and often, within those institutions, to individual departments or even researchers.

76. Identification and quantification of the sources of other R&D income depend on the detail of the accounts kept by central administrations. Generally, some record is kept of monies paid to the higher education institution for R&D, which are easily classified by source of funds.

77. Regulations concerning the freedom of researchers to carry out research on a consultancy basis as part of their overall work-related activity vary from country to country. Payments for such research may not be captured in the accounts of central administrations and care has to be taken to ensure their inclusion when calculating overall R&D expenditures by type of costs and source of funds.

R&D personnel

78. Employment records are part of the information base of most central administrations, so that full and accurate staff numbers are usually available for the higher education sector as a whole. These figures are usually broken down by occupation and are thus an extremely useful input for determining numbers of R&D personnel.

79. If, however, research personnel are employed directly by a researcher and paid directly from external research grants administered by him/her, then there may be no record of such employees in the central administration files. Therefore, if centralised information is being used, a good understanding of the employment mechanisms in the higher education sector, and further information may have to be obtained to supplement central records.

Using central administration information to derive R&D data

80. In order to use central administration information, coefficients of time spent on R&D by staff in higher education institutions must be available. As already indicated in Topic 2, these coefficients can be the results of a time-budget survey (see Topic 1), the opinions of experts in the area, or the outputs of models of research activity. The coefficients are then applied to global data supplied by the central administration to derive the share of higher education statistics that is attributable to R&D.

Derivation of R&D costs

81. The detail of the R&D data depends on the level of disaggregation of the central data and the coefficients being used. The more disaggregated the coefficients and the sectoral data, the greater the accuracy of the R&D costs. R&D labour costs can be derived by applying the research-time coefficient to the total labour cost, possibly even at the level of various categories of staff.

82. It is frequently assumed made that consumption of other current and equipment costs for R&D purposes is directly proportional to the amount of time academic staff spend on R&D. If this assumption is accepted, then the R&D-time coefficient of academic staff can be applied to other current and equipment costs to derive their R&D component (see also Topic 1, paras. 37-3 8).

83. The derivation of the R&D component of land and buildings costs may be more subjective and is fraught with the difficulties outlined in Chapter 5 of the Manual and in paragraph 39 of this annex.

Sources of funds

84. R&D-time coefficients can be applied to general university funds (GUF) to derive the R&D component of these funds. Other sources of research funds are not subject to any proration or further analysis when they are available directly from central administration files (see Topic 1, paras. 41-42).

R&D personnel

85. The derivation of R&D personnel from central data sources is not necessary if a full-coverage time-budget survey is carried out as described in Topic 1. If coefficients of research time are the only source of R&D information, then the coefficients must be offered to a full breakdown of higher education personnel (see para. 7 above).

86. The level of detail of R&D personnel data depends entirely on the disaggregation of both the time coefficients and the available personnel data.

Using central administration data

Advantages

87. There are several advantages to collecting the data of central administrations as part of an overall R&D data collection exercise:

- the data are consistent and unambiguous;
- there is no double-counting of parameters;
- the data apply to a specific period;
- with increased computerisation the data are easily accessible;
- the data form a useful input to the iterative processes in model building;
- use of data from secondary sources lowers the response burden on survey respondents.

Limitations

88. There are also, however, some limitations to such data, some of which, if not taken into account, could lead to inaccuracies in the final R&D statistics:

- the data may not be complete in terms of coverage of costs, sources of funds, and personnel specific to R&D activities;
- the data are usually available at a very aggregate level;
- the R&D component of general higher education statistics is not identified separately.

Future potential for the use of central administration data

89. As more and more higher education statistics are computerised, it will become easier for R&D statisticians to use this information to supplement and complement routine R&D data-gathering exercises. It is generally the case that while central administrations are not very interested in the derivation of R&D data, they are often interested in the results. Therefore, they are usually willing to co-operate in R&D data collection and to make their information available to R&D statisticians.

90. Wherever possible, central administration data should be used by the producers of R&D statistics:

a) to reduce the burden of response on survey participants;

b) to double-check the data collected from the R&D-performing institutes.

Topic 4: Accounting for R&D expenditure by sources of funds

General

91. Funds for higher education sector R&D come from many different sources. The main source in most Member countries is traditionally a proportion of the publicly funded block grant known as public general university funds (GUF) which higher education institutions receive to support all activities. In addition, R&D funds are received in the form of grants or contracts from other sources such as ministries, departments, and other public institutions, including research councils, from private non-profit institutions, and, in recent years, increasingly from industry and from abroad. Some universities may also have "own funds" (such as income from endowments, etc.).

92. Higher education institutions are looking increasingly to outside sources to compensate for absolute cuts or levelling off of traditional GUF resources. In particular, research links with mission-oriented ministries and industry are being intensified, and non-GUF resources will ultimately contribute an increasing share of total expenditure. Such links with outside organisations may or may not be formally identified in the accounts of the institutions and are therefore difficult to quantify in the collection of R&D statistics. Furthermore, these transfers of resources may be in kind (in the form of equipment and materials) rather than in money, thus creating additional measuring difficulties (see Chapter , para. 374).

93. Accounting procedures will therefore largely determine how well the sources of R&D income can be separately defined and identified. Producers of R&D statistics are dependent on the detail available in such accounts.

94. A further complication in identifying the sources of research income is the fact that outside organisations do not always pay the "full market cost", however defined, of the R&D carried out for them in institutions of higher education. It has been suggested that the difference between the amounts received and the "market cost" should logically be credited to GUF or to "own funds" as a supplementary source of finance to cover a "fair contribution" of institutional overhead costs.

95. Some estimation of the amount of money spent on contract research in higher education institutions can also be obtained from information on extramural expenditure on R&D to the higher education sector reported by other sectors. However, this procedure does not conform to the logic of this Manual, which advocates the collection of data from performers of R&D, not from funders and cannot be used for funds from abroad.

96. Problems of accurate coverage of R&D funding sources are common to all Member countries, but the main area of international incomparability lies in distinguishing between general university funds (GUF) and other sources of R&D income.

Separation of general university funds from other funding sources

97. Most governments allocate block grants to the higher education sector. These are usually administered through the Ministry of Education or other ministries (such as Agriculture, Health, etc.) concerned with third-level education and are designated to cover all costs associated with the running of these institutions – salaries of staff, other current costs, and building and equipment costs.

98. The different activities of staff in higher education institutions – teaching, R&D, administration, health care, etc. – are not specifically identified for separate payment from these grants, which, in a general way, cover the payment of all work-related activities.

99. Some of the problems of identifying what part of these grants is attributable to R&D have already been discussed in Topics 1-3 (see paras. 41, *55* and 84). This identification process is an intrinsic part of the survey methodology employed in each country. Inconsistencies arise because different countries classify the R&D component of these general university funds (GUF) differently.

100. Options for classifying such public funds at the sectoral level are:

- general university funds (GUF);
- sector's own funds;
- direct government funds.

General university funds (GUF)

101. A separate category of GUF has been defined for the higher education sector to take account of the unique funding mechanisms for R&D, as compared to other sectors. Most Member countries are of the view that, as R&D forms an intrinsic part of the activities of higher education institutions, any funds allocated to a third-level institution have an inbuilt and automatic R&D component. On this interpretation, such funds are classified as general university funds (GUF). In adding up national totals these data are usually included in subtotals of public finance on the grounds that "as government is the original source and has intended at least part of the funds concerned to be devoted to R&D, the R&D content of these public general university funds should be credited to government as a source of funds", and this is the approach recommended for international comparisons [Chapter , para. 381*c*)].

102. 1GUF should be separately reported and adjustments to the R&D cost series should take account of real or imputed social security and pension provisions, etc., and be credited to GUF as a source of funds.

"Own" funds

103. In their national publications, a few countries continue to classify the higher education block grant of public origin not as GUF but as "own funds", arguing that "it is within the universities that ... the decisions are taken to commit money to R&D out of a pool which contains both 'own funds' ... and public

general university funds; therefore, the sums concerned should be credited to higher education as a source of funds” [Chapter 6, para. 381*c*)].

104. In this situation, the “own funds” category is a significant source of funds for R&D, which will be credited to higher education and not included in public sources when adding national totals.

105. Other monies produced by the sector should be considered as “own funds” [Chapter 6, para. 381*b*)].

106. Although national accounting practices will dictate how easily they can be identified, such R&D income (“retained receipts”) can, notably in the case of private universities, be a considerable source of income and should undeniably be classified as “own funds”.

Direct government funds

107. In addition to the government sector being attributed GUF R&D funds, it also provides money for higher education R&D in the form of earmarked research contracts or other research grants. This source of research income is more readily identified and does not, in general, pose major problems for the producers of statistics, in its classification as a direct government source of funds.

108. Adjustments related to “other current costs” to account for real or imputed payments of rents, etc., should be credited to the category of direct government funds (see Sections 6.2.2.3.1 and 6.3.3.3 of the Manual).

Conclusion

109. To obtain the best possible international comparability of higher education R&D statistics, it is preferable to disaggregate the sources of funds as much as possible; this largely depends on the availability of information from central accounting records in the institutions of higher education.

110. The main problem of international comparability occurs when data for general university funds (GUF) are not separately reported and are classified by different countries either with the higher education sector’s “own funds” or with the government sector.

111. Therefore, public general university funds (GUF), insofar as possible, should be reported separately; if this is not possible, the corresponding funds should be included in “funds from the public sector” and not in the higher education sector’s “own funds” or “other higher education funds.

ANNEX 4

SOFTWARE ISSUES

The reader should refer to Chapter 1, paragraph 7 of the Manual for a comment on the use of this annex before proceeding further.

Coverage of software R&D

1. This is an indicative list of the possible R&D elements in the broad areas of software development.

12. 1. Theoretical computer science	Generally, technological or scientific advances in this are a produce new theorems and algorithms. As in any scientific or technological endeavour where uncertainty exists, some R&D activities are expected to give negative results.
2. Operating systems	Technological advances consist in: *i)* a technological improvement in resource and interface management; *ii)* a truly new operating system; or *iii)* the conversion of an operating system to a significantly different hardware environment. In disputed cases, an assessment of what is “significantly different” needs to be made by computer scientists with experience in the particular area in question.
3. Programming languages	Technological advances are: *i*) new languages; *ii)* significant extension of an existing language; and *iii)* new or significantly different language translators
4. Applications	In addition to the situations previously discussed, technological advances may occur when a development represents a significant technological step forward (*e.g.* and *iii*) new combinations of established computer programme components or known programming principles), provided that this integration requires the resolution of technological uncertainties.
5.Data management	Technological advances include the development of: *i)* algorithms to achieve significantly better basic operations *(e.g.* retrievals from a database); *ii*) new or enhanced query languages for databases that significantly increase the power or search or manipulation capabilities; and *iii)* new object representations or data structures.
6. Software engineering	Advances in the methodology required to construct computer programmes with greater flexibility, efficiency, reliability, and ease of maintenance.
7. Artificial intelligence	Scientific and technological advances are made in such domains as machine vision, robotics, inference, knowledge representation, expert systems, theorem proving, understanding of natural language, automatic language translation, logic programming, and future generation systems. Most areas of AI do not yet have an established practice; however, the attempt to resolve a technological uncertainty must be demonstrated as a basis for establishing the eligibility of expenditures. Frequently in this area, the existence of any kind of solution will reflect this indeterminacy.

Treatment of software expenditures in R&D surveys

2. The following table shows the current treatment of software expenditures. It should be noted that this may change once the revised UN System of National Accounts (CEC *et al.* 1994) applies, as a much larger proportion of software expenditures will be considered as capital expenditures.

Accounting for the acquisition and customising of software in R&D expenditure surveys

R&D cost classes

	Intramural				Extramural
	Current		Capital		
Types of software acquisition	Labour costs	Other current costs	Instruments and equipment	Land and buildings	
Purchase of packaged software		X	*1		
Package of software with hardware		*2			
Customised software bought as service		X			*3
Software customised by specialist and supplied with hardware		*2	X		*3
Software customised in house	*4	*5			
New software developed in house	*4	*5			

X = Probable.

* = Possible.

1. If value exceeds the minimum cost for capital expenditure.
2. If not bought specifically for the R&D project but charged to R&D as part of general costs of computer provision and support.
3. If contract recognises that “scientifically and/or technologically novel” software is to be developed by the servicing company.
4. If customised/developed by persons working directly on the R&D project.
5. If customised/developed by computer department and charged as part of general costs of computer provision and support.

ANNEX 5

SOCIAL SCIENCES AND HUMANITIES DEFINITIONS

Distinction between basic and applied research and experimental development

1. The boundary between basic and applied research and experimental development is difficult to determine for all fields of science. The problem is accentuated in the social sciences and humanities, where the same research project may often straddle more than one type of activity.

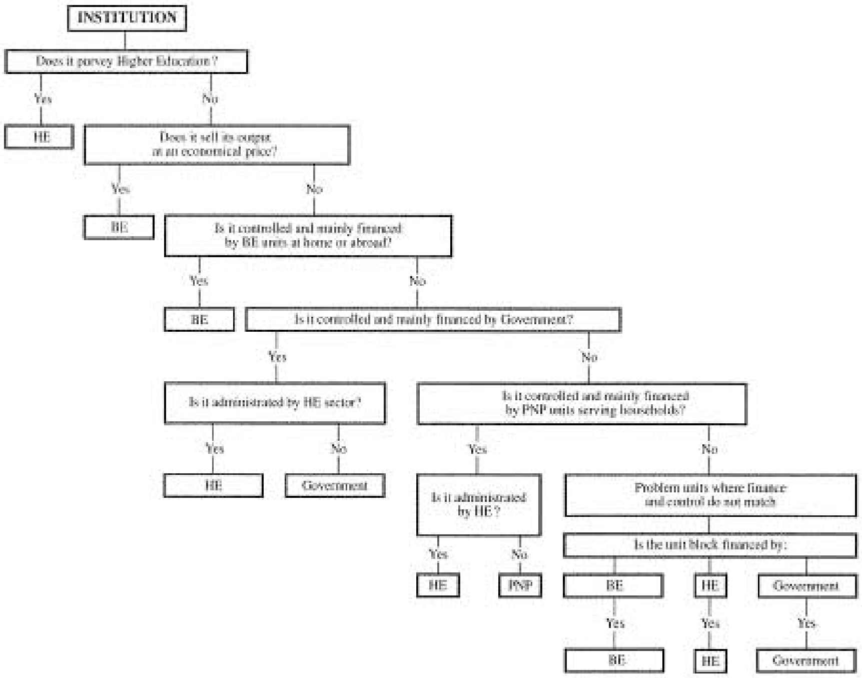
2. Section 4.2.3.2 of the Manual gives examples of different research topics and how they should be classified. The following table, which is extracted from the UNESCO *Manual for Statistics on Scientific and Technological Activities* (1984*c*), gives further examples on distinguishing between the three types of research in the social sciences.

The three types of research in the social sciences

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
2. Study of the social structure and the socio-occupational mobility of a society, *i.e.* its composition and changes in socio-occupational strata, social classes, etc.	Development of a model using the data obtained in order to fore-see future consequences of recent trends in social mobility	Development and testing of a programme to stimulate upward mobility among certain social and ethnic groups
3. Study of the role of the family in different civilisations 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 programme to maintain family structure in low-income working groups
4. Study of the reading process in adults and children, *i.e.* investigating 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 government foreign trade policy	
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 translating from or into that language	
7. Study of the historical develop ment of a language		
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 an individual, etc.)		

Annex 6

Decision Tree for Sectoring R&D Units



ANNEX 7

KEYS BETWEEN R&D PERSONNEL CATEGORIES IN THE FRASCATI MANUAL AND ISCED AND ISCO-88

The reader should refer to Chapter 1, paragraph 7 of the Manual for a comment on the use of this annex before proceeding further.

Table 1. Standard key between ISCED levels and "Frascati" classes for R&D personnel by formal qualifications

The International Standard Classification of Education (ISCED) (UNESCO, 1976) comprises seven categories of education based upon three levels plus a residual category for education not defined by level. Note that levels 4 and 8 have not been used

Levels	Level categories	General coverage	OECD R&D personnel categories
	0..Education preceding the first level	Pre-primary	Not relevant
I	1 Education at the first level	Primary	Other qualifications
II	2 Education at the second level, first stage	Secondary	
	3 Education at the second level second stage		Holders of diplomas of secondary education
III	5 Education at the **third level**, first stage, of the type that leads to an award not equivalent to a first university degree	Post-secondary	Holders of other post-secondary diplomas
	6 Education at the **third level**, first stage, of the type that leads to a first university degree or equivalent		Holders of university level degrees at less than PhD level
	7 Education at the **third level**, second stage, of the type that leads to a postgraduate universal degree or equivalent		Holders of university degrees at PhD level
	9 Education not definable by level		Other qualifications

Table 2. Correspondance between “Frascati” categories of R&D personnel by occupation and ISCO–88 classes

The International Standard Classification of Occupations (ISCO) (ILO, 1990) consists of ten major groups at the top level of aggregation, subdivided into 28 sub-major groups (and 116 minor groups and 390 major unit groups)

“RESEARCHERS” – ISCO-88 CLASSES (sub-major and minor groups):		
21	**Physical, mathematical and engineering science professionals**	
	211	Physicists, chemists and related professionals
	212	Mathematicians, statisticians and related professionals
	213	Computing professionals
	214	Architects, engineers and related professionals
22	**Life science and health professionals**	
	221	Life science professionals
	222	Health professionals (except nursing)
23	**Teaching professionals**	
	231	College, university and higher education teaching professionals
24	**Other professionals**	
	241	Business professionals
	242	Legal professionals
	243	Archivists, librarians and related information professionals
	244	Social science and related professionals
plus	Unit group 1237	
	Research and development department managers	
“TECHNICIANS AND EQUIVALENT STAFF” - ISCO-88 CLASSES (sub-major and minor groups):		
31.	**Physical and engineering science associate professionals**	
	311	Physical and engineering science technicians
	312	Computer associate professionals
	313	Optical and electronic equipment operators
	314	Ship and aircraft controllers and technicians
32	**Life Safety and quality inspectors science and health associate professionals**	
	321	Life science technicians and related associate professionals
	322	Modern health associate professionals (except nursing)
plus	Unit group 3434 **Statistical, mathematical and related associate professionals**	
“OTHER SUPPORTING STAFF” – ISCO-88 CLASSES (major groups):		
4	**Clerks**	
6	**Skilled agricultural and fishery workers**	
8	**Plant and machine operators and assemblers**	
plus	Minor group 343	
		Administrative associate professionals (except Unit group 3434)[1]
1	**Legislators, senior officials and managers n.e.c.**	

1. Statistical, mathematical and related professionals (here included in “technicians and equivalent staff’).

ANNEX 8

R&D FUNDING IN THE MANUAL AND IN STUDIES OF GOVERNMENT SUBSIDIES

1. The OECD is in the process of preparing a set of concepts and methodologies on the measurement of government subsidies to industry, including subsidies for R&D (see also OECD, 1992*a*). This annex explains some of the concepts and problems involved. **The reader should refer to Chapter 1, paragraph 7 of this Manual for a comment on the use of this annex before proceeding further.**

The net budget cost of government aid to industry

2. R&D performers in the business enterprise sector cannot calculate the total cost of government aid to industry, since the Manual recommends taking account only of funds actually transferred and used for the performance of R&D. This recommendation excludes from the coverage certain forms of support that use different financial instruments, such as loans and loan guarantees, interest-rate subsidies, and the whole battery of tax incentives. While most of these forms of aid are non-monetary, they do have a cost to governments, one which is never taken into account by performers. As a result, the actual contribution of government to the industrial R&D effort is underestimated.

3. Since firms are not in a position to estimate the cost, the authorities have to develop appropriate methods for doing so. The following recommendations propose a new method of analysing budget data as a way to measure the actual cost to government of all support to industry.

4. This method, which can be applied only at the end of each budget year when all the tradeoffs and adjustments have been made, also measures some of the economic effects of government support.

5. The first step is to identify government funds intended for the business enterprise sector. This is not always known in advance since significant sums may be paid to intermediary institutions which act as government agents in implementing countries' industrial policies. Given that these institutions enjoy a degree of autonomy, they can amplify the effective impact of the aid programmes by topping up the budget resources allocated by government with other sources of funding. Co-ordination with these intermediary institutions is therefore essential.

6. A second step is to classify the various forms of aid by:

a) policy objective;

b) managing structure;

c) financing instrument;

d) economic costs.

7. In the case of government subsidies for R&D in the business enterprise sector, the most significant categories of interest in the present context are the financing instruments used, in terms of the net cost to government.

Financing instrument

8. The following five instruments may be identified:

- grants or non-repayable advances;
- interest-rate subsidies;
- loans;
- loan guarantees;
- equity participation.

9. The following tax concessions should be identified:

- tax concessions (amounts excluded from the tax base);
- tax allowances (amounts deducted from gross income);
- tax credits (amounts subtracted from tax liabilities);
- special rate reliefs (reduced rates for certain activities);
- tax deferrals (amounting to interest-free loans);
- accelerated depreciation;
- tax-free purchase of equipment.

Net cost to government

10. Government funding of industrial R&D comprises two types of expenditure: **direct budget expenditure** resulting from the various financial instruments (grants, repayable advances, loans, loan guarantees, equity capital) and **tax expenditures** representing the loss in budget revenue when compared with a situation in which tax was paid without relief; these are amounts that are not payable (or of which payment is deferred), primarily for reasons of aid to industry. From an accounting as well as a economic standpoint, this tax exemption corresponds to a government transfer.

11. Direct budget expenditures and tax expenditures constitute gross government budget expenditures. These do not include budget receipts from the same R&D programmes, *i.e.* guarantee premiums, loan interest, debt repayments, and dividends on government shareholdings. The amount of these receipts is generally small by comparison with expenditures, but it is not insignificant and varies considerably across programmes.

12. Gross budget expenditures have, however, three major drawbacks:

- because of the heterogeneous nature of the financial instruments used, it is impossible to
- aggregate the amounts pertaining to each;
- they do not give an estimate of the subsidy element and the net cost to government;
- the volume of aid cannot be compared internationally.

13. To obviate these problems, the net cost **to government** of each instrument used must be calculated as follows:

The instrument

Grants	The net cost is the amount actually paid out in any year. If some grants are reconverted to loans and paid back, in part or fully, the amount is deducted.
Interest-rate subsidies	These are considered as grants.
Loans	The net cost of loans is arrived at by using the formula: VLO = (LS.rg) – IR + CL where VLO = the net cost of the loan LS = outstanding loans at year end Rg = the interest rate[1] IR = interest payments received during the year CL = capital losses.
Loan guarantees	The net cost of guarantees is equal to: VGU = CP-FR-RC where VGU = the net cost of guarantees CP = claims paid during the year FR = fees received RC = recoveries
Equity capital	The net cost of equity is equal to: VEQ = (C.rg) - B + D where VEQ = equity capital C = outstanding equity participations rg = the interest rate (see loans) B = dividends received during the year D = write-offs of capital stake owned by government
Tax expenditures	Responses should specify: – The type of tax concerned *(e.g.* value-added tax,[2] salary tax, etc.). – The way the tax expenditure was determined *(i.e.* revenue foregone by comparison with hypothetical legislation without relief). – If tax payment is reduced but due on time, the expenditure can be treated as a grant, for quantification purposes. If tax payment is delayed, the concession can be considered to be an interest-free loan.

The subsidy element

Grants	Grants contain a very high subsidy element. If no income tax is payable, the subsidy is 100 per cent; otherwise, it is 100 per cent minus the marginal tax rate.
Interest rate subsidies	The subsidy element is the difference between the terms of government loans and those prevailing on private financial markets.
Loans	The subsidy element in government loans is above all the difference between government interest rates and those available on the private market, but there is also the cost of the non-requirement of a mortgage and that of deferring payment without any penalty.

Loan guarantees	The subsidy element included in government guarantees is the difference between any premiums received by the government and the amount that would have been charged for such guarantees on the private loan insurance market (a market which in certain countries does not exist). There are some difficulties involved in making this calculation, and conventions have to be used.
Equity capital infusions	The subsidy element in equity funding varies greatly both among countries and within a given country. In one approach, the subsidy would be constituted by the difference between the income (in dividends and capital gains) obtained by the government from any given industrial investment and the average income obtained over the same period by a representative portfolio of private shares in industry. Obviously, this calculation gives rise to major methodological difficulties. It is no easy matter to estimate the value of government corporations not listed on the stock exchange, or their rates of return. Also, government policies regulating the markets in which government corporations operate (monopolistic, oligopolistic, competitive market regulations) directly influence the profitability and capital value of such corporations. The complexity of the problem calls for a fairly sophisticated method of calculation.
Tax concessions	The subsidy element in tax expenditures is hard to evaluate except when it can be bracketed with direct subsidies. The accumulation of several tax benefits by an individual firm may nullify the effect of certain exemptions. For this reason, for tax concessions that cannot be likened to direct subsidies, special methods will have to be developed in order to calculate the subsidy equivalent.

Notes

1. The interest rate to be used for loans and equity participation is the government borrowing rate. More precisely, the nominal GBR (government borrowing rate) should be applied and the precise rate calculated by taking the average rate on new government borrowing during the year, weighted by the size of individual loans.

2. The treatment of value added taxes varies from one country to another.

Annex 9

Practical Methods of Providing Up-to-date Estimates

and Projections of Resources Devoted to R&D

The reader should refer to Chapter 1, paragraph 7 of this Manual for a comment on the use of this annex before proceeding further.

The demand for projections of R&D data

1. Surveys are the most accurate means of measuring scientific and technological activities. However, due to their complexity, there is some delay between R&D performance, the collection of data, and their publication, and there is thus an increasing demand for forecasts. Both policy makers and users in general desire projections of those indicators most useful for defining, evaluating, monitoring or introducing science and technology programmes and policies.

Types of projections covered

2. A distinction must be made between short-term, medium-term and long-term projections. The issue of medium-term and long-term forecasts (which may be described as prospective analysis) will not be addressed here. This annex only deals with short-term projections and with attempts to estimate the values of a few variables for very recent years or to make provisional estimates for the current year, when survey results are not yet available.

Objective

3. This annex aims to identify methods and guiding principles for forecasting and projecting the values of the variables concerned, without seeking to lay down a set of universally applicable methods (or procedures). The special characteristics of individual countries, and indeed sectors, each with its own determinants and pace of change, militate against the adoption of standard procedures. Here, following some comments on the most frequently used methods, a few basic guiding principles will be presented.

The variables

4. Projections are most often made for:

- R&D expenditures;
- R&D personnel;
- technologies.

5. Given that there is an element of value judgement in projections concerning technologies, no recommendations will be made on this topic.

6. The greatest demand is for indicators of recent and future trends in R&D expenditure, specifically:

- total national R&D expenditure [especially gross domestic expenditure on R&D (GERD) as a percentage of the gross national product (GDP)];

- R&D expenditure by sector.

7. Nevertheless, projections of R&D personnel can play a particularly valuable role in forecasting, as these series are usually less volatile than expenditures.

8. The variables discussed are not necessarily interdependent but, where they are, careful note should be taken of the relationship, in order to check forecasts for coherence (see para. 20 below).

Projection methods

Extrapolation techniques

9. Extrapolation techniques are used with time series for which R&D variables are normally available on at least a biennial basis. Variations are usually analysed using suitable functions *(e.g.* polynomial or exponential functions).

10. When a large number of years are taken into account, it is easier to identify dominant trends and there is a better fit. However, analysis of the more recent years may indicate "new" trends or changes in the system. Constant prices should be used in order to clarify the trends.

Proportional projection

11. Whenever a proportional relation is believed to exist between two variables ,the following procedure should be adopted:

- the existence of the proportional relation is verified by empirical observation, by use of correlation/regression techniques, or by use of a model;

- the proportional coefficient is calculated;

- the later values for the independent variable are obtained (by extrapolation or from another source of information);

- the proportional coefficient is applied to this independent variable to derive the other, dependent, variable.

12. Unless countries are undergoing rapid structural change, this procedure can be used, for example, to estimate total R&D expenditure as a share of GDP.

13. It may also be possible to use this technique to make projections of R&D expenditure or personnel for individual sectors if suitable independent variables for which forecasts are available can be found, for example in national accounts, labour force statistics, or other economic sources.

Growth rates

14. Indications of proposed or expected growth may be available for some of the better known variables, especially for recent years and the current year. This is most likely to be the case for R&D expenditure or personnel of a particular sector. For example, company plans can be a useful input to forecasts of R&D spending or personnel in the business enterprise sector.

15. Expert opinion can also be of great help in the accurate forecasting of sectoral trends. Quite apart from their direct usefulness, such contributions often provide information of a qualitative, and sometimes circumstantial, nature.

Reports of R&D funders

16. While R&D data obtained from performers are generally recommended as being more reliable than those supplied by funders, data from funders are often available more rapidly and can make a valuable contribution to projecting some variables for the public sector. Government budget appropriations or outlays for R&D (GBAORD) data can often be used to construct provisional estimates for R&D carried out in the government sector and in some cases the higher education sector [using the budget forecasts of general university funds (GUF)]. GBAORD data are of less use for projecting R&D spending in the private non-profit (PNP) and especially in the business enterprise sector, as accurate figures on extramural R&D payments to these sectors can rarely be obtained from government budgets.

17. In countries where there are linked reporting procedures for GBAORD, government intramural and extramural R&D, and ultimately GERD, this approach can be quite reliable. Where GBAORD is prepared separately and only for appropriations without subsequent reporting of final outlays, it is much less accurate. Consequently, government budgets, though an important aid in estimating certain variables, must be used with caution.

18. Those reports of non-public R&D funders should also be taken into account, notably of national funds (*e.g.* charities for medical research in the case of funding by the PNP sector) and international organisations. Any major changes in their funding behaviour may cause a discontinuity in the R&D expenditure series.

Coherence and validity of projections

Dispersion of projections

19. Application of a single projection method may produce values for subcomponents which do not add to the projected total (for examples extrapolation of R&D spending in the four sectors of performance and of GERD). Use of several projection methods will yield several values for the same variable.

20. These should first be tested for coherence and plausibility, for example by viewing trends in derived indicators, such as R&D expenditure per researcher. Once any implausible results are excluded, averages, possibly weighted averages, have to be calculated unless the spread is too wide.

21. It is recommended to indicate the interval, as this makes it possible to measure the discrepancies among projections obtained by different methods.

Verifying the projections retrospectively

22. If projections are made regularly, for example for annual or biennial S&T indicators reports, the retrospective R&D survey results should be used when they become available to check the forecasts, identifying successes and inaccuracies and the reasons for both.

Guiding principles

23. As previously noted, the special characteristics of different countries and sectors make it impossible to select a simple methodology and recommend its use without attention to context (particularly the performing sector concerned). Flexibility is needed with regard to the use of different methodologies, and composite approaches are acceptable and very often necessary.

24. Ideally projections would be carried out in the various Member countries using a single agreed projection technique. Since this is not yet feasible, it is essential that Member countries, when publishing the results of their projections, provide relevant documentation on how results have been obtained, regarding:

- variables;
- methodologies;
- hypotheses;
- special circumstances.

25. Compliance with this recommendation is vitally important in order to safeguard international comparability of the forecasts made by Member countries and reported to the OECD for inclusion in its databases and publications.

Other guidelines

26. The ideas presented in this annex are drawn from a paper prepared by Professor F. Niwa of the National Institute of Science and Technology Policy, Japan, for the Expert Conference to Prepare the Revision of the Frascati Manual for R&D Statistics held in Rome in October 1991. The paper presented a framework, guidelines and methods for conducting R&D projections; it suggests methods for projecting R&D expenditures at national and sectoral levels, R&D personnel, and new technologies.

ANNEX 10

R&D DEFLATORS AND CURRENCY CONVERTERS

The reader should refer to Chapter 1, paragraph 7 of this Manual for a comment on the use of this annex before proceeding further.

Introduction

1. This annex examines special methods for deflating and converting data on R&D expenditures expressed in national currencies at current prices to a numeraire currency.

2. Both these issues involve adjusting R&D expenditures for differences in price levels over time (*i.e.* intertemporal differences) and among countries (*i.e.* interspatial differences). In the case of deflators, the price differences are intertemporal, and the question is clearly of interest both in individual countries and for international comparisons of changes over time.

Deflation and currency conversion in the OECD's international R&D statistics

3. As far as possible, the same methodology should be used for both deflation and conversion In the absence of a full set of R&D deflators and R&D converters for all Member countries, Manual (para.35*)* recommends the use of the implicit gross domestic product (GDP) deflator and GDP-PPP (purchasing power parity for GDP), as this provides an approximate measure of the average real "opportunity cost" of carrying out the R&D.

Special R&D deflators and currency converters

4. The implicit GDP deflator and GDP-PPP are, respectively, output-based intertemporal and interspatial deflators. This annex suggests a way to establish special R&D deflators and PPPs either by compiling price indices using data from price surveys of R&D (input) expenditures or by combining proxy prices or price indices.

5. In the case of currency converters, the issue principally concerns international comparisons, including, of course, comparisons of growth-rate estimates. However, the choice of currency converters becomes relevant when examining sectoral or other breakdowns of R&D or when it is necessary to take account of relative international variations in price levels in order to compare R&D with other economic variables. For example, an estimate of R&D expressed as a proportion of GDP, even if both quantities are deflated to "constant prices' using appropriate national price indices, is still affected by differences in relative price levels of R&D activities and all productive activities *(i.e.* GDP), as compared to some international average. In other words this ratio may be affected by whether it is relatively expensive or inexpensive to perform R&D, as compared to other activities.

The need for R&D deflators

6. R&D deflators are justified if it is believed that the cost of R&D has moved in a way that is significantly different from general costs and/or if trends in the cost of R&D have varied considerably among sectors or industries. In general, over the long term, it is reasonable to suppose that the implicit GDP (output) deflator would tend to increase less rapidly than a "true" R&D (input) deflator because of productivity increases.

7. The optimum solution is to calculate special R&D deflators based on weights and prices that are specific to R&D. The cost and complexity of carrying out the price surveys needed for this exercise rules it out except for specialised analysis. The most common approach is to use weights derived from R&D surveys combined with proxy prices.

Past OECD and national efforts

8. Work at the OECD was originally governed by five guidelines laid down in the third edition of the Frascati Manual (OECD, 1976):

- deflators should be produced for homogeneous sectors of the economy, whether or not these correspond with the existing sectoral approach;
- they should be of Laspeyres form;
- in view of the relative importance of manpower in R&D activities (almost 50 per cent of expenditure) they should receive special attention;
- practical characteristics of this work should take precedence over theoretical niceties;
- the best possible use should be made of existing sources of information."

9. During the 1970s Member countries and the OECD Secretariat were active in this area, particularly in preparing deflators for the business enterprise sector. National experts presented papers on their experience at various meetings. Some of the methodologies were very detailed, but most broadly followed the same lines as the 1967 to 1975 (OECD, 1979).

10. In consequence, a special Chapter was included in the fourth edition of the Frascati Manual (OECD, 1981). It described some fairly simple ways of calculating R&D deflators, using weights derived from R&D surveys and proxy prices derived from various national or international sources. The methods were presented as examples for the business enterprise sector in an imaginary country rather than in technical form. Three methods were explained and illustrated:

- applying a composite index number to all expenditures using fixed weights;
- as above, but using changing weights;
- applying separate price indices to the individual expenditure items within subclasses of a sector.

Further details were given on the preparation of sub-weighted indices for labour costs. A technical presentation of the calculation of R&D deflators was included as Annex 4.

Selection of the index-number formula

11. The recommendation to use the Laspeyres formula needs re-examination. Hill (1988) has pointed out that theoretical advances in the past decade have shown that the index number formulas in common use (Laspeyres, Paasche, etc.) have weaknesses with important consequences for economic analysis and policy making based on the results of the deflation process. He argues for the use of chain indices, which have attractive properties from both the theoretical and practical viewpoint and highlight the biases of conventional fixed-weight indices of the Laspeyres or Paasche type.

12. Deflation essentially involves a comparison between situations at two different points of time. The tendency of Laspeyres and Paasche indices to diverge ("index number spread") over time is well known. A chain index should be used when the two situations being compared are dissimilar and when the linking can be achieved by passing through an intermediate point. Ideally, the intermediate situation would be one in which the pattern of relative prices would be approximated by some average of the relative prices in the two situations being compared. In such a case, chaining would reduce the index number spread (between Laspeyres and Paasche).

13. Why chaining? In the real world, the problem faced by the compilers of index numbers is that some commodities are only found in one of the two situations. The quantity vector is always complete (its elements are positive or zero). However, there are many missing prices *(i.e.* missing commodities), and it is impractical to suggest estimating shadow prices on a large scale, as old products disappear as a result of obsolescence and new products appear as a result of technological progress. This is particularly true of the commodities likely to be included in R&D price indices.

14. The further apart the periods are, the greater the problem. The proportion of total value of the expenditures in the two periods actually covered by direct price comparisons decreases. Insisting on direct comparisons between the two periods means accepting that price relatives can be compiled only for a small proportion of the expenditures in both periods (in addition, the index number spread between the Laspeyres and Paasche indices will also tend to be very large).

15. If a chain index is used, and the amount of usable price information is greatly increased, and this is true at each link. It is also true that the amount of price information actually used from the first and last periods will be far greater.

16. If the evolution of prices and quantities is fairly smooth, a chain-Laspeyres will lie below a direct Laspeyres and vice versa for a chain Paasche, thereby reducing the index-number spread. Hill describes a limiting case of a "smooth" chain-index (the "smooth" Divisia index) which eliminates the index number problem and is quite operational.

Choosing the level of aggregation at which to deflate

17. It is possible to prepare a single R&D price index for the whole of GERD, one for each sector or even for individual industries in the business enterprise sector or fields of science in the higher education sector. The choice will depend on whether there are significant differences in the cost structure of R&D expenditures between the different levels and whether there are significant differences in price trends for the same cost item between the levels. For example, it is probable that trends in wages and salaries of researchers will be different in universities, where they are fixed by public sector pay agreements, and in industrial firms. On the other hand, it is debatable whether trends in the wages and salaries of researchers will vary significantly between industries. The choice will also be dictated by the availability of suitable price series, whether they are compiled from specific price surveys or whether proxy indices are used.

Establishing the weighting system

General

18. A simple weighting system can be derived from the recommended breakdown by type of cost. The following shows the average breakdown in industry in the OECD area in 1969 and 1989.

	Percentage	
	1969	1989
Labour costs………………………	57	44
Other current costs………………..	32	44
Land and buildings………………..	3	3
Instruments and equipment………	8	9
Total………………………………	100	100

More detailed treatment of labour costs

19. Labour is typically the major cost item. It is therefore desirable, whenever suitable salary price indices are available, to create a subsystem for labour costs for each sector.

The weighting systems

20. Labour costs are not usually broken down by category of R&D personnel, but staff and salary ratios can be used to estimate the relative weights for the labour costs of different categories of personnel as follows:

	Quantity ratio (%)	Relative salary ratios	Labour cost ratio (%)
Researchers (RSE)………………………	50	x 1.00 = 50.00	59.7
Technicians………………………………	25	x 0.75 = 18.75	22.4
Other supporting staff……………………	25	x 0.60 = 15.00	17.9
Total……………………………………..	100	83.75	100.0

More detailed treatment of other current costs

21. The share of other current costs has risen rapidly. Early versions of this Manual recommended that this category should be subdivided between:

– materials;

– other current costs.

This distinction has, however, been abandoned in the OECD surveys and in most national ones. It is therefore difficult to establish a sub-weighting system.

Selecting proxy price indices

General approach

22. Whenever it is not possible to carry out meaningful price surveys of R&D inputs, proxy price indices for each of the classes identified in the weighting system may be selected from the country's national accounts or other general sources; or efforts can be made to identify the series deemed to possess characteristics most similar to R&D. As the final result will tend to be more sensitive to the evolution of the price series than it will to the weights, the choice of such proxy price indices is the single most important step in the preparation of the R&D deflator and should be made with great care. It is not possible to make firm detailed recommendations, as the amount and type of price index data available vary from country to country. Furthermore, some series would be relevant for a deflator for industrial R&D but not, for example, for university R&D.

Proxies for labour costs

23. For labour costs, the quantity data are usually available (number of researchers, etc.), and two general approaches are possible, either using average R&D labour cost per total R&D person-years or using quite separate proxy series based on wages and salary data. The first type of series is specific to R&D but will not be very exact if there is a significant change in the occupation! qualification pattern within the R&D labour force over the period. Given that such changes have occurred in most Member countries, it is perhaps preferable to use the second method. Here, it is important to select series that are as comparable as possible with the R&D data. Thus, earnings data are generally preferable to rates, and weekly or monthly earnings are preferable to hourly payments. The use of salary scales as proxies for trends in labour costs poses some serious problems, notably concerning "grade drift", changes in employers' social security payments and other "fringe benefits" and declining "quantity" of labour inputs due to shorter hours and longer holidays.

24. It is usual to make a distinction between trends in the private and public sectors. For example, the central government may maintain a pay research bureau in order to ensure that the salaries of public servants are comparable to equivalent workers in other sectors, and professional associations may publish data for their members.

25. There may have to be a trade-off between making a breakdown within labour costs and establishing indices for separate industries. For example, there may be salary indices available for all scientists and engineers or all technicians in industrial employment but they may not be broken down by individual industry. On the other hand, "average weekly wages" may be available for these industries. The choice of method will depend on whether the salaries of researchers move in line with those of the mass of workers in their industry or in line with researchers in other industries.

Proxies for other current expenditures

26. This is the most difficult area to deal with. R&D surveys usually do not reveal anything about the balance of types of expenditures included, and it is not clear which are R&D-specific and which are industry-specific (or sector-specific).

27. A wide range of proxy indices can be used for other current costs. For example, the average wholesale price index for materials and supplies consumed by manufacturing industry, the implicit price

index of the domestic product of industry (DPI), and the consumer price index (excluding food and beverages) have all been used.

28. Where indices are calculated for separate industries, it is possible to use indices for their general input costs, but they may not be typical of R&D. For example, it is suggested that much of the increase in "current costs" is due to growth in the contracting out of support services (matching the decline in the average number of support staff per researcher) and the greater use of leased machinery.

Proxies for capital expenditures

29. Expenditures on land and buildings absorb a relatively low share of R&D expenditures, and a suitable proxy index can easily be selected from the relevant class of gross fixed capital formation (GFCF) from national accounts. The same approach can be used for R&D expenditure on instruments and equipment, though the extent to which such general price indices reflect changes in R&D instrument costs is uncertain.

Currency converters for R&D

The need for special currency converters

30. Using GDP-PPPs to convert R&D expenditures to a common numeraire currency such as the US dollar or the ecu *(i.e.* deflating interspatially) effectively involves adjusting to allow for differences in the general price level between countries, not for differences in the price level for R&D. If R&D is relatively expensive in one country, as compared with another, then use of the GDP-PPP will distort the comparison between real expenditures on R&D.

31. Here, as for intertemporal deflators, the ideal solution is to calculate specific currency converters based on international relative prices for R&D inputs. Once again, carrying out the price surveys needed for this exercise (using an international standard "basket" of R&D inputs) would be both costly and complex. The more practical solution would be to use weights from R&D surveys and detailed parities from general PPP exercises conducted by the OECD and Eurostat, in the context of the International Comparison Project (ICP) carried out under the aegis of the United Nations Statistical Office. A major difficulty arises because the general PPPs are calculated using an international standard basket of goods and services entering into GDP**,** or more precisely, final demand (*i.e.* output), whereas R&D expenditures are mainly inputs.

Past national and OECD efforts

32. The first OECD reports on R&D statistics issued in the early 1 960s used purchasing power parities based on R&D weights and price ratios derived from salary studies and from the 1960 benchmark calculations of general purchasing power parities (Freeman and Young, 1965; OECD, 1968). These efforts were resumed in the late 1970s when new sets of purchasing power parities became available. This was the situation described in Chapter 7 of the last edition of the Manual (OECD, 1981). The most recent benchmark PPPs have been calculated for 1980, 1985 and 1990. These last covered for the first time all 24 OECD Member countries (OECD,199G*b*). The next benchmark year is 1993.

The method

33. The methodology for calculating R&D purchasing power parities should correspond to that established in the context of the ICP.

34. PPPs for GDP (and its expenditure components) for the OECD Member countries are calculated regularly by the OECD and Eurostat. Although the PPPs published by the OECD are expressed in units of national currency per US dollar and those published by Eurostat in units of national currency per ecu, they are:

- consistent *(i.e.* the France-Germany PPP obtained by dividing the ecu PPPs for these two countries published by Eurostat is the same as that obtained by dividing the US dollar PPPs published simultaneously by the OECD), as "block-fixity" for the EC countries has been imposed in the calculations;
- transitive (the PPP between countries A and B multiplied by the PPP between countries B and C gives the PPP between countries A and C).

Choosing the level of aggregation at which to calculate R&D converters

35. Ideally, the level chosen should match that chosen for R&D deflators. In practice, special R&D PPP rates might be calculated for the business enterprise sector and the public sector, perhaps distinguishing government and higher education.

The weighting system

36. As for deflators, the weighting system can be derived from the recommended breakdown by type of cost. However, since the PPP calculations involve simultaneous use of the weight and price data for all the countries included in the comparison (in order to ensure transitivity) it is necessary to have a matching set of weights for all the countries in the group.

Choosing the proxy prices

37. Ideally, data from price surveys of an international standard "basket" of R&D (input) expenditures in each weighting category should be used. As for intertemporal price indices, such an exercise would be costly and extremely complex and can be ruled out for all practical purposes. The next best solution would be to use proxy prices (for which the best source is the set of comparable price data already available from the ICP), if necessary combined with proxy inter-spatial price indices *(i.e.* the disaggregated parities calculated for final expenditure components in the ICP).

Labour costs

38. No intermediate or primary input data are collected in the ICP for the business enterprise sector, hence no wages and salary data. For non-market services, however, the ICP does use input prices and thus includes data on total employment compensation for a selected international standard basket of occupations in the public sector, notably in education, health, and general government services. This information might be supplemented by the results of international surveys of the wages and salaries of scientists and engineers or of certain categories of business management.

Other current costs

39. Once again, the major problem is the lack of price data for intermediate consumption, whether or not for R&D activities, of the business enterprise sector. Certain final goods and services for which prices are collected in the context of the ICP may also be inputs to R&D (*i.e.* "other current costs").

Capital expenditures

40. Suitable proxies for expenditure on land and buildings and on instruments and equipment can be obtained from the ICP, subject to the reservations already noted for estimating intertemporal R&D deflators.

ANNEX 11

THE TREATMENT OF R&D IN THE UNITED NATIONS SYSTEM OF NATIONAL ACCOUNTS AND THE CONSTRUCTION OF SATELLITE ACCOUNTS

The reader should refer to Chapter 1, paragraph 7 of this Manual for a comment on the use of this annex before proceeding further.

Introduction

1. This annex aims: *i)* to explain the treatment of R&D in the System of National Accounts (SNA); and *ii)* to present methods of establishing "satellite accounts" to experts on S&T indicators who are not familiar with SNA concepts and terminology. It deals with three topics;

- history of the relationship between the SNA and Frascati Manual systems;
- similarities and differences between the two systems:

general inclusion of R&D in the SNA;

sectors and their sub-classification;

measuring R&D spending in the SNA;

- model of a satellite account:

the need for satellite accounts;

the French method based on the "market approach".

2. References are generally to the final draft of the latest version (fourth revision) of the SNA, prepared jointly by the Commission of the European Communities, the International Monetary Fund, the OECD, the United Nations, and the World Bank (CEC *et al.*, 1994). The 1968 version is only mentioned when there have been significant changes in treatment between the two versions.

History of relationship between the two systems

3. The United Nations System of National Accounts was first published in 1953. It provided a coherent framework for recording and presenting the main flows relating to production, consumption, accumulation, and external trade. Along with the associated United Nations (UN) international classifications, such as the International Standard Industrial Classification (ISIC), it is the standard framework for economic statistics and analysis in OECD Member countries and is used as such by the Secretariat.

4. The Frascati system of R&D accounts was established in 1961, largely on the basis of US work dating back to the formative years of the SNA. The Frascati system was inspired by the SNA, and adopted the idea of dividing the economy into sectors and of measuring flows of funds between them, but was never conceived as part of it.

5. Three main areas of difference have continued to exist between the two systems:

13. *i)* economic sectors and associated classifications;

14. *ii)* terminology, *i.e.* use of the same term for different concepts or different terms for the same concept;

15. *iii)* basic differences in accounting methods.

6. These differences between the SNA and the Frascati approach have been reviewed systematically three times: first in about 1970 and again in 1990, when the revision of the two systems coincided, and in the mid- 1970s, when the concept of satellite accounts for R&D was introduced.

7. On the first occasion, the SNA revision was completed in 1968. before the main discussion of the revision of the Frascati Manual began. That edition of SNA paid very little attention to R&D. A small but outspoken group of national R&D experts stressed the need to bring the second edition of the Manual in line with the “new” SNA. They succeeded relatively well on sector definitions and terminology but were unable to bring about any changes in accounting methods.

8. The relationship between Frascati and the SNA was discussed by other organisations, including the United Nations Economic Commission for Europe and the European Commission. As a result, a system of satellite accounts for R&D was developed and has been used regularly by a number of Member countries, notably France.

9. R&D was a topic specifically discussed during the preparation of the fourth revision of the SNA in the context of the possible treatment of “intangible investment” in the SNA. It was finally decided not to treat R&D as an investment activity, but the discussions did lead to the inclusion of more specific guidelines for R&D than in the preceding version. Furthermore, the national accountants who discussed the revision became aware of the Frascati Manual, its main recommendations, and the related databases. Changes in the SNA concerning sectors and terminology have been incorporated in the Frascati Manual wherever appropriate, but the differences in accounting practice remain.

Similarities and differences between the treatment of R&D in the Frascati Manual and theUnited Nations System of National Accounts (SNA)

General inclusion of R&D in the SNA

10. The SNA is concerned with economic activities. The first question that must be answered therefore is what constitutes an economic activity, since this determines what falls within the scope of the national accounting system and thus in gross domestic product (GDP). There is no difficulty in defining as economic those activities that result in the production of goods and services for sale on the market. Government activities in the areas of public administration, law and order, health, education, and social services (and activities in similar areas carried out by private non-profit organisations) are also counted as economic, even though their output is not sold on the market. Borderline problems do, however, arise in connection with some other kinds of non-market activities. With the exception of government services and of private non-profit institutions, the SNA does not include in GDP goods and services that are not marketed, unless identical or very similar goods and services are also sold on the market. GDP includes, for example, the construction of buildings by households and enterprises for their own use and the production of crops and livestock for consumption on the farm. There are usually close market parallels for those activities. However, by convention, the SNA does not include unpaid services rendered by household members such as home decorating, cleaning, laundry, etc.

11. R&D is generally an economic activity as defined above. There is, however, one category which is not; it is R&D carried out by postgraduate students who are not employed by higher education institutions but are supported by grants and/or their own resources. All other R&D expenditures contained in the Frascati Manual are treated in the various accounts of the System of National Accounts.

12. There is no definition of R&D in the SNA. It can be assumed that it is defined as in the Frascati Manual. The SNA draws on the latest version of the UN Classification of Economic Activities (ISIC Rev 3) (UN, 1990), where R&D is identified using a definition very similar to that in this Manual. Purely R&D financing activities are excluded (see Chapter 2, Section 2.2.4.1) as is R&D associated with teaching. While the most recent version of the SNA gives guidelines on the treatment of R&D, it does not systematically distinguish it in the accounts, particularly for firms that carry out R&D for own use. This is why satellite accounts (described below) are needed.

Sectors and their subclassifications

Sectors

13. Both the SNA and the Frascati Manual break down “national” efforts into a number of sectors. The broad correspondence is shown in Table 1.

14. Both systems use national territory on the one hand, “the rest of the world” (SNA) or “abroad” (Frascati), on the other.

15. The Frascati Manual applies one set of sector definitions to all its accounts (R&D expenditure by sector of performance, R&D expenditure by source of funds, R&D employment). The SNA has two slightly different approaches (see Table 2), and the treatment of R&D in the Frascati Manual, especially performance, is closer to the second of these.

16. The main difference is that the Frascati Manual separates out the higher education sector. This separation is considered very important by R&D statisticians and policy makers, for the reasons given in Chapter 3 of the Manual. However, this additional sector causes problems in an SNA context. While public universities and colleges belong in the SNA government sector, the other components of the Frascati higher education sector may belong almost anywhere in the SNA. Table 3 shows where they might be classified.

Table 1. Summary of sectors in the SNA and in the Frascati Manual

SNA		FRASCATI	
Institutional sectors	Market & non-market producers	Source of funds	Sector of performance
Non-financial corporations	Mainly market producers	Business enterprise sector	
Financial corporations			
General government	Mainly non market producers	Government sector	
Non-profit institutions serving households		Private non-profit sector	
Households			
(included in other SNA sectors)		Higher education sector	
Rest of the world		Abroad	

Table 2. **Sectors and producers in the SNA**

Sectors	Market producers (1968: industry)	Non-market producers
Non-financial corporate sector (1968: Non-financial enterprises – corporate or quasi-corporate)	Non-financial corporations or quasi-corporations Non-profit institutes engaging in market production[1] NPIs serving business	
Financial corporate sector (1968: Financial institutions)	Financial corporations and quasi-corporations	
General government sector	[Government units engaged in market production [2]]	Government units n.e.c. Social security funds NPIs mainly financed by government n.e.c.
PNPIs serving households		PNPIs serving households
Households	Unincorporated enterprises engaged in market production	Households n.e.c. including unincorporated enterprises engaged in production of goods mainly or wholly for own final use[3]

1. Supplying goods and services at an economically significant price.
2. These are treated as quasi-corporations as long as they have a separate set of accounts.
3. Such unincorporated enterprises were counted as "industry" in the 1968 SNA (UN, 1968b).

17. If the Frascati system had no higher education sector, there would be an almost complete match between the SNA production approach and the R&D sectors as has been intended since the 1970 version of the Frascati Manual (OECD, 1970). For example the Frascati Manual distribution of private non-profit (PNP) institutes among sectors is clearly based on the SNA approach; and the section of Chapter 4 of the new SNA devoted to this topic usefully supplements the discussion in Chapter 3 of this Manual. A possible discrepancy in the treatment of individual consultants between the SNA 1968 (UN, 1968b) and the Frascati Manual 1980 (OECD, 1981) has been corrected in this Manual.

18. Nevertheless, non-higher education units may be treated somewhat differently in the latest versions of the Manual and of the SNA, as the Manual adapted the original SNA definitions to reflect R&D institutional practice. The institutes are often attributed to sectors by two different agencies who may interpret the same instruction differently.

Classifications

19. The SNA does not always recommend the same classification as the Frascati Manual for what the latter refers to as "sector subclassifications". Both use ISIC, but the breakdown of R&D among industries may differ because of variation in the unit classified and the classification criteria (see paras. 43-50 below). In the SNA, government outlays are broken down by the classification of the functions of government outlays (COFOG); R&D experts have rejected this classification, in favour of a NABS-related classification for GBAORD, as they have been unable to agree on a classification for R&D performed in the government sector. In OECD national accounts publications, the PNP sector is subdivided by main types of unit (see Table 4), whereas a field of science classification is recommended in this Manual.

Table 1.

Table 3. The SNA sectoring of units definitely and possibly included in the Frascati higher education sector

	Market producers	Non-market producers
Teaching establishments *i.e.* producing higher education services (PHES)' as a main activity	– All non-financial corporations (or quasi-corporations) PHES[1] – Any unincorporated enterprises PHES' at an economically significant price – Non-profit institutions PHES at an economically significant price – Non-profit institutes serving enterprises PHES[1]	Government units PHES[1] NP institutions controlled and mainly financed by government PHES' NP institutions serving households PHES'
University hospitals (providing health care services, PHSS)[2] controlled, administrated or associated with HE and/or with a significant teaching commitment	–Non-financial corporations (or quasi-corporations) PHSS[2] CAAHE[3] –Non-profit institutions PHSS[2] at an economically significant price CAAHE[3]	Government units PHSS[2] CAAHE[3] NP institutions controlled and mainly financed by government PHSS[2] and CAAHE[3] NP institutions serving households PHSS[2]
Research institutes or experimental stations controlled, administrated by or associated with higher education establishments (CAAHE)[3] ("Borderline" research institutions)	– Non-financial corporations (or quasi-corporations) selling R&D but CAAHE3 – Non-profit institutions selling R&D at an economically significant price CAAHE[3] – Non-profit institutions serving enterprises CAAHE[3]	– Government units controlled, administrated by or associated with HE – NP institutions controlled and mainly financed by government but associated with HE – NP institutions serving households, which are administrated, controlled or associated with HE
Postgraduate students supported by grants		– Households benefiting from subsidies

1. Providing higher education services.
2. Providing health care services.
3. Controlled, administrated by or associated with higher education establishments

Box 1

Market and Non-market Production

Market and non-market output

Market output covers goods and services which are sold or otherwise disposed of on the market, or intended for sale or disposal on the market, excluding output sold at prices that are not economically significant (see below).

Non-market output is not produced for sale or other market use. It has two main components:

a) Output of goods or services that are retained for their own final use by the owners of the enterprises in which they are produced. As corporations have no final consumption, goods and services retained for own final consumption can only be produced by unincorporated enterprises. They include, for example, agricultural products retained for own final consumption by farmers or housing services produced by owners-occupiers. Goods or services for own gross fixed capital formation can be produced by corporations or unincorporated enterprises. They include, for example, the special machine tools produced for their own use by engineering enterprises, or dwellings, or extensions to dwellings, produced by households.

b) Output of goods and individual or collective services that are supplied free, or at prices that are not economically significant, to other institutional units or the community as a whole by government units or PNPIs.

A price is said to be **not economically significant** when it has little or no influence on how much the government unit or PNPI is prepared to supply and is expected to have only a marginal influence on the quantities demanded. Such prices are likely to be charged in order to raise some revenue or achieve some reduction in the excess demand that may occur when services are provided completely free, but they are not intended to eliminate such excess demand.

Market and non-market producers

A **market producer** is an establishment or enterprise most or all of whose output is marketed. It is perfectly possible for market producers, both small unincorporated enterprises and large corporations, to have some non-market output in the form of production for own final consumption or gross fixed capital formation.

A **non-market producer** is an establishment or enterprise most or all of whose output is non-market. There are two kinds of non-market producers corresponding to the two types of non-market output. The first type consists of unincorporated enterprises owned by households, most or all of whose output is intended for final consumption or gross fixed capital formation by those households or enterprises: for example,

(continued on nex page)

(continued)

owner-occupiers or subsistence farmers who sell only a small fraction of their output. The second type of non-market producer consists of establishments owned by government units or PNPIs that supply goods or services free, or at prices that are not economically significant, to households or the community as a whole. These producers may also have some sales of secondary market output whose prices are intended to cover their costs or earn a surplus: for example, sales of reproductions by non-market museums.

Source: System of National Accounts (CEC et al., 1994).

Measuring R&D spending in the SNA

20. Box 2 outlines the ways in which GDP is compiled in the SNA. The following description of the treatment of R&D in the various accounts is largely based on quotations from the latest version of the SNA (CEC *et al.,* 1994).

Identifying and valuing R&D in the production account

21. "Research and development by a market producer [see Box 1] is an activity undertaken for the purpose of discovering or developing new products, including improved versions or qualities of existing products, or discovering or developing new or more efficient processes of production. Research and development is not an ancillary activity, and a separate establishment should be distinguished for it, when possible. The research and development undertaken by market producers on their own behalf should, in principle, be valued on the basis of the estimated basic prices that would be paid if the research were subcontracted commercially, but is likely to have to be valued on the basis of the total production costs, in practice. Research and development undertaken by specialised commercial research laboratories or institutes is valued by receipts from sales, contracts, commissions, fees, etc., in the usual way. Research and development undertaken by government units, universities, non-profit research institutes, etc., is non-market production and is valued on the basis of the total costs incurred. The activity of research and development is different from teaching and is classified separately in ISIC. In principle, the two activities ought to be distinguished from each other when undertaken within a university or other institute of higher education, although there may be considerable practical difficulties when the same staff divide their time between both activities. There may also be interaction between teaching and research which makes it difficult to separate them, even conceptually, in some cases."

(CEC *et al.,* 1994, para. 6.142.)

Table 4. **SNA classifications of government outlays and final consumption expenditure of PNP institutes serving households**

A. Government outlays[1]

- 1. General public services (including basic research)
- 2. Defence
- 3. Public order and safety
- 4. Education (includes universities and colleges)
- 5. Health
- 6. Social security and welfare
- 7. Housing and community amenities
- 8. Recreational, cultural and religious affairs
- 9. Economic services
- 9.1 Fuel and energy
- 9.2 Agriculture, forestry, fishing and hunting
- 9.3 Mining, manufacturing and construction, except fuel and energy
- 9.4 Transportation and communication
- 9.5 Other economic affairs
- 10. Other functions
- Total
- **Final consumption expenditure of private non-profit institutions serving households**
- 1. Research and science
- 2. Education
- 3. Medical and other health services
- 4. Welfare services
- 5. Recreational and related cultural services
- 6. Religious organisations
- 7. Professional and labour organisations serving households
- 8. Miscellaneous
- Total

I. Final consumption expenditure (of which compensation of employees and other subsidies), other current transfers and property income, gross capital formation and other capital outlays.

Source: (OECD, annual *b*), *OECD National Accounts, Detailed Tables, Vol. II*.

22. In terms of this Manual the gross input of an R&D unit in the SNA is not the same as its total intramural expenditure. Gross input corresponds broadly to Frascati current intramural expenditure to which must be added an allowance for capital depreciation and for operating surplus and which should be adjusted for net indirect taxes (payments less subsidies) (see Table 5).

23. Value added in terms of costs is as above, minus intermediate consumption/other current costs.

Box 2

Measuring Gross Domestic Product

GDP may be derived in three ways (or combinations or them):

1. The production approach

The first approach looks at the way output of goods and services is produced. It measures the contribution to output made by each producer, by deducting from the total (gross) value of its output the value of the goods and services it has purchased from other producers and used up in producing its own output. This is done in order to avoid double-counting. What is left is the **value added** by the producer in question; what is used up in production is **intermediate consumption**. The total value added by all producers plus any taxes not payable on production equals GDP.

This production approach may be used to estimate the contribution to GDP of producers engaged in various kinds of economic activity, as in Table 12 of OECD National Accounts, Detailed Statistical Tables Vol. II.

2. The cost or income approach

The second approach considers the costs incurred by the producer within his own operation. The incomes paid out to employees, indirect taxes less subsidies, consumption of fixed capital – and the operating surplus; this also adds up to value added as shown in 2 of Table 1 of the *OECD National Accounts, Detailed Statistical Tables Vol. II.* This approach can also be used to build up GDP by type of activity, as shown in Table 12 of the same publication.

3. The expenditure approach

The third method, known as the expenditure approach, looks at the final use of national output of goods and services for private consumption (households and PNPSH), government consumption, capital formation (change in inventories, gross fixed capital formation), and net exports; in other words, it shows what becomes of the final output once it has been produced.

The expenditure method of estimating GDP leads to a table like Part 1 of Table 1 of the OECD National Accounts, Detailed Statistical Tables Vol. II

Source: Adapted from *Handbook of National Accounting: Accounting for Production: Sources and Methods* (UN, 1986*a*).

Table 5. Gross input and total intramural R&D

	SNA Cost Components	FRASCATI
Similar coverage	Compensation of employees	= Labour costs
	Intermediate consumption[1]	= Other current costs
Different treatment	Indirect taxes paid, less subsidies received	Subsidies included in above; indirect taxes excluded
	Consumption of fixed capital	Gross capital expenditure
	Operating surplus	Not mentioned

1. Intermediate consumption also includes the cost of any bought-in R&D.

R&D as intermediate consumption

24. The revised SNA gives the following instruction for the R&D of market producers (the Frascati business enterprise sector):

> "Research and development are undertaken with the objective of improving efficiency or productivity or deriving other future benefits so that they are inherently investment – rather than consumption-type activities. However, other activities, such as staff training, market research or environmental protection, may have similar characteristics. In order to classify such activities as investment type it would be necessary to have clear criteria for delineating them from other activities, to be able to identify and classify the assets produced, to be able to value such assets in an economically meaningful way and to know the rate at which they depreciate over time. In practice, it is difficult to meet all these requirements. By convention, therefore, all the outputs produced by research and development, staff training, market research and similar activities are treated as being consumed as intermediate inputs even though some of them may bring future benefits."
>
> "As already noted, research and development is not an ancillary activity like purchasing, bookkeeping, storage and maintenance which tend to be found frequently in all establishments. When research and development is carried out on a significant scale within an enterprise, it would be desirable to identify a separate establishment for it so that the relevant inputs and outputs could be distinguished for analytical purposes. Because of the difficulty of obtaining price data, the output will usually have to be valued by total costs of production, as in the case of most other own-account production. The output produced has then to be treated as being delivered to the establishment, or establishments, which make up the rest of the enterprise and included in their intermediate consumption. When there are several other establishments, the amounts of research and development delivered can be distributed in proportion to their total costs, or other indicator, in much the same way that the output of head offices or other central facilities has to be allocated."
>
> "When an enterprise contracts an outside agency to undertake research and development, staff training, market research or similar activities on its behalf, the expenditures incurred by the enterprise are treated as purchases of services used for purposes of intermediate consumption."
>
> (CEC *et al.*, 1994, paras. 6.163-6.165.)

R&D in the expenditure account

25. This Manual distinguishes between performers and funders of R&D. The SNA distinguishes between the producers of R&D services and the users (expenditure account). The unit which "performs" the R&D also "produces" it. The "funder" unit is usually but not always the SNA user.

26. The funding unit is the SNA user when the money is used to finance intramural R&D ("own funds") or to purchase R&D services from another unit. The funding unit is not the SNA user if it transfers money for R&D performance to another unit but does not receive a flow of R&D services in return, *e.g.* all types of R&D grants and also indirect forms of R&D support. In this case the performer is the user. In the case of market producers any grants, etc., from government must be treated as "subsidies" (see Table 5). Problems may arise for the R&D content of procurement contracts. In principle, the R&D is embedded in the product as it is in other purchases of goods and services, and the SNA user of the R&D is the producer/performer. If, however, the funding agency places a separate R&D contract and becomes the owner of the R&D results, then the funder is the SNA user.

27. While all R&D has a user, only part of it appears in the final expenditure account *per Se.* The vast majority of R&D is treated as being used up in the production process and hence already incorporated in goods and services in the expenditure account. They are either carried forward to a subsequent period (capital formation) or used without further transformation to satisfy individual or collective needs of members of the community (final consumption). This covers all R&D financed by market producers and R&D financed by government and private non-profit institutions serving households (PNPSH) which contributes directly to the services they supply. The only R&D activities treated *per se* as final consumption in the expenditure table are those financed as a collective service by government (notably basic research) and similar R&D financed by PNPSH.

"Uses" and "resources"

28. The SNA term "use" is often associated with "resources" to describe two aspects of a transaction, particularly in French texts. A transaction is registered on the "resources" side when it adds to the economic worth of a unit or sector and on the "use" side when it reduces it. For example, the wages and salaries bill is entered under "use" for the firm which pays out but under "resources" for the households receiving the money. This is picked up again in the "supply **(**= resources) and use" tables in input-output analysis. The French satellite account described below makes considerable use of this approach.

29. This approach can be used to deal with the practical problem of whether the data should be based on the performer's or the funder' s report. For R&D, the performer's report is preferred but sometimes only the funder' s report of extramural expenditure is available.

The need for satellite accounts

30. Satellite accounts are an evolving mechanism for presenting particular topics as annexes to main national accounts.

31. The characteristics of satellite accounts can be described as follows:

32. "Over time, satellite accounts for particular fields have come to be associated with the following characteristics:

1. They feature data for a whole field of economic activity and provide a framework for arraying more comprehensive information about a field than can be shown in the main accounts.

2. They are purpose-oriented in that the criterion for a transactor's or transaction's inclusion is its linkage to the field.

3. They are articulated with the main accounts and contain at least one measure that is also in the main accounts.

4. They present information in ways that are different from the main accounts: definitions, classifications, and accounting conventions may differ from those used in the main accounts in order to provide the most useful presentation of information about the field. What is counted as current or capital in the main accounts may be changed, or the boundary of production may be moved. The definitions, classifications, and accounting conventions must be consistent within the account, however.

5. They often contain tables that answer several questions: Who is producing, and what are the means of production? Who is financing? What is the result of the expense, and who is benefiting or using the result?

6. They often encompass monetary and physical data in an integrated fashion. Physical data may relate to production, for example, the number of persons employed in the field of the stocks of equipment. Physical data may also relate to beneficiaries, for example, the number of persons being affected by activities in the field.

The advantage of satellite accounts is that an alternative view of the economy can be obtained without disturbing the main accounts."

(Carson and Grimm, 1991.)

Satellite accounts for R&D: the French approach*

33. Originally constructed in line with the 1970 bases for the national accounts, the R&D satellite account was recast and aligned on the 1980 bases some years ago. It has two main objectives:

– to provide key R&D descriptors for national accounts purposes, in the SNA framework;

– to present R&D from the standpoints of performance, use, and funding, in a framework compatible with national accounts transactions and classifications.

34. This treatment of funding is a prerequisite for calculating R&D expenditures and integrating them in gross capital formation. However, the French satellite account leaves the method of integration, and the consequences for depreciation and balance-sheet accounts, as matters for the national accounts to define.

35. The presentation that follows is simpler than that given in earlier ones. In particular, market R&D is here taken as covering all market R&D services of non-financial corporate and quasi-corporate enterprises, whether R&D is their main activity or a secondary one, *i.e.* no more than a small proportion of their turnover or value added. Accordingly, the output of this sector is equal to the R&D transfers (as understood in this Manual) of these enterprises.

36. In addition, in the methodological presentation, economic activities are shown under just two headings, market and non-market.

37. Two points require particular attention:

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* A slightly different approach developed by the Netherlands Central Bureau of Statistics is described in “A Research and Development Module Supplementing the National Accounts” (Bos *et al.*, 1992).

- the implicit assumption that any gross operating surplus or margin is negligible, in terms of other items, for balancing R&D funding and performance;

- the scope for confusion on the funding side between operating expenditures, which come under current transactions in the national accounts system, and capital, which come under gross fixed capital formation.

Structure of the R&D account

38. The satellite account is constructed in three stages.

39. The first stage is concerned with classifications; it describes the performance of R&D in terms of the resources applied (expenditure and personnel), on the basis of SNA classifications of industries and institutional sectors.

40. The second stage, using SNA categories of transaction, analyses the R&D market flows between units and between the various institutional sectors in which the units are classified. It provides a balanced presentation of these flows, in terms of uses and resources, and leads to the R&D market services account.

41. The third stage integrates the results of the two preceding exercises. It presents the transaction categories of both systems, the R&D statistical system and the national accounts system in two balanced approaches to expenditure and the funding of expenditure: one by institutional sector and the other by industry.

42. Each approach provides a link between gross domestic expenditure on research and development (GERD) and gross national expenditure on research and development (GNERD). The approach by activity provides the link between transactions in the statistical R&D system (performance and funding) via the transactions used for the market services account (intermediate consumption and output) and a grounded correction to the funding data.

Classifications

43. The methods used to classify R&D statistics in France are not the same as those used in the SNA. They are based on the concept of R&D industry, corresponding to the industrial activity making use of the product with which the R&D is concerned; this is one of the three industry descriptions of R&D in the account.

44. For the other two presentations, by performer and by funding, the account makes use of the SNA classification by activity and links the two approaches.

45. When the classification methods used in a system of R&D statistics are the same as in the SNA, by economic activity for instance, there is no need to provide a bridge to the classification by activity; however, the user approach is not possible.

Classification by activity

46. The satellite account accordingly breaks down R&D expenditure into three categories of economic activity:

– R&D activity of units classified according to the industrial activities that use or benefit from R&D (when such classification is provided by surveys);

– economic activity of units in which R&D has been carried out;

– economic activity of the funding agents (based on evaluation in the third stage).

47. The third approach may be used to calculate intangible R&D investment by activity.

48. The three classification systems adopt the same approach to units performing R&D on their own account; they differ in regard to R&D firms or design engineering firms which are classified under "market services for enterprises" and whose R&D funding is supplied by customers in industry or government. These divergences basically concern industrial R&D carried out in units classified under "service enterprises". In practice, such differences almost always relate to R&D sold by service companies.

Classification by institutional sectors performing and financing R&D

49. The satellite account uses the SNA classification of institutional sectors to present R&D. These sectors are defined both by main source of funds and by sub-unit function.

50. In the market sector, these sectors are non-financial corporate and quasi-corporate enterprises (CQCs) and, in the non-market sector, private non-profit institutions and general government, which usually includes higher education (shown separately in R&D statistics).

Constructing the uses and resources balance for market R&D

Valuing uses and resources for market services

51. The R&D statistical system generally allows the same flows to be measured in two ways, either as resources, in the form of receipts of external sources of funds reported by performers of R&D, or as extramural expenditure, *i.e.*uses, reported by funders of R&D. In general, the Manual recommends giving preference to the figures reported by performers, when both are available. Uses by sector can therefore be determined from the sources of funds, by sector of origin. The amount of funds received from a given sector actually devoted to R&D thus provides the measure of uses in the latter.

52. Capital expenditure is not reflected in these flows of market services, since it usually relates to goods and is intramural; purchases of equipment or patents for R&D purposes do not form part of extramural R&D expenditure and should be entered as intramural expenditure.

Uses

53. Intermediate consumption by the market sector **(ICm)** corresponds to uses by non-financial corporate and quasi-corporate enterprises.

54. Intermediate consumption by non-market activities **(ICnm)** includes uses by education, government R&D agencies, and PNPs classified with general government.

55. Exports **EX (EXnm** from the non-market sector, **EXm** from the market sector) correspond to R&D performed by units resident in a given country financed by non-resident units. Their measurement includes funding received from international organisations.

Resources

56. To simplify the presentation of resources, only three sectors are identified here, market, non-market and rest of the world:

– incidental sales by non-market sector (IS):

ISnm for the portion consumed by general government;

ISm for the portion consumed by the market sector;

EXnm for the portion consumed by the rest of the world;

with ISnm + ISm = ISd, incidental domestic sales, and ISd + EXnm = IS;

– R&D transfers (T) as understood in this Manual:

Tnm for the portion consumed by the non-market sector;

Tm for the portion consumed by the market sector;

EXm for the portion consumed by the rest of the world;

with **Tnm** + **Tm = Td,** domestic transfers, and **Td** + **EXm =T**

– R&D imports (I):

- **Inm for the portion consumed by general government;**
- **Im for the portion consumed by the market sector (Inm + Im = I).**

Note: Except in the case of exports, **m** and **nm** denote the consumption sector.

57. Table 6 shows the uses and resources balance for the variables defined above, uses reading down and resources across:

58. The market R&D account describes the general balance of market R&D flows in terms of uses and resources:

– Intermediate R&D consumption by the market sector **(ICm)**

– + Intermediate consumption by the non-market sector **(Cnm)**

– + R&D exports **(EX)**

– = Incidental sales **(IS)**

– + R&D transfers **(T)**

– + Imports **(I)**

– or 1Cm + ICnm + EX = IS + T + I

– and more concisely:

– Distributed output of market R&D services (**IS + T**)

– + R&D imports (**I**)

– = Intermediate R&D consumption **(ICnm** + **1Cm)**

– + R&D exports (**EX**).

Note: National accounts are concerned only with the distributed output of market R&D services and do not indicate output for own account, *i.e.* R&D both performed and used within given industrial units. The corresponding expenditure is included, but not identified, in the units' current expenditure, under remuneration and supplies.

59. For R&D statistics, expenditure on such R&D is included in the intramural R&D expenditure of those units, and needs to be shown in order to present R&D transactions by performance and by funding.

Table 6. Uses and resources balance for R&D

UsesResources	Non-market	Market	Total intermediate consumption	Exports to rest of world	Total resources
Non-market	**ISnm**	**ISm**	**ISd**	**EXnn**	**IS**
Market	**Tnm**	**Tm**	**Td**	**EXm**	**T**
Imports from rest of world	**Inm**	**Im**	**I**	***///***	**I**
TOTAL USES	**ICnm**	**ICm**	**IC**	**EX**	**Total uses/ resources**

60. In the SNA, capital expenditure is included in gross fixed capital formation, and no distinction is made for R&D. To treat R&D as intangible investment, it is necessary to state whether such expenditure is tangible (gross fixed capital formation – GFCF) or intangible.

Output of non-market R&D services

61. The distributed output of non-market R&D services, which can only be supplied by general government and non-profit producers, is equal to the actual output of the non-market sector less incidental sales.

62. It should be noted that the actual output of the non-market sector is measured from its inputs; in the case of non-market R&D, it corresponds approximately to current intramural R&D expenditure by general government, except for the treatment of depreciation and capital expenditure. That marks an essential distinction between non-market and market sectors, as in the latter, R&D on own account is not included in output.

63. Leaving aside the differences in the treatment of capital expenditures, the distributed output of non-market R&D services may be related to intramural R&D by general government (**GERDnm**) as follows:

Distributed output (DO) = GERDnm – IS

64. Use of the distributed output of non-market R&D services equals final government consumption.

Balancing R&D funding and performance

Transactions and aggregates

65. R&D aggregates express the statistical measurements of R&D performance or sources of funds. The two main aggregates are gross domestic expenditure on research and development (GERD), for performance, and gross national expenditure on research and development (GNERD) for funding.

Gross Domestic Expenditure on Research and Development (GERD)

66. GERD comprises all intramural R&D expenditure by units on national territory, regardless of the sources of funds, and thus provides a measurement, without double counting, of all expenditures on R&D carried out (in France, for example) during a given year.

67. Because GERD provides a direct and uniform measurement of the intramural expenditures of performers which does not require consolidation, it is the aggregate most widely used in international comparisons.

68. GERD comprises R&D expenditure financed by external sources and expenditure on intramural R&D financed from own funds.

Gross national expenditure on research and development (GNERD)

69. This aggregate represents the sum of R&D funding contributed by national economic agents during a given year

70. Such expenditures cover intramural R&D from own funds plus R&D subcontracted to outside agents.

71. GNERD is not calculated directly from the extramural expenditure reported by funders but from GERD less funds received from non-residents, plus any payments made abroad for performance of R&D by non-residents:

GNERD = GERD + payments made for R&D performed abroad – R&D funds received from abroad

72. This basic equation gives the linkage between measurement based on expenditure and measurement based on funding. In various forms it provides the basis for all calculations of funding, whether by unit, institutional sector, or industry.

73. It should be borne in mind when using the equation, however, that GNERD combines measurements at cost price (GERD) and measurements at market prices, *i.e.* including gross operating surpluses or margins. So, the R&D inputs and outputs are compiled with an operating surplus element in the market-price data, which may introduce a bias into the calculations. Therefore, it is sometimes necessary to assume that these surpluses or margins are negligible in relation to the other items.

Linking the balances

74. These two approaches to R&D, the first, that of R&D statisticians, based on expenditures on R&D performance (GERD) and R&D funding (GNERD), and the second, that of national accountants, based on the balance of commodity flows reported in the SNA, can be brought together.

75. The uses and resources balance can be used in constructing the funding and performance balance. It is sufficient to add in, on the one hand, the external funding which is not considered as uses, and, on the other, expenditures on own account and the corresponding funding. These additional items balance performance (GERD) and funding (GNERD).

Corrections to R&D funding data

76. The concept of "funding" used in R&D statistics has a broader scope than the SNA concept of "intermediate consumption". "Funding" includes subsidies and refundable loans (SRL) for R&D work performed by enterprises and organisations, as well as payments made to international organisations or public bodies established abroad (PBA).

77. The overall effect of these two corrections to external funding appears clearly in the breakdown of R&D performance and funding by industry (see below). These corrections are also applied in calculations for presenting the same data by sector of performance and by sources of funds, but they are not identified as such.

78. Table 7 sets out the effect of the funding corrections on the uses and resources balance of market flows.

Integration of funding and performance

79. To move from the balance of trade in R&D services to the balance of R&D performance and funding, data on own-account expenditure and its funding must be added. Although surveys do not always specifically ask for such data, they can be calculated from funding payments made and received. Their inclusion simplifies moving from one balance to the other.

80. GERD is the sum of intramural R&D expenditures incurred on own account (own funds) and the funds received from outside for R&D performed on behalf of others.

Table 7**. External funding**

Payments made/received	Non-market	Corrections to public funding	Market	Total national external payments	Payments from rest of world	Total payments received
Non market	**ISnm**		**ISm**	**ISd**	**EXnm**	**IS**
Market	**Tnm**	**SRL**	**Tm**	**Td + SRL**	**EXm**	**T**
Payments to rest of world	**Inm**	**PPBA**	**Im**	**I + PPBA**	**///**	**I + PPBA**
Total payments made	**ICnm**	**Total corrections**	**Icm**	**IC**	**EX**	**Total payments**

81. If external funds are expressed as distributed output, with the corrections described above, then, with regard to the components of the sources of funds for R&D performance, it follows that:

GERD = funding of expenditure on own account
+income from sales of R&D
+subsidies and refundable loans received

82. Similarly, **GNERD** provides an overall measure of the funding of all R&D expenditures on own account and funding supplied to external units for the performance of R&D:

GNERD = expenditure on own account
+intermediate consumption
+subsidies and refundable loans paid
+funding of international organisations and public bodies established abroad

83. The earlier note on the use of cost-price and market-price data applies here as well. Gross operating surpluses included in prices introduce a bias into the calculation of expenditure on own account and its funding. The assumption that gross operating surpluses or sales margins are negligible is accordingly made here and in the following calculations.

Funding and petformance of R&D by institutional sector

84. The square matrix with two entries (Table 8), each using the same simplified notation for institutional sectors, can be used to represent the funding and performance of R&D, for all expenditure, in a partly paired presentation of accounts. The funding sectors are given in the columns, and the performing sectors are shown in the rows, the amount entered in a given cell indicating the funding of the row by a given column.

85. The sum of each row is equal to the total R&D performed by the sector, *i.e.* its intramural expenditure, and the total of intramural domestic expenditure of sectors is equal to GERD.

86. The absolute share of the intramural expenditure funded by the sector is given for each column, as is the total funding of the sector, including funding it supplies to the rest of the world, that corresponds to the sector’s R&D funding effort. The total funding in a given column represents the GNERD (non-market or market, as the case may be).

Box 3

Moving from One Balance to the Other

This demonstrates the link between R&D aggregates and the concepts utilised in the SNA. It takes account of the following:

* Expenditure by CQCs on own account
funding by CQCs of expenditure on own accoun
* Expenditure by general government on own account
= funding by general government of expenditure on own account
* Subsidies and refundable loans paid
= subsidies and refundable loans received
* Income from sales of R&D services
= Distributed output of market R&D services
= T + IS.

The equation linking the two aggregates is therefore:

GNERD + Income from sales of R&D services
= GERD

+ Intermediate consumption
+ Payments to international organisations and public bodies established abroad.

This equation is in fact the same as that used to describe the transfer from GERD to GNERD. Income from sales is equal to distributed output of R&D. This falls within the compass of the overall balance of "market R&D".

Income from sales of R&D services
= Intermediate consumption
+R&D exports
- R&D imports.

It therefore replaces the equation for the GNERD-GERD transfer:

GNERD
+ R&D exports
- R&D imports
=GERD

+Payments to international organisations and public bodies established abroad.

R&D exports correspond to funding received from abroad, and the sum of R&D imports and payments to international bodies and public bodies established abroad corresponds to the funding of R&D performed abroad. This yields the following equation:

GNERD = GERD
+ Funding of R&D performed by external agents
– R&D funding received from external sources.

Table 8. **Funding and performance of R&D by institutional sector**

Performance	Funding				Total performance
	Non-market funding	Market funding	Total national funding	Funding by rest of world	
Non-market	**Own-account expenditure of gen gov't**	**ISM**	**GERDm own funding**	**Exnm**	**GNRDnm**
Market	**Tnm+SRL**	**Own-account expenditure of CQCs**	**GERDnm own funding**	**Exm**	**GERDm**
Total performance	**Intramural funding by gen. gov't**	**Intramural funding by CQCs**	**Nat'l funding of intramural expenditure**	**EX**	**GERD**
Funding to rest of world	**Inm + PPBA**	**Im**	**I + PBA**	***///***	***///***
Total funding	**GERDnm**	**GNRDm**	**GNRD**	***///***	***///***

Calculation in practice

87. In practice, the intramural expenditure of each sector is known, but the own-account items, which figure on the diagonal, are not and have to be calculated by subtraction. The assumption that margins can be disregarded applies here.

88. For reasons related to the accounting difficulties of valuing intermediate consumption in the market R&D sector, the calculation for the French account utilises a larger number of sectors and, in particular, among CQCs, identifies firms specialising in R&D and technical centres belonging to professional organisations. But the principles for calculating the satellite account remain the same, and the approach is the one described here.

Funding and performance of R&D by sector

89. The net funding supplied by each sector provides a measure of the financial contribution that units in this sector make to the national R&D effort, *i.e.* GNERD. It is calculated by means of the equation linking GERD to GNERD on the basis of:

- intramural R&D expenditure by units classified within a given sector;
- intermediate consumption of R&D by units in that sector;
- incidental sales and transfers of R&D services;
- funding corrections.

Intermediate consumption by sector

90. Measurement of intermediate R&D consumption by sector requires an adjustment. In the uses and resources balance the overall measurement of intermediate consumption is based on reported resources (see above). At the same time, units report their funding of extramural expenditure, and this can be used to measure intermediate consumption by sector. All that then remains is to estimate the extramural expenditures of units that do not perform any R&D work themselves but subcontract it to others.

91. These measurements by sector can then be compared and adjusted in accordance with the overall measurement provided by the uses and resources balance.

R&D budget

92. The R&D budget of each sector is equal to the sum of its intramural expenditure and intermediate consumption. It corresponds to the overall amount which units within that sector spend on R&D. For a specific set of units, therefore, the R&D budget systematically double counts overlapping flows of R&D between these units: once as intramural expenditure, and once as extramural expenditure as a component of intermediate consumption. Although such an approach is meaningful at the level of individual units, since it provides an indication of the unit's expenditure on R&D, it cannot be used for economic analysis at aggregate level and is therefore used solely as an intermediary stage in calculations.

Distributed output of market R&D by sector

93. By definition, incidental sales in this account represent the modest level of market R&D accounted for by non-profit producers. Transfers by specialist R&D firms are equal to their sales. Other transfers of market R&D services are determined from the resources received for R&D by other units in the CQC category.

Subsidies and refundable loans

94. These items are not equivalent to sales and are not accounted for under distributed output. They are, however, counted as government-financed R&D performed by non-financial corporate and quasi-corporate enterprises in the calculation of ONERD and must therefore be reattributed to the government as a source of funds. They represent a correction to the calculation of the funding of the market and non-market sectors.

Funding of international organisations and public bodies established abroad

95. This correction reincorporates government funding of international organisations and public bodies established abroad in the funding of the non-profit sector. As a result, such funding is included under total funding of all sectors for the purposes of calculating GNERD.

Net funding by sector

96. The calculation for each sector is based on the equation expressing the overall balance of R&D performance and funding. The effect of the corrections may be seen below in the distinction made between the calculation of the net funding of a given industry and that of all non-profit producers (non-market sector).

97. The balance for each industry may be expressed as follows:

- Net funding of a given industry

- = Intramural expenditure of that industry

– + Intermediate consumption

Sales of market R&D services

Subsidies and refundable loans received and the balance for all non-profit producers:

– Net funding of non-market sector

– = Intramural expenditure of that sector

– +Intermediate consumption

– Incidental sales

– +Subsidies and refundable loans paid

– +Funding given to international organisations and public bodies established abroad.

98. The sum of the net funding of the market and non-market sectors is equal to GNERD, and the sum of intramural expenditure to GERD. Overall equality between performance and funding of R&D is thus satisfied (see above and table 9).

Table 9. Funding and performance of R&D by sector (two-category presentation: market and non-market sector)

Sector	Intramural expenditure	Intermediate consumption	Transfers and incidental sales	Funding correction	National expenditure (funding)
Market	**GERDm**	**ICm**	**T**	**–SRL**	**GNERDm**
Non-market	**GERDnm**	**ICnm**	**IS**	**PPBA + SRL**	**GNERDnm**
Total	**GERD**	**IC**	**T+IS**	**PPBA**	**GNERD**

99. The net funding of each sector is necessarily a positive balance except, in certain cases, for specialist R&D firms. This industry sells all its R&D work; and the output of most of its constituent units is measured by sales, not, as for other industries, by external resources reported to have been received for R&D performance (excluding subsidies and refundable loans). These sales generally cover not only the budgets of specialist R&D units but also items such as depreciation which are not included in the budgets. The differences may be reflected in slightly negative net funding, *i.e.* funding apparently received from elsewhere.

100. Conversely, the capital expenditure of these units is included in their R&D budgets and may have been funded, either in whole or in part, by means of loans or borrowings that are not included in sales.

101. It is possible to move from the institutional sector balance to the industry balance only insofar as all market activity corresponds to the CQC sector and all the remaining institutional sectors correspond to non-market activity form a single item in the nomenclature employed.

102. Another presentation, more complex but more rational in accounting and economic terms, is to make a distinction, when analysing the performance and funding of R&D, between current transactions

and gross fixed capital formation, as these transactions are not funded in the same way and are not set out in the same accounts.

103. There is no problem for transfers or intermediate consumption, which do not relate to capital expenditure, but incentive-type public funding contributed to an R&D project may well be used to fund R&D equipment and current expenditure.

104. The ideal solution here, if the breakdown between current and capital transactions is known, would be to separate the two types in the funding and performance balance so as to relate them to the appropriate specific accounts.

R&D Account for 1989

Table 10**. Uses and resources balance for market R&D services**

(FF millions*)*

Uses Resources	Non-market	Market	Total intermediate consumption	Exports to rest of world	Total resources
Non market	2 952	2 091	5 043	1 066	6 109
Market	12 954	17 104	30 048	9 485	39 543
Imports from rest of world	82	4 696	4 778	–	4 778
Total uses	15 988	23 891	39 879	10 551	50 430

Table 11. External funding
(FE millions)

Payments made/received	Non-market	Corrections to public funding	Market	Total external payments	Payments from rest of world	Total payments received
Non-market	2 952	980	2 091	6 023	1 066	7 079
Market	12.954	3 283	17 104	33 341	9 485	42 826
Payments to rest of world	82	5105	4696	9883	–	9883
Total payments made	15 988	9 368	23 891	49 247	10 551	59 798

Table 12**. Funding and performance of R&D by institutional sector**

Table 2. (FF millions)

Funding Performance	Non-market funding	Market funding	Total national funding	Funding by rest of world	Total performance
Non-market	51 224	2 091	53 315	1 006	54 381
Market	16 237	63 450	76 687	9 485	89 172
Total performance	67 461	65 541	133 002	10 551	143 553
Funding to rest of world	5187	4696	9883	–	–
Total funding	72 648	70 237	142 885	–	–

Table 13. **Funding and performance of R&D by sector**
(two-category presentation: market and non-market sectors)
(FF millions)

Sector	Intramural expenditure	Intermediate consumption	Transfers and incidental sales	Funding correction	National expenditure (funding)
Market	89 172	23 891	39 543	–3 283	70 237
Non-market	54 381	15 988	6 109	8 388	72 648
Total	143 553	39 879	45 652	5 105	142 885

Table 14. **R&D performance and funding by industry**

(FF millions)

	Industry	1989 Intramural R&D expenditure	1989 Intermediate R&D consumption	1989 R&D budget	R&D sales	1989 Subsidies and refundable loans	1989 Int'l funding by government	1989 National R&D expenditure
T 01	Agriculture	331	177	508	50	159	0	299
T 02	Meat and dairy industry	214	20	234	3	6	0	225
T 03	Other agro-food ind.	786	212	998	21	7	0	970
T 04	Solid fuels	60	55	115	8	0	0	107
T 05	Oil and natural gas	1 095	976	2 071	363	51	0	1 657
T 06	Electricity, gas and water	1 809	563	2 372	20	4	0	2 348
T 07	Mining and steel-making	598	465	1 063	37	5	0	1 021
T 08	Non-ferrous metals	376	268	644	37	2	0	605
T 09	Building materials, etc.	245	103	348	66	7	0	275
T 10	Glass	269	149	418	13	1	0	404
T 11	Chemicals, etc.	4 168	1 430	5 598	1 190	16	0	4 392
T 12	Chemicals and pharmaceuticals	6 702	3 293	9 995	991	35	0	8 969
T 13	Casting and metalworking	509	113	622	27	13	0	582
T 14	Mechanical engineering	2 982	576	3 558	483	80	0	2 995
T 15 A	Elect. and electronic equipment	24 069	2 581	26 650	10 070	911	0	15 669
T 15 B	Household appliances	827	29	856	4	20	0	832
T 16	Transport equipment	8 294	2 663	10 957	224	24	0	10 709
T 17	Shipbuilding, aerospace and arms	16 297	6 219	22 516	13 758	1 371	0	7 387
T 18	Textiles and clothing	176	57	233	1	4	0	228
T 19	Leather and footwear	22	15	37	0	0	0	37
T 20	Wood, furniture, etc.	211	46	257	1	0	0	256
T 21	Paper and pulp	204	73	277	26	3	0	248
T 22	Printing and publishing	22	2	24	0	1	0	23
T 23	Rubber and plastics	2 376	130	2 506	1	3	0	2 502
T 24	Building and civil engineering	958	110	1 068	160	31	0	877
T 25-28	Retail trade	223	295	518	8	8	0	502
T 29	Vehicle repairs	0	0	0	0	0	0	0
T 30	Hotels and catering	0	0	0	0	0	0	0
T 31	Transport	200	154	354	7	2	0	345
T 32	Post and telecommunications	1 864	1 303	3 167	68	0	0	3 099
T 33-34	Other market services	13 285	1 814	15 099	11 906	519	0	2 674
	(of which: market R&D)	10 179	1 178	11 357	11 180	366	0	−189
T 35	Industrial leasing	0	0	0	0	0	0	0
T 36	Insurance	0	0	0	0	0	0	0
T 37	Financial services	0	0	0	0	0	0	0
T 38	Non-market services	54 381	15 988	70 369	6 109	−3 283	5 105	72 648
	Total	143 553	39 879	183 432	45 642	0	5 105	142 885

ANNEX 12

SUPPLEMENTARY GUIDANCE ON THE CLASSIFICATION ON LARGE R&D PROJECTS WITH SPECIAL REFERENCE TO THE DEFENCE AND AEROSPACE INDUSTRIES

The reader should refer to Chapter 1, paragraph *7* of the Manual for a comment on the use of this annex before proceeding further.

Introduction

1. This annex aims to provide supplementary guidance on the treatment of large development projects in R&D statistical surveys and in returns to the OECD. The borderline between experimental development and other industrial activities (comprising the two overlapping groups of other innovation activities and production and related technical activities) is described in Sections 1.5.3, 2.2.3 and 2.3.4 of the Manual. Sections 1.5.2 2.2.2 and 2.3.3 deal with the borderline between R&D and other related scientific and technological activities. The distinctions are particularly difficult to establish for large expensive development projects in the defence and aerospace industries. The general issues covered in this annex are nevertheless relevant to all industries.

2. Over many years, several countries have persistently had problems in reconciling the expenditure on R&D reported by defence ministries as contracted out to the business enterprise sector and the amount claimed as received from government for R&D by the defence industry. In general, data based on the government budget tend to be higher and can lead to significant differences in the amounts of defence R&D reported in government budget appropriations or outlays for R&D (GBAORD) and in gross domestic expenditure on R&D (GERD). The differences have been attributed to a number of factors, such as subcontracting and international collaborative projects; but they have also raised questions about the correct application of the Manual's definitions of R&D, especially in the GBAORD series.

3. The first section of this annex compares the categories and terminology used by the United Kingdom, the United States, and France in the defence and aerospace industries. The second section analyses examples of defence R&D projects. Both sections also provide guidance on differentiating between the concept of R&D as defined in the Manual and related activities that do not count as R&D. Throughout, the term "preproduction development" is used to describe non-experimental work on a defence or aerospace product or system before it goes into production and, more specifically, activities that are not part of scientific and technological innovation.

Terminology and categories used in the United Kingdom, the United States, and France

4. One of the specific difficulties in applying the concepts of basic research, applied research, and experimental development to the defence and aerospace industries is that these industries tend to have their own terminology. This terminology differs from country to country and often cuts across the categories of this Manual. This section illustrates these difficulties by comparing the Frascati categories with terms used in the French, UK and US defence ministries and with an industry classification used by a major aerospace company.

5. Table 1 contains a list of the terms in common use in the defence and aerospace industries in these countries, and Table 2 shows how some of these terms are currently interpreted by the three countries in terms of the Frascati Manual terminology and definition of R&D.

United Kingdom categories and terminology

6. Two categories of applied research are used in the United Kingdom's annual survey of government-funded R&D and are the basis of figures reported to the OECD for GBAORD:

> "Strategic research is defined as applied research which is in a subject area which has not yet advanced to the stage where eventual applications can be clearly specified.
>
> Applied research which is not strategic in nature will have quite specific and detailed products, processes, systems, etc., as its aims."

(Cabinet Office, 1991, Annex C, paras. 4-5.)

7. In an internal UK Defence Ministry study of the borderline between R&D and preproduction development, the following non-R&D "scientific and technical innovation" categories were identified:

- new product marketing;
- patent work (but see below);
- financial and organisational changes;
- final product or design engineering;
- tooling and industrial engineering;
- manufacturing start-up;
- user demonstrations (but see below).

8. The Manual (Section 1.5.3) refers to a "demonstration" as "an innovation operated at or near full scale in a realistic environment" to aid policy or promotion, as being outside of R&D. But it is necessary to distinguish these user demonstrations from the technical demonstrations that are part of R&D. The French terms "demonstration project" and "demonstration model" refer to the latter.

9. Patent work, product and design engineering, demonstrations, data collection, testing, and feasibility studies can all be part of an R&D project, as supporting work to the main project (see Section 2.3.4.1). Likewise, production activities can include "feedback" R&D to solve technical problems that emerge after production has started. These are all areas in which the distinction between "experimental development" and "preproduction development" can be difficult and which do not necessarily follow the simple linear model of the steps from basic research to production.

10. The UK study also identified the following non-R&D "related scientific and technical activities'':

- general purpose data collection;
- testing and standardisation;
- feasibility studies;
- –policy-related studies;

- production and related technical activities.

Table 1. Terminology in common use in the defence and aerospace industries

Terminology	Most likely classification[1]
Basic research	BASIC RESEARCH
Fundamental research	..
Upstream research	..
Etudes amont	..
	..
Applied research	APPLIED RESEARCH
Demonstration model	..
Demonstration project	..
Exploratory development	..
Etudes amont	..
	..
Experimental development	EXPERIMENTAL DEVELOPMENT
Advanced development	..
Pilot plant (initially)	..
Prototype	..
Proving model	..
Proving project	..
Systems design and specification studies	..
Systems-oriented preliminary project	..
Technical demonstrations	..
	..
Feedback R&D	R&D (activity unspecified)
RDT&E	..
Design engineering	MIXED R&D/NOT R&D
Feasibility studies	R&D/preproduction
Further development	R&D/preproduction
Maintenance and repairs	R&D/preproduction
Project definition	R&D/preproduction
Policy and operational studies	NOT R&D
Engineering development	Preproduction
Engineering projects	Preproduction
Industrial engineering	Preproduction
Operational development	Preproduction
Post-certification development	Preproduction
Trial production batch	Preproduction
User demonstration	Preproduction
Documentation	S&T innovation
initial development	S&T innovation
Manufacturing start-up	S&T innovation
New product marketing	S&T innovation
Patent work	S&T innovation
Product engineering	S&T innovation
Tooling	S&T innovation
Post-design services	Industrial activity
Series production	Industrial activity
Related S&T activities	Not R&D
S&T innovation	Not R&D

This is only a guide. Actual classification to types of R&D as defined in this Manual depends on the nature of the particular project and the context within which the term is used.

Table 2. **Current Frascati classification treatment of UK, US and French terminology**

FRASCATI MANUAL	UNITED KINGDOM	UNITED STATES	FRANCE
RESEARCH AND DEVELOPMENT			
Basic research	Basic research (0)	Research (0)	Basic research (0), Etudes amont (0); see also below Research work (0); see also Research (I)
Applied research	Strategic applied research (0), Specific applied research (0)	Exploratory Development (0)	Applied research (0) Demonstration project (0) Demonstration model (I) Exploratory development (0) General research (I) Preliminary project (I) Proving project (I) Proving model (I) Research work (0) Systems oriented research (I)
Experimental development	Experimental development (0)	Advanced development (0) Engineering development (0) Management and support (0) Operational systems development (0)	Development (I) Developpements (0) Prototype (I) Pilot plant (1)
NON-R&D ACTIVITIES			
Preproduction development	Scientific and technical innovation (I) Other related scientific and technical activities (0)		S&T services (I) S&T training and development (I)

0 = Official (Defence Ministry) terminology.

I = Industry terminology.

11. The survey concluded that “final product or design engineering”, “feasibility studies”, and “production and related technical activities” were the areas most likely to be incorrectly included as R&D.

United States categories and terminology

12. Six categories (6.1 to 6.6) are defined within the US Department of Defense (DoD) as part of its Research, Development, Test and Evaluation (RDT&E) Funding Program. All of these are allocated to R&D in returns to the National Science Foundation and hence in GBAORD returns to the OECD (see Table 2*).*

13. “Research” (6.1) is defined as:

> “scientific study and experimentation directed toward increasing knowledge and understanding in those fields of the physical, engineering, environmental and life sciences related to long-term national security needs. It provides fundamental knowledge for the solution of military problems
>
> (United States Government Printing Office, 1987.)

This definition puts the DoD’s “research” into the “oriented basic” category because it has a (defence) objective. Some of it probably resembles the United Kingdom’s “Strategic applied research”. University research funded by the DoD and not tied to military problem-solving is also basic research. Scientific fields “related to long-term national security needs” are scientific fields in which basic research can generate military applied research. Funding limited to such fields can still be funding of basic research.

14. “Exploratory development (6.2) is defined as “all effort directed toward the solution of specific military problems, short of major development projects... The dominant characteristic of this category of effort is that it can be pointed toward specific military problem areas with a view toward developing and evaluating the feasibility and practicability of proposed solutions”. This category resembles the s “Specific applied research” and is definitely “Applied research” according to this Manual’s definition.

15. “Advanced development” (6.3) is defined as “all effort directed toward projects which have moved into the development of hardware for test. The prime result of this type of effort is proof of design concept rather than the development of hardware for service use”.

16. “Engineering development” (6.4) involves “those projects in full-scale engineering development for service use but which have not yet received approval for production funds... This area is characterised by major line item projects”.

17. “Operational system development” (6.5.) is development of approved systems. This appears to be the stage after “Advanced development” and “Engineering development”.

18. Most of the work categorised as “Advanced development”, “Engineering development”, and “Operation system development” is undoubtedly experimental development, and is so classified by the DoD. However the fact that these categories take the development to a “proof of design” or “approval” stage suggests that some of it may be preproduction development, and therefore fall outside of the definition of R&D.

19. “Management and support” (6.5) is “support for military R&D infrastructure”. If this is support for all R&D, it should not be assigned exclusively to experimental development, though this probably has little effect on the comparability of the figures.

French categories and terminology

20. In the French Defence Ministry the Frascati standards are applied but the classification of a particular project by type of activity depends on its place in the decision-making process as well as on the nature of the work. Thus the term “les études en amont” (upstream studies) covers basic and applied research; including research study (straddling basic and applied) and exploratory developments (defining the operational application of new technological developments). The term “développements décidés” (defined developments) is used for experimental development. This includes the tasks of perfecting prototypes destined for production and operational use, *i.e.* all work prior to the actual start of production.

21. In the French aerospace industry, the term “research” is used to cover both basic and applied research. The terms “development”, “prototype”, and “pilot plant” would generally fall within this Manual’s concept of experimental development. “Scientific and technical services” and “Education and Development” would generally be excluded from R&D. However, decisions on the precise classification of work are checked by the authorities with the company concerned to ensure compliance with the standards of this Manual.

Examples

22. This section looks at some examples of major technological development projects in the defence and aerospace industries. The objective is to show how the categories of this Manual could be applied and where difficulties might arise.

Example A

23. Project description:

> To establish the feasibility and value of non-equilibrium device structures and to make available the unique properties of narrow-gap semiconductors for opto-electronics and high-speed logic functions at ambient temperatures. If successful, the new devices will offer substantial performance advantages over both silicon and gallium arsenide devices for future high-speed electronic applications. The plan is to identify useful non-equilibrium devices, to confirm some of the key parameters of narrow-gap semiconductor materials, and to use these to predict device performance and, finally, having identified suitable devices, to research their practical realisation and characterise them in simple form.

24. This project is currently **at the strategic applied research stage,** since it is directed at a group of applications but not a particular application. It would have followed on from basic research that discovered non-equilibrium device structures, probably in a university. A potential range of applications in opto-electronics and high-speed logic functions is hypothesised, and the research investigates these possible applications. Testing is involved “to confirm some of the key parameters”, but this testing could well be part of the applied research stage of exploring unknown areas merely suggested by the basic research.

25. Once suitable devices are identified, their “practical realisation” would involve **experimental development**. Early prototype models to “characterise them in simple form” could be part of this experimental development stage. Later models and customer or user demonstration procedures (see para. 7 above) would be preproduction development rather than experimental development.

Example B

26. Project description:

> X is a Short Range Air Defence (SHORAD) missile system, planned to be evolutionary and therefore capable of responding to a developing threat. X2 is being developed as the latest member of the X family. Project B involves development and production of the new X2 missile and new ground equipment. The development programme is for a large system that requires the interaction of a number of complex technologies such as electro-optics, command links, and both tracking and surveillance radars. This will allow the operator to track more targets, with better discrimination, and to fire multiple missiles if required. Under single missile operation, the

thermal picture from the electro-optic (EO) tracker can be used to guide the missile all the way to the target, but another missile cannot be fired until the EO tracker is free again. Under multiple missile operation, a first missile may be guided initially by the EO tracker, but then handed over to a radar tracker for transmission to the target, thus freeing the EO tracker to start guiding a second missile before the first has hit its target. The programme endeavours to integrate the subsystems from high technology subcontractors under the guidance of a single prime contractor.

27. The development of "Mark II" models is common in defence technology, and it is not necessarily easy to decide how much of such development is experimental. In this case the difference between the single missile system and the multiple missile system is big enough to suggest that the development of the latter is experimental development. But the project (and, again, this is common in defence technology) is the development of a complex system involving different pieces of equipment and different technologies. In theory the project could be broken down into a number of subprojects, some of which are subcontracted. Some of the subprojects, involving the application of existing technology to existing equipment, may not be R&D at all. A subcontractor working on such a subproject should not count it as experimental development. The funding organisation and the main contractor, however, may be unable to break the project expenditure down in this way.

28. Example B involves both experimental development and production. It would be necessary to separate out the production aspect at the later stages of the project, in order to distinguish the borderline preproduction and production elements.

Example C

29. Table 3 shows the stages of an armoured tank development programme and a subsequent upgrade development programme.

30. Concept design appears to be borderline with applied research and could be achieved at the end of an applied research project.

31. In the original development programme, detailed design and systems integration appear to be experimental development. Systems integration involves testing, and this is part of the experimental development stage. If the upgrade development programme has to go through all the stages listed, the probability is that a substantial improvement is involved and the work counts as experimental development. Assuming the upgrade is work of this kind, the systems design and systems integration stages again appear to be experimental development.

32. There is a "feedback" situation with the trial and redesign/modification stages. Much of this work would be experimental development. Some of it might not be.

33. The user demonstration and acceptance of design stages appear to be preproduction, rather than experimental development, and outside of R&D.

34. The post-design services stage is comparable with the re-design/modification stage. It could involve some experimental development but in general it would not.

Example D

35. Project description:

A fighter bomber known as QWERTY has successfully passed through the research, technology demonstration, project design and initial development stages to flight testing of a preproduction aircraft. Further airframes are now required to develop and integrate the vehicle into air offence/defence systems in order to ensure full operational capability. This may require up to ten additional aircraft.

Table 3 **Example C – Development of an armoured tank**

1.ORIGINAL DEVELOPMENT PROGRAMME	
User states operational requirements	What is expected of the kit in the field
Detailed specification	What the kit needs to do to achieve its role
Concept design/proof of principle	The initial design to demonstrate the specification can be met
Detail design	Design sub-systems, identify equipment/sub-contractors best suited to achieve specification, looking first to existing kit, then modifying existing kit and if necessary designing a new one
Systems integration	Assembling all sub-systems and testing to ensure all function together as required
Trials	Carry out extensive trials and testing to demonstrate achievement of specification
Re-design/Modify	Incorporate modifications identified as a result of trials
User demonstration	Customer carries out own trials to ensure product meets specification to his satisfaction
Acceptance of design.	Production Build Standard agreed, Technical Data Pack prepared
Production	Series production to agreed build standard
Post-design services	Modification to production build standard after entry into service. This involves design of modification and production of modification kits
2.UPGRADE DEVELOPMENT PROGRAMME	
Identify enhanced operational requirements	What is expected of the equipment following upgrade
Detailed improvements specifications	What the kit should be capable of following improvements
Systems Design	Design of the improved system utilising existing vehicle equipment and new equipment from the development programme
Systems integration	Assembling all subsystems and testing to ensure all function together as required
Trials	Carry out extensive trials and testing to demonstrate achievement of improvements specification
Re-design/Modify	Incorporate modifications identified as a result of trials
User demonstration	Customer carries out own trials to ensure product meets specification to his satisfaction
Acceptance of design	Production Build Standard agreed, Technical Data Pack prepared
Production of modification kits/Upgrade vehicles	Series production/modification to agreed build standard
Post-design services	Modification to improved standards of material already in use. This phase requires design of modifications and production of modification kits

36. Stage one is **development of the integrated air offence/defence system.** This stage involves bringing together developed components and subsystems that have not been integrated in this context before. It requires a large flight test programme of the ten aircraft, which is potentially very expensive and

the dominant element in costs prior to production. Some of the work commissioned during this stage does not have the element of novelty necessary for classification as R&D. Expenditure on this stage should therefore be split between:

a) experimental development (R&D);

b) preproduction development (non-R&D).

37. The distinction between these two categories requires an engineering judgement of when the element of novelty ceases and the work changes to routine development of an integrated system. The description of this stage of the project shows, once again, how difficult it can be to distinguish experimental development from preproduction development. The need for an “engineering judgement” underlines the difficulty.

38. Stage two **covers trials of the integrated air offence/defence system.** Once the system is proved to work at stage one, the development project may move on to produce a trial production batch for operational trials. The full production order is dependent on their success. According to this Manual, this work is not R&D but preproduction development. However, during the trials problems may arise, and new experimental development may be needed to solve them. This work is described in this Manual as **“feedback R&D”** and should be included as R&D.

39. Stage three concerns full production. This is not R&D.

Annex 13

Revised Industrial Classification for Resources Devoted to R&D in the Business Enterprise Sector in OECD R&D Surveys

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

Title	ISIC Rev. 3 Division/Group/Class	Approximate correspond. ISIC Rev. 2 Division/Group/Class [2]	Corresponding NACE Rev. 1 Div./Group/Class [3]
1. AGRICULTURE, HUNTING AND FORESTRY	**01 + 02 + 05**	**1**	**01 + 02 + 05**
2. MINING	**10-14**	**2**	**10-14**
3. MANUFACTURING	**15-37**	**3**	**15-37**
4. Food, beverages and tobacco	**15 + 16**	**31**	**15 + 16**
5. Food products and beverages	15	311-313	15
6. Tobacco products	16	314	16
7. Textiles, wearing apparel, fur and leather	**17-19**	**32**	**17-19**
8. Textiles	17	321	17
9. Wearing apparel and fur	18	322-324	18
10. Leather products and footwear	19		19
11. Wood, paper, printing, publishing	**20-22**	**331 + 34 + 3832 (part)**	**20-22**
12. Wood and cork (not furniture)	20	331	20
13. Pulp, paper and paper products	21	341	21
14. Publishing, printing and reproduction of recorded media	22	342 + 3832 (part)	22
15. Coke, petroleum, nuclear fuel, chemicals and products, rubber and plastics	**23-25**	**35**	**23-25**
16. Coke, refined petroleum products and nuclear fuel	23	353 + 354	23
17. Chemicals and chemical products	24	351 + 352	24
18. Chemicals and chemical products (less pharmaceuticals)	24 less 2423	351 + 352 less 3522	24 less 24.4
19. Pharmaceuticals	2423	3522	24.4
20. Rubber and plastic products	25	355 + 356	25
21. Non-metallic mineral products ("Stone, clay and glass")	**26**	**36**	**26**
22. Basic Metals	**27**	**37**	**27**
23. Basic metals, ferrous	271 + 2731	371	27.1-27.3 + 27.51/52
24. Basic metals, non-ferrous	272 + 2732	372	27.4 + 27.53/54
25. Fabricated metal products (except machinery and equipment)	**28**	**381**	**28**
26. Machinery equipment, instruments and transport equipment	**29-35**	**38 less 381 and 3832 (part)**	**29-35**
27. Machinery, n.e.c.	29	382 less 3825 + 3829 (part)	29
28. Office, accounting and computing machinery	30	3825	30
29. Electrical machinery	31	383 less 3832	31

31.	Electronic components (includes semiconductors)	321		32.1
32.	Television, radio and communications equipment	32 less 321		32 less 32.1
33.	Medical, precision and optical instruments, watches and clocks (instruments)	33	385	33
34.	Motor vehicles	34	3843	34
35.	Other transport equipment	35	384 (part) + 3829 (part)	35
36.	Ships	351	3841	35.1
37.	Aerospace	353	3845 + 3829 (part)	35.3
38.	Other transport n.e.c.	352 + 359	3842 + 3844 + 3849	35.2 + 35.5
39.	**Furniture, Other Manufacturing n.e.c.**	**36**	**332 + 39**	**36**
40.	Furniture	361	332	36.1
41.	Other manufacturing n.e.c.	369	39	36.5
42.	**Recycling**	**37**	**n.a.**	**37**
43.	**ELECTRICITY, GAS AND WATER SUPPLY (UTILITIES)**	**40 + 41**	**4**	**40 + 41**
44.	**CONSTRUCTION**	**45**	**5**	**45**
45.	**SERVICE SECTOR**	**50-99**	**6-9**	**50-99**
46.	**Wholesale, retail trade and motor vehicle, etc., repair**	**50-52**	**61 + 62 + 6 (part)**	**50-52**
47.	**Hotels and restaurants**	**55**	**63**	**55**
48.	**Transport and storage**	**60-63**	**71**	**60-63**
49.	**Communications**	**64**	**72**	**64**
50.	Post	641		64.1
51.	Telecommunications	642		64.2
52.	**Financial intermediation (including insurance)**	**65-67**	**81 + 82**	**65-67**
53.	**Real estate, renting and business activities**	**70-74**	**83 + 93270-74**	
54.	Computer and related activities	72	8323	72
55.	Software consultancy	722		72.2
56.	Other computer services n.e.c.	72 less 722		72 less 72.2
57.	Research and development	73	932	73
58.	Other business activities n.e.c.	70 + 71 + 74	83 (part)	70 + 71 + 74
59.	**Community, social and personal service activ., etc.**[1]	**75-99**	**9 less 932**	**75-99**
60.	**GRAND TOTAL**	**01-99**	**1-9**	**01-99**

1. Activities carried out in these industries by the business enterprise sector only. Figures are expected to be negligible: the heading is included as an aide-memoire.
2. UN, (1968*a*).
3. EUROSTAT, (1990).

n.e.c = not elsewhere classified.

Acronyms

AMT	Advanced manufacturing technology
CAD	Computer-aided design
CAE	Computer-aided engineering
CEC	Commission of the European Communities
CERN	European Centre for Nuclear Research
CIM	Computer-integrated manufacturing
CMEA	Council for Mutual Economic Assistance
COFOG	Classification of the purposes of government
CQC	Corporate and quasi-corporate enterprise
CREST	Scientific and Technical Research Committees
DoD	Department of Defense (US)
DPI	Domestic product of industry
EC	European Community
ECE	United Nations Economic Commission for Europe
EO	Electro-optic
EU	European Union
FMS	Flexible manufacturing systems
FTE	Full-time equivalence
GBAORD	Government budget appropriations or outlays for R&D
GDP	Gross domestic product
GERD	Gross domestic expenditure on R&D
GFCF	Gross fixed capital formation
GNERD	Gross national expenditure on R&D
GUF	General university funds
HERD	Higher education R&D
HRST	Human resources for science and technology
ICP	International comparison project
ILO	International Labour Organisation
ISCED	International standard classification of education
ISCO	International standard classification of occupations
ISIC	International standard industrial classification
NABS	Nomenclature for the analysis and comparison of scientific programmes and budgets
NACE	General Industrial Classification of Economic Activities within the European Communities
NESTI	National experts on science and technology indicators
NPI	Non-profit institution
NPSH	Non-profit serving households
NSE	Natural sciences and engineering
NSF	National Science Foundation
OAS	Organization of American States
OECD	Organisation for Economic Co-operation and Development
OR	Operations research
PBA	Public bodies established abroad
PNP	Private non-profit
PPP	Purchasing power parity
R&D	Research and experimental development
RD&D	Research, development and demonstration

RDT&E	Research, development, test and evaluation funding
RSE	Researchers
SCI	Science Citation Index
SHORAD	Short Range Air Defence
SITC	Standard international trade classification
SNA	System of National Accounts
SRL	Subsidies and refundable loans
SSH	Social sciences and humanities
STA	Scientific and technological activities
STET	Scientific and technical education and training
STID	Scientific and technological information and documentation
STS	Scientific and technological services
TEP	Technology-economy programme
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
VAT	Value-added tax
VSLI	Very large-scale integrated circuits

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