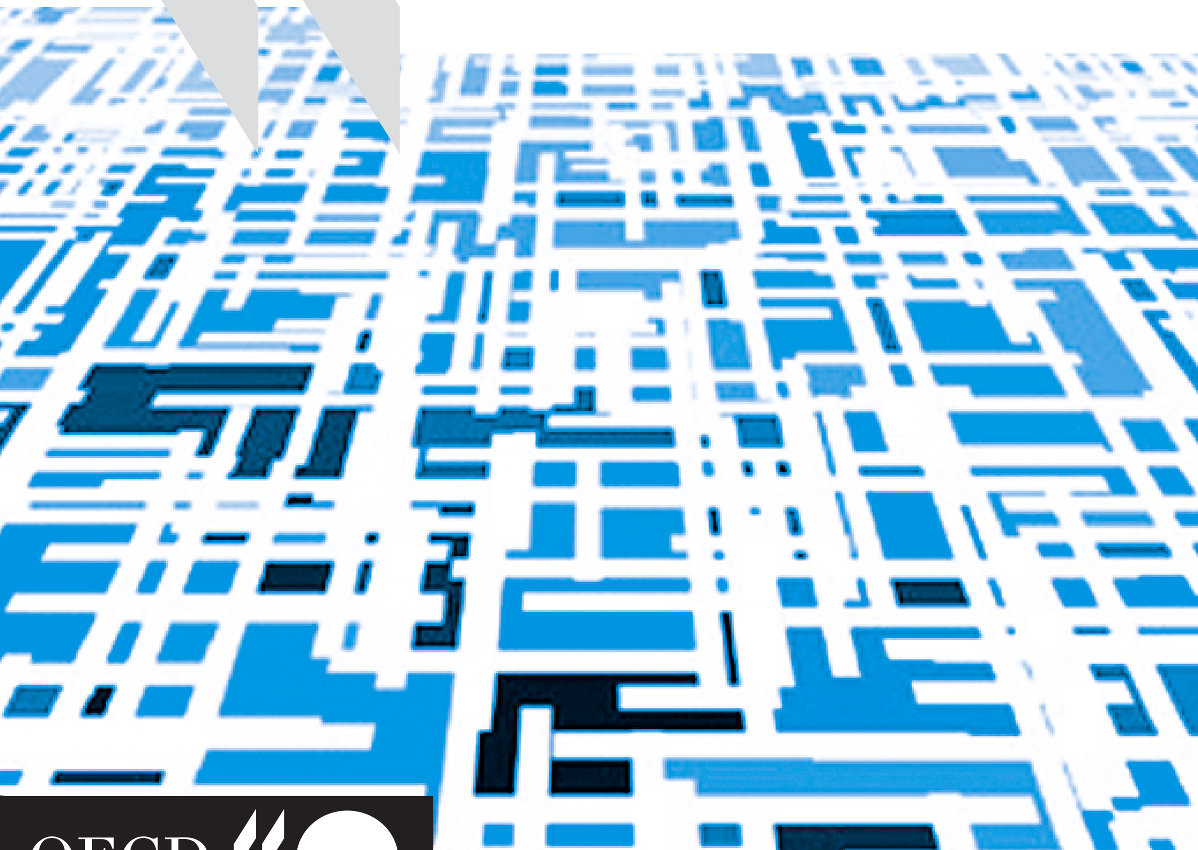
Frascati Manual

PROPOSED STANDARD PRACTICE FOR SURVEYS ON RESEARCH AND EXPERIMENTAL DEVELOPMENT



OECD

2002

THE MEASUREMENT OF SCIENTIFIC
AND TECHNOLOGICAL ACTIVITIES

Proposed Standard Practice for Surveys
on Research and Experimental Development

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Manuel de Frascati 2002

Méthode type proposée pour les enquêtes sur la recherche et le développement expérimental

Foreword

In June 1963, the OECD met with national experts on research and development (R&D) statistics at the Villa Falcioneri in Frascati, Italy. The result was the first official version of the Proposed Standard Practice for Surveys of Research and Development, *better known as the* Frascati Manual. *This publication is the sixth edition.*

Since the fifth edition was issued in 1994, attention has increasingly been paid to R&D and innovation as key elements in the knowledge-based economy. Reliable and comparable statistics and indicators to monitor this area are of crucial importance. This edition therefore makes an effort to strengthen various methodological recommendations and guidelines, in particular for improving R&D statistics in the services sector and collecting more detailed data on human resources for R&D. Because globalisation is a challenge for R&D surveys, the Manual recommends some changes in classifications in an attempt to address this issue.

Today's R&D statistics are the result of the systematic development of surveys based on the Frascati Manual *and are now part of the statistical system of the OECD member countries. Although the Manual is basically a technical document, it is a cornerstone of OECD efforts to increase the understanding of the role played by science and technology by analysing national systems of innovation. Furthermore, by providing internationally accepted definitions of R&D and classifications of its component activities, the Manual contributes to intergovernmental discussions on "best practices" for science and technology policies.*

The Frascati Manual *is not only a standard for R&D surveys in OECD member countries. As a result of initiatives by the OECD, UNESCO, the European Union and various regional organisations, it has become a standard for R&D surveys worldwide.*

The Frascati Manual *is based on experience gained from collecting R&D statistics in OECD member countries. It is a result of the collective work of national experts in NESTI (the Working Party of National Experts on Science and Technology Indicators). The Group, supported by an effective Secretariat, first led by the late Yvan Fabian and subsequently by Alison Young, John Dryden, Daniel Malkin and Andrew Wyckoff, has elaborated over the last 40 years on the concept of science and technology indicators and developed a series of methodological manuals known as the "Frascati Family", which includes manuals on: R&D (*Frascati Manual*), innovation (*Oslo

Manual), *human resources* (Canberra Manual), *technological balance of payments and patents as science and technology indicators.*

The Frascati Manual *is also published in electronic format on the OECD Web site. The idea is to update the electronic version more frequently, as newer material becomes available. The electronic version is complemented by further material related to R&D surveys.*

The sixth edition of the Manual was prepared by teams of experts drawn from the NESTI Group. The OECD Secretariat (especially Dominique Guellec, Laudeline Auriol, Mosahid Khan, Geneviève Muzart and Sharon Standish) played an active role in co-ordinating the process and drafting certain sections. Bill Pattinson (a former Australian NESTI delegate) was responsible for preliminary revisions while working in the OECD. Mikael Åkerblom (Statistics Finland and a Finnish NESTI delegate) worked in the final stage for one year at the OECD to draft the Manual, incorporating various comments and suggestions from NESTI members.

Thanks to a generous voluntary contribution to the OECD from the Japanese government, this revision benefited from substantive contributions by experts and proceeded in a timely fashion. Japan's contribution is gratefully acknowledged. The Manual is published on the responsibility of the Secretary-General of the OECD.

Takayuki Matsuo	*Giorgio Sirilli*	*Fred Gault*
Director for Science, Technology and Industry, OECD	*Chair of NESTI initiating the fifth revision*	*Current Chair of NESTI*

Table of Contents

FRASCATI MANUAL 2002 – ISBN 92-64-19903-9 – © OECD 2002

FRASCATI MANUAL 2002 – ISBN 92-64-19903-9 – © OECD 2002

List of Tables

FRASCATI MANUAL 2002 – ISBN 92-64-19903-9 – © OECD 2002

Figure

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Proposed Standard Practice for Surveys on Research
and Experimental Development

Chapter 1

Aim and Scope of the Manual

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

1. This Manual was written by and for the national experts in member countries who collect and issue national R&D data and submit responses to OECD R&D surveys. Although many examples are given, the Manual remains a technical document which is mainly intended as a reference work.

2. Chapter 1 is addressed principally to users of R&D data. It provides a summary of the coverage and contents of the Manual in order to help them to use it. It also indicates why certain types of data are, or are not, collected, the problems of comparability they pose and what can be said about their interpretation.

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

3. The Manual was first issued nearly 40 years ago and 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 and have been used in various national and international reports. The OECD reports on science and technology indicators (OECD, 1984; OECD, 1986; OECD, 1989a); the Science and Technology Policy Review and Outlook series and the *Science, Technology and Industry Scoreboard* (OECD, every second year) all 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 type of indicator of technological change. Advisors concerned with science policy, but also with industrial policy and even general economic and social policies, use them extensively. R&D statistics are now an essential background element for many government programmes and provide an important tool for evaluating them. In many countries, R&D statistics are regarded as a part of general economic statistics.

5. However, R&D statistics are not enough. In the context of the knowledge-based economy, 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 given R&D activities. This link may be made, for example, via the innovation process (see Section 1.5.3) 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 for 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 single model of the S&T system; its aim is to make it possible 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 seven chapters in addition to this introductory chapter. They 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, there is consensus that these are the standard to which all should aspire.

7. The second part consists of eleven annexes, which interpret and expand upon the basic principles outlined in the preceding chapters in order to provide additional guidelines for R&D surveys or deal with topics relevant to R&D surveys. These annexes can be used for information purposes but are not necessarily an up-to-date interpretation of the subject.

8. The Manual is published both as a paper version and an electronic version available on the Internet. The electronic version will be more frequently updated with new material.

1.3. The relationship between the *Frascati Manual* and other international standards

9. R&D is carried out throughout the economy but has certain 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 such manual; more recently, four others have been added. In addition, other OECD methodological frameworks are available for science and technology and related activities, such as education (see Table 1.1).

10. The OECD did not set out to establish international norms for S&T where these already existed. Thus, the Manual is consistent with UNESCO recommendations for *all* scientific and technological activities (UNESCO, 1978), 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.

Table 1.1. **OECD methodological manuals**

Type of data	Title
A. The "Frascati family"	*The Measurement of Scientific and Technological Activities* Series
R&D	*Frascati Manual: Proposed Standard Practice for Surveys of Research and Experimental Development*
	R&D Statistics and Output Measurement in the Higher Education Sector. "Frascati Manual Supplement" (OECD, 1989b)
Technology balance of payments	"Manual for the Measurement and Interpretation of Technology Balance of Payments Data – TBP Manual" (OECD, 1990)[1]
Innovation	*OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data – Oslo Manual* (OECD, 1997a)
Patents	"Using Patent Data as Science and Technology Indicators – Patent Manual 1994" (OECD, OCDE/GD(94)114, 1994b)[1]
S&T personnel	"The Measurement of Human Resources Devoted to Science and Technology – Canberra Manual" (OECD, 1995)
B. Other methodological frameworks for S&T	
High-technology	"Revision of High-technology Sector and Product Classification" (OECD, STI Working Paper 1997/2)
Bibliometrics	"Bibliometric Indicators and Analysis of Research Systems, Methods and Examples", by Yoshiko Okubo (OECD, STI Working Paper 1997/1)
Globalisation	*Manual of Economic Globalisation Indicators* (provisional title, forthcoming)
C. Other relevant OECD statistical frameworks	
Education statistics	*OECD Manual for Comparative Education Statistics* (forthcoming)
Education classification	*Classifying Educational Programmes, Manual for ISCED-97 Implementation in OECD countries* (OECD, 1999)
Training statistics	*Manual for Better Training Statistics – Conceptual, Measurement and Survey Issues* (OECD, 1997b)

1. Deals mainly with problems of classifying and interpreting existing information.
Source: OECD.

11. Because of the need to place R&D in a wider context, both conceptually and in terms of databases, United Nations (UN) classifications are used as far as possible, *e.g.* System of National Accounts – SNA (UN, 1968); Commission of the European Communities – CEC (CEC *et al.*, 1994); International Standard Industrial Classification – ISIC (UN, 1990); International Standard Classification of Occupations – ISCO (International Labour Organization, 1990); and International Standard Classification of Education – ISCED (UNESCO, 1997). Furthermore, wherever possible, the Manual draws on the experience of regional organisations within the OECD area, notably the European Union (EU) and the Nordic Industrial Fund.

12. 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.

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13. As in the previous editions of the Manual, an attempt has been made to make R&D surveys consistent with the principles laid down in the System of National Accounts (SNA). As far as possible, complementary data should be collected that allow for bridging *Frascati Manual*-type data with SNA-type data. For this reason, recommendations for the breakdown of sources of funds and of extramural R&D expenditures are quite detailed and a recommendation has been introduced to collect data on software investments related to R&D. Annex 3 discusses the relation between R&D surveys and national accounts in more detail.

1.4. R&D input and output

14. This Manual is devoted to measuring R&D inputs. R&D covers both formal R&D in R&D units and informal or occasional R&D in other units. However, interest in R&D depends more on the new knowledge and innovations and the economic and social effects that result than on the activity itself. Unfortunately, while indicators of R&D output are clearly needed to complement input statistics, they are far more difficult to define and produce.

15. The output of R&D or science and technology (S&T) in general can be measured in several ways. Innovation surveys are an attempt to measure outputs and the effects of the innovation process in which R&D plays an important role. A manual on innovation surveys has been issued and revised once (OECD, 1997a).

16. Another option is to use existing data sources. A substantial amount of methodological work was required before recommending international standard practice for using existing sources to derive S&T indicators. Manuals on the technology balance of payments and on the use of patents as S&T indicators have been published (OECD 1990, 1994b). Guidelines are also available 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 and guidelines differ from this Manual in that they focus more on problems of interpretation; the data used are not collected for the purpose of S&T analysis but are extracted from existing sources and rearranged for this purpose (for further details, see Annex 7).

1.5. R&D and related activities

1.5.1. Research and experimental development (R&D)

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

18. R&D is an activity related to a number of others with a scientific and technological basis. 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)

19. UNESCO developed the broader concept of STA and included it in its "Recommendation concerning the International Standardisation of Statistics on Science and Technology" (UNESCO, 1978). In addition to R&D, scientific and technological activities comprise scientific and technical education and training (STET) and scientific and technological services (STS). The latter services include, for example, S&T activities of libraries and museums, translation and editing of S&T literature, surveying and prospecting, data collection on socio-economic phenomena, testing, standardisation and quality control, client counselling and advisory services, patent and licensing activities by public bodies.

20. R&D (defined similarly by UNESCO and the OECD) is thus to be distinguished from both STET and STS.

1.5.3. R&D and technological innovation

21. Technological innovation activities are all of the scientific, technological, organisational, financial and commercial steps, including investments in new knowledge, which actually, or are intended to, lead to the implementation of technologically new or improved products and processes. R&D is only one of these activities and may be carried out at different phases of the innovation process. It may act not only as the original source of inventive ideas but also as a means of problem solving which can be called upon at any point up to implementation.

22. Besides R&D, other forms of innovative activities may be distinguished in the innovation process. According to the *Oslo Manual* (OECD, 1997a), these are "acquisition of disembodied technology and know-how, acquisition of embodied technology, tooling up and industrial engineering, industrial design n.e.c., other capital acquisition, production start-up and marketing for new or improved products".

23. Furthermore, in the case of innovations based on government R&D programmes, the process may include a significant demonstration stage. "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

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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").

24. Possibly the greatest source of error in measuring R&D is the difficulty of locating the cut-off point between experimental development and the related activities required to realise an innovation. Errors in this respect are particularly significant: while many innovations may require costly R&D, the costs of preparing for production are often higher still. Sections 2.3.4 and 2.4.1 of Chapter 2 are devoted to guidelines and conventions for dealing with these problems and give examples. They provide guidelines on this borderline as it relates to the development of computer software and large-scale projects, notably for defence. Supplementary guidance on treating large-scale projects is given in Annex 10, with examples distinguishing between R&D and pre-production development.

1.5.4. The identification of R&D in software, social sciences and service activities

25. In recent years, the desire for better information on R&D in service activities has been expressed. The basic definitions in this Manual were originally developed for manufacturing industry and research in the natural sciences and engineering. Specific problems therefore arise for applying them to service activities, which often involve software applications and research in the social sciences. In Chapter 2, a new section (2.4) is devoted to a discussion of these problems.

1.5.5. R&D administration and other supporting activities

26. To carry out the R&D activities described above, funds must be provided and the project and its financing must be managed. The R&D funding activities of policy agencies, such as ministries of science and technology or research councils, do not constitute R&D. In the case of in-house management of R&D projects and their financing, 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 and who are included in the expenditure series only as an element of overheads. Auxiliary support by catering or transport services is also included in overheads. These distinctions are discussed further in Chapters 2, 5 and 6.

1.6. R&D in all fields of science and technology is covered

27. 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 practice, it is understood that, for various reasons, some deviations may have to be accepted for the social sciences and humanities (SSH). Experience in member countries differs: some find that surveys can cover all sciences in all sectors, others find that common procedures are not always appropriate.

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

1.7. Measures of R&D inputs

29. 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

30. 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 the input of a nation's human resources to the public welfare; 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 the *Canberra Manual* (OECD, 1995); the focus in this Manual is instead the measurement and classification of R&D resources.

31. For R&D personnel data, the problem arises of reducing such data to full-time equivalent (FTE) or person-years spent on R&D (see Chapter 5, Section 5.3). It is recommended therefore 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.

32. The national R&D effort requires a wide variety of personnel, 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.

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33. Two systems are now used by OECD member countries to classify persons engaged in R&D. Chapter 5, Section 5.2, contains definitions both for a classification by occupation, linked as far as possible to the International Standard Classification of Occupation – ISCO (ILO, 1990), and for a classification by level of formal qualification based entirely on the International Standard Classification of Education – ISCED (UNESCO, 1997). While it would be desirable to have data based on both classifications, most member countries use only one. As data are available by occupation for most OECD countries, the fact that a few still collect only qualification data for some or all sectors means that serious problems of international comparability remain. It may be argued that, in an efficient system, there should be no major difference between the two – 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, however, this is not the case. For example, a number of mature researchers do not have university-level qualifications, although they 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

34. The basic measure is "intramural expenditures"; *i.e.* all expenditures for R&D performed within a statistical unit or sector of the economy. Another measure, "extramural expenditures", covers payments for R&D performed outside the statistical unit or sector of the economy. For R&D purposes, both current costs and capital expenditures are measured. In the case of the government sector, expenditures refer to direct rather than indirect expenditures. Depreciation costs are excluded. Further details on the coverage and content of R&D expenditures are given in Chapter 6, Section 6.2, of the Manual.

35. R&D is an activity involving significant transfers of resources among units, organisations and sectors and 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 replies from performers of R&D and not on replies from the source of funds (see Chapter 6, Section 6.3). Guidelines are suggested for the treatment of public general university funds (GUF), also called general university funds, *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 over half of all support for university research and are an important share of all public support for R&D.

36. The main disadvantage of expressing R&D input series 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 using purchasing power parities (PPP) and the implicit gross domestic price (GDP) price index for 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 9.

1.7.3. R&D facilities

37. 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

38. Although R&D activities take place throughout the economy, they are often perceived as a whole for science policy purposes, *i.e.* as the "national R&D effort". One aim of the Manual is therefore to establish specifications for R&D input data that can both be collected from a wide range of performers and also be aggregated to meaningful national totals. The main expenditure aggregate used for international comparison is gross domestic expenditure on R&D (GERD), which covers all expenditures for R&D performed on national territory in a given year. It thus 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 FTE) on national territory during a given year. International comparisons are sometimes restricted to researchers (or university graduates) because it is considered that they are the true core of the R&D system.

1.8. Globalisation of R&D and R&D co-operation

39. Various studies have shown that R&D activities are more and more a worldwide activity and that a bigger share of R&D is performed in co-operation with individual researchers, research teams and research units. Multinational enterprises play an increasing role as does R&D co-operation between university and other research units and enterprises, both formally, via organisations such as the European Union (EU) or the European Organization for

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Nuclear Research (CERN), or informally, via multilateral and bilateral agreements. There is a clear need for more information on these trends.

40. The present edition of the *Frascati Manual* takes the globalisation process into account by suggesting more detailed breakdowns of sources of funds for R&D and extramural R&D for transactions with units abroad. Further information on the need for indicators of technological globalisation will be found in a substantial review of different aspects of measuring globalisation (*Manual of Economic Globalisation Indicators*, provisional title, forthcoming). As the R&D activities of multinational groups of enterprises are usually organised, managed and financed at group level or group division level, it is sometimes very difficult, if not impossible, to identify R&D performed in units of the group in different countries and to obtain information on R&D flows between these units.

41. R&D co-operation is an area that is not traditionally covered in R&D surveys. More information on R&D co-operation would be highly desirable for policy makers. However, owing to lack of sufficient experience in member countries, it has not been possible to include recommendations for data collection on R&D co-operation in this edition of the Manual. There is some relevant information on R&D flows between different kinds of institutions. Experience with innovation surveys has shown that it is possible to ask different types of units in different geographical regions a simple question on co-operation. This could be tried in R&D surveys as well, so that, in future, it may be possible to make explicit recommendations.

1.9. Classification systems for R&D

42. To understand R&D activity and its role, one must examine it 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 distribution).

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

1.9.1. Institutional classifications

44. In the institutional approach, attention focuses 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 sub-class. The advantage 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.

45. 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 UN 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. Sub-classifications are given for three of the four national sectors (business enterprise, PNP and higher education) and additional institutional classifications, designed to reveal national differences in sectoring, are suggested.

1.9.2. Functional distribution

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

47. The distinction between military and civil R&D is considered as an important functional breakdown of the national R&D effort. In most OECD countries, defence R&D plays a relatively minor role. However, in a few countries that perform a high level of R&D, defence R&D expenditure approaches or exceeds half of total government R&D expenditure. As a result, international comparisons differ, depending on whether defence R&D is or is not included. 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, within the overall picture of national R&D effort, it will always be necessary to separate the two categories of R&D expenditure. Defence R&D is further discussed in Annex 10.

48. While 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 one very specific sub-item, such as a sub-field of science or a product field (holography or computer controls for machine tools). As already pointed out, the 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 member countries have pushed sub-categorisation to such a detailed level, and it is unlikely that such detail would be obtainable at the OECD level.

49. Furthermore, it is difficult to establish norms for categories of interest to national governments when reviewing the types of research funded from public monies, when such research may have various policy connotations. Strategic research is one area that has received considerable attention. It is generally taken to mean research which a nation sees as a priority for developing its research base and ultimately its economy. What is and is not strategic varies among member countries. Nevertheless, in recognition of the policy importance of strategic research in certain countries, Chapter 4 of the Manual gives some attention to its identification.

1.10. R&D surveys, reliability of data and international comparability

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

51. 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. Annex 2 and a special supplement to the 1980 edition of the Manual give further guidance on this topic (OECD, 1989b).

52. National surveys which provide R&D data that are reasonably accurate and relevant to national users' needs may not be internationally comparable. This may simply be because national definitions or classifications 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; for administrative reasons, apparently similar institutions may be placed in

different sectors in different countries. Moreover, national perceptions of these norms may be different, notably for type of research analysis and for the analysis of R&D personnel by occupation. Such differences are impossible to quantify.

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

53. GBAORD 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.

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

55. 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 (budget proposals or initial budget appropriations) or retrospective (final budget or outlay). 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 are based on their own standard methods and terminology. Although the links between survey and GBAORD data have improved in recent years, the 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 related sources.

56. The aim of classifying GBAORD by socio-economic objective is to help governments to formulate science and technology policy. 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.). Nevertheless, the fit is never perfect and always reflects the policy intentions of a given programme rather than its precise content. Because of this and because of methodological constraints on the way data 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.

1.12. Topics of special interest

57. There is often a demand for R&D data for a specific priority area, which cuts across the standard institutional and functional classifications. Data to meet this demand often have to be built up from special extractions or tabulations. Annexes 4 and 5 deal with currently popular priority areas.

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58. Health R&D has become a policy concern in recent years, and various international studies have been made. Health R&D data are not directly available from any of the standard classifications described in the Manual. A pragmatic method of deriving estimates of health-related R&D from existing data sources is described in Annex 4. It is an aid to data compilation and interpretation and should not be regarded as an international recommendation.

59. The OECD is developing statistics and indicators on the information economy and information society. It is possible to calculate an aggregate for R&D in selected information and communication technology (ICT) sectors on the basis of the agreed list of industries belonging to the ICT sector, as described in Annex 4.

60. Following information technology, biotechnology is expected to be the next pervasive technology of great significance for future economic development. The OECD has started work to develop a statistical framework for biotechnology. Some ideas for questions on biotechnology in R&D surveys and the concept of a special survey on biotechnology are presented in Annex 4.

61. The regional distribution of R&D activities is of great policy interest not only within the EU but also in other OECD countries, especially those with federal constitutions. A recommendation to distribute some variables by region is included in Chapters 5 and 6, and Annex 5 explains some methodological aspects.

1.13. A final word to the user of R&D data

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

– Such series are only a summary quantitative reflection of very complex patterns of activities and institutions. For this reason, it may be dangerous to use them "neat". They should, as far as possible, be analysed in the light of 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.

– 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. To answer such questions, it is necessary to identify the relevant basic data and then use them to construct an R&D indicator. Some basic data may be accurate enough to answer one question but not another. For example, GBAORD data are useful for answering general questions about trends in easily defined objectives: "Is there any sign that defence R&D is picking up again in the OECD area?" They are not suitable for specific questions about less easily defined objectives: "Does my country spend more or less in absolute terms on R&D for environmental protection than country X?"

- One particularly useful way of constructing such indicators for 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 may be biased if there are major differences in the economic structure of the countries compared. For example, the activities of big R&D-intensive multinationals may influence the GERD/GDP ratio in a particular country quite significantly. The classifications and norms used to collect R&D statistics are, as far as possible, compatible with those for general statistics, and, while 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.
- The problems of data quality and comparability 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.

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Proposed Standard Practice for Surveys on Research
and Experimental Development

Chapter 2

Basic Definitions and Conventions

2.1. Research and experimental development (R&D)

63.

> 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.

64. The term R&D covers three activities: basic research, applied research and experimental development; these are 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, which 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. R&D covers both formal R&D in R&D units and informal or occasional R&D in other units.

2.2. Activities to be excluded from R&D

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

66. 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).

67. The practical definitions given here are intended solely to exclude these activities from R&D.

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2.2.1. Education and training

68. 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 students at the PhD level carried out at universities should be counted, whenever possible, as a part of R&D (see Section 2.3.2).

2.2.2. Other related scientific and technological activities

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

Scientific and technical information services

70. The specialised activities of:

- Collecting
- Coding
- Recording
- Classifying
- Disseminating
- Translating
- Analysing
- Evaluating

by

- Scientific and technical personnel
- Bibliographic services
- Patent services
- Scientific and technical information, extension and advisory services
- Scientific conferences

are to be excluded, except when 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).

General purpose data collection

71. General purpose data collection is 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 collected solely or primarily as part of the R&D process are 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 an 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. However, data collected for other or general purposes, such as quarterly sampling of unemployment, should be excluded from R&D even if exploited for research. Market surveys should also be excluded.

Testing and standardisation

72. This concerns the maintenance of national standards, the calibration of secondary standards and routine testing and analysis of materials, components, products, processes, soils, atmosphere, etc.

Feasibility studies

73. Investigation of proposed engineering projects, using existing techniques to provide additional information before deciding on implementation, is not R&D. 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.

Specialised health care

74. This concerns routine investigation and normal application of specialised medical knowledge. There may, however, be an element of R&D in what is usually called "specialised health care", when it is carried out, for example, in university hospitals (see Section 2.3.2).

Patent and licence work

75. This includes all administrative and legal work connected with patents and licences. However, patent work connected directly with R&D projects is R&D.

Policy-related studies

76. In this context, "policy" refers not only to national policy but also to policy at 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.

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Routine software development

77. Software-related activities of a routine nature are not considered to be R&D. Such activities include work on system-specific or programme-specific advances which were publicly available prior to the commencement of the work. Technical problems that have been overcome in previous projects on the same operating systems and computer architecture are also excluded. Routine computer maintenance is not included in R&D (see Section 2.4.1 for a more detailed discussion of borderline problems between software development and R&D).

2.2.3. Other industrial activities

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

Other innovation activities

79. In the *Oslo Manual* (OECD, 1997a), these are defined as all those scientific, technical, commercial and financial steps, other than R&D, necessary for the implementation of new or improved products or services and the commercial use of new or improved processes. These include acquisition of technology (embodied and disembodied), tooling up and industrial engineering, industrial design n.e.c., other capital acquisition, production start-up and marketing for new and improved products.

Production and related technical activities

80. This covers industrial preproduction and production 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 social science disciplines, such as market research.

2.2.4. Administration and other supporting activities

81. This category has two components.

Purely R&D-financing activities

82. 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).

Indirect supporting activities

83. 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 but exclude indirect supporting activities, whereas an allowance for

these is included under overheads in R&D expenditure of performers. Typical examples are transportation, storage, cleaning, repair, maintenance and security activities. Administration and clerical activities undertaken not 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. Criteria for distinguishing R&D from related activities

84. 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 common knowledge and techniques for the area concerned. Table 2.1 identifies some supplementary criteria for distinguishing R&D.

Table 2.1. **Supplementary criteria for separating R&D from related scientific, technological and industrial activities**

A.	What are the objectives of the project?
B.	What is new or innovative about this project? Is it seeking previously undiscovered phenomena, structures or relationships? Does it apply knowledge or techniques in a new way? 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? Are the results expected to be patentable?
C.	What staff is working on the project?
D.	What methods are being used?
E.	Under what programme is the project funded?
F.	How general are the findings or results of the project likely to be?
G.	Does the project fall more naturally into another scientific, technological or industrial activity?

Source: OECD.

85. One aspect of these criteria is that a particular project may be R&D if undertaken for one reason, but not if carried out for another, as shown in the following examples:

– In the field of medicine, routine autopsy on the causes of death is the practice of medical care and is not R&D; special investigation of a particular mortality 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, whereas a special programme of blood tests in connection with the introduction of a new drug is R&D.

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- The keeping of daily records of temperatures or of atmospheric pressure is not R&D but the operation of a weather forecasting service or general data collection. The investigation of new methods of measuring temperature is R&D, as are the study and development of new systems and techniques for interpreting the data.
- R&D activities in the mechanical engineering industry often have a close connection with design and drawing work. In small and medium-size enterprises (SMEs) in this industry, there is usually no special R&D department, 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, catalogues of spare parts), they should be excluded from R&D.

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

General approach

86. 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.

87. 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*. Its elements of novelty distinguish R&D from routine teaching and other work-related activities. Deciding whether or not to consider as R&D those scientific activities that are the by-products of educational or training activities does present a problem.

88. It exists for a number of the following cases:

- Postgraduate students at the PhD level and their activities.
- Supervision of students by university staff.
- Specialised health care.
- Personal education of academic staff (own reading).

Postgraduate students at the PhD level

89. In some OECD countries, the "postgraduate student" is not a standard national category. In such cases, the R&D activity of such persons is probably included with that of other part-time teaching staff.

90. However, in countries where such students constitute a recognised category, 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.

91. Parts of the curricula for studies at ISCED level 6 are highly structured, involving, for instance, study schemes, set courses, compulsory laboratory work, etc. Here, the teacher transmits knowledge and trains in research methods. Students who fall under this heading typically attend compulsory courses, study the literature on the subject, learn research methodology, etc. These activities do not fulfil the criterion of novelty specified in the definition of R&D.

92. In addition, in order to obtain a final qualification at ISCED level 6, students are also expected to prove their competence by undertaking relatively independent study usually containing the elements of novelty required for R&D projects and presenting their results. These activities should, therefore, be attributed to R&D, and any supervision by the teacher should be as well. 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.

93. In addition, students at this level are often attached to or directly employed by the establishment in which they study and have contracts or similar engagements which oblige them to teach at lower levels or to perform other activities, such as specialised medical care, while allowing them to continue their studies and to do research.

94. Borderlines between R&D and education at ISCED level 6 are illustrated in Table 2.2 which, together with much of the above text, is based on the relevant Nordic Manual, *R&D Statistics in the Higher Education Sector: Work on Improved Guidelines* (Nordforsk, 1986). The more practical problems of applying these concepts are dealt with in Chapter 5 (see Section 5.2.5).

Supervision of students

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

96. 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

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Table 2.2. **Borderline between R&D and education and training at ISCED level 6**

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

Source: OECD.

theses and dissertations or the work of undergraduate students, it should be excluded from R&D.

Specialised health care

97. In university hospitals where the training of medical students is an important activity in addition to the primary activity of health care, the activities of teaching, R&D and advanced as well as routine medical care are frequently closely linked. "Specialised health care" is an activity that is normally to be excluded from R&D (see Section 2.2.2). However, there may be an element of R&D in what is usually called specialised health care, when carried out, for example, in university hospitals. It is difficult for university doctors and their assistants to evaluate the part of their overall activities that is exclusively R&D. If, however, time and money spent on routine medical care are included in the R&D statistics, R&D resources in the medical sciences will be overestimated.

98. Usually, such specialised health 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.

Personal education of academic staff

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

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

101. 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 related scientific and technological activities

General approach

102. Difficulties for separating R&D from other scientific and technological activities arise when several activities are performed at the same institution. In survey practice, using rules of thumb to make distinctions facilitates the identification of the R&D portion. For example:

- 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.
- 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.

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

- 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 only apply when 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.

- 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.
- 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.* conceptual and methodological work in relation to the development of completely new or substantially modified surveys and statistical systems, work on sampling methodologies, small area statistical estimates). Whenever possible, such R&D should be included.

Specific cases

104. 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 and the development of social systems are three areas involving large amounts of resources, and any variations in their treatment 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; these are discussed in Section 2.3.4. The following conventions apply in the four areas mentioned.

- Space exploration

105. The difficulty with space exploration is that, in some respects, much space activity may now be considered routine; certainly, most 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 the 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.

• Mining and prospecting

106. Mining and prospecting sometimes cause problems owing 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:

– The development of new surveying methods and techniques.
– Surveying undertaken as an integral part of a research project on geological phenomena.
– Research on geological phenomena *per se,* undertaken as a subsidiary part of surveying and prospecting programmes.

107. In practice, the last of these presents a number of problems. It is difficult to frame a precise definition that would be meaningful to respondents to national surveys. 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.

108. 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.

• The development of social systems

109. In general, but more particularly in the field of the social sciences, the purpose of a study is to prepare the way for decisions by policy makers at the level of government (central, regional, local) or in industrial and trading enterprises. Usually, such studies employ established methodologies, but it is sometimes necessary to modify existing methodologies or to develop new ones. This requires an appreciable amount of research. In theory, such modification or development should be included in R&D, but one must be aware of the difficulties involved in evaluating the appropriate share of R&D in a given study. In practice, despite the technical and conceptual problems, it may be feasible either to assign studies which include an appreciable element of novelty entirely to research or to attempt to estimate the proportion of research in those studies and attribute this to R&D (see also Section 2.4.2). For

determining whether a particular activity should be regarded as R&D or be attributed to R&D, the fact that the activity is called a study or that the report resulting from the activity performed is called a study is irrelevant. 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.

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

General approach

110. Care must be taken to exclude activities which, although 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 2.3).

Table 2.3. **Some cases at the borderline 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	

Source: OECD.

111. Chapter 4 defines experimental development as "systematic work, drawing on knowledge gained from research and practical experience, which 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". It is difficult to define precisely the cut-off point between experimental development and pre-production development, 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 pre-production planning or to get a production or control system working smoothly, the work is no longer R&D."

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

Specific cases

113. Some common problem areas are described below.

- Prototypes

114. 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.

115. 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. However, when any necessary modifications to the prototype(s) have been made and testing has been satisfactorily completed, the end-point of R&D has been reached. The construction of several copies of a prototype to

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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.

• Pilot plants

116. 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.

117. 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 is sold. Such receipts should not be deducted from the cost of R&D activity.

• Large-scale projects and costly pilot plants

118. Large-scale projects, of which defence and aerospace are the most significant types, usually cover a spectrum of activity from experimental to pre-production development. Under these circumstances, the funding and/or performing organisation often cannot distinguish between the R&D and other elements of expenditure. The 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 10 provides supplementary guidelines on this question.

119. 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 icebreakers. 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, ice breaking). The construction of such plants and prototypes should not be wholly credited to R&D. Only the additional costs due to the prototype nature of these products should be attributed to R&D.

• Trial production

120. After a prototype has been satisfactorily tested and any necessary modifications made, the manufacturing start-up phase may begin. It is 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 start the production process. 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.

121. 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).

- Trouble-shooting

122. Trouble-shooting occasionally shows 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.

- "Feedback" R&D

123. 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.

- Industrial design

124. 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 considered 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.

125. 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 in the drawings or as separate specification sheets, are considered R&D.

- Tooling up and industrial engineering

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

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127. Three phases of tooling up can be identified:

- The first-time use of components (including the use of components resulting from R&D efforts).
- The initial tooling of equipment for mass production.
- Installing equipment linked with the start of mass production.

128. 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, these activities are classified as R&D.

129. "Feedback" R&D resulting from the tooling-up phase should be defined as R&D.

- Clinical trials

130. Before new drugs, vaccines or treatments can be introduced on the market, they must be tested systematically on human volunteers to ensure that they are both safe and effective. These clinical trials are divided into four standard phases, three of which take place before permission to manufacture is accorded. For the purposes of international comparison, by convention, clinical trial phases 1, 2 and 3 can be treated as R&D. Phase 4 clinical trials, which continue testing the drug or treatment after approval and manufacture, should only be treated as R&D if they bring about a further scientific or technological advance. Moreover, not all activities undertaken prior to permission to manufacture are considered to be R&D, especially when there is a significant wait after the completion of phase 3 trials, during which marketing and process development activities may be started.

2.3.5. Problems at the borderline between R&D administration and indirect supporting activities

131. The R&D activities described above are supported by a number of other activities. In R&D statistics, the practice is that personnel data should cover only R&D proper, whereas expenditure data should cover the full cost of R&D, including the indirect supporting activities which are treated as overheads (see Section 2.2.4).

132. 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). The same argument applies for 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 person who produces the interim and final reports containing the results 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 supporting activity if it is carried out in close proximity to the R&D (see Chapter 5, Table 5.1 and Section 5.1).

2.4. Identifying R&D in software development, in the social sciences and humanities and in service activities and industries

133. The model on which the Manual was originally based was that of institutionally structured R&D in the natural sciences and engineering leading to tangible technological innovations in primary and secondary industries. Software development has since become a major intangible innovation activity with a high R&D content. In addition, an increasing share of relevant activities draws on the social sciences and humanities, and, together with advances in computing, leads to intangible innovations in service activities and products, with a growing contributions from service industries in the business enterprise sector.

134. The tools developed for identifying R&D in traditional fields and industries are not always easy to apply to these new areas. This section deals with the problems of identifying R&D in software development, in the social sciences and humanities and in service activities.

2.4.1. Identifying R&D in software development

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

136. In addition to the software that is part of an overall R&D project, the R&D associated with software as an end product should also be classified as R&D.

137. The nature of software development is such as to make identifying its R&D component, if any, difficult. Software development is an integral part of many projects which in themselves have no element of R&D. The software development component of such projects, however, may be classified as R&D if it leads to an advance in the area of computer software. Such advances are generally 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 that 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.

138. A scientific and/or technological advance in software may be achieved even if a project is not completed, because a failure can increase knowledge of the technology of computer software by showing, for example, that a particular approach will not succeed.

139. Advances in other fields resulting from a software project do not determine whether an advance in computer software has occurred.

140. The following examples illustrate the concept of R&D in software. Should be included in R&D:

- R&D producing new theorems and algorithms in the field of theoretical computer science.
- Development of information technology at the level of operating systems, programming languages, data management, communications software and software development tools.
- Development of Internet technology.
- Research into methods of designing, developing, deploying or maintaining software.
- Software development that produces advances in generic approaches for capturing, transmitting, storing, retrieving, manipulating or displaying information.
- Experimental development aimed at filling technology knowledge gaps as necessary to develop a software programme or system.
- R&D on software tools or technologies in specialised areas of computing (image processing, geographic data presentation, character recognition, artificial intelligence and other areas).

141. Software-related activities of a routine nature which do not involve scientific and/or technological advances or resolution of technological uncertainties are not to be included in R&D. Examples are:

- Business application software and information system development using known methods and existing software tools.
- Support for existing systems.
- Converting and/or translating computer languages.
- Adding user functionality to application programmes.
- Debugging of systems.
- Adaptation of existing software.
- Preparation of user documentation.

142. 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 entire modification project may result in the resolution of scientific and/or technological uncertainty and thus be classified as R&D.

2.4.2. Identifying R&D in the social sciences and humanities

143. The social sciences and humanities are covered in the Manual by including in the definition of R&D "knowledge of man, culture and society" (see Chapter 2, Section 2.1). For the social sciences and humanities, an appreciable element of novelty or a resolution of scientific/technological uncertainty is again a useful criterion for defining the boundary between R&D and related (routine) scientific activities. This element may be related to the conceptual, methodological or empirical part of the project concerned. Related activities of a routine nature 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, projects of a routine nature, in which social scientists bring established methodologies, principles and models of the social sciences to bear on a particular problem, cannot be classified as research.

144. The following are examples of work which might fall into this routine category are generally not R&D: commentary on the probable economic effects of a change in the tax structure, using existing economic data; 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.

2.4.3. Special problems for identifying R&D in service activities

145. Defining the boundaries of R&D in service activities is difficult, for two main reasons: first, it is difficult to identify projects involving R&D; and, second, the line between R&D and other innovative activities which are not R&D is a tenuous one.

146. Among the many innovative projects in services, those that constitute R&D result in new knowledge or use of knowledge to devise new applications, in keeping with the definition in the first paragraph of this chapter.

147. Identifying R&D is more difficult in service activities than in manufacturing because it is not necessarily "specialised". It covers several areas: technology-related R&D, R&D in the social sciences and humanities, including R&D relating to the knowledge of behaviour and organisations. This last notion is already included in the criterion "knowledge of man, culture and society", but it is particularly important in the case of service activities. Because these types of R&D may be combined in a given project, it is important to circumscribe clearly the various forms of R&D involved. If the

analysis is confined to technology-related R&D, for example, R&D may be understated. In many cases, R&D findings in service industries are embodied in software which is not necessarily innovative from the technical point of view but innovates by virtue of the *functions* that it performs (see Section 2.4.1).

148. Also, in service companies, R&D is not always organised as formally as in manufacturing companies (*i.e.* with a dedicated R&D department, researchers or research engineers identified as such in the establishment's personnel list, etc.). The concept of R&D in services is still less specific and sometimes goes unrecognised by the enterprises involved. As more experience becomes available on surveying R&D in services, the criteria for identifying R&D and examples of service-related R&D may require further development.

Criteria for identifying R&D in services

149. The following are among the criteria that can help to identify the presence of R&D in service activities:

– Links with public research laboratories.
– The involvement of staff with PhDs, or PhD students.
– The publication of research findings in scientific journals, organisation of scientific conferences or involvement in scientific reviews.
– The construction of prototypes or pilot plants (subject to the reservations noted in Section 2.3.4).

Examples of R&D in selected service activities

150. The R&D activities listed below may serve as examples of R&D in service activities. The general and supplementary criteria for distinguishing R&D presented in Section 2.3.1 have also to be taken into account.

151. The general boundaries of R&D as defined above, especially in Sections 2.2, 2.3.3 and 2.3.4, also largely apply to service activities. The element of novelty is a basic criterion for distinguishing R&D from related activities.

Examples of R&D in banking and insurance

– Mathematical research relating to financial risk analysis.
– Development of risk models for credit policy.
– Experimental development of new software for home banking.
– Development of techniques for investigating consumer behaviour for the purpose of creating new types of accounts and banking services.

- Research to identify new risks or new characteristics of risk that need to be taken into consideration in insurance contracts.
- Research on social phenomena with an impact on new types of insurance (health, retirement, etc.), such as on insurance cover for non-smokers.
- R&D related to electronic banking and insurance, Internet-related services and e-commerce applications.
- R&D related to new or significantly improved financial services (new concepts for accounts, loans, insurance and saving instruments).

Examples of R&D in some other service activities

- Analysis of the effects of economic and social change on consumption and leisure activities.
- Development of new methods for measuring consumer expectations and preferences.
- Development of new survey methods and instruments.
- Development of tracking and tracing procedures (logistics).
- Research into new travel and holiday concepts.
- Launch of prototype and pilot stores.

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Chapter 3

Institutional Classification

3.1. The approach

152. The institutional approach focuses on the characteristic properties of the performing or funding institutions. All of the unit's R&D resources are classified to one class or sub-class, according to the unit's principal activity.

3.2. The reporting unit and the statistical unit

3.2.1. The reporting unit

153. The reporting unit is the entity from which the recommended data items are collected. It will vary from sector to sector and from country to country, depending on institutional structures, the legal framework for data collection, traditions, national priorities and survey resources. In some countries, data may be collected from R&D units; in others, it may be gathered at a more aggregate level. The Manual can make no recommendation to member countries concerning the reporting unit.

3.2.2. The statistical unit

154. The statistical unit is the entity for which the required statistics are compiled. It may be an ***observation unit*** in 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.

155. In principle, the statistical unit should be uniform, within sectors, for all countries. In practice, however, this goal is never fully achieved. One reason is that structures are different and names are different (or misleadingly similar). Another is interaction with the reporting unit. If the reporting unit is larger than the statistical unit, problems may arise for distributing the data among the appropriate classification units. Various units will be recommended in the following sections. Where necessary, reference is made to the definitions of international standard classifications. However, whenever member countries provide statistics for international comparisons, the statistical units should be specified.

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3.3. Sectors

3.3.1. Reasons for sectoring

156. 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 by sectors of the economy, following as closely as possible standard classifications of economic activities. This offers a number of important practical advantages:

– 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.
– When measuring expenditure, the sectoral approach offers the most reliable way of building up national aggregates.
– Sectoring offers a framework for analysing the flows of funds between R&D-funding and R&D-performing entities.
– Since each sector has its own characteristics and its own kinds of R&D, this classification throws some light on differences in the level and direction of R&D.
– Insofar as the sectors are defined on the basis of a standard classification, it may be possible to relate R&D to other statistical series. This may facilitate an understanding of the role of R&D in economic development and the formulation of science policy.
– The institutions of the various sectors are sensitive to different government policy initiatives.

3.3.2. Choice of sectors

157. The System of National Accounts (SNA) (UN, 1968) 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 SNA distinguishes between the following sectors: non-financial corporations; financial corporations; general government; non-profit institutions serving households; and households.

158. The following definitions of sectors for R&D surveys are largely based on the SNA 93 (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 (PNP) sector. Here, as in the SNA, non-profit institutions (NPIs) have been distributed among sectors. For a more detailed discussion of the relationships between SNA sectors and the sectors proposed below for R&D surveys, see Annex 3.

159. Five sectors are identified and discussed below:

- Business enterprise (see Section 3.4).
- Government (see Section 3.5).
- Private non-profit (see Section 3.6).
- Higher education (see Section 3.7).
- Abroad (see Section 3.8).

These, in turn, are divided into sub-sectors appropriate to each sector.

3.3.3. Problems of sectoring

160. In view of the diverse ways in which most contemporary institutions have developed, sector definitions cannot be 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.

161. It is therefore not always clear in which sector a given institute should be classified, and an arbitrary decision may have to be made. Institutions may straddle 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.

162. When two countries classify institutions with the same or similar functions in different sectors, national 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 to allow for rearrangement for international comparisons. This is the reason for the inclusion of "other institutional sub-classifications" for each sector. Figure 3.1 presents a decision tree as a guide for classifying R&D units by institutional sector.

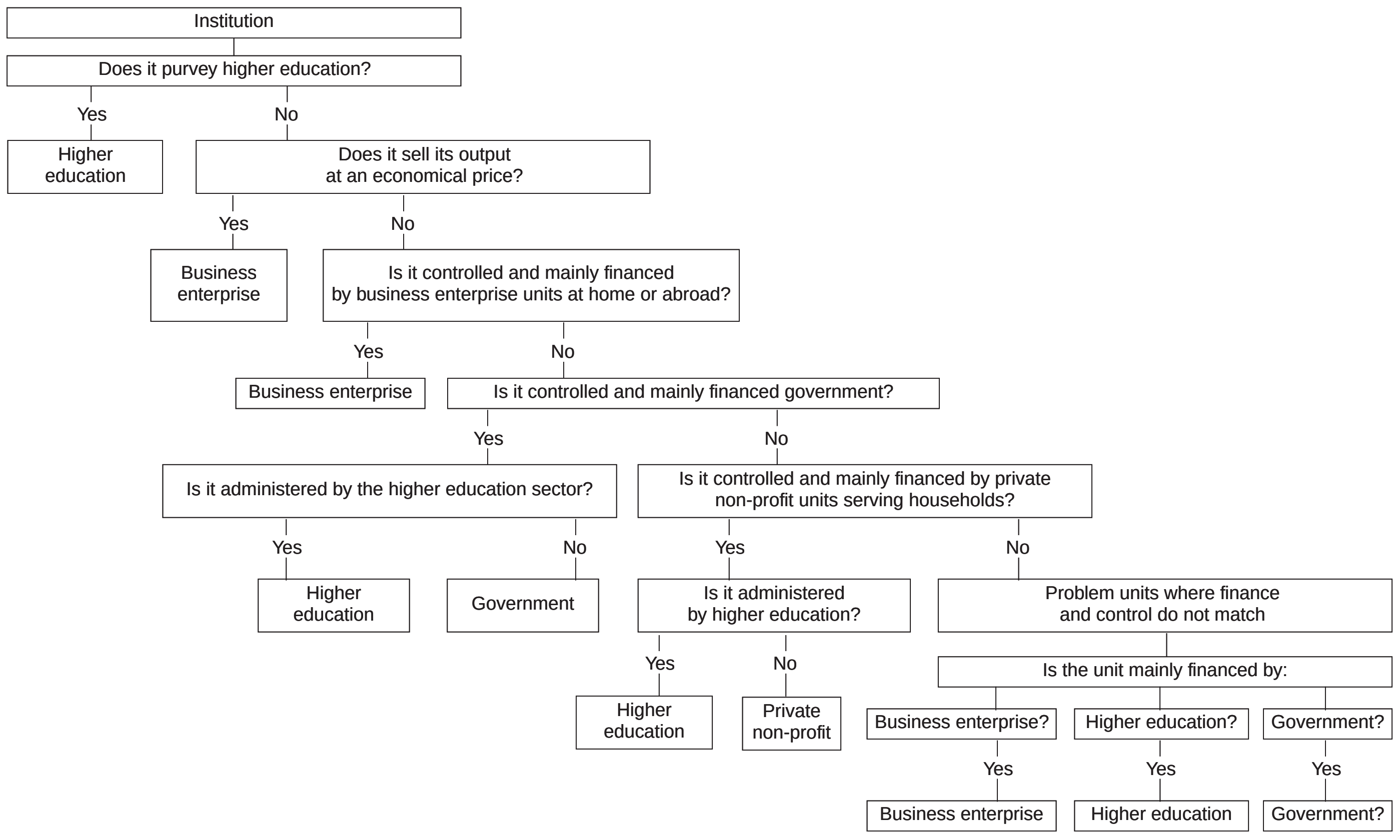
3.4. Business enterprise sector

3.4.1. Coverage

163. 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 institutions mainly serving them.

Figure 3.1. **Decision tree for sectoring R&D units**



Source: OECD.

164. The core of the sector is made up of ***private enterprises*** (corporations or quasi-corporations), whether or not they distribute profits. 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.

165. 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. To qualify as market production in this context, the charges should be related to the value (quality and quantity) of the goods and services furnished, the decision to purchase them should be voluntary, and the price charged should significantly affect supply and demand. Any public enterprises producing higher education services should be included in the higher education sector.

166. This sector also includes ***non-profit institutions*** that are market producers of goods and services other than higher education. These are of two kinds.

167. The first are NPIs engaged in market production whose main activity is the production of goods and services for sale at prices designed to recover most or all of their costs. 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 prices.

168. The second are NPIs serving business. These are typically created and managed by associations of businesses whose activities they are designed to promote, such as chambers of commerce and agricultural, manufacturing or trade associations. These NPIs are usually financed by contributions or subscriptions from the businesses concerned which provide "institutional" support for their R&D. However, NPIs that carry out similar functions but are 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.

3.4.2. The principal sector sub-classification

The classification list

169. For international comparisons of R&D statistics, units in the business enterprise sector are classified into a number of significant industry groups and sub-groups by the International Standard Industrial Classification (ISIC Rev. 3, UN, 1990, and minirevision 3.1, 2002). Table 3.1 shows a rearrangement

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

	ISIC Rev. 3.1 Division/Group/Class	NACE Rev. I.1 Division/Group/Class
AGRICULTURE, HUNTING, FORESTRY AND FISHING	**01, 02, 05**	**01, 02, 05**
MINING AND QUARRYING	**10, 11, 12, 13, 14**	**10, 11, 12, 13, 14**
MANUFACTURING	**15-37**	**15-37**
Food, beverages and tobacco	**15 + 16**	**15 + 16**
Food products and beverages	15	15
Tobacco products	16	16
Textiles, fur and leather	**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	**20 + 21 + 22**	**20 + 21 + 22**
Wood and cork (not furniture)	20	20
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)*
Refined petroleum products	*232*	*23.2*
Chemicals and chemical products	24	24
Chemicals and chemical products (less pharmaceuticals)	*24 (less 2423)*	*24 (less 24.4)*
Pharmaceuticals	*2423*	*24.4*
Rubber and plastics products	25	25
Non-metallic mineral products	**26**	**26**
Basic metals	**27**	**27**
Basic metals, iron and steel	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, except machinery and equipment	28	28
Machinery and equipment, 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	30
Electrical machinery and apparatus n.e.c.	31	31
Electrical motors, generators and transformers	*311*	*31.1*
Electricity distribution and control apparatus (includes semiconductors)	*312*	*31.2*

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

	ISIC Rev. 3.1 Division/Group/Class	NACE Rev. I.1 Division/Group/Class
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*
Radio, television and communication equipment and apparatus	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)	33	33
Medical appliances, instruments and control equipment	*331*	*33.1*
Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	*3312*	*33.2*
Industrial process control equipment	*3313*	*33.3*
Optical instruments and photographic equipment	*332*	*33.4*
Watches and clocks	*333*	*33.5*
Motor vehicles, trailers and semi-trailers	34	34
Other transport equipment	35	35
Ships and boats	*351*	*35.1*
Railway and tramway locomotives and rolling stock	*352*	*35.2*
Aircraft and spacecraft	*353*	*35.3*
Transport equipment, n.e.c.	*359*	*35.4 + 35.5*
Furniture; other manufacturing, n.e.c.	**36**	**36**
Furniture	361	36.1
Other manufacturing, n.e.c	369	36.2-36.5
Recycling	**37**	**37**
ELECTRICITY, GAS AND WATER SUPPLY	**40, 41**	**40, 41**
CONSTRUCTION	**45**	**45**
SERVICES SECTOR	**50-99**	**50-99**
Wholesale, retail trade and motor vehicle repair	**50, 51, 52**	**50, 51, 52**
Wholesale of computers, computer peripheral equipment and software	*5151*	*51.84*
Wholesale of electronic parts and equipment	*5152*	*51.86*
Hotels and restaurants	**55**	**55**
Transport, storage and communications	**60, 61, 62, 63, 64**	**60, 61, 62, 63, 64**
Telecommunications	642	64.2
Other	60-64 less 642	60-64 less 64.2
Financial intermediation (includes insurance)	**65, 66, 67**	**65, 66, 67**

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

	ISIC Rev. 3.1 Division/Group/Class	NACE Rev. I.1 Division/Group/Class
Real estate, renting and business activities	**70, 71, 72, 73, 74**	**70, 71, 72, 73, 74**
Renting of office machinery and equipment (including computers)	*7123*	*71.33*
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 + 74.3*
Community, social and personal service activities, etc.	**75-99**	**75-99**
GRAND TOTAL	**01-99**	**01-99**

Source: OECD.

of ISIC Rev. 3 which is suitable for such comparisons, with a key to the corresponding European classification, NACE Rev. 1 (Eurostat, 1990). Countries that use a national industrial classification system rather than ISIC Rev. 3 should use concordance tables to convert their industrially classified data to ISIC Rev. 3. Every attempt should be made to maintain the consistency of these concordances.

The statistical unit

170. R&D is one of the activities that a business enterprise may undertake. The business enterprise is free to organise this activity according to its production model. Thus, core R&D may be carried out in units attached to production units or in central units serving the whole enterprise. In most cases, the legal entity defined in ISIC Rev. 3, paragraphs 78 and 79, is the appropriate unit. 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 is usually carried out in an operational department of a business enterprise, such as the industrial design, quality or production department.

171. Data requirements determine the choice of the statistical unit(s). These requirements are described in detail in Chapter 6. However, the source and application of R&D funds is one fundamental data item. This is generally the concern of the legal entity that controls the performance of R&D rather than the smaller units that actually carry out the work. The latter may have to prepare budgets and record costs, but the business's central administration knows the source of the funds that cover expenditures. Contracts and taxation are principal activities of the legal entity.

172. The enterprise, as a statistical unit, is defined as the organisational unit of a business which directs and controls the allocation of resources relating to its domestic operations, and for which consolidated financial and balance sheet accounts are maintained. From these accounts, it is possible to derive international transactions, an international investment position and a consolidated financial position for the unit. It is therefore recommended to use the enterprise unit as the reporting unit and, with exceptions, as the statistical unit in the business enterprise sector. Within a group of enterprises, it is desirable to obtain separate returns for each of the legal units performing R&D, using estimations if necessary.

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

Criteria for classification

174. Classification of these statistical units according to principal activity should be determined by "the class of the ISIC in which the principal activity, or range of activities, of the unit is included" (ISIC Rev. 3, paragraph 114).

175. According to ISIC, the principal activity should be determined by computing the contribution of value added of each activity leading to the production of goods or the rendering of services. The activity providing the greatest contribution to the enterprise's value added determines the classification of that enterprise. If it is not possible to compute value added, 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 each of these activities (ISIC Rev. 3, paragraph 115).

176. When the R&D is carried out in a legal entity specialising in R&D:

- The unit should be classified in R&D for enterprises (ISIC Rev. 3, Division 73).

and

- Additional information should be collected for analytical purposes and international comparisons, in order to reflect the division into specific industries benefiting from the R&D activities. This may be done by requesting product field data. In practice, this means giving ISIC codes for the industries served (described in more detail in Chapter 4).

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3.4.3. *Other institutional sub-classifications*

Type of institution

177. The evolving nature of the business sector both within countries and worldwide requires subdividing both private and public enterprises.

178. If private enterprises are broken down between independent enterprises and enterprises belonging to a group and between national and foreign groups, some trends in the internationalisation of industry can be examined.

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

- Private enterprises:
  - ❖ Enterprise not belonging to any group.
  - ❖ Enterprise belonging to a national group.
  - ❖ Enterprise belonging to a foreign multinational group.
- Public enterprises:
  - ❖ Enterprise not belonging to any group.
  - ❖ Enterprise belonging to a national group.
- Other research and co-operative institutes.

180. Public enterprises are distinguished from private enterprises on the basis of control. The SNA 93 (paragraph 4.72) makes the following recommendation for the definition of public non-financial corporations:

> "These consist of resident non-financial corporations and quasi-corporations that are subject to control by government units, control over a corporation being defined as the ability to determine general corporate policy by choosing appropriate directors, if necessary. The government may secure control over a corporation:
>
> – by owning more than half the voting shares or otherwise controlling more than half the shareholders' voting power; or
>
> – as a result of special legislation, decree or regulation which empowers the government to determine corporate policy or to appoint the directors."

181. A group must be considered as foreign when the main shareholder is a foreign resident with more than 50% ownership and voting power, either directly or indirectly through subsidiaries. For more information, see the OECD *Manual of Economic Globalisation Indicators* (provisional title, forthcoming).

Size of institution

182. Size generally affects the extent and nature of the R&D programmes of entities in the business enterprise sector. Size may be classified on the basis of

employment or on the basis of revenue or other financial items. Employment is a less ambiguous measure and therefore preferable. This classification should be applied to statistical units in both the manufacturing and service industries.

183. The following size groups (according to number of employees) are proposed:

0
1-9
10-49
50-99
100-249
250-499
500-999
1 000-4 999
5 000 and above.

These categories have been chosen for a variety of reasons, in particular for their ability to conform to the size classification adopted by the European Commission for small and medium-sized enterprises (which, however, also includes a turnover or balance sheet threshold). It is therefore recommended that, if a number of classes are dropped, the breaks at 49 and 249 employees should be maintained so that comparable statistics can be prepared for small, medium-sized and large businesses. For large economies, the class 250 employees and over would be too large, so that the break at 999 employees should also be maintained. The category 0 employee is relevant in several countries that cover enterprises which only include the entrepreneur.

3.5. Government sector

3.5.1. Coverage

184. 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, as well as those that 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, but not administered by the higher education sector.

185. According to the SNA definition (UN, 1968; CEC *et al.*, 1994) of "producers of government services" (with the exception of publicly controlled higher education institutions), 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 government accounts. Government-administered social security funds are also included. It is immaterial whether they are accounted for in ordinary or extraordinary budgets, or in extra-budgetary funds.

186. With the exception of those administered by the higher education sector, 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 NPI's general policy or programme by having the right to appoint the NPI's management. Such NPIs are mainly financed by block grants from government, and the amounts of "institutional support" are often published in government reports or budgets. NPIs mainly financed by government should be included in the government sector even if the government control is not clear.

187. Units associated with the higher education sector which mainly serve the government sector should also be included in the government sector.

3.5.2. The principal sector sub-classification

The classification list

188. The United Nations' COFOG classification (classification of the purposes of government) is the standard international classification for use within the government sector. Unfortunately, it is not considered appropriate for the classification of R&D activities. No agreement has been reached on the most appropriate sub-classification for the government sector; therefore, no recommendation is made. (See Chapter 4, Table 4.1 and Sections 4.4.1 and 4.5.1, for recommendations for functional distribution.)

The statistical unit

189. ISIC Rev. 3, 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.

Criterion for classification

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

3.5.3. Other institutional sub-classifications

191. The following classifications are mainly designed to reveal differences among countries in the coverage of the government sector, which usually result from differences in institutional arrangements.

Level of government

192. Statistical units should be classified into three categories, according to the level of government involved, along with a fourth category for units that cannot be distributed by level of government.

– Central and federal government units.
– Provincial and state government units.
– Local and municipal government units.
– NPIs controlled and mainly financed by government.

Type of institution

193. When important groups of units are connected both to 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 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 (ISIC Rev. 3, Division 73) and the rest.

3.6. Private non-profit sector

3.6.1. Coverage

194. In line with SNA 93, the coverage of this sector was reduced substantially in the previous revision of this Manual and now includes:

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

195. As a source of funds, this sector covers R&D financed by NPIs serving households (NPSH). These provide individual or collective services to households either 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 subscriptions 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.

196. 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 higher education institutions. However, R&D foundations managed by NPSH but having more than 50% of their running costs covered by a block grant from government should be included in the government sector.

197. By convention, this sector also covers the residual R&D activities of the general public (households), which plays a very small role in the performance of R&D. 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 R&D may be difficult because R&D activities of individuals are not captured in business enterprise R&D surveys. Hence, the PNP sector should only include R&D undertaken by non-market, unincorporated enterprises owned by households, *i.e.* individuals financed by their own resources or by "uneconomic" grants.

198. Furthermore, where grants and contracts are formally awarded to 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 and make no use of their employing unit's staff and facilities, they should be included in the R&D statistics of the employing unit. This also refers to postgraduate students in receipt of research grants known to the research unit. It therefore follows that this sector only includes 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.

199. The following types of PNP organisations should be excluded from this sector:

- Those mainly rendering services to enterprises.
- Those primarily serving government.
- Those entirely or mainly financed and controlled by government.
- Those offering higher education services or controlled by institutions of higher education.

3.6.2. The principal sector sub-classification

The classification list

200. Statistical units in the PNP sector are classified into the six major fields of science and technology suggested in UNESCO's "Recommendation Concerning the International Standardisation of Statistics on Science and Technology" (1978). These fields are:

- Natural sciences.
- Engineering and technology.
- Medical sciences.
- Agricultural sciences.
- Social sciences.
- Humanities.

201. Table 3.2 shows the major fields of science, together with examples of which sub-fields are included.

202. While the major fields of science and technology are clearly defined, the level of disaggregation within each component field is left to each country.

The statistical unit

203. According to the SNA, the legal entity is the recommended statistical unit for this sector. In some cases a smaller statistical unit may be appropriate (see below).

Criterion for classification

204. The criterion for classification is the major field of science in which most of the R&D activity is undertaken. When a major private NPI has significant R&D activity in more than one field of science, an attempt may be made to split the statistical unit into smaller units and classify them to relevant major fields of science.

3.6.3. Other institutional sub-classifications

205. The role of this sector in R&D is very small. Therefore, no further breakdown is proposed.

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 in 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 and 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)
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]

Source: OECD.

3.7. Higher education sector

3.7.1. Coverage

206. This sector is composed of:

> - All universities, colleges of technology and other institutions 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 institutions.

207. This is not an 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.

208. The above definition describes the sector's general coverage. As it is not backed by SNA, it is difficult to provide clear guidelines that ensure internationally comparable reporting of data. Also, because the criteria are mixed, it is particularly susceptible to variations in interpretation as a result of national policy concerns and definitions of the sector.

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

- Post-secondary education.
- University hospitals and clinics.
- "Borderline" research institutions.

Post-secondary education

210. The sector includes all establishments whose primary activity is to provide post-secondary (tertiary 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 NPISHs. 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.).

University hospitals and clinics

211. 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).

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

213. 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 in 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 NPISHs in the PNP sector). Care must be taken to avoid double counting of R&D activities between the sectors concerned.

"Borderline" research institutions

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

215. A particular case arises when special funds are used to set up and finance mainly basic research, which is managed by agencies that not only award grants to universities but also have their "own" research institutes, which may or may not be situated on university campuses. These may be regarded as belonging to the higher education sector.

216. One factor affecting the classification of such research institutions is the purpose for which the research is being carried out. If the research is predominantly to serve government's needs, countries may decide to classify the institution in the government sector. This is the case of "mission-oriented" R&D institutes 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 a country's knowledge, some member countries may have opted to classify the institutes in the higher education sector.

217. A higher education institution may have "links" with other research institutes which are not directly concerned with teaching or which have other non-R&D functions such as consulting, for example through the mobility of personnel between the higher education institution and the research institute concerned or the sharing of facilities between institutes classified in different sectors. These institutes may be classified according to other criteria, such as control and finance or service rendered.

218. In some countries, furthermore, borderline institutions may have a private legal status and carry out contract research for other sectors, or they 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.

219. "Science parks" located at or near universities and colleges, which host a range of manufacturing, service and R&D entities, are a somewhat recent development. For such groupings, it is recommended not to use physical location and use of common resources as a criterion to classify these units in the higher education sector. Units controlled and hosted in these parks and mainly financed by government should be included in the government sector, those controlled and mainly financed by the private non-profit sector should be included in the PNP sector, while enterprises and other units serving enterprises should be classified in the business enterprise sector.

220. 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. This also 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.

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

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3.7.2. The principal sector sub-classification

The classification list

222. 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.

223. Table 3.2 gives the major science fields, together with examples of which sub-fields are included.

224. While the major fields of science and technology are clearly defined, the level of disaggregation within each component is left to each country's discretion. In the higher education sector, where detailed administrative information is available, a detailed field of science classification can be used as an institutional classification.

The statistical unit

225. 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.

Criterion for classification

226. 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 of the statistical unit into smaller units corresponding to several relevant major fields of science could be used.

3.7.3. *Other institutional sub-classifications*

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

228. 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.
- 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*

229. This sector consists of:

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

3.8.2. *The principal sector sub-classification*

230. The principal sector sub-classifications 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 sub-item of the R&D resources of a statistical unit, the choice of a standard sub-classification does not arise.

3.8.3. *Other institutional sub-classifications*

231. The sector may be divided into the four sectors used for domestic R&D, plus a fifth: international organisations. The recommended classifications are:

- Business enterprise.
- Other national governments.
- Private non-profit.
- Higher education.
- International organisations.

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

- Enterprises within the group.
- Other business enterprises.

3.8.4. *Geographic area of origin or destination of funds*

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

- North America: Canada, Mexico, United States.
- European Union.
- Other European OECD countries.
- Asian OECD countries: Japan, Korea.
- Oceanian OECD countries: Australia, New Zealand.
- Other European non-OECD countries.
- Other Asian non-OECD countries.
- South and Central America.
- Other Oceanian non-OECD countries.
- Africa.

234. This categorisation has been chosen to ensure that:

- All countries of the world are included and all continents singled out.
- The OECD zone may be identified separately.
- Major economic blocs (NAFTA and the EU) within the OECD zone are shown separately.
- The list is inclusive.

235. Other groupings, such as the Nordic countries, EU candidate countries, transition countries, etc., may also be of interest. In addition, it is important to identify funding from the EU and from international organisations.

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Chapter 4

Functional Distribution

4.1. The approach

236. 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 in theory functional distribution is quite appropriate for personnel data, it is generally confined to R&D expenditure.

237. The standard nomenclature used in institutional classifications may also be used for functional distribution (*e.g.* field of science). However, much nomenclature is used only for functional distribution (*e.g.* type of R&D). 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 sub-sector prior to functional distribution. In fact, most functional distribution is not appropriate for all sectors (Table 4.1).

Table 4.1. **Utility of functional distributions**

Breakdown by		Business enterprise	Government	Private non-profit	Higher education
Type of R&D	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 for current expenditure**	Unlikely	Unlikely	Unlikely
	Personnel	Possible	Unlikely	Unlikely	Unlikely
Main field of science	Expenditure	Possible	**Recommended**	**Recommended**	**Recommended**
	Personnel	Possible	Possible	Possible	Possible
Socio-economic objective	Expenditure	**Recommended for selected objectives only**	**Recommended**	Possible	Possible
	Personnel	Unlikely	Unlikely	Unlikely	Unlikely

Source: OECD.

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The category "possible" in Table 4.1 means that the breakdown is used in several countries. The category "unlikely" means that the breakdown is not used in any country and its feasibility is unknown.

4.2. Type of R&D

4.2.1. Use of distribution by type of R&D

238. Breakdown by type of R&D is currently recommended for use in all four national sectors of performance. It is usually more easily applied 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.

4.2.2. The distribution list

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

- Basic research.
- Applied research.
- Experimental development.

Basic research

240.

> 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.

241. Basic research analyses properties, structures and relationships with a view to formulating and testing hypotheses, theories or laws. The reference to no "particular application *in view*" in the definition of basic research is crucial, as the performer may not know about actual applications when doing the research or responding to survey questionnaires. 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.

242. In basic research, scientists have some freedom to set their own goals. Such research is usually performed in the higher education sector but also to some extent in the government sector. Basic research can be oriented or directed towards some broad fields of general interest, with the explicit goal of a broad range of applications in the future. One example is the public research

programmes on nanotechnology which several countries have decided on. Firms in the private sector may also undertake basic research, with a view to preparing for the next generation of technology. Research on fuel cell technology is a case in point. Such research is basic according to the above definition as it does not have a *particular* use in view. It is defined in the *Frascati Manual* as "oriented basic research".

243. Oriented basic research may be distinguished from pure basic research as follows:

- Pure basic research is carried out for the advancement of knowledge, without seeking long-term economic or social benefits or making any effort to apply the results to practical problems or to transfer the results to sectors responsible for their application.
- Oriented basic research is carried out with the expectation that it will produce a broad base of knowledge likely to form the basis of the solution to recognised or expected, current or future problems or possibilities.

244. The separate identification of oriented basic research may provide some assistance towards identifying "strategic research", a broad notion often referred to in policy making.

Applied research

245.

> 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.

246. Applied research is undertaken either to determine possible uses for the findings of basic research or to determine new methods or ways of achieving 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 is often marked by the creation of a new project to explore promising results of a basic research programme.

247. 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 gives operational form to ideas. The knowledge or information derived from it is often patented but may be kept secret.

248. It is recognised that an element of applied research can be described as strategic research, but the lack of an agreed approach in member countries to its separate identification prevents making a recommendation.

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Experimental development

249.

> Experimental development is systematic work, drawing on 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.

250. 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 R&D

251. There are many conceptual and operational problems associated with these categories. They seem to imply a sequence and a separation which rarely exist in reality. The three types of R&D 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/ experimental development stage, for example, some funds may have to be spent on additional experimental or theoretical work in order to acquire more knowledge of the underlying foundations of relevant phenomena before further progress can be made. Moreover, some research projects may genuinely straddle categories. For instance, study of the variables affecting the educational attainment of children drawn from different social and ethnic groups may involve both basic and applied research.

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

253. Examples from the natural sciences and engineering:

– 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 "scaling up" the process which has been optimised at the laboratory level and investigating and evaluating possible methods of producing the polymer and perhaps articles to be made from it.

- The study of a crystal's absorption of electromagnetic radiation 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.) to obtain given properties of radiation detection (sensitivity, rapidity, etc.) is applied research. The preparation of a device using this material to obtain better detectors of radiation than those already existing (in the spectral range considered) is experimental development.
- The determination of the amino acid sequence of an antibody molecule is basic research. Investigations undertaken in an effort to distinguish between antibodies for 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.

254. Examples from the social sciences and humanities:

- 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 and aimed at modifying regional disparities, is experimental development.
- 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.
- The development of new risk theories is basic research. Investigation of new types of insurance contracts to cover new market risks is applied research. Investigation of new types of savings instruments is applied research. Development of a new method to manage an investment fund is experimental development.
- 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.

255. Table 4.2 gives further examples of the distinctions between the three types of research in the social sciences.

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Table 4.2. **The three types of research in the social sciences and humanities**

Basic research	Applied research	Experimental development
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
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 foresee future consequences of recent trends in social mobility	Development and testing of a programme to stimulate upward mobility among certain social and ethnic groups
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
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
Study of the international factors influencing 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	–
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	–
Study of the historical development of a language	–	–
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.)	–	–

Source: UNESCO (1984b), “Manual for Statistics on Scientific and Technological Activities”.

256. Examples from software development:

- Search for alternative methods of computation, such as quantum computation and quantum information theory, is basic research.
- 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 tools such as geographical information and expert systems are applied research.
- Development of new applications software, substantial improvements to operating systems and application programmes, etc., are experimental development.

4.3. Product fields

4.3.1. Use of distribution by product fields

257. At present, the distribution of R&D by product fields is confined to the business enterprise sector. It could in theory also be applied to other sectors, but 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.

258. Product field analysis focuses on the actual industrial orientation of the R&D carried out by units in the business enterprise sector. Distribution of R&D by product fields will enhance the quality of data by distributing them more appropriately to the relevant industries, as these are more comparable internationally and allow for more detailed analysis. For example, R&D expenditures by product field are better for comparisons with commodity and production statistics than unmodified, institutionally classified data.

259. In theory, basic research, at least non-oriented basic research, cannot be assigned to product fields. In practice, the basic research carried out by firms is generally oriented towards a field of interest to the firm because of its potential 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 R&D 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 in the product field in which the process will be used.

260. At this time, it is recommended that only current intramural expenditures should be considered for international comparisons. This is because a number of member countries are unable to include capital expenditures, while, on the whole, those that can are also able to report

current expenditures separately from capital expenditures for the purpose of international comparisons.

4.3.2. *The distribution list*

261. The recommended list 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, 1986); industrial output data are classified by the national equivalent of the International Standard Industrial Classification (ISIC) (UN, 1990). At present, comparisons with industrial output data and with trade data are both 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*

262. There are two feasible criteria for distributing R&D by product field. In one case, the distribution 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.

Nature of product

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

264. 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 out, 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."

265. 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, quite

detailed records or consultations with R&D personnel are needed in order to provide complete estimates.

266. The advantage of this approach is that any enterprise in any industry carrying out R&D on a given product should select the same product field, whatever the expected use of the product. Therefore, both inter-firm and, especially, international data should be comparable. The main disadvantage is that R&D on products assembled from a wide range of components, such as aircraft, may be underestimated.

Use of product

267. The "use of product" criterion is applied in order to distribute an enterprise's R&D among the economic activities supported by its R&D programme. The R&D is therefore distributed by industrial activities according to the final products produced by the enterprise.

268. 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 carried out on a product or process in order to enable the enterprise to enter a new industry.

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

– For an enterprise active only in the semiconductor industry, this is R&D for electronic components and accessories.
– For an enterprise active only in the computer industry, this is R&D for office, computing and accounting machines.
– For an enterprise active in the semiconductor and computer industries, the use of the VLSI will determine the choice of product field:
  - ❖ If the VLSI is sold separately, the product field should be electronic components and accessories.
  - ❖ If the VLSI is included in computers sold by the enterprise, the product field should be office, computing and accounting machinery.

270. In theory, the data derived from a functional analysis by use of product should be exactly the same as those derived from an institutional breakdown by industry, if the R&D by enterprises active in more than one industry is 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.

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

272.

> It is recommended that current intramural R&D expenditure in the business enterprise sector should be distributed by product field for all industry groups. However, if this is not possible for all industry groups, it is at least recommended for ISIC Division 73. It is recommended that the product field distribution should be based on the use of product approach (industry served for ISIC Division 73). The classification outlined in Table 3.1 should be used.

4.4. Fields of science and technology

4.4.1. Use of distribution by field of science and technology

273. The fields of science and technology used for functional distribution differ in three ways from the institutional classification by major field described in Chapter 3 (see Sections 3.6.2 and 3.7.2). First, the R&D itself is examined, rather than the main activity of the performing unit. Second, the resources are usually distributed at project level within each performing unit. Third, a more detailed list of fields should be used. Such a detailed list is not agreed; the list in Chapter 3, Table 3.2, is presented as an illustration. However, countries are encouraged to use their detailed classifications of fields of science. Work to develop a more detailed international classification of fields of science for statistical use is to be undertaken. A distribution by fields of science is most easily applied in the higher education and private non-profit sectors. The units surveyed in the government sector may also be able to break down their R&D activities by field of science, but this has rarely been attempted in the business enterprise sector.

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

4.4.2. The distribution list

275. 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 should be adopted as the functional fields of a science classification system.

4.4.3. *The criteria for distribution*

276. 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 and 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.

4.5. Socio-economic objectives

4.5.1. *Use of distribution by socio-economic objectives*

277. 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 (GBAORD), which is treated in Chapter 8. (Chapter 8 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.)

278. 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 in the business enterprise sector. It should be applied to total intramural expenditures in all fields of science.

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

4.5.2. *Minimum recommended breakdown*

280. Although a general recommendation on the utility of detailed analysis by socio-economic objective 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.

Defence R&D

281. 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 funds the programme) but the objective. The objective of

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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 for which the main applications are in the defence area.

282. 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.

283. Where there is pressure to "spin off" defence R&D to civil uses, or *vice versa,* the blurring of the objective may become significant. In such cases, only the entity funding the R&D may be able to define its objective and thus its classification as either defence or civil R&D (see also Chapter 8, paragraphs 21-22).

284. The financing of defence R&D is 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.

Control and care of the environment

285. In recent years, policy makers' attention has focused on all aspects of environmental activity, and environmentally related R&D is no exception.

4.5.3. *The distribution list*

286. The distribution list based on NABS (see Chapter 8, Sections 8.7.3 and 8.7.4) is the same as that suggested for government R&D funding (except for research financed from general university funds which is not appropriate for performer-based surveys, see paragraph 288 below).

1. Exploration and exploitation of the Earth.
2. Infrastructure and general planning of land use.
3. Control and care of the environment.
4. Protection and improvement of human health.
5. Production, distribution and rational utilisation of energy.
6. Agricultural production and technology.
7. Industrial production and technology.
8. Social structures and relationships.
9. Exploration and exploitation of space.
10. Non-oriented research.
11. Other civil research.
12. Defence.

4.5.4. *The criteria for distribution*

287. R&D should be distributed according to the project's primary objective. 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). The latter approach may be the most appropriate for performer-based analysis by socio-economic objective.

288. When this type of analysis is attempted in the higher education sector, general university funds (GUF) (see Chapter 6, Section 6.3.3) should be distributed among objectives and not grouped under "Non-oriented research" (former "Advancement of research").

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Chapter 5

Measurement of R&D Personnel

5.1. Introduction

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

290. The theoretical distinction between R&D and indirect support (ancillary) activities is discussed in Chapter 2. In practice, it is useful to introduce additional criteria concerning the location of the activity in the entity concerned and its relation to the R&D-performing unit, considered as an establishment-type unit that may differ from the statistical unit.

291. In compiling R&D data, it may be difficult to isolate the R&D activities of ancillary staff from those of other R&D staff. In theory, however, the following activities are included in personnel and expenditure data if they are carried out in the R&D unit:

- Performing the scientific and technical work for a project (setting up and carrying out experiments or surveys, building prototypes, etc.).
- Planning and managing R&D projects, especially their S&T aspects.
- Preparing the interim and final reports for R&D projects, especially their R&D aspects.
- Providing internal services for R&D projects, *e.g.* computing or library and documentation work.
- Providing support for the administration of the financial and personnel aspects of R&D projects.

292. 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 overhead:

- Specific services to R&D provided by central computer departments and libraries.
- The services of central finance and personnel departments.
- Security, cleaning, maintenance, canteens, etc.

293. 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 Table 5.1).

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 units (formal R&D) plus other units (informal R&D)	Direct R&D	Carry out experiments, build prototypes, etc.
				Acquisition and treatment of specific information	Drafting, typing and reproducing R&D reports, in-house libraries, etc.
				Specific R&D management	Planning and managing S&T aspects of R&D projects
				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 overhead	Elsewhere in the performing institution (firm, agency, university, etc.) (or contracted out)	Central finance or personnel services On-site consultants	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, cleaning, maintenance, canteen, etc.
Not involved 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

Source: OECD.

5.2. Coverage and definition of R&D personnel

5.2.1. *Initial coverage*

294.

> 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.

295. Persons 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 when measuring expenditure.

296. When measuring human resources devoted to R&D, notice has to be taken of the increased use of on-site consultants as well as the outsourcing of R&D to other units or firms. With the greater use of consultants, human resources devoted to R&D may be underestimated when it is difficult to determine whether consultants are on site or part of an outsourcing arrangement. To remedy this underestimate, it is proposed to request on-site consultants' full-time equivalence (FTE) on R&D in R&D surveys and to highlight the corresponding costs in "Other current costs" in R&D survey results. In the case of outsourcing, consultant costs clearly fall under extramural expenditures.

5.2.2. *Categories of R&D personnel*

297. Two approaches may be used to classify R&D personnel: the most commonly used is by occupation, the other is by level of formal qualification. While both are perfectly reasonable and linked to two different UN classifications – the International Standard Classification of Occupations (ISCO) (ILO, 1990) and the International Standard Classification of Education (ISCED) (UNESCO, 1997) – the differences between them lead to problems of international comparability.

298. Each approach has advantages and disadvantages. Occupation series reflect the present use of resources and thus are more useful for R&D analysis more strictly defined. Furthermore, they are probably easier for employers to provide and allow for comparisons with other employment series of enterprises and R&D institutes. Qualification series are important for broader analyses, for example for setting up total personnel databases and for forecasting needs and supplies of highly qualified S&T personnel; however, they create problems for international comparisons owing to differences in the levels and structures of national educational systems. Both occupation

and qualification series are important in the broader context of studying human resources in science and technology.

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

> The approach by occupation is however preferable for international comparisons of the numbers of personnel employed in R&D.

5.2.3. *Classification by occupation*

Introduction

300. The standard international classification used is the International Standard Classification of Occupations (ISCO). The following definitions of occupations are especially designed for R&D surveys. However, they can be linked to broad categories of ISCO-88 (ILO, 1990) as described below.

Researchers

301.

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

302. Researchers are classified in ISCO-88 Major Group 2, "Professionals", and in "Research and Development Department Managers" (ISCO-88, 1237). By convention, members of the armed forces with similar skills who perform R&D should also be included.

303. Managers and administrators engaged in the planning and management of the scientific and technical aspects of a researcher's work also fall into this category. Their rank is usually equal or superior to that of persons directly employed as researchers and they are often former or part-time researchers.

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

305. Postgraduate students at the PhD level engaged in R&D should be considered as researchers. They typically hold basic university degrees (ISCED level 5A) and perform research while working towards the PhD (ISCED level 6). Where they are not a separate category (see Chapter 2, Section 2.3.2) and are treated as technicians as well as researchers, this may cause inconsistencies in the researcher series.

Technicians and equivalent staff

306.

> 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.

307. Technicians and equivalent staff are classified in ISCO-88 Major Group 3, "Technicians and Associate Professionals", notably in Sub-major Groups 31, "Physical and Engineering Science Associate Professionals", and 32, "Life Science and Health Associate Professionals", and in ISCO-88, 3434, "Statistical, Mathematical and Related Associate Professionals". Members of the armed forces who work on similar tasks should also be included.

308. 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.

Other supporting staff

309.

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

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

311. 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 are mainly found in ISCO-88 Major Group 2, "Professionals", and Minor Group 343, "Administrative Associate Professionals" (except 3434).

5.2.4. Classification by level of formal qualification

Introduction

312. ISCED provides the basis for classifying R&D personnel by formal qualification. Six 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.

Holders of university degrees at PhD level (ISCED level 6)

313. Holders of doctorate degrees of university level or equivalent in all fields (ISCED level 6). This category includes holders of degrees earned at universities proper and also at specialised institutes of university status.

Holders of basic university degrees below the PhD level (ISCED level 5A)

314. Holders of tertiary-level degrees below the PhD level in all fields (ISCED level 5A). This category includes holders of degrees earned at universities proper and also at specialised institutes of university status.

Holders of other tertiary level diplomas (ISCED level 5B)

315. Holders of other post-secondary tertiary (ISCED level 5B) diplomas in all fields. Subject matter is typically specialised, presented at a level requiring the equivalent of full secondary level education to master it. It provides a more practically oriented/occupation-specific education than programmes at ISCED levels 5A and 6.

Holders of other post-secondary non-tertiary diplomas (ISCED level 4)

316. Holders of other post-secondary non-tertiary (ISCED level 4) diplomas in all fields. This class includes holders of degrees preparing students for studies at level 5, who although having completed ISCED level 3, did not follow a curriculum which would allow entry to level 5, *i.e.* pre-degree foundation courses or short vocational programmes.

Holders of diplomas of secondary education (ISCED level 3)

317. Holders of diplomas at the secondary level, upper stage (ISCED level 3). This class includes not only all ISCED level 3 diplomas obtained in the

Table 5.2. **Standard key for ISCED levels and classes of the *Frascati Manual* for R&D personnel by formal qualifications**

<table>
<tr><th colspan="2">ISCED-97 categories</th><th>General coverage</th><th>OECD personnel categories</th></tr>
<tr><td colspan="2">6. Second stage of tertiary education – leading to an advanced research qualification</td><td rowspan="4">Post-secondary</td><td>Holders of university degrees at PhD level</td></tr>
<tr><td>5. First stage of tertiary education – not leading to an advanced research qualification</td><td>5A. Theoretically based tertiary programmes to qualify for entry to advanced research programmes
5B. Practically oriented or occupation-specific programmes</td><td>Holders of basic university degrees below the PhD level
Holders of other tertiary degrees</td></tr>
<tr><td colspan="2">4. Post-secondary, non-tertiary education</td><td>Holders of other post-secondary non-tertiary diplomas</td></tr>
<tr><td colspan="2">3. Upper secondary education</td><td rowspan="2">Secondary</td><td>Holders of secondary education diplomas</td></tr>
<tr><td colspan="2">2. Lower secondary or second stage of basic education</td><td rowspan="3">Other qualifications</td></tr>
<tr><td colspan="2">1. Primary education or first stage of basic education</td><td>Primary</td></tr>
<tr><td colspan="2">0. Pre-primary education</td><td>Pre-primary</td></tr>
</table>

Source: OECD.

secondary school system but also equivalent level 3 vocational diplomas obtained from other types of educational establishments.

Other qualifications

318. This 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.

5.2.5. Treatment of postgraduate students

319. In countries where postgraduates are not a recognised category of S&T personnel, they are probably included in part-time teaching staff. This means that as part of the overall calculation of higher education R&D personnel and expenditures – by either survey or coefficients – their R&D full-time equivalent

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levels, their R&D costs and their sources of R&D funds are measured as for staff employed by the higher education institution.

320. The difficulty 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 are discussed in general terms in Chapter 2 (Section 2.3.2).

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

322. As noted in Chapter 2, postgraduate students 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 specialised medical care, while allowing them to continue their studies and do research.

323. They can be identified according to the level of their studies. They have completed first-stage university education (ISCED level 5A) and are studying at the PhD level (ISCED level 6). ISCED level 6 programmes are described as follows:

> "Tertiary programmes which lead to the award of an advanced research qualification. The programmes are therefore devoted to advanced study and original research and are not based on course work only.
>
> **"Classification criteria**
>
> *Main criterion*
>
> > It typically requires the submission of a thesis or dissertation of publishable quality which is the product of original research and represents a significant contribution to knowledge.
>
> *Subsidiary criterion*
>
> > It prepares graduates for faculty posts in institutions offering ISCED 5A programmes, as well as research posts in government, industry, etc."

324. All postgraduate students working on R&D and receiving funding for this purpose (in the form of a salary from the university or a scholarship or another sort of funding) should in principle be included in R&D personnel headcounts. However, it may be necessary, for practical reasons, to reduce coverage to those students for whom the corresponding R&D expenditures and full-time equivalence can be estimated.

5.3. Measurement and data collection

5.3.1. Introduction

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

- Measuring their number in headcounts.
- Measuring their R&D activities in full-time equivalence (person-years).
- Measuring their characteristics.

5.3.2. Headcount data

Reasons for the approach

326. Data on the total number of persons who are mainly or partially employed on R&D allow links to be made with other data series, 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 technical personnel.

327. Headcount data are also the most appropriate measure for collecting additional information about R&D personnel, such as age, gender or national origin. Such data are needed to conduct analytical studies and implement recruitment or other S&T policies aimed at reducing gender imbalances, shortages of personnel or the effects of ageing, "brain drain", etc. There is an increasing demand from S&T policy makers for such data.

328. The OECD *Manual on the Measurement of Human Resources devoted to S&T – Canberra Manual* (OECD/Eurostat, 1995) presents a set of guidelines aimed at measuring the stocks and flows of scientific and technical manpower. Researchers and technicians represent an important subset of human resources devoted to S&T (HRST), and experience has shown that R&D surveys are the most appropriate instrument for collecting headcount data. Population censuses, labour force surveys or population registers are useful complementary data sources but cannot be used systematically to obtain R&D personnel data.

Possible approaches and options

329. Various options are available for reporting headcount numbers:

- Number of persons engaged in R&D at a given date (*e.g.* end of period).
- Average number of persons engaged in R&D during the (calendar) year.
- Total number of persons engaged in R&D during the (calendar) year.

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

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5.3.3. *Full-time equivalence (FTE) data*

Reasons for the approach

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

332. 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 whose primary function is R&D 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 must, therefore, also be expressed in full-time equivalents on R&D activities.

Measurement in person-years

333. One FTE may be thought of as one person-year. Thus, a person who normally spends 30% of his/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 is 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 not meaningful to express FTE in person-hours.

334. Personnel should be measured as the number of person-years on R&D over the same period as the expenditure series.

FTE on a fixed date

335. In some cases, it may be more practical to survey the FTE 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 allow for comparison with data based on FTE during a period. Where the fixed-date approach is used and data are 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.

Diversity of methods and the need for disclosure of method used

336. A number of restrictions apply to the actual measurement of FTE. It is therefore impossible to avoid differences in the methodology used for different countries and sectors. The most precise method, which is applied in the higher education sector, involves carrying out time-use surveys for each individual researcher. However, more approximate methods are often used in practice. One method often used consists of counting the number of positions for each category of personnel, then multiplying by appropriate R&D coefficients. In some cases, the R&D coefficients used are founded on survey data of some sort, while in others they are simply based on assumptions made by those who compile the statistics.

337. To improve international comparability regardless of the measurement methods used, the details of the methods employed should be made public. In particular, when R&D coefficients are used, information such as the value of coefficients, how they were obtained and how they are used in FTE calculations should be reported with the data, notably when reporting to international bodies (see Chapter 7, Section 7.6).

Specific problems in the higher education sector

338. 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.

339. To obtain appropriate data on R&D personnel in the higher education sector, it may be necessary to carry out time-use surveys or studies. Such surveys can be a source of valuable data even if they are only carried out once every five or ten years. Annex 2 gives more details regarding time-use surveys.

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

- Definition of the working time.
- Calculation of full-time equivalence.

• Definition of working time

341. The one aspect of an academic teacher's/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:

- Number of teaching hours per week.
- Demands made by examinations and student supervision on teachers' time.
- Administrative duties, which vary according to the time of year.

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– Nature of R&D activities and deadlines imposed for publication and/or presentation of results.

– Student vacation periods.

342. The working pattern of the staff therefore is very flexible, as time-use studies have shown. It has been found that much of their professional activity – notably R&D – is carried out outside "normal working hours" and frequently outside the higher education institution itself.

• Calculation of full-time equivalence

343. Much attention has been devoted to defining "normal" working time, particularly since respondents in time-use surveys frequently report much longer working time than most similar categories of civil servants. Calculation of full-time equivalent R&D personnel must be based on total working time. Accordingly, no one person can represent more than one FTE in any year and hence cannot perform more than one FTE on R&D.

344. In practice, however, it may not always be possible to respect this principle. Some researchers, for example, may have activities in several R&D units. This is increasingly the case of academics who also work for enterprises. In such cases, for each individual, it may be possible to reduce the FTE to one.

345. In carrying out surveys, the definition of R&D and of what it includes, *i.e.* "normal time" and "overtime", are very important if the respondent is to report his/her volume of R&D accurately. The method used for the time-use survey will have a bearing on the accuracy of FTE calculations (see Annex 2). 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 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 (as well as to other work-related activities) done outside "normal" hours. Also, the time of year at which a time-use survey is carried out may have a bearing on the calculation of the full-time equivalence.

5.3.4. *Recommended national aggregates and variables*

346.

> The two recommended aggregates are for:
>
> - The number of personnel employed in R&D measured in head counts.
> - Total FTE spent in the performance of R&D on national territory for a given 12-month period.

These should be broken down by sector and by occupation and/or formal qualification, as shown in Tables 5.3*a* and 5.3*b*. In case only one classification can be provided, priority should be given to the distribution by occupation. The other institutional classifications (and sometimes the functional distributions) are applied within this framework.

Table 5.3*a*. **Total national R&D personnel by sector and by occupation**

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

Source: OECD.

Table 5.3*b*. **Total national R&D personnel by sector and by level of qualification**

Qualification	Sector				
	Business enterprise	Government	Private non-profit	Higher education	Total
Holders of:					
University degrees					
PhD (ISCED 6)					
Other (ISCED 5A)					
Other tertiary diplomas (ISCED 5B)					
Other post-secondary non-tertiary diplomas (ISCED 4)					
Secondary diplomas (ISCED 3)					
Other qualifications					
Total					

Source: OECD.

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347.

> 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 recommended to collect headcount data on researchers and, if possible, on other categories of R&D personnel, broken down by:
>
> - Sex.
> - Age.

348. To report data by age, a breakdown into six categories is recommended:

- Under 25 years.
- 25-34 years.
- 35-44 years.
- 45-54 years.
- 55-64 years.
- 65 years and more.

The above categories are in line with the *United Nations Provisional Guidelines on Standard International Age Classifications* (UN, 1982).

349. Other variables are also worth examining, such as salary levels and national origin. The collection of such data, however, may require conducting surveys of individuals, which is very resource-intensive. It is therefore useful to look at other administrative sources of data, such as population registers, social security registers, etc.

350. Different criteria are used to identify national origin: nationality, citizenship or country of birth. Others may also be of interest, such as country of previous residence, previous occupation or country of study at the highest level. All have advantages and disadvantages and provide different types of information. The combination of at least two of these criteria will give more information. However, collection of such data for R&D personnel is still at a preliminary stage.

351. Finally, it may be useful to collect headcount data on the educational background of R&D personnel, *i.e.* field of highest qualification. Fields of study are defined in ISCED-97 and may be related to the fields of science and technology presented in Chapter 3, Table 3.2.

5.3.5. *Cross-classified data by occupation and qualification*

352. Approaches by occupation and qualification have both strengths and weaknesses when used to classify R&D personnel. However, since each is

associated with a useful body of 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, furthermore, that data should be collected – perhaps every five years – for cross-classification between occupation and qualification on a headcount basis, as shown in Table 5.4.

Table 5.4. **R&D personnel classified by occupation and by formal qualification**

Headcount

Qualification	Occupation			
	Researchers	Technicians and equivalent staff	Other supporting staff	Total
Holders of:				
University degrees				
PhDs (ISCED 6)				
Others (ISCED 5A)				
Other tertiary diplomas (ISCED 5B)				
Other post-secondary non-tertiary diplomas (ISCED 4)				
Secondary diplomas (ISCED 3)				
Other qualifications				
Total				

Source: OECD.

353. The correspondence between researchers and university graduates – researchers are generally expected to have university-level diplomas – does not always hold. Certain researchers have lower qualifications supplemented by on-the-job experience. It is also increasingly common to find university graduates with science and engineering (NSE) degrees employed as technicians. The correspondence is even more tenuous for the other occupational categories. For example, 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 in Table 5.4 is useful for attempts to understand another country's R&D personnel statistics, to evaluate the international comparability of these statistics, or, indeed, for discussing trends in one's own country's R&D labour force. Furthermore, it helps to identify the share of R&D personnel that is a subset of HRST, in particular the share referred to as "core" in the *Canberra Manual*, *i.e.* researchers and technicians who have completed tertiary education.

354. In addition, it would be desirable to have a measure of all high-level personnel working on R&D. The continued use of occupation and qualification as classifications has prevented defining a single measure of this category of personnel. Table 5.4 would therefore also provide a good basis for identifying proxy categories of high-level personnel.

5.3.6. Regional data

355. A regional breakdown of total R&D personnel and of researchers is also recommended for both headcounts and full-time equivalents. For EU member states, the regional levels are given by the Nomenclature of Territorial Units for Statistics (NUTS) classification. For other OECD member countries, regional distribution has to be determined according to national needs. In federal countries it might be at state level. Further details on the methods to be used for compiling regional R&D data are found in Annex 5.

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Chapter 6

Measurement of Expenditures Devoted to R&D

6.1. Introduction

356. A statistical unit may have expenditures on R&D either within the unit (intramural) or outside it (extramural). The full procedure for measuring these expenditures is as follows:

- Identify the intramural expenditure on R&D performed by each statistical unit (see Section 6.2).
- Identify the sources of funds for these intramural R&D expenditures as reported by the performer (see Section 6.3).
- Identify the extramural R&D expenditures of each statistical unit (see Section 6.4).
- Aggregate the data by sectors of performance and sources of funds to derive significant national totals. Other classifications and distributions are then compiled within this framework (see Section 6.7).

357. The first two steps are essential and generally suffice for undertaking the fourth. R&D expenditure data should be compiled on the basis of performers' reports of intramural expenditures. As supplementary information, the collection of extramural expenditures is desirable.

6.2. Intramural expenditures

6.2.1. Definition

358.

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

359. 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.

6.2.2. Current costs

360. Current costs are composed of labour costs and other current costs (see also Section 6.2.3).

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Labour costs of R&D personnel

361. 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 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.

362. Labour costs are often the largest component of current costs. Countries may find it useful to collect or otherwise secure labour costs by type of personnel (*e.g.* researchers, technicians and equivalent staff, other supporting staff, etc.). These extra classifications will be particularly helpful for constructing cost indices for R&D expenditures.

363. Calculation of the salary element for postgraduate students at the PhD level may sometimes cause a problem. Only those students who are on the payroll of universities or R&D units (*e.g.* as research assistants) and/or receive external funds for R&D (such as research scholarships) should be included in the statistics. Sometimes, they receive less money for their work than they would at "market value". Only actual "salaries"/stipends and similar expenditures associated with such students should be reported in the R&D statistics. No inflated values should be derived.

Other current costs

364. 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, etc.; imputed or actual cost of small prototypes or models made outside the research organisation; materials for laboratories (chemicals, animals, etc.). Costs for on-site consultants should be included in other current costs and identified separately if possible. (See Chapter 5, Section 5.2.1, for their treatment in personnel data). Administrative and other overhead costs (*e.g.* office, post and telecommunications, insurance) should also be included, prorated if necessary to allow for non-R&D activities within the same statistical unit. All costs for 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. Interest charges should be excluded.

Indirectly paid current costs

365. R&D activities may incur costs which are often not paid by the sector but borne by institutions classified in other sectors of the economy, usually the government sector. Two examples are discussed below.

- Rents for research facilities

366. In many countries, responsibility for "housing" public institutions (including universities) lies with 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 concern both the administration of ongoing accommodation and temporary arrangements for premises and equipment and is particularly relevant for the higher education sector.

367. In some cases, such facilities are available to institutions free of charge or are not accounted for in the institutions' books. To obtain a realistic cost of R&D, 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 may still be desirable, for reasons of international comparability, to include a notional amount that represents an actual payment known to have been made from one agency to another in a different sector. This might serve as 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.

368. If actual payments are made (even if not necessarily revealed by the R&D surveys), the national authorities should make an adjustment in their data series – for instance, to account for the estimated market value of the facilities concerned. This should be included under other current costs in the receiving sector and should be subtracted, as appropriate, from the accounts of the donating sectors concerned.

- Social security costs and pensions for R&D personnel

369. 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." (see paragraph 361).

370. Where there is an actual provision for social security and/or pensions for R&D personnel, these amounts should be included in R&D labour costs. They need not necessarily be visible in the bookkeeping accounts of cost to the sector concerned; they may often involve transactions within or between sectors. Even when no transactions are involved, an attempt should be made to estimate these costs. Care should be taken to avoid double counting of such expenditure.

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Value added tax (VAT)

371. Data on R&D expenditure, on both a provider and a 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. Not only will this help to make valid international comparisons, it will also help countries in their 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.

372. For 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 is generally reclaimable and therefore separately identifiable.

373. 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; it 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 that figures forwarded to the OECD should be exclusive of VAT.

6.2.3. Capital expenditures

374.

> 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.

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

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

376. Capital expenditures are composed of expenditures on:

– Land and buildings.
– Instruments and equipment.
– Computer software.

Land and buildings

377. 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.

378. The R&D share of the expenditures 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 on the basis of scheduled use (see the section on identifying the R&D content of capital expenditures below).

379. Purchase of new research equipment is often included in the cost of new buildings and is not separately identifiable. This may result, in some years, in underestimation of the "instruments and equipment" component in total capital R&D expenditures.

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

Instruments and equipment

381. This covers major instruments and equipment acquired for use in the performance of R&D including embodied software.

Computer software

382. This includes acquisition of separately identifiable computer software for use in the performance of R&D, including programme descriptions and supporting materials for both systems and applications software. Annual licensing fees for the use of acquired computer software are also included.

383. In R&D surveys, however, software for own account produced as part of R&D is included in the relevant cost category: labour costs or other current costs.

Conventions for distinguishing between current and capital items

384. 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 cost accounts. The boundary between "minor" and "major" items varies slightly among countries according to their taxation practices and among different firms and organisations in the same country according to their accounting

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practices. These differences are rarely significant, and it is neither necessary nor practical to insist on any rigid standard. 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 costs, such conventions should always be made explicit.

Identifying the R&D content of capital expenditures

385. Occasionally, the R&D term of a fixed asset may be known at the time of acquisition. In this case, the appropriate portion of the expenditure for the acquisition of the asset should be attributed to R&D capital expenditures. Similarly, when the R&D term of the asset is not known and a fixed asset will be used for more than one activity and neither the R&D nor any of the non-R&D activities predominates (*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. This 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).

Sale of R&D capital goods

386. The sale/transfer of fixed assets originally acquired for R&D creates a problem. Their disposal could be considered as a disinvestment in R&D. However, no adjustment should be made to recorded capital expenditures. 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.

Libraries

387. Although payments for current purchases 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 under expenditure on major equipment, especially if made when equipping a new institution (see UNESCO, 1984b, Section 3.2.1).

388. Each country should adopt the UNESCO approach when 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, so that it is possible to observe changes in the pattern of such expenditure.

6.3. Sources of funds

6.3.1. Methods of measurement

389. R&D is an activity involving 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.

390. One is performer-based reporting of the sums which one unit, organisation or sector has received or will receive from another unit, organisation or sector for the performance of intramural R&D during a specific period. Funds received for R&D performed during earlier periods or for R&D not yet started should be excluded from the sources of funds reported for the specific period.

391. The second is source-based reporting of extramural expenditures which are the sums a unit, organisation or sector reports having paid or committed itself to pay to another unit, organisation or sector for the performance of R&D during a specific period.

392. The first of these approaches is strongly recommended.

6.3.2. Criteria for identifying flows of R&D funds

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

– There must be a direct transfer of resources.
– The transfer must be both intended and used for the performance of R&D.

Direct transfer

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

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

396. 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.

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

– Those that 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, which is not necessarily the funder of the R&D.

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– Those that are provided to the performers of R&D in the form of grants or other financial incentives, with the results of the R&D becoming the property of the R&D performers.

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

399. 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 will not normally be able to make such an estimate, and the donor may also not be able to do so.

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

401. Other government incentives for R&D in the business enterprise sector include 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's 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 when 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.

Transfers both intended and used for R&D

402. In many R&D transfers this can be taken for granted. There are instances, however, when some clarification may be required (particularly if there is a discrepancy between the performer's and the funder's report):

– 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 carries out no R&D itself and would report no R&D funded by the government. For R&D statistics, these expenditures should be considered by the government laboratory to be intramural capital and intramural other current costs, respectively.

– In a second case, the transfers of funds 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.
– 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

403. 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 sub-sector and funds from other sectors and sub-sectors. They can usually do so relatively easily, but there are one or two problem areas.

Sub-contracting and intermediaries

404. Problems arise when funds pass through several organisations. This may occur when R&D is sub-contracted, as sometimes happens in the business enterprise sector. The performer should indicate, as far as possible, the original source of the funds for R&D. The same problems arise for EU funding, as the funds first go to the main contractor and are then distributed among the other participants (sub-contractors). 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, while it is acceptable to regard these organisations as the source, it is nonetheless preferable to attempt to trace the funds to their original sources.

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Public general university funds (GUF)

405. To finance their R&D activities, universities usually draw on three types of funds:

- R&D contracts and earmarked grants received from government and other outside sources. These should be credited to their original source.
- Income from endowments, shareholdings and property, plus surplus from the sale of non-R&D services such as fees from individual students, subscriptions to journals and sale of serum or agricultural produce. These are the universities' "own funds". In the case of private universities, these may be a major source of R&D funds.
- 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. One could argue 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. One could also argue that it is within universities that decisions are taken to commit money to R&D out of a pool which contains both "own funds" as defined above and public GUF; therefore, the sums concerned should be credited to higher education as a source of funds. 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 and GUF.

406. The following procedures should be adopted. GUF should be separately reported and any adjustments to the R&D cost series should take account of real or imputed social security and pensions provisions, which should be attributed to GUF as a source of funds. Monies from the higher education "block grant" should be classified as GUF, and other monies generated by the sector should be considered as "own funds". Adjustments to other current costs to account for real or imputed payments of rents, etc., should be attributed to direct government funds.

407. As far as possible, the following sources of funds should be identified in R&D surveys:

- Business enterprise sector:
  - ❖ Own enterprise.
  - ❖ Other enterprise in the same group.
  - ❖ Other enterprise.
- Government sector:
  - ❖ Central or federal government (excluding general university funds).
  - ❖ Provincial or state government.(excluding general university funds).
  - ❖ Public general university funds.

- Private non profit sector.
- Higher education sector.
- Abroad:
  - ❖ Business enterprise:
    - ● Enterprises within the same group.
    - ● Other enterprises.
  - ❖ Other national governments.
  - ❖ Private non-profit.
  - ❖ Higher education.
  - ❖ EU.
  - ❖ International organisations.

6.4. Extramural expenditures

408.

> Extramural expenditures are the sums a unit, organisation or sector reports having paid or committed themselves to pay to another unit, organisation or sector for the performance of R&D during a specific period. This includes acquisition of R&D performed by other units and grants given to others for performing R&D.

409. For the acquisition of services closely related to intramural R&D activities, the borderline between intramural and extramural expenditures is not always clear. If these services are separate R&D projects, the expenditures can in most cases be regarded as extramural R&D. If they are certain tasks (not necessarily R&D as such) necessary for the intramural R&D of the unit but contracted out, they can generally be regarded as intramural R&D expenditure (other current costs). In principle, the same rules apply to consultants. However, costs for on-site consultants come under other current costs (as mentioned in paragraph 364) as their R&D activity is a direct part of the R&D activity of the unit.

410. Data on the extramural R&D expenditures of statistical units are a useful supplement to the information collected on intramural expenditures. The collection of these data is therefore encouraged. 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 survey coverage.

411. The focus of R&D data is necessarily individual countries, and it is very difficult to track international flows of R&D funds. In the context of the

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increasingly worldwide organisation of R&D, more use should be made of analysis of extramural R&D funds to address this problem. It is therefore recommended that some details on international flows, similar to those used in the source of funds classification above, should be added to the classification used to distribute extramural R&D.

412. For the distribution of extramural R&D, the following classification is recommended:

- Business enterprise sector:
  - ❖ Other enterprise in the same group.
  - ❖ Other enterprise.
- Government sector.
- Private non-profit sector.
- Higher education sector.
- Abroad:
  - ❖ Business enterprise:
    - Enterprise within the same group.
    - Other enterprise.
  - ❖ Other national government.
  - ❖ Private non-profit.
  - ❖ Higher education.
  - ❖ International organisations.

6.5. Reconciling differences in performer-based and source-based reporting

413. In principle, the estimated total of R&D expenditure within a country based on performer reports should equal the total based on reports from those funding R&D (including funder reports to abroad). In practice, however, this is not likely to be the case owing to sampling difficulties and reporting differences.

414. In addition to reporting differences arising as a result of sampling error (estimates of GERD are often obtained from sample surveys instead of surveys of the entire population), countries have difficulty in reconciling funder and performer data for several reasons.

415. Funders' and performers' views of whether the work being performed meets the definition of R&D may differ. For example, in the US defence industry, the emergence of new non-traditional contractors (including large telecommunications carriers, small high-technology firms) and increased R&D funding of more generalised technical, analytical and professional contracts (whose deliverables may be a small component of the overall defence R&D project) have resulted in differing interpretations of what constitutes R&D.

416. The financing may be provided by an intermediary, making it difficult for the performer to know the original source of funds (see paragraph 404). A related problem is funding that goes outside of the funding sector but comes back to the sector as externally funded R&D.

417. Contracts for research often extend over more than one year, with the result that there may be timing discrepancies between funder and performer.

418. In many countries, it may be difficult to identify firms that pay for R&D performed overseas. In fact, in cases of multinational firms, an enterprise in one country may not know precisely how much it is funding R&D in another. It may merely make a payment to a head office in another country for a range of services, one of which is R&D.

419. A variant is the reconciliation of GBAORD data, which is essentially government funder data (appropriations rather than expenditures, however), to R&D performer data. In this case, the lack of comparability may be due to the performance of a different amount of R&D than was expected at the appropriations stage; it may also be due to an imprecision in the budget appropriations that does not allow for separate identification of appropriations that are specifically targeted to R&D (for more information on GBAORD methodology, see Chapter 8).

420. In addition to the business enterprise and government sectors, problems for reconciling funder- and performer-based R&D data arise for other major funders of R&D, such as research councils and abroad.

421. To the extent possible, it is recommended that differences in R&D expenditure totals between those estimated from the funders of R&D and those estimated from the performers of R&D should be reported, and that causal factors for the differences, if known, should be identified. It should be recognised that such differences are not necessarily a result of inadequate or inaccurate measurement and that providing these data will aid analytical and statistical accuracy.

6.6. Regional distribution

422. A regional distribution of R&D intramural expenditures is also recommended. For the EU member states, regional levels are given by the Nomenclature of Territorial Units for Statistics (NUTS) classification. For other OECD member countries, the regional distribution has to be determined according to national needs. In federal countries, for example, it might be the state level. Further details on the methods to be used for compiling regional R&D data are found in Annex 5.

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6.7. National totals

6.7.1. Gross domestic expenditure on R&D (GERD)

423.

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

424. GERD includes R&D performed within a country and funded from abroad but excludes payments for R&D performed abroad. 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). GERD and the GERD matrix are the basis of international comparisons of R&D expenditures. They also provide the accounting system within which the institutional classifications and functional distributions may be applied.

425. It would be useful to have separate tables for defence and civil GERD, in order to map how trends in these areas affect the level and structure of total GERD. This is particularly true for countries with significant defence R&D programmes. The separation is encouraged for other countries as well, as a way to increase the comparability of data on civil R&D.

6.7.2. Gross national expenditure on R&D (GNERD)

426. The GNERD aggregate comprises total expenditure on R&D financed by a country's institutions 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). It gives some supplementary information on R&D co-operation between different kinds of units.

427. To allow for the identification of R&D activities of international organisations, the "Abroad" sector should have sub-categories for international organisations, as recommended in the institutional sub-classification (see Chapter 3, Section 3.8.3).

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

Funding sector	Sector of performance				Total
	Business enterprise	Government	Private non-profit	Higher education	
Business enterprise					Total domestic performance financed by the business enterprise sector
Government					Total domestic performance financed by the government sector
Public general university funds (GUF)					Total domestic performance financed by public general university funds (GUF)
Higher education					Total domestic performance financed by the higher education sector
Private non-profit (PNP)					Total domestic performance financed by the private non-profit sector
Abroad • Foreign enterprises – Within the same group – Other • Foreign government • European Union • International organisations • Other					Total domestic performance financed by abroad
Total	Total performed in the business enterprise sector	Total performed in the government sector	Total performed in the private non-profit sector	Total performed in the higher education sector	GERD

Source: OECD.

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

Funding sector	Sector of performance								Total
	National territory				Abroad				
					Business enterprise				
	Business enterprise	Government	Private non-profit	Higher education	Within the same group	Other business enterprise	International organisations	Other	
Business enterprise									Total financed by the business enterprise sector
Government									Total financed by the government sector
Public general university funds (GUF)									Total financed by public GUF
Higher education									Total financed by the higher education sector
Private non-profit									Total financed by the PNP sector
Total	Total nationally financed performed in the business enterprise sector	Total nationally financed performed in the government sector	Total nationally financed performed in the private non-profit sector	Total nationally financed performed in the higher education sector	Total nationally financed performed abroad in business enterprise within the same group	Total nationally financed performed abroad in other business enterprise	Total nationally financed performed abroad in international organisations	Total nationally financed performed abroad in other organisations	GNERD

Source: OECD.

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and Experimental Development

Chapter 7

Survey Methodology and Procedures

7.1. Introduction

428. Information on R&D may be obtained from different sources, such as annual reports of research councils or major R&D-performing institutions. These data can only give an approximate measure of R&D efforts. Not only do the concepts of R&D used often differ from the definitions given in this Manual; they may also change over time. It is also very difficult to obtain all data for the same period and to avoid double counting when tracking flows from financial statements and other sources. For these reasons, statistics on R&D require regular, systematic and harmonised special surveys. However, because of lack of satisfactory records, costs of statistical surveys and the need to restrict statistical demands on respondents, surveys cannot always provide all the information needed.

429. Estimates are a necessary supplement to surveys (respondents must often make estimates in order to provide the requested "survey" information). Using ratios derived from survey data, it is possible to provide adequate aggregate trends or totals from incomplete information without recourse to a costly survey. Indeed, the R&D inputs of the higher education sector are often partially, and in some countries wholly, estimated. When statistics are released, full information on the sources and generation of the statistics should be provided.

430. To improve international comparability, this chapter gives some methodological guidelines for conducting R&D surveys. These are based on identified best practices. As R&D survey methodologies and procedures are well established in many countries, the guidelines are quite general so as to be as widely applicable as possible.

7.2. Scope of R&D surveys

431. In theory, R&D surveys should identify and measure all financial and personnel resources devoted to all R&D activities in all R&D units. R&D surveys are mainly addressed to R&D-performing units, which may also finance R&D performed in other units (this is covered by a question on extramural expenditure). Units which only finance R&D are surveyed to some extent by member countries. Government departments, for example, are surveyed in the context of calculating government budget appropriations or outlays for R&D (GBAORD) by socio-economic objectives. This chapter, however, only addresses performer-based surveys. Statistical methodologies and other procedures have

to be established to capture all R&D, especially for units in the business enterprise sector with little R&D. These are described in more detail below.

7.3. Identifying target population and survey respondents

432. Only in a few member countries can the surveying agency make an exhaustive survey of all possible R&D performers. Generally, there are many constraints on the extent of surveys. 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.

433. It is not possible to make detailed recommendations on survey methods that would be equally relevant to all member countries, as the size and structure of national R&D capacities vary widely. Suggestions are given for the business enterprise, government, private non-profit and higher education sectors, although it is recognised that some countries use different systems of sectoring for surveying and reporting data. For example, some countries undertake surveys of enterprises, institutes and higher education teaching establishments and redistribute the institutes among the four standard sectors of performance.

434. Hospitals/healthcare institutions are a special category. They carry out R&D which may relate to any of the four standard sectors of performance. Health-related research has increased significantly in recent years, and it is worth reviewing survey coverage to ensure that R&D data are collected for all hospitals and healthcare units that are liable to undertake such activities, not only university hospitals and other research-intensive hospitals but also general hospitals and other healthcare units (ISIC 8512 and 8519). In several countries, some categories of publicly funded hospitals/healthcare units may not be officially permitted to use their funds for R&D but may nevertheless host some research activities. If possible, the major research-performing units should be surveyed following the standard national timetable. For general hospitals and other healthcare units, benchmark surveys should be made at least every decade and methods of estimation established for the intervening years.

7.3.1. Business enterprise sector

435. The enterprise is recommended as the main statistical unit in the business enterprise sector (see also Chapter 3, Section 3.4.2). Some enterprises perform R&D on a regular basis from year to year, and they may have one or several R&D units. Other enterprises perform R&D only occasionally. They may be engaged in a project in one year and not perform any R&D in the next. This R&D is often performed by people from various parts of the enterprise on a

project basis without a formal R&D organisation. In the general *Frascati Manual* definition of R&D, the criterion of "creative work undertaken on a systematic basis" is fulfilled by a project which has specific goals and a budget.

> It is recommended that all enterprises performing R&D, either continuously or occasionally, should be included in R&D surveys.

436. There are at least two feasible approaches for establishing the survey population of the business enterprise sector. One is to take a census-based survey of large enterprises and a sample of smaller ones belonging to a certain population (in terms of industry and size class) from the entire sector in order to identify R&D performers and request the information from them. The choice of enterprises should be based on a business register of good quality. In this approach, R&D performed in the past in the enterprise is not considered. This is the approach followed in innovation surveys.

437. Surveys of this kind will cover a large number of enterprises and are expensive if applied to all industries and all enterprises regardless of size. It is therefore necessary to limit the target population in terms of size of enterprise and industries covered. This normally leads to the systematic exclusion of very small enterprises and enterprises in certain less R&D-intensive industries. When the sample size is very small, estimates may be less reliable, owing to raising factors. In practice, no member country follows this approach strictly.

438. In R&D surveys for the business enterprise sector, most member countries use the second approach, *i.e.* they try to survey all enterprises known or assumed to perform R&D. The survey is based on a register of R&D-performing enterprises. The sources of this register include lists of enterprises receiving government grants and contracts for R&D, lists of enterprises reporting R&D activities in previous R&D surveys, in innovation surveys or other enterprise surveys, directories of R&D laboratories, members of industrial research associations, employers of very highly qualified personnel and lists of enterprises claiming tax deductions for R&D. Several countries only use this kind of information to identify R&D performers.

439. It is very difficult to maintain completely up-to-date registers of enterprises that occasionally perform R&D from these sources. This may lead to undercoverage of R&D in small or medium-sized enterprises. The effect on total business enterprise R&D, however, is not significant, as the large R&D performers are included in any case.

440. To improve the coverage of R&D surveys that use this approach, many countries use a combination of these approaches, *i.e.* they systematically take a census/sample survey to collect information on R&D from enterprises not

included in registers of R&D-performing enterprises. For cost reasons, such surveys are limited in terms of industries covered and enterprise size. The limitations mainly concern the services sectors, as there is little experience with surveying their R&D activities. Enterprises with a very low probability of performing R&D should be excluded in order to reduce the response burden. The advantage of this approach is that it considerably reduces the uncertainty in estimating figures for the target population as compared to the pure sampling approach described above, which does not take previous R&D into account. Its disadvantage is the cost, which may make it difficult to apply in bigger countries.

441. It is therefore recommended:

- To include in R&D surveys of the business enterprise sector all firms known or supposed to perform R&D.
- To identify R&D performers not known or supposed to perform R&D by a census/sample of all other firms in the industries listed below. In principle, enterprises in all size classes should be included, but if a cut-off point is necessary, it should be at ten employees.

442. The following industries should be included:

Industry	ISIC Rev. 3/NACE Rev. 1
Mining	14
Manufacturing	15-37
Utilities, construction	40, 41, 45
Wholesale	50
Transport, storage and communication	60-64
Financial intermediation	65-67
Computer and related activities	72
R&D services	73
Architectural, engineering and other technical activities	742

In addition, other sectors, for example agriculture (ISIC Rev. 3, Divisions 01, 02, 05), should be covered in countries with significant amounts of research in these sectors.

7.3.2. Government sector

443. Units to include in surveys are:

- R&D institutes.
- R&D activities of general administrations of central or state government, statistical, meteorological, geological and other public services, museums, hospitals.

– R&D activities at the municipality level.

> The best way to survey is to send questionnaires to all units known or assumed to perform R&D.

444. There may be several ways of updating lists of R&D-performing units, such as business registers, directories of R&D-performing units, research associations, bibliometric sources, requests for updates from administrative bodies, etc.

445. It is especially difficult to identify R&D activities at the municipality level owing to the large number of units, the small number of likely R&D performers and difficulties in the interpretation of the concept of R&D. Lists of R&D performers usually do not include these units. It may be worthwhile to make an effort to identify R&D performers in large cities.

7.3.3. Private non-profit sector

446. The sources for identifying possible survey respondents are mainly the same as for the government sector. Register information may be less comprehensive and could be completed by information from researchers or research administrations. This sector may be more relevant for surveys on R&D funding.

7.3.4. Higher education sector

447.

> The surveys and estimation procedures (see below) should cover all universities and corresponding institutions, especially those awarding degrees at the doctorate level. Other institutions in the sector known or assumed to perform R&D should also be included.

448. Identification of these institutions is generally relatively easy. If possible, it is often preferable to use smaller units, such as departments or institutes of the university, as statistical units.

7.3.5. Hospitals

449. Some countries may find it satisfactory to include hospitals and healthcare institutions in regular R&D surveys, using the standard questionnaire for the sector concerned. Indeed, this may be the only option for hospitals and other healthcare units in the business enterprise sector. In this

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case, additional guidance on the borderline between research and healthcare and on the treatment of clinical trials might be supplied. Where university hospitals are administratively and financially very closely integrated with teaching establishments (see Chapter 3, Section 3.7.1), they might be treated together for the purposes of R&D surveys/data compilation. If they are separate units with separate accounts and administrations, they might receive a special questionnaire directed to government hospitals (see below) or a normal R&D questionnaire. For hospitals in the government and non-profit sectors and university hospitals (or parts thereof) which are not integrated with teaching establishments, a special survey may be useful. If this is not possible, the normal R&D questionnaire may be used.

450. Whatever survey approach is taken, care should be taken to ensure coherent treatment of R&D in units/projects under joint management by two or more entities, by persons receiving two salaries from different entities and by persons working at hospitals but employed by other institutions.

7.4. Working with respondents

7.4.1. Encouraging co-operation

451. The survey questionnaire must include a minimum number of basic questions on the R&D activity in order to produce harmonised and comparable statistics for transmission to international organisations. Owing to the response burden, the questionnaire should be as simple and short as possible, logically structured and have clear definitions and instructions. Generally, the longer the questionnaire, the lower the unit and item response rates. For smaller units, a simplified survey questionnaire could be used. It is highly recommended to test draft questionnaires on a sample of respondents. Work has started to develop a harmonised OECD questionnaire for R&D surveys in the business enterprise sector.

452. Once the survey respondent has been identified, it is necessary to identify the best person to fill in the questionnaire. In R&D surveys, he/she is usually in the accounting or personnel unit or in the R&D unit. Each has advantages and disadvantages. The R&D manager can identify the R&D of the unit according to *Frascati Manual* norms better but may not be able to supply exact figures. The accountant or personnel manager has the exact figures, but may not refer exactly to R&D as defined in the *Frascati Manual*. In bigger units, the co-operation of all three types of respondents is essential. Nevertheless, one person must co-ordinate the response. It is often useful to send the questionnaire to the person who responded the previous year. If this is not known, surveys should be addressed to the managing director. In big, complex institutions like universities and large enterprises or groups of enterprises,

it is useful to identify in advance the person responsible for providing information and for co-ordinating information from smaller sub-units.

453. It is very important to secure the co-operation of the person in charge of responding. Respondents are asked to spend time on a task which is often of no direct benefit to them; they may even see completing a questionnaire on R&D as a waste of time and money. It is the responsibility of the surveying agency to help contributors to appreciate the potential uses of the data and to be alert to respondents' potential needs in terms of R&D statistics. It is also its responsibility to respect confidential data and to ensure that users are aware of respondents' concerns. In the design of surveys, it should consider the need to minimise the burden on respondents.

454. The respondent is rarely a user of the statistics, but it is important to show what has been done with the data in order to encourage co-operation. The respondent might receive the publication, or, if this is not feasible, a summary. Customised information which allows the respondent to compare his/her unit with corresponding national totals may also be useful.

455. The statistical agency should provide the respondent with technical assistance and name, phone number, fax number and e-mail addresses for all contact persons within the agency. The extent to which follow-up procedures are used will depend on the level and quality of responses, the number of units surveyed and the resources available to the surveying authority. It is rarely feasible to contact personally 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 entities very thoroughly. Personal contacts with respondents who require guidance or who submit unsatisfactory returns should be encouraged.

456. Almost all respondents will have to make some estimates. Not only is R&D a complex activity in itself, 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.

457. R&D is not only what R&D laboratories and research institutes do. It is both less and more than this, since very few of the surveyed entities 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 measurement of their total activity.
- Estimates of the non-R&D portions of their activity and subtraction of these estimates from the total.
- Estimates of the inputs used for R&D in other units and addition of these estimates to the total.

458. 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.

7.4.2. Operational criteria

459. Operational criteria that are suitable for the sector surveyed must be developed. Thus, on questionnaires intended for the business enterprise sector, it would be appropriate to give guidance for distinguishing between R&D and pre-production, whereas a government questionnaire might concentrate on the difference between R&D, on the one hand, and data collection and information, on the other. Sector-specific examples might be useful to guide respondents. Reference might be made to detailed examples in this Manual. Responding units may need criteria for distinguishing between contracts to industry for goods and services required for intramural R&D and those awarded for the performance of industrial R&D. Criteria with the same intent but different wording may be useful in 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 well suited to the electrical products industry. In discussions with respondents, supplementary criteria are often useful. Examples are given in Chapter 2, Table 2.1.

460. During R&D surveys, respondents may find it very difficult to apply the theoretical distinctions made in earlier chapters of this Manual to the wide range of projects under way in their organisation. As surveying agencies are not always able to check responses and are usually obliged to accept them as given, it is of utmost importance that they provide the institutions surveyed with clear explanations and guidance to complement the formal definitions in order to ensure uniformity.

461. Four important tools for achieving this objective are:

- Explanatory notes.
- Hypothetical examples.
- Guidance to individual respondents.
- Documentation on treatment of different cases.

462. For obvious reasons, this Manual deals exclusively with the first two tools. Formal definitions and theoretical distinctions have to be complemented by the last two. To ensure that the guidance given by surveying agencies is consistent, it is essential to develop documentation on how difficult borderline cases have been solved. Such documentation can also

serve as a valuable source of hypothetical examples and may help countries to develop more uniform classification practices.

7.5. Estimation procedures

463. In the process of compiling R&D statistics, various estimation procedures are used. Results from sample surveys have to be grossed up, using various methods, to correspond to the total target population. Especially in surveys of the business enterprise and government sectors, there are problems of unit and item non-response. In the higher education sector, statistics in most countries are based on a combination of surveys and estimation procedures.

7.5.1. Unit and item non-response

464. In practice, responses to R&D surveys are often incomplete, irrespective of the survey method used. Two types of missing values can be distinguished: item and unit non-responses. Unit non-response means that a reporting unit does not reply at all. The surveying institute may not be able to reach the reporting unit or the reporting unit may refuse to answer. For item non-response, a unit does answer but leaves at least one question blank or even, in an extreme case, leaves all questions but one blank.

465. Item and unit non-responses would be less of a problem if missing values were randomly distributed over all sampling units and all questions. In reality, however, both types of missing values are biased with respect to certain characteristics of the population and the questionnaire. Item non-response is more likely when the question is (or seems to be) difficult. Examples are the breakdown of R&D investments (land and buildings and equipment) or of R&D by type of R&D.

466. These non-responses clearly affect the comparability of the results of national and international R&D surveys. Appropriate methods to overcome this problem have to be developed and used. As different methods may lead to different results, some general recommendations should be followed. Otherwise, differences in results over time and/or among countries may arise from using different concepts to reduce the bias of item and unit non-responses.

467. For practical as well as theoretical reasons, one recommended way to overcome the problem of item non-response is a group of methods called "imputation methods" for estimating missing values on the basis of additional information. The easiest method is to use the previous answer for the same enterprise. Another possibility is to use statistical techniques such as "hot decking", using information from the same survey, or "cold decking", using information from previous surveys.

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468. In the case of unit non-response, past R&D data at firm level can be used to estimate the R&D expenditures for the same firm for the current period. The evolution of sales and or employment can be used to adapt the previous figures. In cases where no previous R&D data at firm level are available, as R&D is a metric variable correlated to a certain degree with sales, a recommended method is to use the relation between the sales of the total population and the sales of the realised sample for each cell in the sample. Another method is to use employment as a variable. This procedure is based on the assumption that the ratios of R&D to sales or R&D personnel to total personnel of responding and non-responding units are identical. This assumption can be tested through non-response analysis of a representative sample of non-responding units. Even if the assumption is wrong, the bias introduced can be disregarded as long as the fraction of non-responding units is fairly small.

7.5.2. Estimation procedures in the higher education sector

469.

> It is recommended that information on R&D in this sector should be based on surveys of the performing units, supplemented, if necessary, by estimations.

470. Often over half of the funding of R&D is given as general university funds, not earmarked for research but given for the general functioning of the university. The R&D share of these funds is often unknown to the universities themselves. To determine which part should be devoted to R&D, a variety of methods have been used:

- Central estimates not based on empirical knowledge of how time is spent on different activities.
- Time-use surveys/studies concerning the distribution of time by various categories of personnel.
- Time-use surveys/studies based on researchers' own evaluation of their working time.

471. From the time-use studies, research coefficients are derived for use in calculating full-time equivalents on R&D (FTEs) and R&D labour costs. Other R&D costs should primarily be estimated on the basis of purpose. For example, the acquisition of research equipment and expenditures for a research laboratory should be put under research, while maintenance of teaching facilities should be put under teaching. For expenditures not clearly attributable to either research or teaching, an estimate can be made using the research coefficients as the basis of calculation.

472. For a more detailed discussion of various time-use survey methods and issues related to the compilation of R&D statistics for the higher education sector, see Annex 2.

7.6. Reporting to the OECD or to other international organisations

473. National authorities carry out R&D surveys to obtain data relevant to national concerns in the framework of national institutional arrangements. Discrepancies may exist between national practices and international norms laid down in this or other manuals. 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 the R&D data in international sources will differ from those in national documents. If national authorities are unable to make such adjustments on their own responsibility, they might help the relevant organisations to make informed estimates. Where such adjustments cannot be made, full technical notes should be submitted. Discrepancies are generally of two kinds:

- Explicit differences in approach between national R&D surveys and that recommended in this Manual.
- "Implicit" differences between the standard national economic or educational classifications used in the country's surveys and the international classifications recommended in this Manual.

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

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and Experimental Development

Chapter 8

Government Budget Appropriations or Outlays for R&D by Socio-economic Objectives (GBAORD)

8.1. Introduction

474. 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 that carry out R&D (firms, institutes, universities, etc.) in order to identify the amount effectively spent on R&D over the previous year and the share financed by government. The sum of the R&D spending in a national territory (see Chapter 6, Table 6.1) is known as "government-financed gross domestic expenditure on R&D" (government-financed GERD).

475. Unfortunately, owing to the time required to carry out such surveys and process the results, government-financed GERD data do not become available until between one and two 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.

476. In consequence, a second way of measuring government support for R&D has been developed using data 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 performance-based data but as they are derived from the budget, they can be linked to policy through classification by "objectives" or "goals". The specifications of such budget-based data are described in this chapter. Budget-based data are now officially referred to as "government budget appropriations or outlays for R&D" (GBAORD).

8.2. Relationship with other international standards

477. The definitions discussed in this chapter are, as far as possible, compatible with the methodologies developed by Eurostat and by Nordforsk/Nordic Industrial Fund (Nordforsk, 1983).

8.3. Sources of budgetary data for GBAORD

478. Although details of the budgetary procedure vary from country to country, seven broad stages can be identified:

i) Forecasts (estimates of funding before beginning of budget discussion).

ii) Budget forecasts (preliminary figures as requested by ministries, especially for inter-ministerial discussions).

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iii) Budget proposal (figures presented to the parliament for the coming year).

iv) Initial budget appropriations (figures as voted by the parliament for the coming year, including changes introduced in the parliamentary debate).

v) Final budget appropriations (figures as voted by the parliament for the coming year, including additional votes during the year).

vi) Obligations (money actually committed during the year).

vii) Actual outlays (money paid out during the year).

479. Stages *i)*-*iv)* describe the government's intentions. The data for budgetary year *y* should be available as soon as possible after the end of year *y* – 1. It is suggested that the preliminary GBAORD data should be based on the first budget agreed between the government and the parliament, or stage *iv)*. Some countries might even base their preliminary figures on stage *iii)*. During the budgetary year, supplementary budgets may be voted, including increases, cuts and reallocations of R&D funding. These are reflected in stage *v)*. Data should be available as soon as possible after the end of the budgetary year. It is suggested that the final GBAORD data should be based on final budget appropriations. Some countries may have to base their final figures on stages *vi)* or *vii)*.

8.4. Coverage of R&D

8.4.1. Basic definition

480. The basic definition is the one given in Chapter 2, 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

481.

> The analysis covers natural sciences and engineering (NSE) and social sciences and humanities (SSH) and makes no distinction between the two.

8.4.3. Identifying R&D

482. As far as possible, all guidelines and conventions listed in Chapter 2 for distinguishing R&D from non-R&D activities 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 Chapter 2, Section 2.3.4, and Chapter 6, Section 6.3.2, as well as Annex 10.

483. Countries may need to develop a set of coefficients according to discipline, institution, other criteria or a mixture of these in order to determine the proportion of R&D in non-exclusive budget items like GUF but also for a range of institutions which also perform activities other than R&D. As far as possible, these coefficients should be consistent with what is reported by these institutions as R&D in performer-based surveys.

8.5. Definition of government

484. "Government" should cover central (or federal), provincial (or state) and local government (see Chapter 3, Section 3.5). Public enterprises are excluded, as they are treated as part of the business enterprise sector. For the purposes of GBAORD, however, it is recommended that:

- Central or federal government should always be included.
- Provincial or state government should be included when its contribution is significant.
- 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

485.

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) as well as abroad (including international organisations).

8.6.2. Funding and performer-based reporting

486. R&D expenditures can be reported either by the agency providing the money (funding) or by the agency actually performing the R&D. In general, this Manual recommends the second approach, which is used in the standard tables in OECD surveys. However, the first approach is preferred for the GBAORD series.

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

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8.6.3. Budgetary funds

487.

> GBAORD clearly includes all outlays to be met from taxation or other government revenue within the budget.

488. A problem arises for appropriations for R&D performed by government institutions but expected to be financed from other sources. In some countries, these may be included in the government budget, on the grounds that the agency concerned needs government permission to spend them (gross approach). In others they may be excluded (net approach). When dealing with these government funds, a distinction should be made between:

- Contracts or grants from other sectors for the performance of R&D by government institutions.
- Other government funds, such as the retained receipts of government laboratories, receipts from levies, etc.

Net budgetary appropriations

489.

> Appropriations for which corresponding revenue is expected either from other government sources or other sectors should be excluded from GBAORD according to the net principle.

490. If an R&D institute has a total gross budget of 10 million (including 3 million for externally financed contract research), for example, only 7 million should be counted as net budgetary appropriations for the institute, as the 3 million is on the budget of the funder of the contract research.

Other government funds

491. No specific guidelines can be suggested, but other government funds should generally be included in GBAORD if they are in the budget. This also concerns social security funds, if they are voted on in the parliament during the budgetary process.

8.6.4. Direct and indirect funding

Treatment of public general university funds

492.

> GBAORD includes public general university funds (GUF).

Loans and indirect funding of industrial R&D

493. As far as possible, instructions regarding both loans and indirect funding apply (Chapter 6, Section 6.3.2). 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 inter-ministerial 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. *Types of expenditure*

General coverage

494.

> GBAORD includes both current costs and capital expenditure.

Money carried forward

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

> Multi-annual projects budgeted in only one year or over several should be allocated to the GBAORD of the year(s) in which they are budgeted, not in the years of performance. Multi-annual programmes that are authorised at some stage but budgeted over several years should be allocated to the years in which they are budgeted, not the year of authorisation.

8.6.6. *GBAORD going to R&D abroad*

496. Only contributions to international R&D programmes or organisations solely or mainly concerned with R&D should be included. Contributions of a general nature (like those to the UN, the OECD, the EU, etc.) should be excluded. Appropriations to the following institutions should be included:

- CERN (European Organisation for Nuclear Research).
- ESA (European Space Agency).
- CGIAR (Consultative Group on International Agricultural Research).
- ESRF (European Synchrotron Radiation Facility).

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– EMBO (European Molecular Biology Organisation), including EMBL, EMBC.
– IAEA (International Atomic Energy Agency).
– COST (Co-operation in Scientific and Technical Research, EU programme accessible to non-members).
– EUREKA (European Network for Market-Oriented Industrial R&D).

8.7. Distribution by socio-economic objectives

8.7.1. Criteria for distribution

Purpose or content

497. Two approaches to distribution are possible:

– According to the purpose of the R&D programme or project.
– According to the general content of the R&D programme or project.

498. The difference between the two is illustrated by the following examples:

– A research project on the effects on human body functions of various chemicals which could be used as weapons: the purpose is "defence" but the R&D 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".

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

Primary and secondary objectives

499. Though some government-supported R&D programmes have only one purpose, others may have several. 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-offs to civil aviation. However, in reports to the OECD, R&D should be classified according to its primary objective.

Identifying primary objectives

500. 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 EU reporting using NABS ("Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets") may be of use:

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

8.7.2. Distribution of budgetary items

501. The allocation of R&D appropriations or outlays to socio-economic objectives should be at the level that most accurately reflects the funder's purpose(s). The actual reporting level chosen will depend on practical possibilities. The whole appropriation may be to an R&D-performing or R&D-funding unit. In some cases, information on programme or project level may be obtained.

8.7.3. The distribution

502. The OECD distribution list given in Section 8.7.4 is the EU classification adopted by Eurostat for the analysis and comparison of scientific programmes and budgets at the one-digit level (NABS) (Eurostat, 1986; 1994). The correspondence between the NABS list and the *Frascati Manual* 1993 list (which was almost identical to NABS 1986) is shown in Table 8.1 and should be used for reporting to the OECD, even if member countries use their own classifications or the Nordforsk classification (Table 8.2) in their national GBAORD compilations.

8.7.4. Socio-economic objectives – SEO

1. Exploration and exploitation of the Earth

503. This SEO covers research with objectives related to the exploration of the Earth's crust and mantle, seas, oceans and atmosphere, and research on their exploitation. It also includes climatic and meteorological research, polar exploration (under various SEOs, as appropriate) and hydrology. It does not include:

- Soil improvement and land use (SEO 2).
- Research on pollution (SEO 3).
- Fishing (SEO 6).

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2. *Infrastructure and general planning of land use*

504. This SEO covers research on infrastructure and land development, including research on the construction of buildings. More generally, this SEO covers all research relating to the general planning of land use. This includes research into protection against harmful effects in town and country planning but not research into other types of pollution (SEO 3).

3. *Control and care of the environment*

505. This SEO covers research into the control of pollution, aimed at the identification and analysis of the sources of pollution and their causes, and all pollutants, including their dispersal in the environment and the effects on man, species (fauna, flora, micro-organisms) and the biosphere. Development of monitoring facilities for the measurement of all kinds of pollution is included. The same is valid for the elimination and prevention of all forms of pollution in all types of environment.

4. *Protection and improvement of human health*

506. This SEO covers research aimed at protecting, promoting and restoring human health, broadly interpreted to include health aspects of nutrition and food hygiene. It ranges from preventive medicine, including all aspects of medical and surgical treatment, both for individuals and groups, and the provision of hospital and home care, to social medicine and paediatric and geriatric research.

5. *Production, distribution and rational utilisation of energy*

507. This SEO covers research into the production, storage, transportation, distribution and rational use of all forms of energy. It also includes research on processes designed to increase the efficiency of energy production and distribution, and the study of energy conservation. It does not include:

- Research relating to prospecting (SEO 1).
- Research into vehicle and engine propulsion (SEO 7).

6. *Agricultural production and technology*

508. This SEO covers all research on the promotion of agriculture, forestry, fisheries and foodstuff production. It includes: research on chemical fertilisers, biocides, biological pest control and the mechanisation of agriculture; research on the impact of agricultural and forestry activities on the environment; research in the field of developing food productivity and technology. It does not include:

- Research on the reduction of pollution (SEO 3).

- Research into the development of rural areas, the construction and planning of buildings, the improvement of rural rest and recreation amenities and agricultural water supply (SEO 2).
- Research on energy measures (SEO 5).
- Research for the food industry (SEO 7).

7. Industrial production and technology

509. This SEO covers research on the improvement of industrial production and technology. It includes research on industrial products and their manufacturing processes, except where they form an integral part of the pursuit of other objectives (*e.g.* defence, space, energy, agriculture).

8. Social structures and relationships

510. This SEO covers research on social objectives, as analysed in particular by social and human sciences, which have no obvious connection with other SEOs. This analysis includes quantitative, qualitative, organisational and forecasting aspects of social problems.

9. Exploration and exploitation of space

511. This SEO covers all civil space research and technology. Corresponding research in the defence field is classified in SEO 13. Although civil space research is not in general concerned with particular objectives, it frequently has a specific goal, such as the increase of general knowledge (*e.g.* astronomy), or relates to particular applications (*e.g.* telecommunications satellites).

10. Research financed from general university funds

512. 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 problem 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.

11. Non-oriented research

513. 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.

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12. Other civil research

514. This SEO covers civil research which cannot (yet) be classified to a particular SEO.

13. Defence

515. This SEO covers research (and development) for military purposes. It also includes basic research and nuclear and space research financed by ministries of defence. Civil research financed by ministries of defence, for example in the fields of meteorology, telecommunications and health, should be classified in the relevant SEOs.

Table 8.1. **Standard key between NABS 1992 and previous OECD GBAORD objectives**

NABS categories	Previous OECD categories
1. Exploration and exploitation of the Earth	8. Exploration and exploitation of Earth and atmosphere
2. Infrastructure and general planning of land use	4. Development of the infrastructure
Transport and telecommunication systems (2.4 + 2.5)	*4.1. Transport and telecommunications*
Other infrastructure (2 less 2.4 and 2.5)	*4.2. Urban and rural planning*
3. Control and care of the environment	5. Sub-total environment
	5.1. The prevention of pollution
	5.2. Identification and treatment of pollution
4. Protection and improvement of human health	6. Health (excluding pollution)
5. Production, distribution and rational utilisation of energy	3. Production and rational use of energy
6. Agricultural production and technology	1. Development of agriculture, forestry and fishing
7. Industrial production and technology	2. Promotion of industrial development technology
8. Social structures and relationships	7. Social development and services
9. Exploration and exploitation of space	10. Civil space
10. Research financed from general university funds	*9.2. General university funds*
11. Non-oriented research	*9.1. Advancement of research*
12. Other civil research	
13. Defence	11. Defence
	12. Not specified

Source: OECD.

Table 8.2. **Standard key between NABS 1992 and Nordforsk GBAORD objectives**

NABS categories	Nordforsk categories
1. Exploration and exploitation of the Earth	13. Exploration and exploitation of Earth and atmosphere
2. Infrastructure and general planning of land use	
Transport and telecommunication systems (2.4 + 2.5)	4. Transport and telecommunication
Other infrastructure (2 less 2.4 and 2.5)	5. Living conditions and physical planning
3. Control and care of the environment	6. Combating pollution and physical planning
4. Protection and improvement of human health	7. Preventing and combating disease
5. Production, distribution and rational utilisation of energy	3. Production and distribution of energy
6. Agricultural production and technology	1. Agriculture, forestry, hunting and construction and services
7. Industrial production and technology	2. Mining, trade and industry, building and construction and services
8. Social structures and relationships	10. Education
Education, training, recurrent education and training (8.1)	9. Culture mass media and leisure
Cultural activities (8.2)	11. Working conditions
Improvement of working conditions (8.4)	8. Social conditions
Management of business and institutions, social security systems, political structure of society, social change, social processes and social conflicts (8 less 8.1, 8.2 and 8.4)	12. Economic planning and public administration
9. Exploration and exploitation of space	15. Space research
10. Research financed from general university funds	14. General advancement of knowledge
11. Non-oriented research	14. General advancement of knowledge
12. Other civil research	
13. Defence	16. Defence

Source: OECD.

8.7.5. *Principal areas of difficulty*

Exploration and exploitation of space

516. This is not a purpose in its own right for most OECD countries, as such R&D is usually undertaken for another purpose, such as non-oriented research (astronomy) or for specified applications (*e.g.* telecommunications satellites). Nevertheless, it has been maintained, as it cannot be deleted without seriously affecting the distribution among the objectives to which it would be reallocated for the few OECD countries that have major space programmes.

Mining

517. Both Nordforsk and NABS agree that R&D related to prospecting should be included in "Exploration and exploitation of the Earth". However, they part company on mining. According to NABS, fuel mining and extraction belong in "Production, distribution and rational utilisation of energy", but

mining of non-energy minerals belongs in "Industrial production and technology"; according to the Nordforsk classification, all R&D in favour of the mining industry should be included in "Industrial production and technology". In the 1993 OECD distribution list, the problem of the treatment of mining and prospecting was mentioned, and 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 the Earth" and were invited to mention specifically the treatment of mining R&D.

Construction

518. A further difference occurs with respect to construction. Logically, if one applies main-purpose analysis with the aid of the "derivation" convention (see Section 8.7.1), construction R&D programmes should be broken down according to their main aim (missile silos in "Defence", hospitals in "Protection and improvement of human health", agricultural buildings in "Agricultural production and technology", etc., and R&D in favour of the building industry in "Industrial production and technology"). This would leave a residual problem of where to classify construction R&D not elsewhere classified (n.e.c.). However, NABS has taken the approach that construction R&D should not be considered as derived except for "defence" and "space" programmes. According to NABS, R&D on construction materials belongs in "Industrial production and technology", but general construction R&D in "Infrastructure and general planning of land use"; according to Nordforsk, construction R&D is included in "Industrial production and technology". The treatment of construction R&D also appears to vary in the "independent" countries. Here again, it is important to specify the approach used.

Production, distribution and rational utilisation of energy

519. The series of data collected and issued by the OECD Directorate for Science, Technology and Industry for GBAORD for the objective "Production, distribution and rational utilisation of energy", as defined in Section 8.7.4, should not be confused with the special series collected and issued by the International Energy Agency (IEA) of the OECD, which covers energy research, development and demonstration expenditures, or "RD&D", a somewhat broader concept.

8.8. Main differences between GBAORD and GERD data

520. 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 Chapter 4, Section 4.5. The variations in the sums reported spring from differences in the specifications of the data.

8.8.1. General differences

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

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

523. Differences may also occur because the periods covered are different (calendar or 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

524. 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

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

526. 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.

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Annex 1

Brief History and Origins of the Present Manual

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. In doing so, 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, they encountered theoretical difficulties when starting R&D surveys, and differences in scope, methods and concepts made international comparisons difficult. The need for some attempt at standardisation of the kind undertaken for economic statistics was increasingly felt.

2. The OECD's interest in this question dates back to the Organisation for European Economic Co-operation (OEEC). In 1957, the Committee for Applied Research of the European Productivity Agency of the OEEC 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 conference to study 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; the document 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, France, Germany, the Netherlands and the United Kingdom), the United States and the USSR. While the study (Freeman and Young, 1965) was based on statistics from surveys undertaken before international standards had been decided, it also tested the first draft definitions. It concluded that the available statistical information left a great deal to be desired. The main improvements suggested were:

– A more rigorous conceptual separation of research and experimental development and "related scientific activities".
– Careful studies in the higher education sector to estimate the proportion of time devoted to research by teaching staff and postgraduate (PhD level) students.
– A more detailed breakdown of R&D manpower and expenditure data to permit, *inter alia,* a more exact calculation of research exchange rates.
– A more systematic measurement of expenditure flows between R&D sectors.
– More data on flows of technological payments and on international migration of scientific personnel.

5. In 1964, following the acceptance of the *Frascati Manual* by member countries, the OECD launched the International Statistical Year (ISY) on Research and Experimental Development. Member countries returned data for 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 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. For this revision, particular attention was paid to making the Manual conform, as far as possible, to existing United Nations' international standards such as the

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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 data accuracy and comparability had benefited greatly from this continued experience. National survey techniques had also greatly improved. Second, 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 some subjects and addressed new ones. The scope of the Manual 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 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. For this edition, national experts recommended undertaking only an intermediate revision exercise, with no significant changes to be made in key concepts and classifications. The main stress was to be placed on improving drafting and layout. However, a number of revisions were in fact made to reflect the recommendations of 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 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 in July 1979 for more detailed discussions of a draft prepared by a consultant. 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. The OECD and UNESCO, however, introduced the sector 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. Nonetheless, the problems associated with the collection of accurate data for this sector are significant. They were discussed at the seminar on S&T indicators for this sector held at the OECD in June 1985. The experts felt that, while the Manual gave general guidance, it sometimes gave insufficient practical advice. Therefore, 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 to some final adjustments, it was recommended for derestriction in December 1987 (OECD, 1989b). Certain of its recommendations are also relevant to other sectors of performance. The supplement remains valid, although many of its recommendations were 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 address 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 context of the OECD's Technology-Economy Programme – TEP (*e.g.* internationalisation, software, transfer sciences, etc.). Others concerned 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 proposals for revisions to the *Frascati Manual*. The conference took place in Rome in October 1991. It was hosted by the Italian Ministry for Universities and Scientific Research. For the first time, experts from the eastern European countries attended.

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 light of the recommendations made there, the draft was adopted early in 1993 (OECD, 1994a).

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Sixth edition

14. The rationale for undertaking a fifth revision of the *Frascati Manual* included the need to update various classifications and an increasing need for data on R&D in the services sector, on the globalisation of R&D and on human resources for R&D. Various benchmarking projects have also increased the need for comparable data.

15. NESTI took the decision to revise the *Frascati Manual* at its 1999 meeting, and various topics for revision were discussed at a special meeting in March 2000. At the meeting in 2000, 19 topics were identified for further investigation. For each of these, a small group was established, with a lead country or the OECD Secretariat in charge of the work. The groups' reports were discussed at a meeting hosted by the Italian authorities in Rome in May 2001. At the subsequent NESTI meeting in Rome, decisions were taken on the substantial revisions to be made. Proposals for changes in wording were discussed at a meeting in October 2001. The revised Manual was adopted in late 2002. The sixth edition of the Manual is published in both paper and electronic versions.

Main changes in the sixth edition

16. In this edition of the Manual, an explicit effort has been made to strengthen various methodological recommendations. As in the previous revisions, recommendations in the National Accounts are followed as far as possible and feasible for the purposes of R&D surveys. Some of the recommendations made in this edition result from needs to bring R&D statistics closer to the National Accounts.

17. Chapter 1 contains new sections on R&D in software and services, the SNA, globalisation and co-operation on R&D and topics of special interest: health, biotechnology, information and communication technology (ICT).

18. Chapter 2 has a new section on R&D in software, the social sciences and services. The discussion of services is completely new and includes some examples of R&D. The software and social sciences sections have been partly revised to integrate material previously distributed elsewhere in the chapter.

19. In Chapter 3, the classification by type of institution in the business enterprise sector has been changed. Sector definitions have remained unchanged, but some recommendations are made concerning borderline institutions in the higher education sector.

20. Chapter 4 has received additional information on the concept of basic research. Examples of the type of R&D in the financial services industry have been added. A more explicit recommendation is made on the use of the product field classification in the business enterprise sector, at least for ISIC Rev. 3, Division 73.

21. Chapter 5 has been restructured into two main parts: one on coverage and definition of R&D personnel and one on measurement issues and data collection. The recommendation to collect headcount data in addition to FTEs has been strengthened. Further guidelines for compiling FTEs are given. The recommendation to report data by gender and age (with a proposed classification by age) is new.

22. Chapter 6 offers more detailed recommendations on sources of funds and the breakdown of extramural expenditure. The need for sources of funds to be directly related to expenditure for R&D in a given period has been clarified. Software acquisitions have been added as an investment item in line with the new SNA.

23. Chapter 7 has been quite substantially modified. The main aim is to give more specific recommendations on survey methods in the business enterprise sector and on various estimation issues. An attempt is also made to make the text clearer and more relevant for R&D surveys.

24. Some additional recommendations adopted by Eurostat since the last revision of the Manual have been integrated into Chapter 8, and NABS has been adopted as the basic classification by socio-economic objective. Several other concepts and methodological issues have also been clarified.

25. New annexes have been introduced on R&D in some specific fields of interest, such as ICT, health and biotechnology. One annex contains guidelines on the regionalisation of R&D variables. The decision tree for sectoring has been introduced in Chapter 3 and there are examples of software R&D in Chapter 2. Most annexes in the previous version of the Manual have been updated and further developed.

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27. 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 générale à la recherche scientifique et technique (DGRST).

28. 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) made major contributions to the second edition.

29. 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), as well as to Mrs. K. Arnow (National Institutes of Health, United States), Chairman of the 1973 meeting of experts, and 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).

30. 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.

31. 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. M. Åkerblom (Central Statistical Office of Finland). The 1985 Conference on S&T Indicators for the Higher Education Sector was chaired by Mr. T. Berglund (Statistics Sweden).

32. The fifth edition was largely prepared by Ms. A. FitzGerald (EOLAS) 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 la Technologie, France), Prof. F. Niwa (National Institute of Science and Technology Policy, Japan), Dr. E. Rost (Bundesministerium für Forschung und Technologie, Germany), Mr. P. Turnbull (Central Statistical Office, United Kingdom), and Mrs. K. Wille-Maus (Norges allmennvitenskaplige forskningråd, Norway). Mr. G. Sirilli (Consiglio nazionale delle ricerche, Italy) was Chairman of the Group of National Experts on Science and Technology Indicators during this period and also organised the Rome Conference.

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Annex 2

Obtaining Data on R&D in the Higher Education Sector

Introduction

1. Obtaining data on R&D in the higher education sector presents special problems, which this annex attempts to explain in some detail. The discussion mainly draws on methodological work from the middle of the 1980s which led to a special supplement to the fourth edition of the *Frascati Manual* (*R&D Statistics and Output Measurement in the Higher Education Sector*, OECD, 1989b).

2. Time-use surveys or, if these are not possible, other methods of estimating shares of R&D (R&D coefficients) in total activities in the higher education sector are a necessary basis for statistics. They are described below.

3. The use of coefficients based on these methods to estimate R&D expenditure and personnel based on information on total activities in universities is discussed next, along with some other measurement issues.

Time-use surveys and other methods of estimating shares of R&D in total activities in the higher education sector

General

4. Member countries use various kinds of time-use surveys or other methods to establish a basis for identifying the share of R&D in total university activities (*i.e.* for calculating R&D coefficients). R&D coefficients are fractions or proportions of the statistics covering the higher education sector's total resources. They serve as a tool for calculating/estimating the shares of personnel and expenditure data attributable to R&D.

5. Caution must be exercised when using time-use 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 may therefore be difficult for respondents to identify unambiguously that part of their time (working or otherwise) that is devoted exclusively to R&D. First, several survey methods that may help to minimise some of the problems raised by such estimations are outlined. Then, other ways of establishing R&D coefficients are described.

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Methods for time-use surveys

6. 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.

7. Two methods for time-use studies can be distinguished:

– Those based on researchers' own evaluation of the distribution of their working time.
– 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

8. 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 "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

9. In this type of survey, questionnaires can be sent to all individual staff members or only to a representative sample. 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 according to various categories of work-related activities. In recent surveys undertaken by member countries, the number of activities has varied from the two categories "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.

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

– Undergraduate time.
– Postgraduate course-work time.
– Postgraduate research time.

– Personal research time.
– Administration.
– Unallocable internal time.
– External professional time.

11. 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

12. Questionnaires may be sent to all staff or to a representative sample of staff. The questionnaire is in the form of a diary in which the respondents mark, according to the list presented, the activity that best represents the use of each hour or half-hour of each day.

13. 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

14. 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 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.

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

– Defining the survey population.
– Drawing a sample from the population if a full survey is not made.
– Assigning one (or several) survey week(s) to each person included in the survey.

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

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17. While countries offer their respondents different options, 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).

18. General information of the kind referred to in paragraph 11 may also be collected as part of the survey.

19. All survey methods based on responses from individual staff members are comparatively expensive, and surveys of this kind are often undertaken at rather long intervals.

Methods based on estimates by heads of university institutes

20. 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 staff members. The questionnaires addressed to the institutes often contain questions on certain types of expenditures and other total resources available and on the estimated share of R&D in these resources.

21. Several countries have found it convenient to include questions on time use at a more aggregate level in a questionnaire addressed to the university institutes, rather than make time-use studies of individual researchers. The method is 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 needed to supply sufficiently accurate estimates. However, consultations with individual staff members are also often necessary to prepare the best possible estimates.

Treatment of borderline R&D activities

22. Respondents to time-use 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 recommended guidelines given in Chapter 2 of the Manual should be followed.

Response rates

23. Methods based on estimates obtained from the university institutes place virtually no burden on the individual researcher (or other categories of respondents) but a modest one on the university institute itself. The diary

exercise makes rather heavy demands on the academic staff but none on the university institute. The burden on the individual respondent is smaller in surveys when he/she only has to indicate the distribution of time over the whole year.

24. Response rates are generally comparatively 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 for surveys addressed to the university institutes are often close to 100%.

Methods based on other sources

25. While surveys are the most systematic and accurate way of collecting information on time use, 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 heavy demands on the resources of producers of statistics. Large countries, in particular, may find it difficult to carry out detailed time-use surveys, given their many higher education institutions and researchers.

26. In addition, the formulation of education and research policy in some countries may not require information at the level of detail available from time-use surveys.

27. Therefore, alternative data collection methods are needed to accommodate resource constraints and meet information needs.

28. Non-survey-based R&D coefficients are derived in a number of ways, ranging from informed guesses to sophisticated models. Whatever the method used, they may be an alternative to the more costly large-scale surveys of researchers and/or higher education institutions described above.

29. The accuracy of the coefficients depends on the quality of the judgement used in calculating them; the accuracy of the resulting estimates depends on the quality of the data to which they are applied and the detail available for both data and coefficients.

30. 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.

31. A variety of relevant information will normally be available. 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; other countries with similar education systems may have derived relevant coefficients.

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32. Coefficients derived for calculating overall R&D activity can sometimes be validated by comparison with the results of time-use surveys of other countries with similar higher education structures.

33. The use of models to derive research coefficients is a relatively new activity resulting from the increased computerisation of information on the higher education sector. Different models are developed by applying different coefficients to weighted or unweighted higher education data.

Use of coefficients to estimate R&D expenditure and R&D personnel

34. The aim of the time-use studies and other methods described above is to obtain a basis for distributing total university resources among research, teaching and other activities (including administration). These studies are therefore only the first step in establishing R&D statistics. The next step is to derive the universities' total resources; nowadays, this is often done on the basis of various administrative sources. The final step is to use R&D coefficients to estimate the shares of R&D in total personnel and expenditure resources and to break these down into more detailed categories.

35. Thus, to establish R&D statistics for the higher education sector, it is necessary to estimate:

- The sector's total available resources, both personnel and financial.
- The corresponding R&D expenditure by type of cost.
- The corresponding R&D expenditure by source of funds.

Total resources

36. Calculations of R&D resources are based on data on total available resources by applying the R&D coefficients derived from time-use studies or other sources. Total data include general university funds (GUF) and a variety of external sources and may be derived from:

- University accounts.
- Administrative records.
- Additional breakdowns made by universities' central administrations on the basis of general accounts and registers.
- Surveys addressed to university institutes.
- Other statistical systems (statistics on public servants, general wage statistics).

37. In many cases, total data are derived from various administrative sources. 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 their level, such centres usually have a vast quantity of information as a result of their administrative activities. The information held by central administrations, while not necessarily specifically related to R&D, is a useful source of overall data from which R&D data can be extracted using either estimated R&D coefficients or R&D coefficients drawn from time-use surveys. R&D information is sometimes available directly from central administrations. It is not completely certain, however, that this information conforms to the definitions of the *Frascati Manual*, and this limits the possibilities for using it directly.

38. 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 with individual researchers and other staff.

39. To identify the R&D in individual disciplines/fields of science may require information at the researcher level at large institutions carrying out research in many disciplines. Information at the level of the institution is sufficient if its R&D is confined to a single field of science.

40. 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.
- The data are easily accessible.
- The data form a useful input to the iterative process of model building.
- Use of data from secondary sources lowers the response burden on survey respondents.

41. There are also limitations to such data, some of which, if not taken into account, could lead to inaccuracies in the final R&D statistics:

- Incomplete specific data on R&D activities in terms of coverage of costs, sources of funds and personnel.
- Problems of comparability between different universities.
- Data usually available at a very aggregate level.
- R&D component of general higher education statistics not separately identified.

42. Countries have 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 in terms of the level of detail available may also cause variations in countries' ability to supply sufficiently detailed data to the OECD.

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43. The results of time-use studies are used to derive countries' full-time equivalents for R&D from data on total full-time equivalents, which in theory can 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 positions on R&D held by one person in one year, with salary as the criterion.

44. The first corresponds broadly to the definition of FTE given in Chapter 5, Section 5.3.3. In practice, the second is probably more feasible for data collection. As in most cases it is not possible to have information on persons who have several positions, one person may conceivably count for more than one full-time equivalent.

Type of costs

45. According to Chapter 6, Sections 6.2.2 and 6.2.3 of the 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 expenditures and land/buildings expenditures, on the other.

46. If no data are directly available for each of these R&D components for a certain unit, an estimate must be made on the basis of information on total expenditure.

47. ***Labour costs*** (*i.e.* salaries and related social costs) usually represent around half 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.

48. R&D coefficients derived from time-use studies are used directly at an appropriate level (individual, institute, department, university) to estimate the share of R&D in total labour costs; if necessary, adjustments should be made to take account of the costs of various associated social security or retirement schemes.

49. R&D 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 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 positions of the institutions in terms of R&D, for example, whether they are small liberal arts colleges, technical universities or major teaching and research universities.

50. 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.

51. 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. If intended use is not feasible as a criterion, the same distribution coefficients as for labour costs may be used. The shares of R&D may also be determined on the basis of conventions or the opinion of institutes.

52. Information on total investment in ***instruments and equipment*** is usually available at the level of the institution. In many surveys, the shares of R&D are estimated by the institutes according to the intended use of the equipment. R&D coefficients are probably of less use for estimating the shares of R&D in instruments and equipment than for estimating various types of current expenditure. The share of R&D in investments in instruments and equipment may also be based on conventions or on opinion, as for certain types of other current costs discussed above.

53. Information on total investments in ***land and buildings*** is usually available only at the level of the institute or the university. R&D coefficients are seldom used to estimate the shares of R&D in these investments. Here again, the R&D data are often estimated on the basis of the intended use of the facilities.

54. From the above, it may be concluded that R&D coefficients offer the only way to estimate the share of R&D in labour costs, play a significant role in estimating shares of R&D in other current costs, but are of minor importance in calculating shares of R&D in investments in instruments and equipment or in land and buildings.

Sources of funds

General

55. Funds for R&D in the higher education sector come from many different sources. The main source in most member countries is traditionally

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a proportion of the publicly funded block grant known as public general university funds (GUF) which higher education institutions receive to support all activities. The different activities of the 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. 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.).

56. Time-use studies and other methods used to identify the R&D share of universities' total activities usually only concern GUF, which account for the major part of higher education R&D (HERD). External funds are often for R&D but may be used for other purposes as well. For each project funded by external sources, therefore, the survey respondent often has to evaluate whether or not it funds research, if the information is not available from central administration registers.

57. Some 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 to 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) or should, at least, be double-checked against those accounts. Funder-based data usually give only expenditures, and the problem of acquiring the corresponding R&D personnel data is therefore a tricky one.

58. 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 the share of total expenditure from non-GUF resources will ultimately increase. 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 money, thus creating additional measuring difficulties.

59. 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. 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. Theoretically, a part of GUF spent on administration and other extra costs for externally financed research should be counted as research in addition to the R&D estimated on the basis of the coefficients used above.

60. Problems of accurate coverage of R&D funding sources are common to all member countries, but the main area of lack of international comparability is that of distinguishing between GUF and other sources of public R&D income.

Separation of general university funds from other funding sources

61. Some of the problems of identifying what part of these grants is attributable to R&D have already been discussed above. 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 GUF differently.

62. Options for classifying such public funds at the sectoral level are:

– General university funds.
– Sector's own funds.
– Direct government funds.

• General university funds

63. A separate category of GUF has been defined for the higher education sector to take account of the special 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 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.

64. GUF 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

65. "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

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public general university funds; therefore, the sums concerned should be credited to higher education as a source of funds".

66. 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.

67. Other monies produced by the sector should be considered as "own funds".

68. 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

69. In addition to GUF, the government sector provides money for higher education R&D in the form of earmarked research contracts or research grants. This source of research income is more readily identified and does not, in general, pose major problems for the producers of statistics, as they readily classify it as a direct source of government funds.

70. 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 Chapter 6, Section 6.2.2 and 6.3.3 of the Manual).

Recommendations

71. 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 institutions of higher education.

72. The main problem for international comparability occurs when data for 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.

73. Therefore, 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".

74. When reporting data to the OECD, member countries are encouraged to indicate on which sets of expenditure and personnel data coefficients are applied to calculate R&D data, together with the actual coefficients used.

Annex 3

The Treatment of R&D in the United Nations System of National Accounts

Introduction

1. The aim of this annex is to explain the treatment of R&D in the System of National Accounts (SNA) to experts on S&T indicators who are unfamiliar with SNA concepts and terminology. It deals with two 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-classifications.
  ❖ Measuring R&D spending in the SNA.

2. References are generally to the latest 1993 version 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 significant changes in treatment have occurred between the two versions.

History of the 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 OECD.

4. The *Frascati Manual* system of R&D accounts was established in 1961, largely on the basis of work by the United States dating back to the formative years of the SNA. The 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 of as part of the SNA.

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5. Three main areas of difference have continued to exist between the two systems:

– Economic sectors and associated classifications.
– Terminology, *i.e.* use of the same term for different concepts or different terms for the same concept.
– Basic differences in accounting methods.

6. These differences between the SNA and the *Frascati Manual* have been systematically reviewed on three occasions: in about 1970 and again in 1990, when the revision of the two systems coincided, and also in the mid-1970s, when the concept of satellite accounts for R&D was introduced.

7. On the first occasion, the revision of the SNA was completed in 1968, prior to the main discussion of the revision of the *Frascati Manual*. 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. As a result, sector definitions and terminology were somewhat changed but differences in accounting methods remained.

8. The relationship between the *Frascati Manual* and the SNA was discussed by various international 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. The need for satellite accounts was also recognised in the SNA 1993, which contains a chapter discussing the compilation of satellite accounts in areas of particular interest, such as R&D.

9. R&D was specifically discussed during the preparation of the SNA 1993 in the context of the possible treatment of "intangible investment" rather than as intermediate consumption as in the SNA 1968. It was finally decided not to treat R&D as an investment activity owing to difficulties for implementing such a revision in practice, but the discussions did lead to the inclusion of more specific guidelines for R&D than in the preceding version.

10. 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 differences in accounting practice remain.

Similarities and differences in the treatment of R&D in the *Frascati Manual* and the System of National Accounts

General inclusion of R&D in the SNA

11. 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 enters 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. Notably, production of goods by households for own consumption is included in GDP but not services, except for services of owner-occupied dwellings. 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. However, by convention, the SNA does not include unpaid services rendered by household members such as home decorating, cleaning, laundry, etc.

12. 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.

13. 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 are needed.

Sectors and their sub-classifications

Sectors

14. Both the SNA and the *Frascati Manual* break down institutional units into a number of sectors. The broad correspondence is shown in Table 1.

15. Both systems use national territory on the one hand and "rest of the world" (SNA) or "abroad" (*Frascati Manual*), on the other.

16. 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

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Table 1. **Summary of sectors in the SNA and in the *Frascati Manual***

SNA	*Frascati Manual*
Non-financial corporations Financial corporations	Business enterprise sector
General government	Government sector
Non-profit institutions serving households Households	Private non-profit sector
(Included in other SNA sectors)	Higher education sector
Rest of the world	Abroad

Source: OECD.

Table 2. **Sectors and producers in the SNA**

Sectors	Market producers	Non-market producers
Non-financial corporate sector	Non-financial corporations or quasi-corporations Non-profit institutions (NPIs) engaging in market production[1] NPIs serving business	
Financial corporate sector	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.
Non-profit institutions serving households (NPISH)		NPISH
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

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.

Source: OECD.

approaches (see Table 2), and the treatment of R&D in the *Frascati Manual*, especially performance, is closer to the second of these.

17. 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 Manual* higher education sector may belong almost anywhere in the SNA. Table 3 shows where they might be classified.

Table 3. **The SNA sectoring of units definitely and possibly included in the *Frascati Manual* 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[1] at an economically significant price NPIs PHES at an economically significant price NPIs serving enterprises PHES[1]	Government units PHES[1] Non-profit institutions (NPIs) controlled and mainly financed by government PHES[1] NPISHs PHES'
University hospitals providing healthcare services (PHSS) controlled by administered by or associated with higher education (CAAHE) and/or with a significant teaching commitment	Non-financial corporations (or quasi-corporations) PHSS[2] CAAHE[3] NPIs PHSS[2] at an economically significant price CAAHE[3]	Government units PHSS[2] CAAHE[3] NPIs controlled and mainly financed by government PHSS[2] and CAAHE[3] NPIs serving households PHSS[2]
Research institutes or experimental stations CAAHE[3] ("borderline" research institutions)	Non-financial corporations (or quasi-corporations) selling R&D but CAAHE[3] NPIs selling R&D at an economically significant price CAAHE[3] NPIs serving enterprises CAAHE[3]	Government units CAAHE[3] NPIs controlled and mainly financed by government but associated with HE NPISHs which are CAAHE[3]
Postgraduate students supported by grants		Households benefiting from subsidies

1. Providing higher education services.
2. Providing healthcare services.
3. Controlled, administrated by or associated with higher education establishments.
Source: OECD.

18. If the *Frascati Manual* system had no higher education sector, there would be an almost complete match between the SNA sector classification and the R&D sectors, as has been intended since the 1970 version of the *Frascati Manual* (OECD, 1970). For example, distribution of private non-profit (PNP) institutions among sectors in the *Frascati Manual* is clearly based on the SNA; and the section of Chapter 4 of the SNA 1993 devoted to this topic usefully supplements the discussion in Chapter 3 of this Manual.

19. 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 institutions are often attributed to sectors by two different agencies which may interpret the same instruction differently.

Classifications

20. The SNA does not always recommend the same classification as the *Frascati Manual* for what the latter refers to as "sector sub-classifications". Both use ISIC, but the breakdown of R&D among industries may differ because of

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variation in the unit classified and the classification criteria. 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 the NABS 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 government and NPISHs are subdivided by main types of unit (see Table 4), whereas a field of science classification is recommended in this Manual.

Table 4. **SNA classifications of government outlays and final consumption expenditure of NPI 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	
B. Final consumption expenditure of 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	

1. 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 National Accounts, Detailed Tables, Vol. II.

Measuring R&D spending in the SNA

21. The SNA and the *Frascati Manual* also differ in the way they account for R&D, as they rely on different conceptual frameworks. Moreover, as the *Frascati Manual* also serves as a manual for the collection of data, it is more directly influenced by feasibility concerns. The following description of the treatment of R&D in the various accounts is largely based on quotations from the SNA 1993 (CEC *et al.,* 1994).

Identifying and valuing R&D in the production account

22. "Research and development by a market producer 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, paragraph 6.142.)

23. The definition of R&D by the SNA as an activity aimed at developing new products and processes differs somewhat from the *Frascati Manual* definition. It characterises R&D only by its purpose, which is innovation, whereas the major characteristic of R&D according to the *Frascati Manual* is the production of new knowledge. While the two approaches are quite similar, they do not entirely overlap. The SNA definition is closer to the *Oslo Manual* definition of innovative activities, which encompasses activities such as training and tooling up related to innovation, which are not R&D. In addition, the SNA definition may lead the user to overlook basic research performed by business, for which innovation is only a very indirect goal.

24. In terms of accounting principles, the SNA recommends measuring gross output of R&D for market producers (firms that sell R&D) and total cost for other producers (own account R&D). This is essentially different from the *Frascati Manual* concept, which recommends measuring expenditure on R&D. The major difference between total cost (SNA) and expenditure (*Frascati Manual*) is in the treatment of fixed capital: whereas the cost approach counts consumption of existing fixed capital, the expenditure approach counts the expenditure (purchase) of new fixed capital. The *Frascati Manual* applies the same treatment to intermediate goods, which are measured by purchases instead of consumption (under the heading "Other current costs"). For gross output, recommended by the SNA for market producers, it equals total cost plus an operating surplus and adjustment for net taxes on production (payments less subsidies) (Table 5).

Table 5. **Gross output and total intramural R&D**

	SNA cost components	*Frascati Manual* cost components
Similar coverage	Compensation of employees	= Labour costs
	Intermediate consumption[1]	= Other current costs
Different treatment	Taxes on production paid, less subsidies received	Subsidies included in above; taxes on production excluded
	Consumption of fixed capital	Gross capital expenditure
	Operating surplus	Not included

1. Intermediate consumption also includes the cost of any bought-in R&D.
Source: OECD.

25. There are other, smaller differences in the treatment of fixed capital in the SNA and the *Frascati Manual*: *i)* in the SNA, gross fixed capital formation (GFCF) on buildings excludes the value of the land on which they are situated, whereas the *Frascati Manual* includes land and buildings as capital expenditures, with no separate identification; *ii)* disposal, especially sales, of fixed capital, is not considered in the *Frascati Manual* and might lead to double counting, as part of the capital expenditure of one entity would correspond to a reduction in the capital stock of another. This is hard to measure, and it is likely to be small in practice.

R&D as intermediate consumption

26. The SNA 1993 gives the following instruction for the R&D of market producers (the *Frascati Manual* 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, paragraphs 6.163-6.165.)

27. The consideration of "software and large databases" as an investment good in the SNA 93 raises particular issues for R&D. The above text mentions that "all the outputs produced by research and development (…) are treated as being consumed as intermediate inputs". This is in fact contradicted by the capitalisation of own account software production in national accounts, as a substantial part of own account software consists of R&D (R&D performed in software companies and R&D on software performed in other companies). Available figures show that a substantial and increasing share of R&D is in programming software.

R&D in the expenditure account

28. The Manual distinguishes between performers and funders of R&D. The SNA distinguishes between the producers and the users of R&D services (expenditure account). The unit which "performs" the R&D also "produces" it. The "funder" unit is usually, but not always, the SNA "user".

29. 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. When a funding entity other than the government is not the performer (extramural R&D), the *Frascati Manual* makes no specific recommendation regarding the classification of such transfers of funds, whereas the SNA proposes various categories (income from sales, subsidies, current transfers and capital transfers), with the idea of gaining a better understanding of the economic mechanisms at work.

30. While all R&D has a user, only part of R&D appears *per se* in the final expenditure account. In the expenditure account, the vast majority of R&D is treated as being used up in the production process and hence already incorporated in goods and services. These are either carried forward to a subsequent period (capital formation) or used without further transformation to satisfy the 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 non-profit institutions serving households (NPSH) 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 NPISH.

The need for satellite accounts

31. Satellite accounts are an evolving mechanism for presenting particular topics as annexes to main national accounts.

32. The characteristics of satellite accounts can be described as follows:

"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, such as the number of persons employed in the field or the stocks of equipment. Physical data may also relate to beneficiaries, such as the number of persons 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)

Annex 4

R&D Related to Health, Information and Communication Technology (ICT) and Biotechnology

1. This annex presents three areas of R&D for which it is not possible to derive information through direct use of the classifications recommended elsewhere in the Manual. All three are of high policy relevance, and there is a clear need for data on R&D related to these fields. To obtain the data, it is often necessary to combine R&D data from various classifications or even to develop new survey questions.

Deriving data on health-related R&D from regular R&D statistics

Introduction

2. Recently, demand for data on health-related R&D has been particularly strong. As international comparisons are often requested, this section provides general guidance on how to compile data on health-related R&D from existing surveys and more general sources. In this context, "health-related" refers not only to biomedical research but also to a wider category including relevant R&D in the social sciences, notably on health services.

3. The aim of the exercise is to establish gross expenditure on R&D (GERD) for health, broken down by sector of performance and source of funds. There should be matching R&D personnel data by sector of employment. Guidance is also given on GBAORD, as those who seek health R&D series often use this source. Further information on international comparisons and examples of national efforts can be found in *Measuring Expenditure on Health-related R&D* (OECD, 2001).

4. In principle, similar compilations could be made for other fields such as agriculture.

General approach

5. There is demand for a data set covering all health-related R&D, but regular R&D surveys normally break down expenditure and personnel according to the primary aim/field/industrial activity of the unit concerned.

Furthermore, classifications may not be detailed enough to identify small categories of health-related units.

6. The process thus has to be to break out the data for categories that are clearly health-related (core elements) and then to use various adjustment and estimation methods to refine these data and to add in the health-related component of other categories. This generally means starting from institutional classes, for which a full set of data is available (sources of funds, personnel, etc.) and then using functional data to make the necessary adjustments. The process will vary among sectors and also among countries because different institutional and functional breakdowns may be used and also because data providers have special knowledge of national specificities in the organisation of health R&D.

7. In principle, the preferred source should be GERD data reported by performers. In practice, several sources may be used to compile health-related R&D spending. In some countries, especially those where the collection of GBAORD data is associated with the general R&D survey, these budget series (particularly those for which data on first destination are compiled) may identify central government funds for R&D on health which are not immediately visible in the survey of performers by socio-economic objective (protection and improvement of human health) or field of science (medical sciences). Similarly, useful additional information and data may be gleaned from the reports of medical charities, health research councils and funds and even from the reports of pharmaceutical industry associations. Building up a reasonable picture of GERD for health may involve mixing and matching data from a variety of sources.

Identifying health-related R&D in GBAORD

8. Those seeking data on government funding of health-related R&D are often drawn to GBAORD because there is a specific category of socio-economic objective for this topic. However, they may not realise that this category only covers R&D whose primary purpose is the protection and improvement of human health (NABS 4) and that funds for relevant activities may be included in other categories.

9. The most important additional category is "General university funds and non-oriented research". The core coverage recommended for health in GBAORD is therefore:

– Health.
– General university funds and non-oriented research: medical sciences.

10. Health-related research funded for other objectives, for example military medical research, health and safety research at nuclear establishments or support for relevant enterprise R&D as part of industrial policy should also be included when available.

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11. Countries that collect and report two-digit NABS data to Eurostat may include two sub-categories of aid to industry (Table 1):

- Manufacture of pharmaceutical products (NABS 0742).
- Manufacture of medical and surgical equipment and orthopaedic appliances (NABS 0791).

Table 1. **Identifying health-related R&D in GBAORD**

One-digit NABS	For countries using detailed NABS
Protection and improvement of human health	All
Non-oriented research	Medical sciences
General university funds	Medical sciences
Industrial production and technology	Support for the pharmaceutical industry Support for the medical instrument industry

Source: OECD.

12. Perhaps the most important gap is the health-related R&D included in general university funds or non-oriented research elsewhere than in the medical sciences, especially in the biological sciences. Where any R&D funded by health research councils or similar research programmes is included in non-oriented research, it may be possible to identify the health-related element of biology to be included.

13. Health-related R&D data derived from GBAORD give an incomplete picture of total public funding of such R&D, as GBAORD only covers the central government budget. Some health R&D may be funded by extra-budgetary public sources such as social security funds. Provincial and local governments may fund health R&D, particularly when they are responsible for higher education or for general hospitals. Where these sums are significant, an effort should be made to add them to the data derived from GBAORD in order to obtain a figure for total government funding of health-related R&D.

Building GERD for health

The business enterprise sector

14. There are two manufacturing ISIC categories mainly relevant to health:

- 2423 Pharmaceuticals.
- 3311 Medical instruments.

15. Taken together, these can be considered the core components of health-related R&D (Table 2), although medical instruments may require special extraction in the first instance. A full set of data should be available for

Table 2. **Health-related R&D from performer-reported data: business enterprise sector**

Category	Source
Pharmaceutical industry (ISIC Rev. 3, 2423)	Possible to derive from R&D surveys either as industry group or product field
Medical instruments (ISIC Rev. 3, 3311)	Requires special extraction from R&D surveys either as industry group or product field
R&D on pharmaceuticals performed in other industries	May be possible to derive from product field classification, other functional classification or extramural R&D expenditure of the pharmaceutical industry
R&D on medical instruments performed in other industries	May be possible to derive from product field classification, other functional classification or extramural R&D expenditure of medical instruments
Private health services (ISIC Rev. 3, 851)	Extract if included in the scope of R&D surveys
R&D in other industries done for private health services	May be possible to distinguish if health services are a separate product group or from extramural R&D expenditures of private health services

Source: OECD.

each, thus making it possible to compile data on total intramural R&D by source of funds and R&D personnel by occupation/qualification.

16. Health-related R&D also takes place in the health services industry itself.

– 851 Human health activities, notably:
  ❖ 8511 Hospitals.
  ❖ 8519 (part) Testing laboratories, medical, analytical or diagnostic.

17. These may not be included in the R&D survey at all, especially if the health services are mainly public. If they are included, they will probably require special extraction. The extraction should also cover sources of funds and R&D personnel.

18. Health-related R&D may be carried out in the services for the pharmaceutical, medical instruments and health services industries, notably in the R&D services industry and the IT services industry (and indeed in medical analytical and testing laboratories). The best way of identifying the health R&D component is via cross-tabulation of industries and product fields. This should reveal in particular how much pharmaceutical R&D is being done outside the industry itself and also whether firms classified in the pharmaceutical industry are engaged in R&D on other products. Estimates must be made of the sources of funds of the additional health-related R&D in the services and of the R&D personnel concerned. Where product field data are not available, other series might be examined for additional information on health-related R&D, including R&D by field of science (medical sciences),

R&D by socio-economic objective (health as SEO) or extramural expenditure by the pharmaceutical and medical instrument industries. Care should be taken to ensure that relevant R&D by biotechnology companies is included.

R&D in the non-market sectors (government, private non-profit, higher education)

19. Some countries undertake a standard survey of all R&D institutes, and these are subsequently divided among sectors of performance of the *Frascati Manual*. Others undertake separate surveys for each sector.

- General approach

20. This Manual proposes collecting data by field of science, such as medical sciences, as both an institutional and a functional classification, and by socio-economic objective, with health as a functional classification.

21. Experience shows that neither health as a socio-economic objective nor the medical sciences as a field of science is enough to describe adequately the field of health-related R&D. A combination is needed, as shown in Table 3.

Table 3. **Identifying health-related R&D by field of science and socio-economic objective**

Socio-economic objective	Fields of science and technology			
	Medical/health	Biological	Other natural sciences and engineering	Social sciences and humanities
Protection and improvement of human health	**X**	**X**	**X**	**X**
Non-oriented research	X	?		
All other	X			

X = to be included.
Source: OECD.

22. The core consists of all R&D for health in the medical sciences and/or for health as an SEO (shown bolded in Table 3). Obtaining this depends on how the two classifications are applied in each country. In theory, where the field of science classification matches that in Table 3, there should be little R&D for health as an SEO which is not included under medical sciences. However, the classification is not entirely clear for genetics, hence the column for the biological sciences and the potential problem of identifying how much biological R&D undertaken as non-oriented research is health-related.

23. Deriving the sources of funds and calculating the R&D personnel data for such a combination may involve some estimations.

24. This functional or semi-functional approach can be supplemented or replaced by data sets based on national institutional classifications, local knowledge about the national health R&D system and additional material from funding sources. For example, a list of the core national performers of health-related R&D in the government and private non-profit (PNP) sectors can be established, and special extractions from their responses can be made.

- Higher education

25. Where teaching establishments receive a detailed R&D questionnaire, health-related R&D data can be compiled in the same way as R&D for other surveyed units. However, they often do not receive such a questionnaire and the data are derived from responses to a simpler questionnaire or are compiled from administrative sources. Usually, but not always, there is a breakdown by major field of science.

26. The core category is thus medical sciences as an institutional category for which intramural expenditure, sources of funds and R&D personnel should be available. However, if the classification unit is large, *e.g.* the medical faculty, health-related R&D in other faculties, such as biological sciences and social sciences, may be left out. The R&D funds are usually divided into direct funds and GUF, and details may be available on the institutional sources of the direct funds. Where direct research funds flow to non-medical faculties from a health research council, a programme of a health department, a medical charity or the pharmaceutical industry, these can be added.

- Private non-profit sector

27. The recommended institutional breakdown is by field of science, which is used in most countries that separate out the PNP sector. R&D expenditure in the medical sciences is thus the core category, and sources of funds and personnel data should also be available. In this sector, expenditure on the medical sciences is generally higher than expenditure on health as an SEO. There is not likely to be additional health-related R&D spending unless units classified in the social sciences carry out health services R&D or general life science units classified in the natural sciences carry out medical research.

28. Where there is no classification by field of science, the units concerned may have to be selected individually on the basis of local knowledge. This sector may include a significant number of research units belonging to medical charities and should not be ignored merely because it is small overall.

- The government sector

29. The Manual does not recommend an institutional classification for this sector and the breakdown used is often based on national administrative

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categories. For this reason and because of international differences in the way health-related R&D is organised in the government sector, it is particularly difficult to propose standard methods of identifying health-related R&D in this sector.

30. Where data are collected on both field of science and SEOs, R&D spending on health as an SEO is often higher than spending for the medical sciences in this sector, particularly where the medical sciences are an institutional category and SEO is a functional category. For this sector, the core should be all institutional units whose principal R&D activity is health as an SEO and/or the medical sciences. Any R&D in the field and/or relevant SEO in other institutions should be added. The additional information may be derived from crossing institutional and functional classifications or from other sources, for example programme descriptions in R&D budgets, annual reports of institutions, etc.

- Special institutional problems

31. Some countries have multidisciplinary research councils with R&D-performing units in the government or higher education sectors which are classified under non-oriented research as an SEO and which do not break down their expenditures on life sciences as recommended in the Manual. It is difficult to identify the health-related component of these funds, as they are often earmarked for basic research.

32. When obtaining funds for health-related R&D, it is useful to look at how hospitals are treated in the national R&D survey in terms of coverage and classification.

Aggregating GERD on health

33. In principle, GERD is obtained by adding health-related R&D in each of the four sectors of performance. Sources of funds are found by aggregating what each sector receives from business enterprise, government, private non-profit (PNP), higher education and abroad for carrying out health-related R&D. At this stage, it may be useful to check figures against any funder-reported series and perhaps calculate a health GNERD (gross national expenditure on R&D). Differences are to be expected, but if there are major discrepancies, for example if medical charities report much higher research funding than appears in GERD on health as funded by the PNP sector, further enquiries may be worthwhile.

ICT-related R&D

34. In recent years, there has been quite intensive work at the OECD by the Working Party on Indicators of the Information Society (WPIIS) to develop statistics and indicators for the ICT sector or, more broadly, the information

economy sector. The aim is to develop statistics and indicators that result in a better understanding of the information economy/information society.

35. A fundamental milestone was the reaching of an agreement on a definition of the ICT sector based on ISIC Rev. 3. This definition identifies key industries whose main activity is producing or distributing ICT products or services and which constitute an approximation of the "ICT-producing sector". It needs to be complemented by a product-based definition.

36. The list of industries belonging to the ICT sector in ISIC Rev. 3 is as follows:

Manufacturing

- 3000 Office, accounting and computing machinery
- 3130 Insulated wire and cable
- 3210 Electronic valves and tubes and other electronic components
- 3220 Television and radio transmitters and apparatus for line telephony and line telegraphy
- 3230 Television and radio receivers, sound and video recording or reproducing apparatus, and associated goods
- 3312 Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process equipment
- 3313 Industrial process control equipment

Services

- 5150 Wholesale of machinery, equipment and supplies (in ISIC Rev. 3.1 limited to class 5151 "Wholesale of computers, computer peripheral equipment and software" and class 5152 "Wholesale of electronic and telecommunication parts and equipment")
- 6420 Telecommunications
- 7123 Renting of office machinery and equipment (including computers)
- 72 Computer and related activities

37. This classification is a good starting point for defining ICT-related R&D in the business enterprise sector. In R&D surveys, data are often available only at ISIC 2-digit classifications. This makes direct application of this list difficult. In addition, some categories have rather limited ICT content (ISIC 3130) or are somewhat irrelevant for R&D surveys (*e.g.* the wholesale or renting categories). An operational definition of ICT-related R&D may therefore include ISIC 30, 32 and 33 (ICT-related R&D in manufacturing) and ISIC 64 and 72 (ICT-related R&D in services).

38. The above classification needs to be complemented by a classification that is more relevant for defining ICT-related research, *i.e.* a product field classification, which is a functional classification. Work is under way to reach an international recommendation on which product fields are to be regarded as ICT-related. Although the product field classification is not used in R&D

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surveys in every country, a definition in terms of product field, when agreed, may be more relevant for defining ICT-related R&D in the business enterprise sector. Chapter 4, Section 4.3, of the Manual now includes a more explicit recommendation on the use of a product field classification in R&D surveys. The product field is defined according to the final product of the enterprise. This means, for example, that R&D performed by a car manufacturer for software included in cars will not be considered as ICT-related R&D, as the software is not the car manufacturer's final product. However, if the software is bought from an outside company, any R&D carried out by that company for the software product is considered ICT-related R&D.

39. One problem with using the product field classification could be that the level of aggregation of the product field classification used in R&D surveys may be too broad to distinguish ICT-related R&D that is defined according to very disaggregated product groups.

40. R&D that is relevant for ICT or, more broadly, for the information economy/information society also takes place in other sectors of performance. Here, the field of science classification is useful. However, the field of science classification recommended in Chapter 3 of the Manual is not very helpful for identifying ICT-related R&D. Work is to start to develop a new classification by field of science that is applicable for statistical purposes. It would be essential to identify under natural sciences and engineering, and probably also social sciences, sub-fields of relevance for the ICT sector or, more broadly, the information economy/information society. Examples are computer hardware, communication technologies and information, computing and communication sciences. The application of a very detailed field of science classification certainly causes difficulties in several countries. This will affect their possibilities for using the field of science classification to produce information on ICT-related R&D.

41. In theory, the classification by socio-economic objective (SEO) may also be used to distinguish ICT-related R&D. Relevant sub-classes are included at the 2-digit level of the present NABS. However, the SEO classification is applied at this level of detail only in some EU countries.

Biotechnology-related R&D

Introduction

42. Biotechnology is perceived as having the potential to be the next pervasive technology of great significance for future economic development. Work is under way at the OECD to develop a statistical framework for the measurement of biotechnology activities and to identify more closely the needs of users for indicators on biotechnology activities and on the effects of

biotechnology. On the basis of these considerations, a model survey of biotechnology is under development. As an aid, a definition of biotechnology, in terms of a single definition and a list of technologies, has been agreed as a basis for further work and is presented at the end of this annex.

Classifications

43. Classifications are usually used to delimit a field. Because biotechnology is a process as opposed to a product or an industry, it is not easily identifiable on the basis of existing classifications. ISIC, the standard international classification of economic activities, was revised during the 1980s when interest in biotechnology was rather limited. For the moment, it is not possible to identify specific biotechnology industries at any level of ISIC (division, group, class). Some preliminary discussions have taken place on the possibility of identifying biotechnology-related industries in the next major revision of the classification. The situation is more or less the same for the central product group classification (CPC) and the harmonised commodity description and coding system HS 2002.

44. In their present form, the more R&D-related classifications by field of science and socio-economic objectives (SEO) are not suitable for the identification of biotechnology. Biotechnology is related to several of the major fields of science recommended in the Manual, including natural sciences, engineering, medical sciences and agricultural sciences. It may be possible to identify biotechnology on the basis of a more detailed classification by field of science, including agreed sub-fields of the major fields of science. This has to be investigated during work to revise the field of science classification.

45. Experience in Australia indicates possibilities for identifying biotechnology-related R&D on the basis of a detailed field of science classification. The Australian classification has a specific category called "biotechnology", but there are also relevant categories at different levels of the classification, such as biochemistry and cell biology, genetics, microbiology, industrial biotechnology, bioremediation, biomaterials and medical biotechnology.

46. It will be difficult to identify biotechnology in any revised classification by socio-economic objectives.

Model surveys

47. The only possibility for obtaining information on biotechnology R&D or use of biotechnology is therefore to develop special surveys on biotechnology or to ask additional questions in existing surveys, such as the R&D survey. The first option is being explored in work to develop model surveys for biotechnology. The second option is to obtain information on biotechnology R&D from normal R&D surveys through use of the OECD definition of biotechnology.

Adding questions on biotechnology to R&D surveys

48. The following paragraphs address the issue of adding questions to an existing R&D survey.

49. Special questions on biotechnology to be added to R&D surveys or collected in connection with them have some limitations. These are:

- The variable should be included in the general R&D survey framework.
- Appropriate classifications should be available for describing biotechnology-related R&D.
- The additions on biotechnology should increase the response burden only marginally.

50. Some ten countries have experience in requesting information on the share of biotechnology R&D in total R&D expenditure. A question is often asked in the context of a list of interesting technologies, of which biotechnology is one. The surveys give a single definition, a list of relevant technologies or a combination of the two. The definitions used in various surveys differ. To improve comparability, it is recommended to use the OECD definitions (both the single definition and the list presented at the end of this annex). This would be the first step towards having more comparable data on biotechnology R&D.

The following type of question could be asked in the general R&D survey:

Did the R&D reported above include any biotechnology R&D (see definition)?

Yes ( )
No ( )

If yes, please provide an estimate of the share of the total intramural R&D expenditure reported earlier that is attributable to biotechnology. _____%.

51. To guide the respondent, the OECD definition of biotechnology should be provided. The list-based definition may be more helpful, but both may be needed.

52. Another question that might be considered is the share of public funding of R&D going to biotechnology R&D. The detailed formulation of this variable may need further elaboration.

53. As the interaction between science and technology is particularly strong in the field of biotechnology, it is also recommended to include this kind of question for R&D surveys in the other *Frascati Manual* sectors. The experience of a few countries suggests that this is feasible.

54. It is recommended to introduce a few simple questions on biotechnology R&D in R&D surveys in as many member countries as possible to have a broader comparable overview of the role of biotechnology in their R&D efforts.

55. Biotechnology is a multidisciplinary field. This poses particular problems in categorising biotechnology for survey purposes. The current OECD definition of biotechnology is preliminary and has mainly been piloted in R&D surveys of the business enterprise sector. For comparability, the definition is also recommended for use in other sectors. The experience gained from using the definition in all sectors will lead to further revisions of the current definition.

OECD definition of biotechnology

56.

> "The application of S&T to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services."
>
> The (indicative, not exhaustive) list-based definition is:
>
> - DNA (coding): genomics, pharmaco-genetics, gene probes, DNA sequencing/synthesis/amplification, genetic engineering.
> - Proteins and molecules (functional blocks): protein/peptide sequencing/synthesis, lipid/protein glyco–engineering, proteomics, hormones and growth factors, cell receptors/signalling/pheromones.
> - Cell and tissue culture and engineering : cell/tissue culture, tissue engineering, hybridisation, cellular fusion, vaccine/immune stimulants, embryo manipulation.
> - Process biotechnologies: bioreactors, fermentation, bioprocessing, bioleaching, biopulping, biobleaching, biodesulphurisation, bioremediation and biofiltration.
> - Sub-cellular organisms: gene therapy, viral vectors.

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Annex 5

Methods of Deriving Regional R&D Data

Introduction

1. Chapters 5 and 6 of the Manual make recommendations for breaking down data on R&D personnel and R&D expenditure by region. This annex briefly discusses various methods of doing so. It draws on work by Eurostat, which has investigated the methods in greater detail. Regional data can be derived either directly, by classifying the statistical units, or by including a separate question on this breakdown in surveys. This annex does not discuss details of the regional breakdown. This has to be determined according to national or international needs for information.

Classifying the statistical units

2. In many cases it is possible and feasible to attribute statistical units to regions on the basis of the postal address of the entity. The advantage of this approach is that all variables will automatically be available by region. Problems may arise if sampling is used, as the region can seldom be used as a stratification variable. For regionalisation of R&D variables, the ideal solution would be to have statistical units small enough to avoid their having activities in several regions. This would in many cases imply establishment-type units. However, this is generally not feasible from the point of view of data collection and compiling of meaningful national aggregates by industry. The data for R&D surveys are usually available only at the level of enterprise-type units, and an attempt to split these units into smaller ones would create extra work for the respondent and for the surveying agency. Sectoral aggregates by industry would also be rather different if the establishment is used as the statistical unit. Therefore, the *Frascati Manual* recommends using the enterprise-type unit as the most appropriate for R&D surveys in all sectors except the higher education sector.

3. Attributing large units with activities in many regions to a single region will, however, lead to distortions in the breakdowns. It is therefore recommended, if it is not possible to have a separate question on regional breakdown (as described below), to have, at least for the biggest units, a

separate breakdown by region for the most important variables (R&D expenditures, R&D personnel). If it is not possible to obtain the information directly, it may have to be estimated on the basis of variables that can be assumed to be closely related to R&D.

4. Depending on the method used to obtain data on the higher education sector, the establishment unit (for example the university institutes or corresponding units) may be more feasible. In this case, regional data can be derived directly. Otherwise, the discussion above and in the following section is applicable.

Asking a separate question on the regional breakdown

5. Compared with the above alternative, this option gives more precision to regional breakdowns. It serves as a substitute when information at establishment level is lacking. The question can be asked in many ways. The table below indicates the information to be requested without suggesting the formulation of the question or the priority of the variables.

Region, municipality or establishment	R&D personnel (headcount)	R&D personnel (FTE)	R&D expenditure

6. Information on the regions might be asked for directly. In some countries, however, respondents may not be aware of how the regions are defined. An alternative is to ask for the municipalities of the sub-units and to code them later for the appropriate regions. A third alternative is to ask for establishment-type units and to try to identify the address of the establishment. It is usually possible to have the variables for which regionalisation is required at establishment level. The table needs additional columns for data on researchers by region. With this approach, problems of sampling may arise, as raising factors have to be applied.

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Annex 6

Work on S&T Indicators in Other International Organisations

1. The problems of comparing R&D data and other S&T indicators 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. This annex presents an overview of the activities undertaken to develop S&T indicators in various international organisations.

UNESCO (United Nations Educational, Scientific and Cultural Organisation)

2. Since 1965, the UNESCO Division of Statistics has organised the systematic collection, analysis, publication and standardisation of data on science and technology (S&T), and, more specifically, 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 on qualified S&T human resources and R&D personnel and expenditure conducted worldwide since 1970, a database has been built that covers at present some 100 countries and territories. These data were published regularly in the *UNESCO Statistical Yearbook* (UNESCO annual until 1999) and have also been used for special reports and analyses, such as the *World Science Report*.

3. 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 was 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 the International Standardisation of Statistics in Science and Technology, which was reviewed by a meeting of governmental experts and then proposed for adoption by the UNESCO General Conference in 1978. This Recommendation detailed international statistical standards that could be

applied by all member states, both those with advanced S&T statistical systems and those whose systems were still being developed. Although designed to provide standardised information on S&T activities, it concentrated on R&D. However, it proposed a gradual extension of the statistics beyond R&D.

4. Following the adoption of the Recommendation, two successive stages at international level were proposed: the first, over a period of at least five years after the adoption of the Recommendation, was to cover only R&D in all sectors of performance, together with the stock of, 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 the Collection of Statistics on Science and Technology" (UNESCO, 1984a), for use by 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 the ECE (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.

5. Since 1976, UNESCO has also made efforts to develop a methodology for collecting data on scientific and technological information and documentation (STID); this work resulted in the publication of a provisional STID Guide in 1984 (UNESCO, 1984c). Work to establish a methodology for collecting statistics on STET began in 1981. Case studies were carried out in various regions of the world to determine the state of S&T statistics, problems encountered in the implementation of the Recommendation, and the need for new S&T indicators.

6. With the changes that occurred during the 1980s and early 1990s especially with respect to the organisation and measurement of S&T activities in the former centrally planned economies, a special external evaluation of UNESCO's S&T statistical programme was carried out in 1996. The findings and recommendations of this evaluation concluded, *inter alia*, that UNESCO's R&D statistical programme should align its methodology on that of the *Frascati Manual*, and that priority should be given to further development of international S&T indicators that respond to the needs of all countries.

7. Since the establishment of the UNESCO Institute for Statistics (UIS) in 1999, UNESCO's activities focus on a fundamental international review of policy needs in S&T and of existing S&T statistical systems and capacities, in

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close co-operation with international expert networks, the OECD and Eurostat. The main objective of this review is to help UNESCO to redefine its programme priorities and implementation strategies in the area of S&T statistics. The results of this review will become available in 2003 and the priorities and strategies will be submitted to the 32nd UNESCO General Conference for approval, before implementation begins in 2004.

Eurostat (Statistical Office of the European Communities)

8. Eurostat, with the collaboration of EU and EEA member states represented in Eurostat's Working Party on R&D and Innovation Statistics, draws up annual reports on the public financing of R&D by socio-economic objective in member states, on the R&D appropriations of Community institutions, the regional distribution of R&D personnel, R&D expenditure and European patent applications. Data are collected through an annual survey of member states and processed for presentation in comparable form. Eurostat also collects and disseminates R&D and innovation statistics from EU candidate countries and the Russian Federation.

9. Eurostat has been co-responsible for methodological work in various domains. It actively participated with the OECD in the first revision of the *Oslo Manual* (OECD, 1997a). Innovation survey methodology has been largely influenced by the three Community Innovation Surveys prepared and co-ordinated by Eurostat. Eurostat has developed a manual on the regional aspects of R&D and innovation statistics and has developed guidelines for collecting data on government appropriations for R&D which complement those in the previous edition of the *Frascati Manual*. Eurostat also participated actively with the OECD in the development of the *Canberra Manual* (OECD, 1995) on human resources for science and technology and has pioneered the collection and publication of statistics consistent with that manual.

Nordforsk/Nordic Industrial Fund

10. Since 1968, the Nordic countries have collaborated to co-ordinate 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 produced a "Nordic Manual" in the Nordic languages, which was a detailed supplement to the *Frascati Manual*. Selected chapters were translated into English and presented by Nordforsk at various meetings of experts at the OECD. The Committee also worked 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).

11. In 1987, Nordforsk merged with the Nordic Industrial Fund which took over responsibility for the Committee. The Committee continues to give 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.

12. In 1989 the Nordic Industrial Fund set up a special working group for innovation studies, which launched a Nordic survey on innovation using a common questionnaire. It also organised several international seminars to discuss guidelines for innovation surveys. These were the basis for discussions at the OECD, which led to the adoption and publication of the *Oslo Manual* in 1992 (OECD, 1992). In the 1990s, activities have mainly focused on the publication of R&D statistics (every other year) and of more comprehensive science and technology indicators (at longer intervals).

RICYT (*Red Iberoamericana de Indicadores de Ciencia y Tecnología*)

13. The Ibero American Network of Science and Technology Indicators (*Red Iberoamericana de Indicadores de Ciencia y Tecnología* – RICYT) was created by the Ibero American Programme of Science and Technology for Development (*Programa Iberoamericana de Ciencia y Tecnología para el Desarrollo* – CYTED) on the basis of a proposal arising from the First Ibero American Workshop on Science and Technology Indicators held at the National University of Quilmes in late 1994. Since it was set up, RICYT has co-ordinated its activities with the Organisation of American States (OAS).

14. RICYT's general aim is to promote the development of instruments for the measurement and analysis of science and technology in Latin America, within a framework of international co-operation, with a view to increasing their use as a political instrument for decision making.

15. RICYT's activities take the following forms:

– Workshops with methodological discussions on the problems of science and technology indicators in Latin America and intensified the exchange of information among the various members of the network. One result has been the publication of a Latin American manual of indicators on technological innovation, the "Bogotá Manual".

- Publication of the indicators of the region in the series, "Main Ibero and Inter-American Science and Technology Indicators" (*Principales Indicadores de Ciencia y Tecnología*).
- Creation of mechanisms of mutual assistance in Latin America.
- Diffusion activities through the publication of "Indicios", a news and opinion bulletin, a Web page (*www.ricyt.edu.ar*) devoted to the network's activities which presents regularly updated information on the indicators, and the edition of bibliographic material.

Annex 7

Other Science and Technology Indicators

Introduction

1. As discussed in Chapter 1 of the Manual, 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, Freeman 1987).

2. The OECD, recognising the need to facilitate the development of indicators other than those directly associated with R&D, has prepared a series of non-R&D methodological manuals or other guidelines (see Chapter 1, Table 1.1). These manuals and guidelines are intended to be complementary and, in time, to provide guidance 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 guidelines are prepared 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 and describes some drawbacks relating to their use. The indicators are presented in historical order in terms of development. The situation is described as of 2002.

Patent statistics

Coverage

4. A patent is an intellectual property right relating to inventions in the technical field. A patent may be granted to a firm, an individual or a public body by a patent office. An application for a patent has to meet certain requirements: the invention must be novel, involve a (non-obvious) inventive step and be capable of industrial application. A patent is valid in a given country for a limited period (20 years).

5. For purposes of international comparison, statistics on patent applications are preferable to statistics on patents granted because of the lag

between application date and grant date, which may be up to ten years in certain countries.

6. Patent indicators based on simple counts of patents filed at an intellectual property office are influenced by various sources of bias, such as weaknesses in international comparability (home advantage for patent applications) or high heterogeneity in patent values within a single office. Furthermore, differences in patent regulations across countries make it very difficult to compare patent statistics between two (or more) patent offices.

7. To overcome the problems associated with the traditional patent indicators (described above), the OECD has been working towards developing a new type of patent-based indicator: patent family counts. A patent family is defined as a set of patents taken in various countries to protect a single invention (characterised by a first application in a country – called the priority application – which has been extended to other offices). The advantages of using indicators based on patent families for statistical purposes are twofold: they improve international comparability by eliminating home advantage and geographical influence; patents included in the patent family are of high value.

8. Patent documents contain a rich source of information on the invention that is unavailable elsewhere and therefore constitutes a significant complement to the traditional sources of information for measuring diffusion of technological/scientific information (see section on bibliometrics). Patent documents contain information on: *i)* technical features (such as list of claims, technical classification, list of cited patents, etc.); *ii)* history of the application (such as priority date, date of publication, date of filing in the country concerned, date of grant, etc.); and *iii)* information about the inventor (such as name and address of inventors, country of residence, name of applicants, etc.).

Use of patent statistics

9. Among the few available indicators of technology output, patent-based indicators are probably the most frequently used. Patent-based indicators provide a measure of the output of a country's innovative activity: its inventions. The scientific literature on the determinants and impact of innovative activity increasingly uses patent data at aggregate (national) or firm level, because of the widely recognised close relationship between patents and innovative output. Patent data are also used to identify changes in the structure and evolution of inventive activity in countries, industries, companies and technologies by mapping changes in technology dependency, diffusion and penetration.

Availability

10. National and international (*e.g.* European Patent Office – EPO; World Intellectual Property Organisation – WIPO) patent offices are the primary data sources. The OECD assembles, stocks and publishes various patent-based indicators for its member countries in the *Main Science and Technology Indicators* (OECD, biannual) and the *OECD Science, Technology and Industry Scoreboard* (OECD, biennial) and in the associated diskettes and CD-ROMs. The OECD patent database also includes information on patents filed at the EPO, the Japanese Patent Office and the United States Patent and Trademark Office (USPTO), broken down by country of residence and technological areas.

Drawbacks

11. There are some drawbacks associated with using patent indicators for the measurement of R&D output and/or innovative activity. Many innovations are not patented because they are protected by other means, such as copyright, trade secrecy, etc. The propensity to patent varies across countries and across industries, and this makes cross-country or cross-industry comparisons difficult. The distribution of the value of patents is skewed, as many patents have no industrial application, hence are of little value, whereas a relatively few are of substantial value. Given such heterogeneity, patent counts that assume all patents to be of generally equal value are misleading. The number of patent applications or grants *per se* is difficult to interpret; the number of patents has to be used in conjunction with other indicators.

International guidelines

12. The growing role of international patent organisations contributes to creating greater comparability of the patent data available for individual countries, although it is still affected by the special characteristics of patents. The OECD patent manual ("Using Patent Data as Science and Technology Indicators – Patent Manual 1994") (OECD, 1994b) outlines the general guidelines for the use and interpretation of patent data as indicators of S&T.

The technology balance of payments (TBP)

Coverage

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

14. The following operations are included in the TBP: patents (purchases, sales); licences for patents; know-how (not patented); models and designs; trademarks (including franchising); technical services; finance of industrial R&D outside national territory.

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15. The following operations are excluded: commercial, financial, managerial and legal assistance; advertising; insurance; transport; films, recordings, material covered by copyright; design; software.

Use of TBP statistics

16. 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.

Availability

17. 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.

18. The OECD has assembled a database of "macro" TBP data for most of its member countries which covers total transactions (receipts and payments) by partner country from 1970. Data for periods since the late 1980s are published in *Main Science and Technology Indicators* (OECD, biannual) and in the associated CD-ROM. In 2000 a new international database for detailed TBP series broken down by industry, type of operation and geographical area was established.

Drawbacks

19. For many countries the data are available only at a rather aggregate level. The available data do not necessarily correspond to the definition of TBP, *i.e.* they may cover more or less than transactions with a technological content. The balance is affected by sometimes non-monetary transactions within multinational firms. There are difficulties for interpreting the data, and the international comparability of the data may be weak.

International guidelines

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

Bibliometrics

Coverage

21. Bibliometrics is the generic term for data on publications. Originally, it was limited to collecting data on numbers of scientific articles and other

publications, classified by author and/or by institution, field 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

22. Bibliometric analysis uses data on numbers and authors of scientific publications and on articles and the citations therein (as well as the citations 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 (multidisciplinary) fields of science and technology.

Availability

23. Most bibliometric data come from commercial companies or professional societies. The main general source is the set of Science Citation Index (SCI) databases created by the Institute for Scientific Information (United States), which Computer Horizons, Inc., has used to develop several major databases of science indicators. Bibliometric data can also be derived from other, more specialised databases. The OECD currently has neither the plans, the resources, nor the competence to undertake basic data collection, although it regularly uses bibliometric data in its analytical reports.

Drawbacks

24. The propensity to publish varies between fields of science. The utility of bibliometric indicators is greatest for the medical sciences and certain natural sciences. The databases are biased towards articles in English, which may affect international comparisons.

International guidelines

25. Bibliometric methods have essentially been developed by university groups and by private consultancy firms. There are currently 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 was published 1997 as an STI working paper (Okubo, 1997).

High-technology products and industries

Coverage

26. To contribute to analyses of the impact of technology on industrial performance, it is helpful to identify those activities and products which are most technology-intensive, using criteria that allow for constructing special internationally harmonised classifications. In recent years, the OECD has developed technology classifications both by industry, which has generated much interest and widespread application in member countries, and by product.

27. In the industry approach, manufacturing industries are allocated to one of four groups: "high", "medium-high", "medium-low" or "low" technology. Until the late 1990s, a technology classification using ISIC Rev. 2 was widely used. It was based on an evaluation of the ranking of three indicators of technology intensity reflecting, to different degrees, the "technology-producer" and "technology-user" aspects: *i)* R&D expenditures divided by value added; *ii)* R&D expenditures divided by production; and *iii)* R&D expenditures plus technology embodied in intermediate and investment goods divided by production. Since the adoption by the OECD of ISIC Rev. 3 for presenting data by industrial activity, the work on technology groups has been updated. However, at present, the limited availability of ISIC Rev. 3 input-output tables (required for estimating embodied technology) means that only the first two indicators cited above are considered. For early results, see Annex 1 of the *OECD Science, Technology and Industry Scoreboard 2001*.

28. A product approach has the advantage of allowing more detailed analysis and identification of the technology content of products. Not all products in a "high-technology industry" necessarily have a high technology content; likewise, a high degree of technological sophistication may be found in products from industries with lower technology intensities. In collaboration with Eurostat, the OECD used detailed R&D data by product field to produce a list of high-technology products and an associated database based on SITC Rev. 3 classes at the 5-digit level of detail. Updating this work to generate a list based on 6-digit Harmonised System (HS) products could be an important next step.

Use of high-technology products and industry statistics

29. 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-technology markets. Such markets are characterised by rapid growth of world demand, offer higher than average returns to trade and affect the evolution of the structure of industry.

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

Availability

31. Data based on the OECD definitions of high technology are published in the OECD's *Main Science and Technology Indicators* and the *Science, Technology and Industry Scoreboard*. They are also used in many national publications.

Drawbacks

32. At present, the classifications do not take into account products and industries with low R&D intensities but produced with high-technology machinery and equipment. The classifications are based on R&D intensities only in a certain number of OECD countries.

International guidelines

33. International guidelines do not exist, but the OECD approach to measuring high-technology products and industries is presented and comprehensively discussed in "Revision of the High-technology Sector and Product Classification" (Hatzichronoglou, 1997).

Innovation statistics

Coverage

34. The *OECD Proposed Guidelines for Collecting and Interpreting Innovation Data – Oslo Manual* (OECD, 1997a) defines technological product and process innovations as those implemented in technologically new products and processes and in significant technological improvements in products and processes. An innovation is implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). Innovation involves a series of scientific, technological, organisational, financial and commercial activities. In the various Community Innovation Surveys (CIS) implemented by Eurostat on the basis of the *Oslo Manual*, various modifications have been made to this definition.

Use of innovation statistics

35. 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 that enhance or hinder innovation, on the impact of innovation, on the performance of the enterprise

and on the diffusion of innovation. A few countries have also introduced some questions on innovation in other surveys, such as the R&D survey.

Availability

36. National data on innovation activities are generally collected by means of surveys addressed to industrial firms on an *ad hoc* basis. Most OECD member countries have organised such surveys, and the *Oslo Manual* is based on their experience.

37. 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.

38. The first internationally comparable series of data on innovation 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 of the first Community Innovation Survey by the European Union. The experience gained from this survey was used in preparing the second edition of the *Oslo Manual*. Many OECD countries have used the EU questionnaire as a basis for developing their own innovation surveys. Currently (autumn 2002), the third CIS is in the data-processing stage.

Drawbacks

39. Innovation surveys suffer from some problems of quality owing to unsatisfactory response rates in the case of voluntary surveys and differences in the understanding of the concept of innovation among enterprises. The *ad hoc* nature of national surveys is not satisfactory for users, and in many countries innovation surveys give information on R&D that is not consistent with information from R&D surveys.

International guidelines

40. The initial *Oslo Manual* (OECD, 1992) was prepared jointly by the OECD and the Nordic Fund for Industrial Development (Nordisk Industrifond, Oslo) in 1990 and was officially adopted by the OECD as the third in the “Frascati” family of manuals. The manual was jointly revised with Eurostat in 1997. A second revision may take place during the coming years.

Human resources for science and technology (HRST)

Coverage

41. The *Frascati Manual* discusses only the measurement of R&D personnel. The concept of HRST is much wider and covers other categories of personnel engaged in scientific and technological activities.

42. HRST are defined in the *Canberra Manual* (see below) in terms of qualifications or current occupation. In the first case, the appropriate classification is the International Standard Classification of Education (ISCED) (UNESCO, 1976; 1997) and, in the second, it is the International Standard Classification of Occupations (ISCO) (ILO, 1968; 1990). Data sets and analyses may cover only persons with university qualifications/professional occupations or they may 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 at given points in time, broken down by employment status and by sector and type of employment, as well as 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 origin. Data on specific categories of interest (PhDs, post-doctorates, researchers, IT professionals, etc.) are also needed.

Use of HRST data

44. Co-ordinated sets of data on HRST can be used (when linked to demographic statistics) to review the current and possible future supply and use of and demand for scientific and technical personnel (at home and abroad), 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 role of women (and minorities) in science and technology activities.

Availability

45. A few small OECD countries are able to maintain complete nominal registers of all S&T graduates and their whereabouts, from which HRST data may be produced. The National Science Foundation in the United States also maintains a comprehensive database on the characteristics of scientists and engineers. In most countries, however, databases on HRST have to be built up from several sources, notably education statistics (numbers of teachers and graduates), labour force surveys and other employment statistics, and population censuses, supplemented by special surveys.

46. Eurostat compiles basic HRST stock data from the European Community labour force survey and education inflow data from education statistics, which provide fairly harmonised results. UNESCO, Eurostat and the OECD have developed a common questionnaire to collect education statistics. These organisations publish data on teaching personnel and on students and

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graduates by ISCED level and field of study. The OECD hopes to build a more detailed database and set of indicators.

Drawbacks

47. The existing statistics are quite fragmented, and the level of aggregation is quite high owing to the use of sample surveys (*e.g.* the labour force survey) as the main sources of data for the stocks of HRST.

International guidelines

48. In 1995, Eurostat and the OECD jointly released the *Canberra Manual* (OECD, 1995), which includes international standards for measuring stocks and flows of HRST. This manual is currently under review.

Information society statistics and indicators

Coverage

49. The aim is to develop indicators and analysis of the information society for policy making and analysis. The work involves the production of internationally comparable and policy-relevant indicators for measuring the supply of and demand for ICT infrastructure, related services, content and applications, in particular for electronic commerce.

50. The approach followed is that of "building blocks". Methodological work and data collection have proceeded in several areas at different speeds, in a step-by-step, pragmatic way, by looking first at supply-side statistics for the information society (statistics on the ICT sector) and then at the demand side (ICT usage statistics).

Use of ICT sector and ICT usage statistics

51. Development and analysis of new and existing ICT indicators are an aid to formulating policies and monitoring progress related to the information society. ICT sector statistics help to measure the contribution of ICT-producing industries to economic activity (*e.g.* value added, employment, R&D and innovation performed, contribution to the trade balance). ICT access and usage indicators help to identify the degree of countries' "readiness" to adopt new technologies and the rate of diffusion of these technologies among all actors in the economy (businesses, households, individuals, governments). Indicators of electronic commerce transactions are based on common OECD definitions and measure the relative size of on-line sales and purchases and their breakdown by type of customer and geographical destination.

Availability

52. Pilot collections of ICT indicators related to the ICT sector (supply statistics) and to ICT use and electronic commerce (demand statistics) are under way, and information on methodologies and survey vehicles used by member countries is been collected. The indicators are used in OECD publications such as the *Information Technology Outlook*, the *Communications Outlook*, and the *Science, Technology and Industry Scoreboard*. The OECD's *Measuring the Information Economy* (2002) looks at the role played by ICT investment, consumption and ICT-related innovation in OECD economies; at the size and growth of ICT activities and their contribution to employment and international trade; at the extent to which businesses and individuals access and use new technologies and the reasons why they do not. It has a special focus on electronic commerce transactions and their drivers and inhibitors.

Drawbacks

53. Drawbacks for measuring ICT usage and electronic commerce statistics are linked both to definitional issues and to the typical structure of member countries' data collection programmes. The target populations and sampling methodologies may differ in countries' surveys of ICT use in enterprises. This can lead to misleading international comparisons of aggregate figures, since ICT usage statistics are very sensitive to size cut-off and industry coverage. In surveys on ICT use in the household sector, problems of comparability may be affected by whether the statistical unit is the individual or the household. As relatively few businesses or individuals currently engage in electronic commerce transactions, the statistics may not meet the statistical standards for publication. For statistics on ICT supply, classification is crucial. International comparability of activity-based classifications can be hard to achieve, given the level of detail required by the OECD definition of the ICT sector, which is based on the 4-digit classes of ISIC Rev. 3. Problems of confidentiality are sometimes encountered when collecting data on telecommunication services, while very few countries can provide data on ICT wholesaling.

International guidelines

54. The methodological work entails the development of guidelines and model surveys. Examples are: the OECD definition of ICT sector, which covers a group of ISIC Rev. 3 manufacturing and service activities; the OECD definitions of electronic commerce transactions and the guidelines for implementation; the OECD model survey on ICT usage in business; the OECD model survey on ICT usage by households/individuals. Model surveys are

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intended to provide guidance on the measurement of ICT indicators, Internet use and electronic commerce and are composed of separate, self-contained modules to ensure flexibility and adaptability to a rapidly changing environment. While the use of "core" modules allows measurement on an internationally comparable basis, additional modules can be added to respond to evolving or country-specific policy needs.

Annex 8

Practical Methods of Providing Up-to-date Estimates and Projections of Resources Devoted to R&D

The demand for projections of R&D data

1. Surveys are the most accurate means of measuring scientific and technological activities. They involve a complex process, however, and there is some delay between R&D performance, collection of data and publication. There is therefore an increasing demand for forecasts. Both policy makers and other users desire projections of the most useful indicators for defining, evaluating, monitoring or introducing science and technology programmes and policies.

Types of projections covered

2. A distinction should be made between short-term, medium-term and long-term projections. The issue of medium-term and long-term forecasts (which may be called prospective analysis) is not 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 describes the most frequently used methods and offers a few basic guiding principles for forecasting and projecting the values of such variables, but it does not seek to lay down universally applicable methods (or procedures). The special characteristics of individual countries, and indeed sectors, each with its own determinants and pace of change, argue against adopting standard procedures.

The variables

4. Projections are most often made for:

- R&D expenditures.
- R&D personnel.
- Technologies.

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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. Projections of R&D personnel can be particularly valuable for forecasting, as the series are usually less volatile than those for 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 paragraph 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 many years are taken into account, it is easier to identify dominant trends and the fit is better. However, analysis of 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.
- 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 project R&D expenditures or personnel for individual sectors if suitable independent variables can be found for which forecasts are available, 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 the 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 for accurately forecasting 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 in 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 sectors, 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 and there is no subsequent reporting of final outlays, it is much less accurate. Consequently, while government budgets are an important aid in estimating certain variables, they must be used with caution.

18. Reports of non-public R&D funders should also be taken into account, notably in the case 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.

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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 example, 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 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, retrospective R&D survey results should be used when they become available to check the forecasts and to identify 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 in using methodologies is needed, and composite approaches are acceptable and very often necessary.

24. Ideally, projections would be carried out 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 to ensure international comparability of member countries' forecasts 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 presents 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 9

R&D Deflators and Currency Converters

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, the Manual recommends the use of the implicit gross domestic product (GDP) deflator and GDP-PPP (purchasing power parity for GDP), which provide 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. Currency converters are mainly important for international comparisons, including, of course, those of estimated growth rates. However, the choice of currency converters is also 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, the 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 optimal 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 out using them 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 to the existing sectoral approach.
- They should be of Laspeyres form.
- In view of the relative importance of manpower in R&D activities (almost 50% of expenditure), it should receive special attention.
- Practical characteristics 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 lines developed by the OECD in *Trends in Industrial R&D in Selected OECD Member Countries, 1967-1979* (OECD, 1979).

10. In consequence, the fourth edition of the *Frascati Manual* (OECD, 1981) included a special chapter, which 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

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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 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 have shown that the index number formulas in common use (Laspeyres, Paasche, etc.) have weaknesses with important consequences for economic analysis and policy making. 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 linking can be achieved by passing through an intermediate point. Ideally, the intermediate situation is one in which the pattern of relative prices is approximated by some average of the relative prices in the two situations being compared. In such a case, chaining reduces the index number spread (between Laspeyres and Paasche).

13. Why chaining? In the real world, the problem faced by 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 share 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 tends to be very large).

15. If a chain index is used and the amount of usable price information is greatly increased, 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 one 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 between the different levels in the cost structure of R&D expenditures and whether there are significant differences between the levels in price trends for the same cost item. For example, it is probable that trends in wages and salaries of researchers will be different in universities, where they are often 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 is also dictated by the availability of suitable price series, whether 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 1989 and 1999.

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	Percentage	
	1989	1999
Labour costs	43	44
Other current costs	43	45
Land and buildings	3	2
Instruments and equipment	10	9
Total	100	100

More detailed treatment of labour costs

19. Labour is typically one of the major cost items. 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 relative weights for labour costs of different categories of personnel as follows:

	Quantity ratio (%)	Relative salary ratios	Labour cost ratio (%)
Researchers (RSE)	50	1.00 = 50.00	59.7
Technicians	25	0.75 = 18.75	22.4
Other supporting staff	25	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 the Manual recommended that this category should be subdivided between:

- Materials.
- Other current costs.

This distinction has since been abandoned in OECD surveys and in most national ones. It is therefore difficult to establish a sub-weighting system.

Selecting proxy price indices

General approach

22. When 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; alternatively, an attempt can be made to identify the series whose

characteristics are most similar to R&D. As the final result will tend to be more sensitive to the evolution of the price series than to that of the weights, the choice of proxy price indices is the single most important decision 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, quantity data are usually available (number of researchers, etc.), and two general approaches are possible: using average R&D labour cost per total R&D person-years; using separate proxy series based on wages and salary data. The first type of series is specific to R&D but is not very exact if there is a significant change in the occupational qualification pattern within the R&D labour force over the period. Given that such changes have occurred in most member countries, it may be preferable to use the second method. Here, it is important to select series which 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 serious problems, notably concerning "grade drift", changes in employers' social security payments and other fringe benefits, and declining "quantity" of labour inputs owing to shorter hours and longer holidays.

24. It is usual to make a distinction between trends in the private and public sectors. There may have to be a trade-off between breaking down labour costs and establishing indices for separate industries. For example, salary indices may be 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

25. 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).

26. 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 (CPI) (excluding food and beverages) have all been used.

27. 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

28. 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) in national accounts. The same approach can be used for R&D expenditure on instruments and equipment, but 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

29. Using GDP-PPPs to convert R&D expenditures to a common numeraire currency such as the US dollar or the euro (*i.e.* deflating interspatially) effectively involves adjusting to allow for differences in general price levels between countries, not for differences in price levels for R&D. If R&D is relatively expensive in one country, as compared with another, the use of the GDP-PPP will distort the comparison of real expenditures on R&D.

30. As for intertemporal deflators, the ideal solution is to calculate specific currency converters based on relative prices for R&D inputs. Once again, carrying out the price surveys needed for this exercise (using a standard "basket" of R&D inputs) would be both costly and complex. The more practical solution is 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 a standard basket of goods and services entering GDP or, more precisely, final demand (*i.e.* output), whereas R&D expenditures are mainly inputs.

Past national and OECD efforts

31. The first OECD reports on R&D statistics issued in the early 1960s 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). Further efforts were made in the late 1970s when new sets of purchasing power parities became available. This situation was described in Chapter 7 of the fourth edition of the Manual (OECD, 1981). Since 1990, PPPs have been calculated every three years for OECD member countries (1993, 1996, 1999) and annually for EU countries. Data collection for the 2002 round is under way.

The method

32. The methodology for calculating R&D PPPs should correspond to that established in the context of the ICP.

33. The OECD and Eurostat regularly calculate PPPs for GDP (and its expenditure components) for OECD member countries. Although the PPPs published by the OECD are expressed in units of national currency per USD and those published by Eurostat are in units of national currency per euro, they are:

- Consistent (*i.e.* the France-Germany PPP obtained by dividing the euro PPPs for these two countries is the same as that obtained by dividing the USD PPPs), 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

34. 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

35. As for deflators, the weighting system can be derived from the recommended breakdown by type of cost. However, since the PPP calculations involve the simultaneous use of the weight and price data for all the countries included in the comparison (to ensure transitivity), it is necessary to have a matching set of weights for all the countries in the group.

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Choosing the proxy prices

36. Ideally, data from price surveys of a standard "basket" of R&D (input) expenditures in each weighting category should be used. As in the case of 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 is to use proxy prices (for which the best source is the set of comparable price data already available from the ICP), combined, if necessary, with proxy interspatial price indices (*i.e.* the disaggregated parities calculated for final expenditure components in the ICP).

Labour costs

37. No intermediate or primary input data are collected in the ICP for the business enterprise sector, hence no data on wages and salaries. For non-market services, however, the ICP uses input prices and thus includes data on total employment compensation for a selected 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 wages and salaries of scientists and engineers or of certain categories of business management.

Other current costs

38. Once again, the major problem is the lack of price data for intermediate consumption, whether or not for R&D activities, in 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

39. Suitable proxies for expenditures 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 10

Supplementary Guidance on the Classification of Large R&D Projects with Special Reference to the Defence and Aerospace Industries

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 Chapter 1, Section 1.5.3, and Chapter 2, Sections 2.2.3 and 2.3.4 of the Manual. Chapter 1, Section 1.5.2, and Chapter 2, Sections 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, some 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 "pre-production

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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 France, the United Kingdom and the United States

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 used in the Manual. This section illustrates these difficulties by comparing the Manual's 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, paragraphs 4-5.)

7. In an internal UK Defence Ministry study of the borderline between R&D and pre-production 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).

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	. .
Upstream studies	. .
Applied research	APPLIED RESEARCH
Demonstration model	. .
Demonstration project	. .
Exploratory development	. .
Upstream studies	. .
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)
Research, development, test and evaluation	. .
Design engineering	MIXED R&D/NOT R&D
Feasibility studies	R&D/pre-production
Further development	R&D/pre-production
Maintenance and repairs	R&D/pre-production
Project definition	R&D/pre-production
Engineering development	R&D/pre-production
Engineering projects	R&D/pre-production
Operational development	R&D/pre-production
Policy and operational studies	NOT R&D
Industrial engineering	Pre-production
Post-certification development	Pre-production
Trial production batch	Pre-production
User demonstration	Pre-production
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

1. 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.

Source: OECD.

Table 2. **Current classification of French, UK and US terminology in the *Frascati Manual***

Frascati Manual	United Kingdom	United States	France
RESEARCH AND DEVELOPMENT			
Basic research	Basic research (O)	Basic research (O)	Basic research (O)
			Upstream studies (O)
			See also below Research work (O)
			See also Research (I)
Applied research	Strategic applied research (O)	Applied research (O)	Applied research (O)
			Demonstration project (O)
			Demonstration model (I)
	Specific applied research (O)		
			Exploratory development (O)
			Development (O)
			General research (I)
			Preliminary project (I)
			Proving project (I)
			Proving model (I)
			Research work (O)
			Systems-oriented research (I)
Experimental development	Experimental development (O)	Advanced technology development (O)	Development (I)
		Demonstration and validation (O)	Defined development (O)
			Prototype (I)
		Engineering and manufacturing development (O)	Pilot plant (1)
		Management support (O)	
		Operational systems development (O)	
NON-R&D ACTIVITIES			
Pre-production development	Scientific and technical innovation (I)		S&T services (I)
			S&T training and development (I)
	Other related scientific and technical activities (O)		

O = Official (Defence Ministry) terminology.
I = Industry terminology.
Source: OECD.

8. The Manual (Chapter 1, 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 Chapter 2, Section 2.3.4). 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 "pre-production 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.

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.

US categories and terminology

12. Seven categories (6.1-6.7) are defined within the US Department of Defense (DoD) as part of its research, development, test and evaluation (RDT&E) budget: basic research, applied research, advanced technology development, demonstration and validation, engineering, manufacturing development, management support and operational systems development. All of these funds are allocated to R&D in returns to the National Science Foundation (NSF) and hence in GBAORD returns to the OECD. Performers of this R&D work, however, who also report to NSF (and therefore provide the basis for GERD totals) may make different distinctions.

13. Funding for 6.1 and 6.2 activities constitute what is called DoD's Technology Base programme and is often referred to as the "seed corn" of DoD's technological capabilities. It is here that new technologies and their potential for military application are explored and developed (sometimes over long periods of time). Advanced technology development (6.3) activities are meant to help technology make the transition from the laboratory to the field.

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Taken together, activities 6.1-6.3 constitute what is called DoD's Science and Technology (S&T) programme.

Formal definitions for RDT&E budget activities

14. *Budget Activity 6.1*. Basic research is defined as systematic study directed towards greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts, without specific applications for processes or products in mind. It includes activities directed towards increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental and life sciences related to long-term national security needs. It forms the basis for subsequent applied research and advanced technology developments in defence-related technologies and for new and improved military functional capabilities.

15. *Budget Activity 6.2*. Applied research is defined as systematic study to gain the knowledge or understanding necessary to determine the means by which a recognised and specific need may be met. This activity translates promising basic research into solutions for broadly defined military needs, short of development projects. The dominant characteristic of this category is that it is pointed towards specific military needs with a view to developing and evaluating the feasibility and practicability of proposed solutions and determining their parameters.

16. *Budget Activity 6.3*. Advanced technology development includes all efforts involved in the development and integration of hardware for field experiments and tests. The results are proof of technological feasibility and assessment of operability and producibility rather than development of hardware for service use. Projects in this category are directly relevant to identified military needs.

17. *Budget Activity 6.4*. Demonstration and validation includes all efforts necessary to evaluate integrated technologies in as realistic an operating environment as possible to assess the performance or cost reduction potential of advanced technology.

18. *Budget Activity 6.5*. Engineering and manufacturing development includes projects in engineering and manufacturing development for service use which have not received approval for full-scale production. This area is characterised by major line item projects.

19. *Budget Activity 6.6*. RDT&E management support includes support of installations or operations required for general research and development use. Included are test ranges, military construction, maintenance support of laboratories, operation and maintenance of test aircraft and ships, and studies and analyses in support of the R&D programme. Costs of laboratory personnel, either in-house or contractor-operated, are assigned as a line item in the basic

research, applied research or advanced technology development programme areas, as appropriate.

20. *Budget Activity 6.7*. Operational system development includes those development projects in support of development acquisition programmes or upgrades still in engineering and manufacturing development, but which have received approval for production. This area also includes major system testing and research into upgrades of existing weapon systems.

21. The US DoD reports major systems development activities (defined to encompass budget activities 6.4 to 6.7) separately from advanced technology development (6.3). In reporting to the OECD, all defence development activities (6.3 through 6.7) are categorised by NSF as "experimental development". Most of the work categorised as advanced technology development (6.3), demonstration and validation (6.4), engineering and manufacturing development (6.5) is undoubtedly "experimental development". However, since "operational systems development" (6.7) supports development of projects that have been "approved for production", at least some of these funds may be considered pre-production development and therefore fall outside of the definition of experimental development.

French categories and terminology

22. In the French Defence Ministry the Manual's 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 development (defining the operational application of new technological developments). The term "développements décidés" (defined developments) is used for experimental development. This includes the task of perfecting prototypes destined for production and operational use, *i.e.* all work prior to the actual start of production.

23. 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 the 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 Manual's terminology.

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Examples

24. This section looks at some examples of major technological development projects in the defence and aerospace industries. The objective is to show how the Manual's categories may be applied and where difficulties may arise.

Example A

25. 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, to use these to predict device performance and, finally, having identified suitable devices, to research their practical realisation and characterise them in simple form.

26. 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 the 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.

27. 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 paragraph 7 above) would be pre-production development rather than experimental development.

Example B

28. 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. The project 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.

29. 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. However, the project (as 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. 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 project expenditure down in this way.

30. 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 pre-production and production elements.

Example C

31. Table 3 shows the stages of an armoured tank development programme and a subsequent upgrade development programme.

32. Concept design appears to be at the borderline of applied research and could be achieved at the end of an applied research project.

33. 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

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Table 3. **Development of an armoured tank**

1. ORIGINAL DEVELOPMENT PROGRAMME	
User's 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 subsystems, identify equipment/subcontractors 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 subsystems and testing to ensure all function together as required
Trials	Carry out extensive trials and testing to demonstrate achievement of specifications
Re-design/modify	Incorporate modifications identified as a result of trials
User demonstration	Customer carries out own trials to ensure product meets specifications 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 modifications 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 improvement specifications
Redesign/modify	Incorporate modifications identified as a result of trials
User demonstration	Customer carries out own trials to ensure product meets specifications 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

Source: OECD.

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.

34. 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.

35. The user demonstration and acceptance of design stages appear to be pre-production, rather than experimental development, and thus outside of R&D.

36. 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

37. 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 pre-production 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.

38. Stage one is development of the integrated air offence/defence system. This stage involves bringing together developed components and subsystems that have not previously been integrated in this context. It requires a large flight test programme of the ten aircraft, which is potentially very expensive and the main cost element 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:

- Experimental development (R&D).
- Pre-production development (non-R&D).

39. The distinction between these two categories requires engineering judgement as to 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 pre-production development. The need for "engineering judgement" underlines the difficulty.

40. 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 depends on their success. According to the Manual, this work is not R&D but pre-production development. However, problems may arise during the trials, and new experimental development may be needed to solve them. This work is described in the Manual as “feedback R&D” and should be included as R&D.

41. Stage three concerns full production. This is not R&D.

Annex 11

Correspondence between the Categories of R&D Personnel by Occupation in the *Frascati Manual* and ISCO–88 Classes

1. Table 1 below gives an indication of the ISCO-88 classes in which researchers and other categories of R&D personnel are found. It should be read only in one direction, *e.g.* researchers are found among health professionals (ISCO-88 minor group 222) but not all health professionals are researchers. Also, the table does not capture certain categories of R&D personnel, *i.e.* those in the "Armed Forces" (ISCO-88 major group 0) and post-graduate students who are not registered under a specific job.

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Table 1. **Correspondence between *Frascati Manual* 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 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
	315	Safety and quality inspectors
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 associate professionals (here included in "technicians and equivalent staff").

Source: OECD.

Acronyms

CEC	Commission of the European Communities
CERN	European Organization for Nuclear Research
COFOG	Classification of the purposes of government
DPI	Domestic product of industry
EC	European Community
ECE	United Nations Economic Commission for Europe
EU	European Union
FTE	Full-time equivalence on R&D
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
ICT	Information and communication technology
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 Union
NESTI	Working party of national experts on science and technology indicators
NPI	Non-profit institution
NPSH	Non-profit institutions serving households
NSE	Natural sciences and engineering
NSF	National Science Foundation
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
RSE	Researchers
SCI	Science Citation Index
SITC	Standard international trade classification
SNA	System of National Accounts
SSH	Social sciences and humanities

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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
TBP	Technology Balance of Payments
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
VAT	Value-added tax

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Index by Paragraph Number

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