MEGASCIENCE: THE OECD FORUM

CONNECTIONS AMONG SCIENTISTS, AGENCIES AND GOVERNMENTS IN DECISION MAKING FOR REGIONAL AND/OR GLOBAL MEGAPROJECTS

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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During its 5th meeting, on 7 and 8 July 1994, the Megascience Forum discussed the Chairman’s Conclusions resulting from the Forum’s review of the field on Particle Physics. The Summary Record of this Meeting, held in Villigen (Switzerland) says that “With regard to interaction between the scientific community and governments and the need for an interregional mechanism for communication among governments, the Megascience Forum discussed the three-stage process mentioned in the Conclusions of the Villigen meeting. Stressing the importance of interaction neither too early nor too late and in order to work out concrete forms for it, the Forum discussed the possibility of case studies based on existing examples of planning within the scientific community, e.g. for the next generation of linear colliders. Such a study would focus on connecting the stages of the planning process in the scientific community, where factors such as scientific priority and technological feasibility are dominant, with the planning and decision processes within governments, which are governed by budgetary forecasts and broad policy priorities.” (OECD, Particle Physics, 1995)

A study group was formed in order to develop concrete ideas on how to set up the “three-stage process” and to link, in a coherent way, the three levels of actors which are comprised of national and international scientific community in a particular field of science, national funding agencies (or equivalent bodies), and the governments at both national and international level. The study group included: Prof. S. Wojcicki (Stanford University, United States), Dr. K. Nakai (National Laboratory for High Energy Physics, KEK, Japan), Mr. H. von Bülow (Chairman of the JET Council, Denmark), and Dr. K.H. Chang (Director, FOM, the Netherlands) with the assistance of Mr. H. van Vuren (Science Policy Department, FOM, the Netherlands).

The group worked during the first several months of 1995, had a meeting in Amsterdam on 27-28 February 1995, and generally communicated among themselves by e-mail. The group developed recommendations, not focusing on any specific project, but analysing the ability of the existing decision-making procedure in various countries to adapt to regional or global megaprojects decision. This document was presented and discussed by the Megascience Forum at their meeting of 12-13 June 1995.
PART I: RECOMMENDATIONS ON DECISION-MAKING PROCESSES FOR REGIONAL AND/OR GLOBAL MEGAPROJECTS

In decision-making processes for regional and/or global megaprojects, four phases can be distinguished: 1. project definition; 2. project evaluation under the responsibility of agencies; 3. conveying information among agencies and to governments; and 4. intergovernmental negotiation. With regard to these phases, we recommend the following guidelines. They are addressed to the three levels of actors that play a key role in these processes: scientific community, science agencies (including research councils) and governments.

General

1. Given the progress of scientific and technical development, the increase in the scale of research facilities as well as the scarcity of resources, there soon will arise a growing need for wide international collaboration on large facilities. The scientific community, science agencies and governments all over the world are urged to take this natural development seriously and to start organising the decision-making process for such projects on a regional or even a global basis.

2. The establishment of large regional or even global installations should not be seen as an objective in itself, but as a means to realise facilities which, by reason of their scale, can no longer be achieved through national or regional co-operation.

Project definition (phase 1)

3. Whether a project for a large facility is on a national, regional or global scale, the position and purpose of the project within the international scientific landscape should be agreed upon by the particular international scientific community concerned as a whole. It is therefore advisable to have a broad spectrum of members of that scientific community involved in defining the project from the very early stages. Such an international approach can be an effective way to place the project in a world-wide perspective and avoid duplication of effort in various countries.

4. The organisation of the entire international scientific community needs to be adapted to undertake the activities required for defining megaprojects. Among others, the International Council of Scientific Unions (ICSU) and the international scientific unions could be appropriate bodies to stimulate and conduct this process, if necessary.

For the project definition of multi-user facilities, special attention should be paid to organising the multi-disciplinary user community and ensuring their links with the designers/builders of the machine.

5. National science agencies (including research councils) should make funds available to enable scientists/engineers belonging to a particular scientific community to participate in and contribute to the activities of the project definition phase, mainly by organising meetings/workshops and preliminary (feasibility) studies. Such support does not in any sense
commit a science agency to a future policy position. Costs of personnel and preliminary R&D will normally be at the expense of the institutions involved.

6. It is strongly recommended to involve relevant actors from outside the OECD area (Eastern Europe, China, developing countries, etc.) in the project definition. So, a lack of funds for participating in the final project should not mean exclusion at the start of the discussions. The leading countries should facilitate involvement from outside the OECD countries by contributing to travel and accommodation expenses.

**Project evaluation under the responsibility of agencies (phase 2)**

7. The science agencies should first be organised at a regional level (e.g. Asia-Pacific, Europe, North America) taking into account differences in regional circumstances and also, in due time, at a global level, as actual developments in the various fields of science warrant. The OECD Megascience Forum or its successor is an appropriate body for encouraging this process, if initiatives such as EUROHORCS in Europe do not gain the necessary momentum.

8. The (joint) science agencies should set up a (regional) clearing-house with three functions:

a) to act as the "post-box" to which members of an international scientific community can submit their project proposals;

b) to inform the member agencies and other related science agencies about the proposals received;

c) to bring together an *ad hoc* set of potentially interested science agencies to organise a broad and detailed evaluation of the proposal.

**Conveying information among agencies and to governments (phase 3)**

9. On the basis of the conclusions of an independent evaluation organised by these science agencies, other science agencies and governments can be informed about the project proposal (adapted if necessary) and the conclusions of the evaluation.

In this respect we welcome the recent decision of the OECD Megascience Forum to advocate the establishment of *ad hoc* working groups under the aegis of the Megascience Forum, in its second mandate (subject to the agreement of the Committee for Scientific and Technological Policy at its 26-27 September 1995 meeting at Ministerial level).

Once the project definition phase is well under way, an SLSP decision to create an *ad hoc* working group -- with representatives from governments and science agencies/research councils -- would enable all the actors involved to start consultations at the right moment.

**Intergovernmental negotiation (phase 4)**

10. Recommended action no. 7 in "A Proposal for a Follow-on to the OECD Megascience Forum" (21 February, 1995) is fully endorsed. It reads:
"If opportunities for co-operation are identified in a Working Group, interested governments will decide (in conformity with their national decision-making procedures) whether they wish to participate in discussions leading to the negotiation and implementation of international projects. The appropriate forum and modalities for such discussions will be decided on a case-by-case basis. The responsibility for negotiating the final agreement and administering the co-operation will reside with participating governments. Only those countries interested in the particular activity will participate."
PART II:  DEMARCATION AND INTERPRETATION

1.  Introduction and general remarks

1.1  Task and composition of the study group

This report was prepared at the request of the OECD Megascience Forum by a group of five consultants. The members of the study group were:

- Mr. H. von Bülow (Denmark; Chairman, Joint European Torus Council, JET);
- Dr. K.H. Chang (The Netherlands; Director, Stichting Fundamenteel Onderzoek der Materie, FOM; and Chairman, European Union of Physics Research Organisations, EUPRO);
- Dr. K. Nakai (Japan; Head of the Experimental Programming and Planning Division, National Laboratory for High Energy Physics, KEK; and science advisor to the Ministry of Education, Monbusho);
- Prof. S. Wojcicki (United States; Professor of Physics, Stanford University; and Chairman, High Energy Physics Advisory Panel, HEPAP);
- Mr. H.G. van Vuren (The Netherlands; Head, Science Policy Department, Stichting Fundamenteel Onderzoek der Materie, FOM).

It must be stressed that the opinions expressed in this report are those of the individuals involved and not those of the countries and the organisation they represent.

1.2  Relevant literature

After several weeks of individual preparation, the group of consultants started its work at the end of February 1995. The consultants took note of the fact that the OECD Megascience Forum has produced a wealth of information/documents, including:

- the seven titles published in the series "Megascience: The OECD Forum", especially Particle Physics and the conclusions of the corresponding Expert Meeting;

The consultants were informed of the conclusions of the OECD Megascience Forum meeting in January 1995 concerning a proposed follow-on body to the OECD Megascience Forum.
1.3 Definition of the study

The consultants realise that one of the key issues for the OECD Megascience Forum is the wish to have inter-regional mechanisms for consultation among scientific communities, scientific organisations (including research councils) and government officials in which each partner enters the scene neither too early nor too late.

In our discussions, we identified three main types of projects:

- large facilities for basic science;
- research programmes on general problems concerning planet Earth, nature, man and society;
- development programmes for emerging industrial technologies.

The consultants decided to focus solely on mechanisms for consultation with respect to the projects for large facilities for basic science.

This topic is developed in Section 2, and Section 3 is devoted to a definition and discussion of key terms. The recommendations reached by the consultants, mainly on the basis of Chapters 1-3, were presented in Part I.

To a significant extent, however, the different existing decision-making processes with which individual consultants are most familiar also influence the group’s conclusions and recommendations. In Annexes I-III, therefore, the consultants have presented separate decision-making processes in the three regions/countries represented in the group: the United States, Japan and Europe. Annex IV pays special attention to the on-going global fusion energy research project ITER.

2. Focusing on the scope of the study

Even in a single country, decision making for a large national research facility is a complex process. In general, three actors play an important role: the scientific community, one or more science agencies, and the government. There is some hierarchy involved; moreover, all actors have their own justified motives, opinions and wishes, which have to be communicated in order to reach a mutually satisfactory compromise. The quality of the decision-making process and the solidity of the final decision require good connections among the different actors. Hence, a more or less complicated process with repeated forward and backward coupling is inevitable.

Decision-making on large international scientific projects is even more complex. Independent nations with different science systems, science and technology policies, traditions, policy cultures, interests, etc., must reach total agreement. Thus, in addition to the vertical connections in individual countries, horizontal links must be forged among scientific communities, science agencies and governments of many different countries (see Figure 1).
Our study seeks to identify the problems that may occur in the decision-making process before a large international facility is built. As the study does not focus on any single particular case, this is to some extent an abstract exercise. We have tried to generalise from our varied experiences with large facilities and international collaborations. To some extent, these experiences are presented in the descriptions and observations of the American, Japanese, and European situations as seen individually by members of our study group (see the Annexes).

### 3. Definition of key terms

#### 3.1 Characteristics of large international projects

Our recommendations concern projects with the following characteristics:

- The project’s main objective is to be instrumental in furthering basic science.

- The project concerns a single facility at a single site (e.g. a synchrotron radiation source) or an integrated system of a restricted number of smaller facilities at different sites run under regional or global control (e.g. a network of related detectors to measure gravitational waves). (Megaprogrammes, such as the Human Genome and Global Change, which also require large resources and international co-operation, but typically not in the form of very large single-site facilities or large-facility networks, are not included here.)

- The project requires very considerable budgets, typically an investment budget of more than $1 billion and/or a running budget of more than $0.2 billion a year.

- A facility is defined as global when it involves inter-regional co-operation, i.e. when it involves two or more countries and extends across regions (Europe, America, Asia-Pacific). A European facility, an Asia-Pacific facility, or a US-Canadian facility are considered to be regional.
– It is useful to distinguish between a multi-user facility (e.g. a space lab or neutron source which can serve several purposes and several scientific disciplines) or a mono-user facility (e.g. a particle accelerator exclusively used for high energy physics).

Of course, this does not mean that our general recommendations are not valid for other situations as well. They might well apply to smaller facilities, other modes of international co-operation and projects aimed at applied science or technological development.

3.2 Acts and their responsibilities

Our study focuses on the role of major actors in the decision-making process; they engage in intense interaction throughout the process, thereby influencing one another. They are grouped here according to three levels:

a) the scientific community includes individual scientists or groups of scientists, university faculties, national laboratories and research institutes, and international scientific organisations;

b) the scientific agencies comprise research councils or any other institutional structure that takes part in an evaluating or consultative capacity in the decision-making process;

c) the governments include not only the responsible government departments concerned with science and the funding of science, with their planners and other officers (departments of science and finance, foreign services and possible other parties concerned), but also the national parliaments, to the extent that they are directly involved in the decision-making process.

Although they are not discussed here, we realise that other actors, e.g. the public and industry, also play an important role. Moreover, we are aware that the actual responsibilities of the three groups of actors that we consider differ in different countries. For this reason we distinguish among them on the basis of their functional roles. Thus, the US Department of Energy performs the role both of science agency and, in part, of the government. While the Japanese National Inter-university Research Institutes represent the scientific community, they may also play to some extent the role of science agency.

Generally speaking, the original impetus for scientific projects comes from a scientific community. The community concerned has the expertise to define the best scenario for the scientific development of a given area and, as a consequence of its scientific strategy, has to define the best "machines" to pursue its goals.

It is the role of the scientific community to prepare the scientific and technical case on the basis of a general consensus and firm support on the part of its members and to present the best project proposal, from the scientific point of view, to the science agencies.

It is the role of the science agencies to organise an independent assessment of the proposals with regard to the scientific case, the technical feasibility and the required budget. The agencies are expected to act as co-ordinators for the scientific community and for government, and to have enough information on budget prospects, claims on resources, and competing plans in the same and other scientific areas to set the priority of the project from a scientific point of view. Finally, it is the agencies' role to formulate recommendations to governments regarding possible policy positions.
It is the competence of the governments (including the related parliaments) to decide on their countries’ participation in large international projects and to fix their contribution to the total budget. In completing the decision-making process, other considerations may also play a role: socio-economic aspects, a nation's science policy, negotiations with governments of other countries, and so on.

3.3 Phases in the decision-making process

In the decision-making process for large international projects, we schematically distinguish four functional phases. This distinction is the basis of our recommendations in Part I.

Project definition

This phase covers the following activities:

− establishment of the scientific case within the scientific community through workshops, conferences, etc.;

− study of technical options (including a review of the R&D status) and assessment of machine specifications;

− preliminary design of the facility;

− identification of spin-offs;

− budget estimate for initial investments as well as for running costs;

− science and technology considerations with regard to choice of site (see OECD, *Megascience Policy Issues*, Chapter 4).

For practical reasons, these activities can best be undertaken by ad hoc groups of scientists and/or engineers. Of course, there has to be strong co-ordination. The results of these activities are part of the final project proposal.

Project evaluation under the responsibility of agencies/research councils

The main part of the evaluation can be done by one or more expert groups set up by the agencies. For a multi-user facility, the demands of the non-homogeneous users’ group deserves special attention. At the end of this phase, the agencies themselves must draw their own conclusions about the project proposal.

Conveying information among agencies and to governments

In the first place, agencies have to exchange among themselves the conclusions they reach in phase 2 and their policy positions and/or ideas with regard to a possible follow-up. Second, the agencies have to inform their governments about their own opinion and the opinion of agencies in other countries.
**Intergovernmental negotiation**

The main subjects in this phase are a country’s interest in joining the proposed project (intention), its interest in co-ownership, budgets for construction, and, at a later stage, operating costs of the facility. Important other items are users’ access to the facility, the choice of site, and the legal status of the international enterprise.

We stress that the four phases do not constitute a linear sequence. There will be a continuous exchange of information and views in each country among the scientific community, the science agencies, and the government, bottom-up as well as top-down, but such exchange will also take place among the scientists, science agencies and governments of the various countries involved. So, in practice, there are a number of feedback and feed-forward loops. In itself, this is a sound situation: it will keep all actors in the process well informed at all times, thereby preventing sudden disappointments and accidents.

This process of communication can be stimulated by the working groups that the OECD Megascience Forum will be entitled to establish in its second phase.
PART III: ANNEXES

Please note that all acronyms used are fully defined in the List of Acronyms at the end of the document.
ANNEX I: DECISION MAKING FOR GLOBAL MEGAPROJECTS: THE CURRENT US SITUATION

S. Wojcicki

1. Introduction

For the purpose of this report, we describe the evolution of big science projects through four distinct phases: conceptualisation, evaluation (a review), information exchange (between agencies and to governments), and governmental decision (or intergovernmental negotiations in the case of international projects). We also define groups of actors: scientific community, scientific agencies, and government. We examine the interaction of these actors as the project proceeds through its four phases and describe the current situation in the United States. For clarity’s sake, some simplifications and generalisations are made which may not necessarily apply to all cases.

2. Definition of actors

The three "levels" involved in the decision-making process for large scientific projects --- scientific community, appropriate agencies, and government -- need to be defined for each region or country. The disparity probably occurs in the definition of agencies. In the situation of Italy and France, the obvious agencies are the INFN and the CNRS, but the US equivalent is less clear. I propose that we define the "agencies" as the government-constituted body (bodies) that play the major official role in recommending for or against a specific large scientific project. What is implicit here is that this agency may have as its task to decide among competing scientific projects, but not between a scientific project and another possible use of government funds, e.g. on an aircraft carrier, subsidies to agriculture, reduction of deficit, etc. It is the third level of decision making, the government, that makes the latter decisions. According to this definition, good examples of agencies in the United States would be NSF, NASA, NIH and parts of the Department of Energy (DOE) (and to a lesser extent the Department of Defense -- DOD). I would propose that the scientific part of the DOE, i.e. the OER, be classified as an agency for this discussion and that the higher echelons of DOE be included as part of the third level.

The other major distinction between the United States and the other regions lies in the duality of the decision-making process at the government level, both the Congress and the Executive Branch being relevant participants. It is essential to consider the role played by each. Both the Congress and the Executive Branch play an essential role in the budgetary process, but the focus of their activities occurs at different times.

Thus, for the United States, the three actors can be defined as:

- the scientific communities;
- the agencies, i.e. mainly NSF and DOE (from the director of OER down);
We proceed next to discuss the roles played by these three actors during the evolution of the project.

3. Conceptualisation phase

It is traditional in the United States for large scientific projects to originate from the bottom up. Thus, the original impetus comes from the scientific community, which plays the main role during the conceptualisation phase. The role of the scientific community starts with the original idea, proceeds to its refinement through discussions and R&D (at both national and international levels), then continues by building a scientific case for it. During this phase, the scientists will mainly interact with the appropriate scientific agency but some interaction with the government level also takes place.

Interaction with other levels will evolve as the project develops. Large scientific projects generally originate in response to the perception that a new tool is needed to address the frontier problems in the field. Frequently, a large stimulus is provided by significant new advances in technology: what was not feasible (technically or economically) earlier may now be possible. Large scientific projects may be totally new or may represent a major upgrade of an existing facility.

The initial stage, i.e. planning and early R&D, involves only minimal interaction with the agencies or the government. The agency staff at the programme level keeps abreast of these plans by attending scientific meetings, performing on-site reviews of laboratories (which are generally centres of this effort), and reviewing budgetary proposals. Thus, the conceptualisation and evaluation phases are not completely distinct. The distinction is mainly one of degree, as reviews and monitoring of progress play a relatively minor role during the initial phase.

During the conceptualisation stage, there might be extensive interaction with scientific communities abroad, even if the project is planned as a national project. On the part of the proponents, this is due to the desire to draw on specialised expertise abroad; on the part of the potential users from other countries, it is motivated by a desire to influence the design so as to maximise eventual scientific productivity and at the same time to position themselves so as to be able to participate effectively in the exploitation of the new facility.

4. Evaluation phase

When the project becomes more mature, interaction between the scientific community and the agencies becomes more formal and extensive. The agency will generally conduct extensive reviews of the project, frequently with participation of uninvolved experts from the scientific communities both at home and abroad. The standing advisory group to the agency (e.g. HEPAP, NSF Physics Advisory Committee) will be asked to review and comment. If two or more projects are competing for funds or relative priority at this time, the advisory group may be asked to establish scientific priority, sometimes through an ad hoc panel convened in close collaboration with the agency. The outcome of this process is the agency’s recommendation to the government (e.g. to the Department Secretary) for or against a given project. The agency’s response will be shaped by the projected budgetary situation both for the immediate fiscal year and for future years (equally important for multi-year projects). The outyear projections originate from
negotiations at the top levels in the Executive Branch: President's Office, OSTP, OMB, and Department Secretaries.

Except in given subfields (e.g. high energy physics, fusion research) the scientific community has found it difficult, perhaps impossible, to set priorities among different projects. The American Physical Society has traditionally shied away from such activities. The National Academies, through the National Research Council, have conducted periodic evaluations of status and opportunities in different fields (e.g. the Brinkman report) but have been reluctant to participate in setting priorities. The NRC has also been involved in specific projects through publication of in-depth position papers (referred to as research briefings) on issues that may be relevant to a project under consideration.

The ultimate responsibility for the evaluation of the project (and deciding whether to recommend its funding) rests with the agency, even though in reaching this decision it draws extensively on advice and input from the scientific community. The scientific agencies play the role of intermediary between the scientific community and the government. They are frequently viewed as part of the scientific community by the government, but as part of the government by the scientific community. Their role is to oversee scientific activities in general, and therefore they play a major role in evaluating future projects. Their interaction with the scientific community has been described above. They have the primary role in recommending for or against a given project, in defining its schedule and funding profile, and, if appropriate, in adjudicating between competing projects. This last encompasses choices between projects in different scientific subfields; the expected funds may not be sufficient for funding everything that is presented and is scientifically worthwhile. Sometimes these choices are made after taking advice from special ad hoc committees, e.g. the panel, chaired by C. Townes, convened by the Director of OER, W. Happer, to offer advice on the relative importance of several new large initiatives.

The scientific community interacts to some extent with the government sector during this phase through contacts with members or committees of the US Congress. Members of Congress periodically interact with the senior staff of laboratories in their own or neighbouring districts. Senior members of the scientific community periodically testify before the US Congress about their scientific programme and about future projects. In some cases involving larger projects, special hearings might even be held on these projects. This, however, does not ordinarily happen until the third phase, when the project has received a positive evaluation by the agency and been forwarded to the higher levels of the government for final decision.

Of course, the scientific community also interacts with the Administration through informal contacts with the different members of the Executive Branch and participation in advisory groups which report directly to the Secretaries. Most of these interactions, however, are channelled through the agencies.

5. Information exchange phase

It is the role of the agencies to present the case for new projects, and hence for funds, to the government level. Within the DOE, support and approval is needed from the Secretary's office. This may require adjudicating competition between scientific projects and expenditures outside of science. Subsequently, the relevant departments will present and argue their case with the OMB, a government body charged with formulating an overall budget. The President’s Science Adviser (through OSTP) may give important input at this stage, especially in the case of large and expensive projects.
The agencies also have some interaction with the legislature, largely once a given agency has decided to seek funding for a given project. Thus, for example, the Director of NSF and the Director of OER in DOE periodically testify before the US Congress about the programmes for which they are responsible. Agency staff may also interact more informally with the Congressional staff and will generally be responsible for preparing replies to inquiries from Congress.

When it comes to potential international projects, the agencies will take the lead in the initial negotiations, but OSTP will provide general guidelines from the national perspective. For example, the leadership in the initial negotiations with CERN on US participation in the LHC would be provided by the Director and Deputy Director of the OER. Members of the US scientific community would generally be involved in these negotiations in an advisory capacity. For new projects, the agencies would conduct initial discussions to determine whether there is joint interest in a given project and if so, pass this information to their respective governments for a final decision.

6. Decision phase

The governments make the final decision as to whether to proceed with a given national project. They also make the final decision as to whether their country will participate in an international scientific project. This decision will be made after extensive discussion with their opposite numbers in other countries. If the decision is positive, they will have ultimate responsibility for negotiating the conditions of their co-operation and for overseeing the execution of the project. For some international projects, especially those where the United States is expected to play a leading role, a decision to proceed might be taken before international negotiations are concluded. Based on the SSC experience, however, that is not viewed as the best way to ensure international participation.

The budgetary (and hence decision-making process) in the United States can be viewed as a two-step process: initially, the Administration "proposes"; subsequently, the Congress "disposes". Formally, there is also a third step, namely the signing of the appropriations bill, and hence its final approval by the President, but changes are seldom made at this stage. The initial "proposal" stage of the process involves a submission of budgets by different departments to OMB. These budgets will take cognizance of long-term budgetary guidelines; from the programmatic point of view they should be consistent with the national scientific and technological priorities formulated under the leadership of OSTP. There are some back-and-forth negotiations at this level, which eventually result in the overall US budget presented by the President to the Congress, typically at the end of January, for the fiscal year starting 1 October of the same year. For a large and highly visible project, the President might be personally involved in the decision process.

The budget process subsequently enters its second stage, i.e. debate by the US Congress, and substantial modification of the budget, hence of the scientific programme, are possible at this time. Congress has to give explicit approval to initiate a new large project, and it has the power to terminate it at any time by refusing to appropriate funds for its continuation. Support or opposition to science projects generally does not split along party lines; thus, control of the White House and Congress by different parties is not necessarily a large impediment to the final approval of a project.

As mentioned before, the Congressional approval process involves significant interaction with the appropriate science agencies and, to a somewhat lesser extent, with representatives of the scientific communities. The yearly approval process for the budget presents some drawbacks for large projects which may take up to a decade to build. Very likely some means to circumvent or alleviate this problem
will have to be found for international projects; foreign governments may be quite reluctant to embark on co-operation without some assurance that the US commitment will continue all the way to completion.

Figure 2. Schematic of US decision-making process (national projects)
ANNEX II: MEGASCIENCE DECISION-MAKING PROCESSES:  
THE CURRENT SITUATION IN JAPAN

K. Nakai

1. Introduction

Because the decision-making processes for megascience projects in Japan differ in different fields, it is very difficult to make a general presentation of decision-making mechanisms. This paper therefore presents typical cases in academic basic science. It is also difficult to explain the existing Japanese mechanisms in terms of the “three actors” and “four phases”, and no attempt is made to do so.

Among the various decision-making mechanisms used, particle and nuclear physics offer the best example of a bottom-up process. This mechanism was first developed in the 1950s, when, thanks to the efforts of Professors S. Kikuchi, S. Tomonaga and H. Yukawa, the Yukawa Institute in Kyoto University and the Institute for Nuclear Study (INS) at the University of Tokyo were founded. It has been very effective for the healthy and peaceful evolution of Japanese scientific activities in the past half century since the disastrous situation after the Second World War. The INS cyclotron and electron synchrotron, the KEK proton synchrotron and electron-positron colliders (TRISTAN) as well as the synchrotron-radiation facility (KEK-PF) were realised on the basis of this mechanism, as were the successful Kamiokande experiments and the new super-Kamiokande. This report describes the Japanese bottom-up mechanism for large projects in fundamental science. Section 2 presents the Japanese system and Section 3 the bottom-up mechanism. Other examples of Japanese megascience projects will be discussed in Section 4. Finally, Section 5 discusses Japanese efforts for the future.

2. The Japanese systems

2.1 Ministries

Funding for scientific activities involves several governmental bodies in the following five ministries:

– Ministry of Education, Science and Culture (Monbusho);
– Science and Technology Agency (STA);
– Ministry of International Trade and Industry (MITI);
– Ministry of Agriculture, Forestry and Fisheries;
– Ministry of Health and Welfare.

While the other bodies provide funds for in mission-oriented projects, Monbusho’s role is to promote scientific research in universities and in inter-university research institutes. Of the five ministries, Monbusho and STA are most relevant for megascience, although other ministries, such as MITI, carry out megaprojects as well. Both Monbusho and STA have megaprojects in space science, nuclear science, nuclear fusion research, neutron sources and synchrotron radiation, materials science, life sciences, etc., but high energy particle physics and astronomical research are covered mainly by Monbusho.
Monbusho and STA differ in their decision-making mechanisms. Monbusho, which covers academic science activities, takes a “bottom-up” approach based almost exclusively on general consensus and support by the scientific communities. The STA’s decision-making mechanisms are different, as its programmes are mostly based on national or social needs, although some projects, like SPring-8, are motivated by both industrial and academic interests.

2.2 The Science Council of Japan

The Science Council of Japan (JSC) is an organisation which represents Japanese scientists. It is under the Office of the Prime Minister, and its members are appointed on the basis of elections in which all Japanese scientists take part. While it does not fund projects, it plays an important role in promoting scientific activities through discussion among scientists in committees and/or subcommittees.

The views of JSC, which are sometimes presented as recommendations, play a very important role in decision making. JSC support for a megaproject does not ensure a positive decision by Monbusho, but may be a necessary condition. JSC recommendations are, in any case, a very influential aspect of the review activity for decisions by Monbusho’s Science Council.

2.3 Monbusho’s Science Council

Monbusho’s Science Council gives advice and makes suggestions on scientific policy to the Minister of Education, Science and Culture at his request. Council members are appointed by the government. The Council consists of eminent scientists representing all scientific fields and non-academic members who represent the opinion of industry and society in general. When a proposal for a large project is brought to Monbusho, the Science Council examines its scientific justification as well as the technical and financial feasibility of the project in appropriate committees and/or subcommittees. JSC’s recommendation, or opinion, is one of the most important factors in this examination. With the help of government officials it examines, in addition to scientific and technical justifications, the financial feasibility of the project, including long-range planning. When the project is recommended to the Minister, Monbusho must defend it to the Ministry of Finance, whose positive decision is the final goal.

3. The bottom-up decision-making process for academic projects in Japan

3.1 High energy physics projects

A typical bottom-up decision-making mechanism for high energy physics projects in Japan is shown schematically in Figure 3.
Figure 3. Bottom-up decision-making mechanisms for academic research projects in Japan
**Project definition and review activities in scientific communities**

The proposal for a large accelerator project starts with a community of scientists. In the field of nuclear science (particle and nuclear physics), physicists work in four areas -- high energy physics, nuclear physics, cosmic ray physics and theoretical physics. Each group has a steering committee (independent of any governmental activities), and discussions in these communities are most important for initiating a proposal for a new project. Occasions such as workshops, town meetings, and/or physical society meetings are used to discuss the community’s scientific motivations and interests.

When the project has been defined and meets with the approval of the community, the committee brings the proposal to the Nuclear Science Committee of the JSC whose members are appointed as described above. A proposal from the group is then discussed by members from all four groups in nuclear science. Quite often the proposal competes with those from other groups.

The proposal is then presented to all physicists in the Physics Liaison Committee of the JSC. This is an important step not only for obtaining consensus but also for stimulating possible spin-off activities. Through these review activities in the JSC committees, the project is polished, and, when necessary, the general assembly of JSC makes a recommendation to the government.

**Governmental activities**

The government’s efforts start with critical reviews of the project in the Accelerator Science Subcommittee of Monbusho’s Science Council. When the subcommittee responds positively to the proposal, Monbusho officials contact experts in the national inter-university research institutes (such as KEK), or any other equivalent body, for a more detailed definition of the project. The most critical evaluation and detailed investigation by a government agency takes place in this step. When the subcommittee approves the proposal, it is sent to the Committee on the Promotion of Research in Special Fields, and then to the General Assembly of the Science Council.

On the basis of the suggestion of the Science Council of Monbusho to the Minister, Monbusho makes a budget request to the Ministry of Finance.

The Japanese bottom-up decision-making process may be considered to have a handicap when international negotiations are involved because of its lack of flexibility. It should be emphasized, however, that the Japanese system is extremely reliable once a decision is taken and that the bottom-up mechanism assures majority support for a project. This is a very important feature of Japan’s policy for promoting fundamental science.

3.2 **The case of the SSC: an example of an effort for international co-operation**

Table 1 presents the case of the SSC. Discussions on Japanese involvement in the SSC were started by an unofficial (i.e. non-governmental) committee of high energy physicists; the Nuclear Science Committee, the Physics Liaison Committee and the General Assembly of JSC became involved later. These discussions of the project took place purely within the scientific community. Then, the proposal for US-Japan co-operation on the SSC became a government matter and was examined by the Accelerator Science Subcommittee of Monbusho’s Science Council.
Table 1. Efforts of Japanese scientists and government actions for the SSC project

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr 1984</td>
<td>High Energy Physics Committee (NGO) set up a Future Planning Subcommittee.</td>
</tr>
<tr>
<td>Mar 1986</td>
<td>The Future Planning Subcommittee summarised two years of examination and proposed:</td>
</tr>
<tr>
<td></td>
<td>− immediate start of R&amp;D for construction of a linear collider (JLC) as a domestic facility;</td>
</tr>
<tr>
<td></td>
<td>− promotion of international co-operation at the SSC.</td>
</tr>
<tr>
<td>Mar 1986</td>
<td>High Energy Physics Committee endorsed the proposal by the subcommittee.</td>
</tr>
<tr>
<td>Sept 1986</td>
<td>Nuclear Science Committee, JSC, discussed the Proposal for Future Plan, and sent a Letter of Request to the JSC President for &quot;Promotion of Large-scale International Co-operation in Fundamental Science&quot;.</td>
</tr>
<tr>
<td>June 1990</td>
<td>Physics Liaison Committee, JSC, discussed the SSC project and:</td>
</tr>
<tr>
<td></td>
<td>− endorsed the significant scientific motivation of the SSC;</td>
</tr>
<tr>
<td></td>
<td>− summarised opinions on large-scale international co-operation in fundamental science.</td>
</tr>
<tr>
<td>Apr 1990</td>
<td>Official request for SSC co-operation was made by the US government.</td>
</tr>
<tr>
<td>Dec 1990</td>
<td>Chairman of the Physics Liaison committee sent a letter to the JSC President, summarising the committee's discussion under the following four points:</td>
</tr>
<tr>
<td></td>
<td>− SSC co-operation must be based upon well-developed domestic activities, and Japanese initiatives have to be maintained;</td>
</tr>
<tr>
<td></td>
<td>− the co-operative project must be pursued under the leadership of scientists and not by others;</td>
</tr>
<tr>
<td></td>
<td>− the project must be truly international;</td>
</tr>
<tr>
<td></td>
<td>− the project must be funded without disturbing domestic programmes.</td>
</tr>
<tr>
<td>Nov 1991</td>
<td>The Science Council of Japan (JSC) discussed the SSC project and made the following points to the government:</td>
</tr>
<tr>
<td></td>
<td>− in order to make international contributions in academic fields, domestic research and educational activities have to be maintained at world-class level;</td>
</tr>
<tr>
<td></td>
<td>− current trends towards internationalisation of academic research activities require the government to establish new systems for international co-operation;</td>
</tr>
<tr>
<td></td>
<td>− funds for participation in the SSC project must be considered as separate from the basic funds for domestic activities.</td>
</tr>
<tr>
<td>Apr 1992</td>
<td>The first Working Group (only with governmental officials) was held in Tokyo. The second meeting was in Washington (July 1992).</td>
</tr>
<tr>
<td>May 1992</td>
<td>The Accelerator Science Subcommittee, Science Council, Monbusho, began examination of the SSC project. The project was discussed in six later meetings (until June 1993).</td>
</tr>
<tr>
<td>Oct 1993</td>
<td>The US Government cancelled the SSC project.</td>
</tr>
</tbody>
</table>
Other ministries were also involved in this very large co-operation project. Many aspects of the SSC negotiation were difficult for the Japanese science community because of the United States’ top-down style of negotiation.

4. Further examples

The previous section described academic research projects which are mainly handled by Monbusho. Examples of such large projects are the TRISTAN and B factory projects of KEK, the National Laboratory of High Energy Physics, SUBARU (the optical infrared telescope on Mauna Kea, Hawaii) and the NOBEYAMA Cosmic and Solar Radio Observatory projects of the National Astronomical Observatory, the launching of a scientific satellite by ISAS (the Institute of Space and Astronautical Science), and the construction of a large-scale helical apparatus for nuclear fusion research by the National Institute for Fusion Science. All these projects are managed by the national inter-university research institutes operated by Monbusho.

Although there are differences in the decision-making processes for such projects, especially when the project is being defined by the respective scientific communities, all have been approved through a bottom-up process.

Large projects are also supported by other ministries, such as STA and MITI. However, since those projects are mostly mission-oriented, they were designed and managed under the top-down decision-making systems which are much simpler than the bottom-up procedures for academic projects.

Each ministry mentioned in 2.1 above has councils or committees which make recommendations on large projects in the ministry. Their decisions dominate the decision-making process for mission-oriented projects. Without exception, members of the councils are appointed by the government. Decisions about atomic energy projects at STA, for instance, are made by the Atomic Energy Committee chaired by the minister of STA; its members are appointed by the Prime Minister. Political, economic, and industrial issues are more important than scientific ones in this case.

Unique among STA projects is SPring-8, the synchrotron radiation source. The project started from a proposal by scientists in two institutes, RIKEN and JAERI, operated by STA. Both industrial use and academic research were emphasized in the course of decision making in STA. After its construction was approved, negotiations between STA and Monbusho were started for a supporting mechanism for academic research.1

5. Future perspectives: towards regional co-operation

Although the SSC project was unfortunately cancelled by the US government, it gave Japanese scientists an opportunity to consider what their contribution to international science should be. There has been criticism about the way of participating in international co-operation, as in the case of the SSC or the LHC, where Japan would contribute to financing foreign facilities, and where Japanese physicists would be simply users. The best Japanese contribution to international science should be to build up domestic and/or regional

1 For promotion of synchrotron radiation research, the Science Council of Japan recommended establishing a new institute in 1974. Although the new institute was not established, extensive synchrotron radiation research activities have taken place at the KEK-PF (2.5 and 6-GeV SR facilities), and the Japanese Society for Synchrotron Radiation Research has been established. The research activity at SPring-8 is now supported by those scientists.
activities. Many physicists now believe that Japan must build a world-class large facility together with other Asian countries at some place in Asia.

Among the various efforts needed to encourage activities in Asia, the most important is to build up a strong regional scientific community. Japanese high energy physicists are preparing to form the Asian Committee for Future Accelerators (ACFA) as an equivalent to the European Committee for Future Accelerators (ECFA).

Both direct and indirect approaches to Asian science are important. Such regional efforts must have a broader scope, including education. Not only in the world of science, but also in a more general sense, its contribution to other Asian countries is a top-priority issue in Japanese society, and therefore in the Japanese government. The most important contribution in fundamental science will be to encourage young Asians to enter scientific fields. Efforts to build strong Asian regional activities will also provide a firm base for future global-scale co-operation. Asian contributions to global programmes should not only bring resources, but also new concepts, ideas and methodologies based on a different philosophy from that of Euro-American society.
ANNEX III: DECISION MAKING FOR LARGE SCIENCE PROJECTS:
THE CURRENT SITUATION IN EUROPE

H. von Bülow

and

K.H. Chang

1. General situation

In Europe, fundamental science is not formally co-ordinated or in any other way centrally controlled. Yet by long historical tradition it is strongly developed and interrelated. Through the realisation of a number of major common institutions or other forms of intensive collaboration, Europe has demonstrated in the post-war decades strong will and ability to overcome the many national, cultural -- and indeed linguistic -- barriers across the continent. It is the experience thus garnered that may be assumed to be relevant in global contexts.

Furthermore, whereas fundamental scientific research is by its very nature international and its achievements globally shared and vetted, active collaboration among governments has become the condition sine qua non of major steps towards providing the ever more costly tools that scientists need.

Unlike Japan and the United States, Europe is not a well-defined entity and is changing (growing) all the time. Since the fall of the Berlin wall and the Iron Curtain, all sorts of hitherto contained movements and (disruptive) forces have changed the familiar political landscape. That process is by no means ended. Meanwhile, however, we must remember that even before the dramatic events that heralded the 1990s, scientific collaboration in Europe never presented a uniform or a co-ordinated picture, yet it resulted in the establishment of important scientific institutions.

Leaving aside for the moment whether or not they are examples of megascience, let us look at the membership of the following six European institutions in order of their 1995 membership numbers (noted in brackets after the year of establishment):

CERN (1954, 19) Includes 15 countries from Western Europe and four from Eastern Europe: Poland, Hungary, the Czech Republic and Slovakia. Israel, Russia and Turkey have observer status.

EMBL (1973, 15) All members, except Israel, are western European.

ESA (1975, 14) Founded by fusion of ESRO and ELDO, established in 1964. Finland became a member only in 1995.

ESRF (1985, 12) Organised with only eight contracting parties: the five initiators (France, Germany, Italy, Spain and the United Kingdom) plus Switzerland, Benesync (Belgium and the Netherlands) and Nordsync (Denmark, Finland, Norway and Sweden).
ESO (1962, 8) Brings together a "hard core" of eight countries that are members of all the institutions mentioned so far: Belgium, Denmark, France, Germany, Italy, the Netherlands, Sweden and Switzerland.

ILL (1968, 6) Initiated by France and Germany, it was joined subsequently by the United Kingdom as a full member and -- under special contracts of scientific participation -- by Austria, Spain and Switzerland.

The above "roll call" shows at least some aspects of the prevailing diversity. CERN, already past its 40th anniversary, is a special case, with its doors open to a large number of scientists from all corners of the world: Brazil, Canada and the United States, as well as China, Israel, Japan and Australia. EMBL has membership of the European Molecular Biology Conference as a condition of participation. ESA operates both an obligatory common programme and a number of optional ones. ESO has a similar mode of operation; in addition to the obligatory programme, there is a possibility of optional complementary programmes, which has never been used. ESRF and ILL have circumvented difficulties by creating private companies under the laws and regulations of the host country (France), thereby limiting the scope of the necessary intergovernmental agreement.

All six institutions are very much alive today and have programmes and plans that reach into the next century. They all have well-established lines of communication with the governments of member countries. Thus, for instance, their boards of directors ("councils") can in effect take decisions that normally would have to be taken at ministerial level. With their permanent staff and consultative bodies they are capable of handling all four phases of the decision-making process identified in our report.

As for world-wide, transnational and large scientific projects, there are only two at present: the International Thermonuclear Experimental Reactor (ITER) and the International Space Station (ISS). Both of these projects involve Europe but under different arrangements. We do not deal with these projects in our report but have added a separate annex on ITER, the "global" fusion research project presently under way (see Annex IV).

Regarding the six European organisations listed above, it is worth noting that they were all conceived and developed "bottom-up", albeit eased towards realisation by "top-down" sympathy for collaboration across national borders as well as for science in general. We may conclude, like others before us, that in scientific collaboration the bottom-up element is essential, but that government support -- financial and other -- is necessary for any proposal involving sizeable sums of money to be committed over a number of years.

What is also worth noting is the à la carte nature of the collaboration hitherto realised. On a non-exclusive basis, only those countries who wish to do so participate, and no governing or sheltering umbrella institution has been involved in the creation of this impressive patchwork of realisations, although organisations like the European Science Foundation (ESF), have served as "midwives" in the early phases.

Analysed against the background of the four phases identified in Part II, Section 3, a number of conclusions emerge:

− In the specific cases mentioned (and also in others) the scientific community has demonstrated its ability to define and develop the various projects using its own resources (phase 1).
− In each case it has proved possible to gain sufficient support from a sufficient number of science agencies (research councils) and governments to realise the projects initiated by the scientific community without any established path for carrying it out (phases 2 and 4).

− Once set up under some form of intergovernmental agreement, the institutions thus created have been able to establish on their own the background for further development, be it of participation and/or programmes, and to bring about the necessary political decisions (phases 1 and 4).

− It is evident that the ESF, created as late as 1974, had no part in the establishment of earlier institutions. It has, however, played a role in offering a neutral place for discussion among scientists and agencies, and thus in advancing the ESRF. It is possible that, in the future, the ESF may play a similar role in the decision-making processes dealing with a new large European Spallation Source (ESS).

− In most European countries, intermediate organisations to stimulate and co-ordinate government-supported research, mostly called research councils (or science agencies), have existed for a more or less long time. Examples are CNRS and CEA (France), EPSRC (United Kingdom), CNR (Italy), MPG (Germany), NWO (the Netherlands). Since each country has its own science policy structure and culture, the position and functioning of each research council is different.

− There are many bilateral/trilateral agreements for international co-operation among research councils. There is also a growing awareness of the need to co-operate on a larger scale with respect to large research facilities (construction and exploitation) and common research programmes. The heads of these research councils are currently establishing a co-ordination and co-operation structure (European Union Research Organisations’ Heads of Research Councils: EUROHORCS).

− It is also worth noting that neither the European Union nor its predecessor had any formal role in the establishment of the institutions mentioned. Nor does it have any say in their operation. The budget of the Framework Programme for Research and Development of the EU represents about 4 per cent (1992) of the Community’s total R&D effort, and only little more than one-half of the amount spent collectively on research by other European science institutions (including those mentioned above). The Framework Programme of the EU is devoted entirely to the promotion of the economic and social goals of the Union. It includes fundamental research only in so far as training, mobility and international use of large national installations are concerned (under which heading the Commission has lent some support to the effort needed to design the ESS project mentioned above). The Maastricht Treaty does foresee (Article 130 H) a role for the Union in co-ordinating national and European R&D, but until now this clause has remained a dead letter, notwithstanding efforts made since 1992 by the Danish, Italian and Dutch governments during their respective presidencies of the European Council, and more recently (October 1994) by the Commission. Furthermore, as a consequence of the above, the European Parliament has had no influence on the development of fundamental science in Europe. What the 1996 European Review Conference will or will not change in this respect remains to be seen.
2. **New big science fields**

We have seen how certain science fields -- particle physics, space, astronomy, and so on -- have established major European institutions of collaboration that manage without any common superstructure, whether formal or informal. However, it also appears that governments increasingly tend to question whether this situation -- even though quite adequate until now -- will remain satisfactory much longer. The appearance on the scene of a number of new megascience fields, and the prospect of more to come, combined with a tightening of financial and perhaps human resources, raises questions as to the adequacy of the present unstructured set-up. Also, the small countries in particular wonder whether they should continue to accept a decision process that they consider as favouring the larger countries, especially in the matter of choosing sites for international facilities.

Any new approach would have to take into consideration the need for the intellectual framework for the major future developments of a field of science to be formulated exclusively by a representative group of the scientific community. European examples are NuPECC in the field of nuclear physics, ECFA in the field of particle physics, and possibly the TMR Study Panel on Free Electron Lasers. There are only a few of these international committees of scientists, but they do not exist on a permanent basis. On the other hand, the self-organising power of a given field at European level can be considered as a practical Darwinistic criterion for selecting science policy issues to be discussed at the European or, later, global level. Of course, this kind of "grass-roots" organisation can be stimulated in some cases by science agencies and governments who are unable or unwilling to finance national initiatives for a large project on a national basis alone.

While we maintain that the bottom-up approach is the only one that guarantees scientific validity, we also realise that even excellent projects may face serious difficulties on their way to the top, and this is as it should be. However, it seems unsatisfactory not to have a European forum for discussing plans which are produced by an international scientific community and which may raise major scientific issues such as possible future effects on scientific programmes, structures and (large) facilities. Such a forum would serve as a meeting place for representatives of scientists and research institutions in Europe, as well as for national research agencies and government planners. ESF has not quite filled that role, and, as pointed out above, the European Union does not constitute a forum for taking care of phase 2 of the decision process.

It is clear that in the near future, a number of plans for facilities to be built in European co-operation will be put forward. Some examples are: the new Electron Laboratory for Europe reactor (ELFE) for the nuclear physics community; a large spallation neutron source (ESS); and a high magnetic field project (100 Tesla, 1 sec.) for chemists, physicists, materials researchers and biologists. Owing to the absence of an established forum, it is understandable that protagonists of the ESS should organise, single-handed, an external evaluation of the science case for this project through the ESF. Because of the lack of appropriate mechanisms, a government sometimes takes the initiative to put a plan/project on the international science policy agenda. The latest example we know of is the project for a new spallation source in Austria (AUSTRON), for which the Government of Austria contacted other European governments through diplomatic channels to explore the possibility of some kind of collaboration or co-ownership.

In our opinion the plans for large European projects -- such as ELFE, ESS, 100 Tesla -- should be first discussed and evaluated by European science agencies/research councils. These agencies should therefore establish a clearing-house -- such as the secretariat of the EUROHORCS, or the ESF -- to which such plans can be addressed. Upon being informed of such a plan by their clearing-house, the agencies tentatively interested in the plan could form an *ad hoc* group to organise an evaluation. They could, for
instance, ask disciplinary organisations such as the European Union of Physics Research Organisations (EUPRO) or the Chairmen of European Research Council Chemistry Committees (CERC3) or others to be instrumental in the evaluation process.

In phases 3 and 4, a similar need arises for European governments to organise their own clearing-house, which can decide when and how to act on proposals issuing from the process described above.

The proposal to organise a more systematic approach to "global" activities of megascience character under the auspices of the OECD may indeed underline the need for Europe to organise its own decision process and accelerate action on the part of the European governments.

The change in the political landscape associated with the breakdown of old fronts and/or frontiers may, however, influence the ways in which individual European governments react to, and meet the challenges created by, new developments in science.

At first sight, the logic of the "subsidiarity" principle, much favoured by the member nations of the European Union, would seem to militate for a common European position on megascience projects. In areas of activity where the EU has adopted a common programme -- for example the development of fusion energy -- this would almost of necessity be the case, as demonstrated in the ITER-EDA agreement.

Also, and in order to strengthen the European position as well as its own, the European Commission may be counted on to advocate the case for implementing the co-ordination of national and European policies enshrined in Article 130 H of the Maastricht Treaty. The Commission’s viewpoint might seem to be supported by the need for "Europe to speak with one voice", argued most recently by the French minister for higher education and research. This same minister, however, argues for the separation of the Committee for Research and Technology (CREST) from the European Commission that chairs it!

It is quite possible, perhaps likely, that European states will finally wish to retain unrestrained freedom of action with respect to participation in megascience projects. The consultation procedure proposed for the OECD as a follow-up action to the Megascience Forum activities seems to be compatible with such a position. The proposal not only emphasizes a case-by-case approach. It also leaves open the possibility for interested European states to combine with other OECD Member countries -- altogether a minimum of (only) three interested parties -- to explore more closely, or even realise in common, a megascience project.
ANNEX IV: ITER, AN EXAMPLE OF ON-GOING GLOBAL CO-OPERATION

H. von Bülow

The work going on around the International Thermonuclear Experimental Reactor (ITER) is a unique example of an international collaborative effort. It involves all nations that have devoted important resources to magnetic fusion programmes which aim to obtain the knowledge required to construct a fusion power station. (There are other conceivable approaches to fusion power, but magnetic confinement of the fusion process in a so-called "tokamak" device is the one most efforts are devoted to at present.)

Four parties -- Europe, Japan, Russia (formerly the USSR) and the United States -- have signed a six-year agreement that came into force in July 1992. Under the name ITER-EDA it is the aim of the agreed joint effort to design a large tokamak device comparable in size to that of a future commercial power plant.

Each party is expected to provide a quarter of the resources needed, mostly in the form of R&D but also some 1 200 professional man-years for the design activities. For ITER-EDA, the total effort can be measured as equivalent to about $1 billion.

A first design phase, in which an agreed conceptual design was established, ended in March 1994. The joint activities then entered into the second and final phase to end in July 1998; during this phase, the engineering design activities will produce blueprints for construction decisions.

The parties have not committed themselves to proceed together into the construction phase proper (nor indeed to construct the device at all), but the possibilities of doing so are actively considered. In particular, the estimated $5.6 billion (at January 1989 value) that it would cost to build the device serve as an incentive.

The question of agreeing on a site would, of course, be crucial and has therefore also been taken up. It is complicated by the fact that, in all probability, each of the parties would be able to propose technically suitable sites on its own territory. Already in the present EDA phase, considerations of balance associated with selecting locations in which to pursue work in common resulted in a compromise solution involving the creation of not one, but three joint work sites: Garching in Europe, Naka in Japan and San Diego in the United States. Moscow was chosen as the formal venue for the meetings of the ITER Council that is responsible for the entire operation.

Without going into detail about ITER, it is important to note some important features of this unique example of a truly world-wide scientific effort. In general, they set ITER apart from other collaborative scientific efforts to which it might be compared.

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2 The author acknowledges his debt to the “Report of the EC-US Workshop on International Collaboration in Science Megaprojects, Brussels, 6-8 October 1991”, which contains a chapter on fusion research from which he has quoted directly or indirectly in the following text.
First there is the object of the joint design activities. ITER is not a facility like an accelerator or space laboratory where scientists perform experiments. ITER is the experiment; it is a logical extension of other, smaller experiments realised by the four parties individually, and it will in turn provide the basis for extrapolation to the next step: an electricity-producing demonstration reactor.

This means that although it is not yet a commercial venture, ITER ultimately aims to be one. The pre-competitive nature of ITER-EDA does not eliminate the fact that each of the parties desires to maintain the capability to construct fusion power plants on its own, when the time comes. That ambition is also demonstrated in the concept of four equal partners which has influenced the project throughout, as seen for instance in the principle of equal contributions to the EDA.

It is further worth noting that, apart from a special host contribution by the German government which provides accommodations for the joint work that goes on at the Max-Planck Institut für Plasma Physik (IPP), Garching, the European share in the project is entirely provided by the Fusion Programme of which the European contribution to ITER is an integral and focal part. No separate funding is involved from either the European member states or the associated laboratories. It is the European Union (Euratom) that is the European partner in ITER. The Council of Ministers is kept regularly informed, but the European contribution to ITER-EDA is the responsibility of the Commission, which is assisted by the Consultative Committee on the Fusion Programme (CCFP). It has already been noted that, under the rules established by the Euratom Treaty, Europe institutionally speaks with one voice in international collaboration on fusion energy research.

Finally, it should be recalled that this research field was given decisive "top-down" support, when in 1985 Presidents Gorbachev, Mitterand and Reagan chose fusion research as a showcase for collaboration in the post "cold war" world. No other international science project has had such an array of sponsors, but while it is clear that the blessing thus bestowed upon this particular project did advance its chances of being realised, it is equally clear that the political limelight has its drawbacks. Therefore, it is important to underline what ITER owes to patient and careful step-by-step actions taken throughout by the actors on the stage, the scientists as well as the administrators involved.

These actors knew each other well from years of contact in international fora, including the fusion study group of the International Atomic Energy Agency (IAEA). That in itself was important, for to launch ITER-EDA meant accepting commitments that had consequences reaching beyond the mere direct costs of the actions agreed upon -- commitments that could not, and should not, be taken lightly. Then, over three full years, the ITER-EDA project took shape and acquired substance. If any lesson for international collaboration in megascience can be learned from ITER, as I believe it can, it is that of the value of progressing at such a deliberate pace that steps backwards never occur, simply because each step forward is so carefully conceived that all participants know what commitments they are making and are ready to honour them.

Some specifics deserve mention. It is worth noting, for instance, that the ITER-EDA agreement was solid enough to withstand the effects of the dissolution of the USSR, and also that its statutory provisions allow for the participation of other countries wishing to associate themselves with and participate in the design activities. Canada has taken advantage of this possibility by associating itself with the European party to the agreement.

Other potentially problematic issues have also been resolved, but it is of no use concealing the fact that an agreement to build ITER would have to overcome a number of severe obstacles. Agreeing on a common site is but one of them. Industrial property rights, procurement of reactor components, and arrangements for staffing are examples of other equally challenging issues that would have to be settled.
and for which there are no ready-made solutions, although there may be several that have been tried and proved unsatisfactory.
<table>
<thead>
<tr>
<th>ACRONYMS</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACFA</td>
<td>Asian Committee for Future Accelerators</td>
</tr>
<tr>
<td>AUSTRON</td>
<td>New Spallation Source in Austria (project)</td>
</tr>
<tr>
<td>CCPF</td>
<td>Consultative Committee on the Fusion Programme (CCFP)</td>
</tr>
<tr>
<td>CEA</td>
<td>Commissariat à l’Énergie Atomique (France)</td>
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<tr>
<td>CERC3</td>
<td>Chairmen of European Research Council Chemistry Committees</td>
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<tr>
<td>CERN</td>
<td>European Organisation for Nuclear Research</td>
</tr>
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<td>CNR</td>
<td>Consiglio Nazionale delle Ricerche (Italy)</td>
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<tr>
<td>CNRS</td>
<td>Centre national de la recherche scientifique (France)</td>
</tr>
<tr>
<td>CREST</td>
<td>Committee for Research and Technology (ECC)</td>
</tr>
<tr>
<td>DOE</td>
<td>Department of Energy (United States)</td>
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<tr>
<td>DOD</td>
<td>Department of Defense (United States)</td>
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<tr>
<td>ECFB</td>
<td>European Committee for Future Accelerators</td>
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<tr>
<td>ELDO</td>
<td>European Launcher Development Organisation</td>
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<td>ELEF</td>
<td>Electron Laboratory for Europe</td>
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<td>EMBL</td>
<td>European Molecular Biology Laboratory</td>
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<td>EPSRC</td>
<td>Engineering and Physical Science Research Council (United Kingdom)</td>
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<td>ESA</td>
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<td>ESF</td>
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<td>ESO</td>
<td>European Southern Observatory</td>
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<td>ESRO</td>
<td>European Synchrotron Radiation Facility</td>
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<td>ESRO</td>
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<tr>
<td>ESS</td>
<td>European Spallation Source</td>
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<tr>
<td>EUROHRCS</td>
<td>European Union Research Organisations’ Heads of Research Councils</td>
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<tr>
<td>EUPRO</td>
<td>European Union of Physics Research Organisations</td>
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<tr>
<td>FOM</td>
<td>Stichting Fundamenteel Onderzoek der Materie (Netherlands)</td>
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<td>HEPAP</td>
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<td>IAEA</td>
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<td>ISAS</td>
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<td>ISS</td>
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<td>ITER</td>
<td>International Thermonuclear Experimental Reactor</td>
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<td>ITER-EDA</td>
<td>ITER Engineering Design Activities</td>
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<td>JET</td>
<td>Joint European Torus</td>
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<td>JLC</td>
<td>Japan Linear Collider</td>
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<td>Science Council of Japan</td>
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<td>KEK</td>
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<td>LHC</td>
<td>Large Hadron Collider (CERN)</td>
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<tr>
<td>MITI</td>
<td>Ministry of International Trade and Industry (Japan)</td>
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<tr>
<td>Monbusho</td>
<td>Ministry of Education, Science and Culture (Japan)</td>
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<tr>
<td>Abbreviation</td>
<td>Full Name</td>
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<tr>
<td>MPG</td>
<td>Max-Planck Gesellschaft (Germany)</td>
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<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration (United States)</td>
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<tr>
<td>NGO</td>
<td>Non-governmental organisation</td>
</tr>
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<td>NRC</td>
<td>National Research Council</td>
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<td>NSF</td>
<td>National Science Foundation (United States)</td>
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<td>NWO</td>
<td>Nederlandse Organisatie voor Wetenschappelijk Onderzoek (The Netherlands)</td>
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<tr>
<td>OER</td>
<td>Office of Energy Research (DOE, United States)</td>
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<tr>
<td>OMB</td>
<td>Office of Management and Budget (United States)</td>
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<tr>
<td>OSTP</td>
<td>Office for Science and Technology Policy (United States)</td>
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<tr>
<td>RIKEN</td>
<td>Institute of Physical and Chemical Research (Japan)</td>
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<tr>
<td>SSC</td>
<td>Superconducting Supercollider (United States)</td>
</tr>
<tr>
<td>STA</td>
<td>Science and Technology Agency (Japan)</td>
</tr>
<tr>
<td>SUBARU</td>
<td>8 m Japanese telescope on Maura Kea (Hawaii)</td>
</tr>
<tr>
<td>TRISTAN</td>
<td>Transportable Ring Intersecting Storage Accelerator (Japan)</td>
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</tbody>
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