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**DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INDUSTRY
COMMITTEE FOR SCIENTIFIC AND TECHNOLOGICAL POLICY**

Working Party of National Experts on Science and Technology Indicators

**REVISED FIELD OF SCIENCE AND TECHNOLOGY (FOS) CLASSIFICATION IN THE FRASCATI
MANUAL**

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FOREWORD

The review of the field of science and technology (FOS) classification was discussed several times in the framework of the last revision of the *Frascati Manual* (FM). In particular, it was felt at the time that the FOS classification, the most appropriate classification for R&D in the public sector, needed to be re-examined in order to reflect the latest changes in the science and technology area, especially with regard to emerging technology fields such as ICT, biotechnology and nanotechnology.

Following these discussions, in 2002, the Working Party of National Experts on Science and Technology Indicators (NESTI) decided to set up a Task Force to work on the revision of the FOS classification. The OECD Task Force was led by Jan C. G. van Steen (the Netherlands) and included Australia, Norway, Portugal, as well as EUROSTAT and UNESCO.

During the process, several drafts were discussed by NESTI. The *Ad Hoc* Meeting on Biotechnology Statistics was also consulted. However, owing to the different perspectives of the scientific community, administrative systems, and users of the classification, and to the dynamics of science itself (such as the emergence of interdisciplinary sciences), it was not possible to develop a FOS classification that satisfied the needs of all actors involved. As a result, the final classification represents a compromise between different viewpoints and user needs.

The Committee for Scientific and Technological Policy (CSTP) was invited to declassify the document under the written procedure. This was completed in June 2006.

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REVISED FIELD OF SCIENCE AND TECHNOLOGY (FOS) CLASSIFICATION IN THE *FRASCATI MANUAL*

Background

The *Frascati Manual* (FM) 2002 deals with the FOS classification in Chapter 4.4, par. 273-276. Table 3.2 contains the FOS classification itself. The FM recommends that the major fields of science and technology should be adopted as the functional fields of a science classification system. This classification should be used for the R&D expenditure of the government, higher education and PNP (Private Non-Profit) sectors – and if possible of the BE (Business enterprise) sector – and for personnel data in all sectors. However, the current implementation can be characterised as quite diverse across countries.

The existing FOS classification does not fully reflect changes in the science and technology area, especially with regard to emerging technology fields such as ICT, biotechnology and nanotechnology. This, as well as the need to obtain better coverage of the data based on the FOS, the most appropriate classification for R&D in the public sector, motivated the NESTI Group to review the classification. However, it is not realistic to think that it is possible to develop a FOS classification that satisfies the needs of all actors involved. This is due to different perspectives of the scientific community, administrative systems, and users of the classification and to the dynamics of science itself (such as the emergence of interdisciplinary sciences). Therefore, the final classification represents a compromise between different viewpoints and user needs represented by NESTI.

The review of the field of science and technology (FOS) classification was discussed several times in the framework of the last revision of the *Frascati Manual*. In its 2000 meeting NESTI concluded that the FOS classification ought to be reviewed, but it was not until 2002 that NESTI decided to set up a Task Force to work on this specific issue. The Task Force was composed of Australia, the Netherlands (lead country), Norway, Portugal, as well as EUROSTAT and UNESCO. The OECD Secretariat took a co-ordinating role.

At the 2004 NESTI meeting, a first draft of the revised FOS classification, prepared by a consultant and reviewed by the Task Force, was discussed [Secretariat working document DSTI/EAS/STP/NESTI(2004)26]. Although the proposal was appreciated to some extent, a number of critical comments were made. It was concluded that the Task Force would take into account those and additional written comments in order to ensure a well described 2-digit classification rolling up to the present 1-digit reporting categories.

A second draft of the FOS classification was tabled at the NESTI meeting in 2005 [Secretariat working document DSTI/EAS/STP/NESTI(2005)15]. After a lengthy discussion, the group approved the revised FOS classification pending some changes discussed at the meeting and to be submitted in written form. NESTI also decided to seek the advice of the OECD *Ad Hoc* Meeting on Biotechnology statistics on the best way of classifying biotechnology within the FOS and to take into account a recommendation in this respect.

A number of written comments were received after the NESTI meeting, some of which were taken on board, some not. The *Ad Hoc* Meeting on Biotechnology statistics was also consulted, which led to the recommendation to split up biotechnology into four components to be assigned to three different 1-digit

FOS fields (two were classified under Engineering and Technology, one under Medical Sciences and one under Agricultural Sciences). The persons who commented were given feedback on the way their proposed changes were incorporated. The final version was sent to the Task Force for a last round of checks and endorsement of the changes made. The revised classification is presented in Annex 1. A comparison of this version with the one included in the *Frascati Manual 2002* is presented in Annex 2.

The remainder of this document illustrates the principles guiding the revised FOS classification, presents its content and identifies the implications of its implementation in the FM (2002). The classification has not been changed at the first digit level (six major fields), which is the level at which variables are collected in the MSTI questionnaire at the moment, in order to ensure the continuity of time series for the purpose of international comparisons. The novelty consists of a breakdown at the 2-digit level that takes into account emerging and interdisciplinary fields, and for which internationally comparable data are sought. Each 2-digit category is accompanied by a description of its content to aid bridging the 2-digit international classification with the more detailed national classifications.

Principles for a revised classification

A number of guidelines for the revised classification were outlined by NESTI in 2004 and further discussed by the Task Force. The following principles for the revised FOS classification were outlined:

- The major 6 fields were sub-categorised into the 2-digit level (see Annex 2).
- “Other” categories were attached to every major field in order to keep the classification flexible and allow for the appearance of new areas of studies.
- The “other” categories of engineering and technology, social sciences and humanities in the FM 2002 were split into several sub-categories.
- In particular, “bio-technology” and “nano-technology” were newly introduced in the “Engineering and technology” field.
- Data collection and reporting of the major six fields guarantee international comparability of the R&D data over time.

Implementation of the revised classification in the *Frascati Manual*

The revised international classification will have implications for many different areas of interest (R&D surveys, R&D projects, policy issues). The implementation of the FOS classification will depend on a number of factors:

- The purpose for which the classification is used (monitoring, evaluation, allocation of funds).
- The different possible actors using the classification (government, research councils, universities, international organisations, others).
- The specific relationship between the government and the institutions in the higher education and government sectors).
- The extent to which institutions are able and willing or can even be induced to deliver the data.
- The administrative burden on the institutions concerned.

As a first step, the implementation of the classification will require changes to the OECD R&D questionnaire and subsequently it will influence data collection in OECD countries. It is envisaged that countries supply data for the different sectors at the 2-digit level of the classification. This implies that the R&D questionnaire will need to be changed to incorporate the 2-digit reporting categories. However, some member countries will find it difficult, at this stage, to report R&D data at the more detailed 2-digit level of the FOS. Hence, the 1-digit will still appear in the experimental table for those countries that will not, initially, be able to deliver such data, and in order to preserve continuity of time series at the 1-digit level.

Conclusions and next steps

A distinction should be made between national and international purposes in using classifications. The classification contained in Annex 1 does not aim at harmonising data classified by field of science and technology for national purposes, rather it aims at achieving a minimum level of comparability of R&D data at the international level. Moreover, there is a balance to be achieved between the – often detailed – needs of the users on the one hand, and the need to minimise the administrative burden on statistical offices on the other hand. Furthermore, R&D surveys are not the best suited to collect very detailed data (alternative sources can be used such as databases at project level in countries and databases with publication and citation data).

For these reasons a pragmatic approach in drafting the classification was taken and an effort was made to keep the number of 2-digit categories low rather than high. Avoiding trend breaks was also an important consideration and the final version tries to stay as close as possible to the existing FOS classification.

Furthermore, progress of science and technology on the leading edge is very fast, so that new and emerging multi- or inter-disciplinary areas will need to be classified in the future in order to measure R&D inputs and performances. The current FOS classification is not necessarily a final one but will need to be revised regularly, as in the case of the *Frascati Manual* that was revised after ten years of implementation. Empirical studies can aid in improving the basis of the FOS classification.

The NESTI group will be expected to follow closely the developments in science and technology and the evolving user needs at the national and international level in order to review the FOS classification when needed.

ANNEX 1

THE REVISED FIELD OF SCIENCE AND TECHNOLOGY CLASSIFICATION

1. Natural sciences

1.1 Mathematics

- Pure mathematics, Applied mathematics; Statistics and probability¹;

1.2 Computer and information sciences

- Computer sciences, information science and bioinformatics (*hardware development to be 2.2, social aspect to be 5.8*);

1.3 Physical sciences

- Atomic, molecular and chemical physics (physics of atoms and molecules including collision, interaction with radiation; magnetic resonances; Moessbauer effect); Condensed matter physics (including formerly solid state physics, superconductivity); Particles and fields physics; Nuclear physics; Fluids and plasma physics (including surface physics); Optics (including laser optics and quantum optics), Acoustics; Astronomy (including astrophysics, space science);

1.4 Chemical sciences

- Organic chemistry; Inorganic and nuclear chemistry; Physical chemistry, Polymer science, Electrochemistry (dry cells, batteries, fuel cells, corrosion metals, electrolysis); Colloid chemistry; Analytical chemistry;

1.5 Earth and related Environmental sciences

- Geosciences, multidisciplinary; Mineralogy; Palaeontology; Geochemistry and geophysics; Physical geography; Geology; Volcanology; Environmental sciences (*social aspects to be 5.7*);
- Meteorology and atmospheric sciences; climatic research;
- Oceanography, Hydrology, Water resources;

1. This includes research on statistical methodologies, but excludes research on applied statistics which should be classified under the relevant field of application (*e.g.* Economics, Sociology, etc.)

1.6 Biological sciences (Medical to be 3, and Agricultural to be 4)

- Cell biology, Microbiology; Virology; Biochemistry and molecular biology; Biochemical research methods; Mycology; Biophysics;
- Genetics and heredity (*medical genetics to be 3*); reproductive biology (*medical aspects to be 3*); developmental biology;
- Plant sciences, botany;
- Zoology, Ornithology, Entomology, Behavioural sciences biology;
- Marine biology, freshwater biology, limnology; Ecology; Biodiversity conservation;
- Biology (theoretical, mathematical, thermal, cryobiology, biological rhythm), Evolutionary biology; other biological topics;

1.7 Other natural sciences

2. Engineering and technology

2.1 Civil engineering

- Civil engineering; Architecture engineering; Construction engineering, Municipal and structural engineering; Transport engineering;

2.2 Electrical engineering, Electronic engineering, Information engineering

- Electrical and electronic engineering; Robotics and automatic control; Automation and control systems; Communication engineering and systems; telecommunications; Computer hardware and architecture;

2.3 Mechanical engineering

- Mechanical engineering; Applied mechanics; Thermodynamics;
- Aerospace engineering;
- Nuclear related engineering; (*nuclear physics to be 1.3*);
- Audio engineering, reliability analysis;

2.4 Chemical engineering

- Chemical engineering (plants, products); Chemical process engineering;

2.5 Materials engineering

- Materials engineering; Ceramics; Coating and films; Composites (including laminates, reinforced plastics, cermets, combined natural and synthetic fibre fabrics; filled composites); Paper and wood; textiles; including synthetic dyes, colours, fibres; (*nanoscale materials to be 2.10*; *biomaterials to be 2.9*);

2.6 Medical engineering

- Medical engineering; Medical laboratory technology (including laboratory samples analysis; diagnostic technologies); (*Biomaterials to be 2.9 [physical characteristics of living material as related to medical implants, devices, sensors]*);

2.7 Environmental engineering

- Environmental and geological engineering, geotechnics; Petroleum engineering, (fuel, oils), Energy and fuels; Remote sensing; Mining and mineral processing; Marine engineering, sea vessels; Ocean engineering;

2.8 Environmental biotechnology

- Environmental biotechnology; Bioremediation, diagnostic biotechnologies (DNA chips and biosensing devices) in environmental management; environmental biotechnology related ethics;

2.9 Industrial biotechnology

- Industrial biotechnology; Bioprocessing technologies (industrial processes relying on biological agents to drive the process) biocatalysis, fermentation; bioproducts (products that are manufactured using biological material as feedstock) biomaterials, bioplastics, biofuels, bio-derived bulk and fine chemicals, bio-derived novel materials;

2.10 Nano-technology

- Nano-materials [production and properties];
- Nano-processes [applications on nano-scale]; (*biomaterials to be 2.9*);

2.11 Other engineering and technologies

- Food and beverages;
- Other engineering and technologies;

3. Medical and Health sciences

3.1 Basic medicine

- Anatomy and morphology (*plant science to be 1.6*); Human genetics; Immunology; Neurosciences (including psychophysiology); Pharmacology and pharmacy; Medicinal chemistry; Toxicology; Physiology (including cytology); Pathology;

3.2 Clinical medicine

- Andrology; Obstetrics and gynaecology; Paediatrics; Cardiac and Cardiovascular systems; Peripheral vascular disease; Hematology; Respiratory systems; Critical care medicine and Emergency medicine; Anaesthesiology; Orthopaedics; Surgery; Radiology, nuclear medicine and medical imaging; Transplantation; Dentistry, oral surgery and medicine; Dermatology and venereal diseases; Allergy; Rheumatology; Endocrinology and metabolism (including diabetes, hormones); Gastroenterology and hepatology; Urology and nephrology; Oncology; Ophthalmology; Otorhinolaryngology; Psychiatry; Clinical neurology; Geriatrics and gerontology; General and internal medicine; other clinical medicine subjects; Integrative and complementary medicine (alternative practice systems);

3.3 Health sciences

- Health care sciences and services (including hospital administration, health care financing); Health policy and services;
- Nursing; Nutrition, Dietetics;
- Public and environmental health; Tropical medicine; Parasitology; Infectious diseases; epidemiology;
- Occupational health; Sport and fitness sciences;
- Social biomedical sciences (includes family planning, sexual health, psycho-oncology, political and social effects of biomedical research); Medical ethics; Substance abuse;

3.4 Medical biotechnology

- Health-related biotechnology; Technologies involving the manipulation of cells, tissues, organs or the whole organism (assisted reproduction); Technologies involving identifying the functioning of DNA, proteins and enzymes and how they influence the onset of disease and maintenance of well-being (gene-based diagnostics and therapeutic interventions (pharmacogenomics, gene-based therapeutics); Biomaterials (as related to medical implants, devices, sensors); Medical biotechnology related ethics;

3.5 Other medical sciences

- Forensic science
- Other medical sciences

4. Agricultural sciences

4.1 Agriculture, Forestry, and Fisheries

- Agriculture; Forestry; Fishery; Soil science; Horticulture, viticulture; Agronomy, plant breeding and plant protection; (*Agricultural biotechnology to be 4.4*)

4.2 Animal and Dairy science

- Animal and dairy science; (*Animal biotechnology to be 4.4*)
- Husbandry; Pets;

4.3 Veterinary science

4.4 Agricultural biotechnology

- Agricultural biotechnology and food biotechnology; GM technology (crops and livestock), livestock cloning, marker assisted selection, diagnostics (DNA chips and biosensing devices for the early/accurate detection of diseases) biomass feedstock production technologies, biopharming; agricultural biotechnology related ethics;

4.5 Other agricultural sciences

5. Social sciences

5.1 Psychology

- Psychology (including human - machine relations);
- Psychology, special (including therapy for learning, speech, hearing, visual and other physical and mental disabilities);

5.2 Economics and Business

- Economics, Econometrics; Industrial relations;
- Business and Management;

5.3 Educational sciences

- Education, general; including training, pedagogy, didactics;
- Education, special (to gifted persons, those with learning disabilities);

5.4 Sociology

- Sociology; Demography; Anthropology, ethnology,
- Social topics (Women's and gender studies; Social issues; Family studies, Social work);

5.5 Law

- Law, criminology, penology;

5.6 Political science

- Political science; public administration; organisation theory;

5.7 Social and economic geography

- Environmental sciences (social aspects); Cultural and economic geography; Urban studies (Planning and development); Transport planning and social aspects of transport (*transport engineering to be 2.1*);

5.8 Media and communications

- Journalism; Information science (social aspects); Library science; Media and socio-cultural communication;

5.9 Other social sciences

- Social sciences, interdisciplinary;
- Other social sciences;

6. Humanities

6.1 History and Archaeology

- History (*history of science and technology to be 6.3, history of specific sciences to be under the respective headings*); Archaeology;

6.2 Languages and Literature

- General language studies; Specific languages; General literature studies; Literary theory; Specific literatures; Linguistics;

6.3 Philosophy, Ethics and Religion

- Philosophy, History and philosophy of science and technology;
- Ethics (except ethics related to specific subfields); Theology; Religious studies;

6.4 Arts (arts, history of arts, performing arts, music)

- Arts, Art history; Architectural design; Performing arts studies (Musicology, Theater science, Dramaturgy); Folklore studies;
- Studies on Film, Radio and Television;

6.5 Other humanities

ANNEX 2

COMPARISON OF THE REVISED FOS CLASSIFICATION WITH THAT IN FM 2002

| | FOS in FM 2002 | Revised FOS |
|---------------------------------------|--|---|
| 1. Natural Sciences | 1.1 Mathematics and computer sciences 1.2 Physical sciences 1.3 Chemical sciences 1.4 Earth and related environmental sciences 1.5 Biological sciences | 1.1 Mathematics 1.2 Computer and information sciences 1.3 Physical sciences 1.4 Chemical sciences 1.5 Earth and related environmental sciences 1.6 Biological sciences 1.7 Other natural sciences |
| 2. Engineering and Technology | 2.1 Civil engineering 2.2 Electrical engineering, electronics 2.3 Other engineering sciences | 2.1 Civil engineering 2.2 Electrical engineering, electronic engineering, information engineering 2.3 Mechanical engineering 2.4 Chemical engineering 2.5 Materials engineering 2.6 Medical engineering 2.7 Environmental engineering 2.8 Environmental biotechnology 2.9 Industrial Biotechnology 2.10 Nano-technology 2.11 Other engineering and technologies |
| 3. Medical and Health Sciences | 3.1 Basic medicine 3.2 Clinical medicine 3.3 Health sciences | 3.1 Basic medicine 3.2 Clinical medicine 3.3 Health sciences 3.4 Health biotechnology 3.5 Other medical sciences |
| 4. Agricultural Sciences | 4.1 Agriculture, forestry, fisheries and allied sciences 4.2 Veterinary medicine | 4.1 Agriculture, forestry, and fisheries 4.2 Animal and dairy science 4.3 Veterinary science 4.4 Agricultural biotechnology 4.5 Other agricultural sciences |
| 5. Social Sciences | 5.1 Psychology 5.2 Economics 5.3 Educational sciences 5.4 Other social sciences | 5.1 Psychology 5.2 Economics and business 5.3 Educational sciences 5.3 Sociology 5.5 Law 5.6 Political Science 5.7 Social and economic geography 5.8 Media and communications 5.7 Other social sciences |
| 6. Humanities | 6.1 History 6.2 Languages and literature 6.3 Other humanities | 6.1 History and archaeology 6.2 Languages and literature 6.3 Philosophy, ethics and religion 6.4 Art (arts, history of arts, performing arts, music) 6.5 Other humanities |