Office of the
National Science Advisor

Bureau du
Conseiller national des sciences

Proposed Framework for the Evaluation, Funding and Oversight of Canadian Major Science Investments

Discussion Paper

September 2005

Canada

Executive Summary

Over the past decade, the design, development, commissioning and management of large-scale scientific projects in the natural, health and social sciences have become more complex, costly, interdisciplinary and international. This trend poses important science policy challenges for governments, the academic community and the Canadian public on how we agree on priorities, how we make decisions and how we manage our major science investments (MSIs) to ensure that Canada is an active participant in leading research fields.

The Organisation for Economic Co-operation and Development (OECD) defines an MSI as "a project that addresses a set of scientific problems of such significance, scope and complexity as to require an unusually large-scale collaborative effort, along with the facilities, instruments, human resources and logistic support to carry it out." A project qualifies as a major science investment when the following criteria are met: the magnitude or cost of the project exceeds the capacity of a single institution, department or agency; scientific research is a primary objective; long-term financial responsibility or legacy issues exist; the scope and scale of the non-scientific benefits require attention; and, there are elements of critical mass and large-scale coordination required.

The Government of Canada currently has no framework or systematic process for evaluating, funding or overseeing such investments. Calls for an MSI framework have been made by the Auditor General[1], the scientific community and science-funding organisations. Several OECD countries, including the United States and United Kingdom, have promulgated MSI guidelines. The purpose of this paper is to present options and a recommended approach for establishing an MSI framework in Canada.

The framework must address both bottom-up and top-down initiatives; provide an efficient, effective way to systematically prioritize projects; ensure the early engagement of key stakeholders; include a mechanism to secure timely decisions on project funding; encompass all lifecycle costs; and, incorporate measures to ensure informed decision making and accountability. Scientific peer review will remain a central component.

The elements to be taken into account when evaluating MSI proposals are scientific excellence; expected economic, social and environmental benefits; impact on highly qualified personnel; the project's full lifetime costs and contingencies; a thorough evaluation of all types of risks (e.g., scientific, financial, environmental, security); and, clear management, audit and oversight mechanisms.

Section III presents a range of framework models. The models are presented in a matrix (see Figure 1) reflecting process and funding options along two continuums, from distributed to centralized.

[1] Auditor General's December 2000 Report available at www.oag-bvg.gc.ca

All of the models call for the creation of a Major Science Investment Panel (MSIP) and a supporting secretariat housed within the Office of the National Science Advisor. The roles of these bodies vary across the continuum from no involvement in proposal development or recommendations to Minister(s) on Cabinet submissions, to active involvement. All of the options also entail the creation of an annual overview document casting past and ongoing major science investments, as well as the pipeline of approved, proposed and potential MSIs, in the context of Canadian and international science.

Model 3A is the recommended model. It best fits the needs of the framework; responds to stakeholder feedback; utilizes existing structures as much as possible; and, limits additional bureaucratic weight. In Model 3A, the MSIP secretariat plays a coordinating role as a project moves beyond the capacity of a single department or agency to support it. Once a proposal is approved by the relevant departments/agencies, it is championed by one of these to the MSIP. The champion department/agency then becomes the Lead Agency. The MSIP has two roles: it publishes and updates an MSI overview document and it makes recommendations to Minister(s) regarding new projects that require Cabinet submissions, renewal of operating funds that require Cabinet submissions, and the conclusion/decommissioning of MSIs. To ensure appropriate oversight and provide a link back into government decision making, each approved MSI would have an Oversight and Advisory Board (OAB) appointed by the Lead Agency. For an existing MSI, the OAB role could be fulfilled by the existing Board of Directors or Advisory Committee. The OAB would submit annual reports to the MSIP on the project's progress and future directions.

Figure 1: Matrix of Process and Funding Options

<table>
<tr><td></td><td></td><td colspan="3">Decentralized   **PROCESS**   Centralized</td></tr>
<tr><td rowspan="4"></td><td rowspan="4"></td><td>**1**</td><td>**2**</td><td>**3**</td></tr>
<tr><td colspan="3">MSIP publishes an annual overview document, "Outlook and Perspectives on MSIs in Canada," which casts past and ongoing investments, as well as the pipeline of approved, proposed and potential MSIs, in the context of Canadian and international science.</td></tr>
<tr><td rowspan="2">Proposals flow through departments and agencies and engage Cabinet process through existing channels.</td><td colspan="2">The MSIP recommends to Minister(s) on Cabinet submissions regarding new project funding, operating fund renewal and project decommissioning. The MSIP would be advised by a scientific subcommittee.</td></tr>
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<tr><td rowspan="3">**FUNDING**</td><td>**A**
Dedicated Secretariat</td><td>**1A**</td><td>**2A**</td><td>**3A**</td></tr>
<tr><td>**B**
Dedicated secretariat and proposal development funds. Projects funded from existing budgets and Cabinet submissions.</td><td>**N/A**</td><td>**2B**</td><td>**3B**</td></tr>
<tr><td>**C**
Expanded secretariat and central fund for proposal development and partial project funding.</td><td>**N/A**</td><td>**2C**</td><td>**3C**</td></tr>
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Table of Contents

Executive Summary .... **ii**

Introduction **1**

I. Context: The Changing Face of Scientific Research **2**

II. Scope of the Framework **4**

A. Definition 4
B. When the Framework Would be Invoked 4
C. Required Elements in the MSI Framework 5
D. Priority-setting Criteria 7

III. Options for an MSI Framework **9**

A. Matrix of Framework Options 9
B. Process Option 3 10
C. Process Option 2 14
D. Process Option 1 14

IV. Conclusion and Next Steps **15**

Appendix A: Composition of the Working Group **A.1**

Appendix B: Overview of comments received on the Major Science Investments discussion paper **B.1**

Appendix C: Country Comparisons **C.1**

1. United Kingdom C.1
2. United States' National Science Foundation (NSF) C.8
3. Australia C.12
4. Germany C.13
5. European Union C.15

Introduction

The development of this document responds to a generally perceived need expressed by the scientific and science policy community as well as research funding agencies for a systematic, transparent and robust decision-making framework for Canada's investments in major science projects.

This document builds on a previous discussion paper, released in January 2005 to interested stakeholders and the broader scientific community, which outlined some of the reasons why a framework is required and broadly discussed some options for how such a framework might work. The paper explained the issues, challenges and considerations that must be taken into account in developing a framework; outlined the broad criteria prescribing when such a framework would be applied; and, provided a general discussion of MSIs, along with examples of existing major science projects both within Canada or in which Canada is involved.[2]

More than 70 organisations, universities and individuals responded to the discussion paper, several following extensive consultations with their constituencies. Their comments added depth and breadth to the discussion, and many of their suggestions have been incorporated into this draft. Overall, the feedback indicated strong support for the development of an MSI framework. A list of respondents and an overview of their comments are presented in Appendix B.

This document builds on the original paper in two important ways. First, it recognizes a broader, more inclusive context for MSIs to reflect the new reality that such projects are no longer restricted to large facilities in the physical sciences. Many of the major scientific challenges of the 21st century, such as climate change, population health and exploring the ocean floor or the origins of the universe, involve distributed networks of facilities, people and resources whose cumulative magnitude and required level of coordination qualify them as MSIs. Second, this document presents a framework model for discussion, along with a matrix of various process and funding options to illustrate the model's position along a continuum from decentralized to centralized decision making.

This discussion document, released in September 2005, will be discussed at an October 3, 2005, workshop of senior officials from the university and government S&T communities. After the workshop, a new document combining the workshop results and the highlights of this document and its predecessor will be produced for review by the Science Deputy Ministers' Committee and the Committee of Presidents of Research Councils and Agencies before being submitted to the Minister of Industry and the Prime Minister for consideration. These documents, and subsequent updates, will be available on the Office of the National Science Advisor's website at http://science.pco-bcp.gc.ca.

[2] The original paper, entitled "Framework for the Evaluation, Funding and Oversight of Canadian Major Science Investments", is available at http://science.pco-bcp.gc.ca

I. Context: The Changing Face of Scientific Research

Science, technology and innovation are crucial to Canada's future and prosperity. Governments, industry and society at large increasingly look to science and technology to solve salient issues of economic competitiveness, environmental sustainability, health and understanding of the world in which we live; all hallmarks of a prosperous, equitable and well-educated 21st-century society.

Canada has a world-class scientific research system that has benefited significantly over the past seven years from strong federal investment through the creation of new initiatives such as the Canada Foundation for Innovation (CFI), Canada Research Chairs and Genome Canada, as well as the doubling of granting council budgets, the funding of the Indirect Costs program for university and college research, and providing base funding for the Networks of Centres of Excellence. While substantial progress has been made in improving the overall university funding environment in Canada, many significant challenges remain.

In the specific context of major science investments, Canada has often been regarded participating in international science projects without paying its due share of the costs. As research becomes increasingly global, collaborative and interdisciplinary in nature, the need for nations to cooperate and share the costs of major scientific endeavours becomes more important. If Canada hopes to be at the forefront of international science, it will need not only to prioritize and plan its investments over the long term but also contribute in a fair way to the full costs of its participation.

While MSIs do not represent the largest portion of Canadian research funding, their long-term nature, distinct funding profile, impact on other science projects and programs, and intermittent appearance, make a specific MSI framework necessary. A rigorous framework will help to ensure that decisions concerning proposal evaluations, assembling of funds and governance are made in a coherent, systematic manner based on common criteria. It will also help to prevent cost overruns, ensure adequate commitments for ongoing operations and provide accountability mechanisms. These components, in turn, will assist in maximizing the return on the major science investment and the potential benefits for Canada.

Over the past decade, several factors have contributed to a more complex and globally networked science and innovation system. These factors include rapid changes in information and computational technologies, the growth of the internet, the increasingly interdisciplinary nature of new scientific fields, and the emergence of many Asian and European economies with rapidly evolving scientific capabilities. In parallel with these developments, several challenging global issues, such as climate change, infectious diseases, biodiversity, and security and safety, have crossed traditional institutional, traditional discipline and national boundaries, and increasingly demand globally coordinated efforts in scientific research.

The notion of MSIs has also evolved considerably since Canada's first major science project – the NRX research reactor at Chalk River Laboratories – almost 60 years ago. Traditionally, MSIs referred to large capital-intensive projects and facilities that focussed on single-discipline research. Today, major facilities such as space exploration platforms, synchrotrons and neutron scattering facilities are increasingly used by scientists from a range of fields, often in collaborative, multidisciplinary projects. As well, with the emergence of grid computing infrastructures and advances in high-performance computing, large projects and facilities are increasingly integrated into global systems connecting to regional centres of specialized instrumentation, data processing and experimentation facilities for the production, verification, analysis, distribution and archiving of massive amounts of scientific data.

Major science investments have a history of reaping important benefits for Canadian society through large-scale infrastructure investments in physics, chemistry and biology. In recent years MSIs have become increasingly applicable and important to the advancement of health and social sciences through distributed knowledge infrastructure projects which produce key datasets that exist as continuing research resources. Long-term population cohort studies addressing health, demographic, economic and social issues require coordinated, collaborative research networks that cut across disciplines, jurisdictional boundaries and institutions. Large distributed projects on a scientific theme such as the Human Genome Project have emerged to rival large-scale facilities that would previously have been identified as the primary major science projects.

This paper, therefore, pertains both to facilities (centralized infrastructures for the benefit of a user community, such as the synchrotron at the Canadian Light Source), and networks (large-scale, long-term distributed efforts of scientific research).

Given the changing face of scientific research and the expanded notion of MSIs, the Government of Canada must make well-considered, strategic and properly managed investments so that our country remains at the cutting edge of new developments in scientific research, and is positioned to reap the long-term economic, social and other benefits of research discoveries. A rigorous MSI framework constitutes an important step in this direction.

Examples of Existing MSIs in Canada

- Facilities funded and located in Canada as part of a global network.
- Facilities located in Canada as a major or unique contribution to the global scientific community.
- International facilities located outside Canada, in which Canada is a partner.
- A distributed infrastructure that constitutes a major science investment when considered as a whole.
- A distributed research program on a scientific theme.

II. Scope of the Framework

A. Definition

A major science project is one which "… addresses a set of scientific problems of such significance, scope and complexity as to require an unusually large-scale collaborative effort, along with the facilities, instruments, human resources and logistic support to carry it out" (*Megascience and Its Background*, OECD, Paris, 1993).

B. When the Framework Would be Invoked

Five criteria define the types of projects that would be considered under the MSI framework.

1. **The magnitude and cost of the project is beyond the scope of any single institution, department or agency, and thus would require the collaboration of multiple institutions and/or international partnerships and/or the commitment of major funds from the centre of government.**

   While the diverse nature of major science projects makes it difficult to define a precise lower limit of costs, the international rule of thumb is that the project would cost more than $100 million over 10 years. In recognition of the different funding requirements for emerging major science investment fields, this threshold should be modified to $100 million over 10 years or more than 15 percent of the major funding agency's annual budget in a given year (whichever is less)[3]. However, some discretion in this regard should be built into the framework.

2. **The primary objective is to advance scientific research.**

   Any kind of technology development, engineering testing or demonstration project for which the primary objective is commercial development rather than scientific research would not satisfy this criterion.

3. **Long-term financial responsibility or legacy issues are considerations.**

   Major science projects are long term. Historically, they have exceeded 20 years from genesis to completion, although this may vary from discipline to discipline. The full lifecycle cost must be presented at the outset as an important input into decision making.

4. **The scope and scale of the non-scientific benefits require particular attention.**

[3] The United Kingdom uses a threshold of £25 million or 10% of the Research Council's annual grant-in-aid. See Appendix C for more details.

When evaluating large investments such as major science projects, Canadians attach significant weight to the project's larger economic, health, social and other benefits for both Canada and the world.

5. **Critical mass and large-scale coordination are required.**

   The project requires a minimum scale and level of coordination to ensure long-term success, international positioning and impact. This is particularly the case for large distributed networks.

C. Required Elements in the MSI Framework

To address current concerns regarding the evaluation, prioritization and oversight of MSIs, a robust framework must address the following six elements.

1. Proposal Initiation:

MSI proposals are often brought forward in a "bottom-up" fashion from a group of researchers (proponents) who wish to explore new ideas and concepts at the forefront of science and who require access to major science resources to do so. The proponents may represent a single discipline or several. They may come forward from a well-organized community, with an effective leadership, that has previously discussed long-range plans and priorities, or they may do so from an informal network of collaborators. Proponents may also come forward with international partners whose own national priorities and operating environments add a layer of complexity to the decision making.

The degree and nature of stakeholder support behind large-scale projects can differ and has to be understood. For example, the recent United Kingdom investment of £140 million in e-science[4] needed strong political leadership as support was difficult to organize at the grassroots science level. Although the concept was more diffuse and less well-defined than "an accelerator" for example, and lacked a well-organized advocacy community, the e-science initiative is very likely to be just as influential. There may be occasions, therefore, for the solicitation of proposals on a MSI. The framework must be able to address both bottom-up and top-down initiatives.

2. Systematic Prioritization

Prioritizing MSI projects is challenging as the proposals tend to arise on an irregular basis. The evaluation must be completed in such a way that projects can be prioritized periodically without repeating the entire process. A clearly defined, transparent evaluation process is particularly important when the project involves large facilities

[4] The UK e-Science Programme is a cross-Council initiative launched by Research Councils UK (RCUK) to develop new Grid middleware and technology to enable "flexible, secure, coordinated resource sharing among dynamic collections of individuals, institutions and resources." Each Research Council has launched its own e-science initiative in addition to a Core e-Science Programme across Councils. See www.rcuk.ac.uk/escience for more details.

whose location, construction and operation could have significant local economic benefits.

Each MSI project should be assessed in the larger context of the government's research, innovation and skills development objectives. In this context, all MSI projects should include, at the outset, systematic and reasonably detailed descriptions of key outcomes that will provide the decision-making process with a view on the expected return on the investment. This will also help in assessing the success of the project in the future.

A key feature of the framework models presented in Section III is the creation of an annual overview document which would place past and current MSIs, as well as the pipeline of approved, proposed and potential MSIs, in the context of Canadian and international science. This type of document is consistent with international models such as the United Kingdom's Large Science Facilities Road Map, the recommendations of the United States National Academies of Sciences to the National Science Foundation, and the Australian National Research Infrastructure Task Force's recommendations. (See Appendix C for details.) Although the overview document is not intended to directly prioritize projects, it will provide the context and basis for funding recommendations.

3. Stakeholder Engagement

The framework must require the engagement and buy-in of partners and other key stakeholders early in the proposal development process. Early collaboration and coordination are especially critical when partner funds will be sought. A robust framework would require that all stakeholders be identified in the preliminary stages of proposal development, along with the actions that have to be taken to engage them. As well, early discussion and agreement of the roles and contributions (financial and otherwise) of the various stakeholders, both in developing the proposal and as the project comes onboard, is required. The presence of project champions in the proposal development process is an important element in driving the project forward.

4. Timing

The framework should involve an iterative approval process to ensure projects are given ample feedback to best frame their proposal. As well, it should have a mechanism to ensure that a final decision is made in a timely manner. This will help to avoid situations where proponents are endlessly told to consider other options, make improvements, reduce the scope, attract foreign partners, etc. A negative decision is better than no decision, as it releases researchers to pursue other endeavours.

5. Funding

The framework must address all lifecycle costs, from the project's conception to its eventual conclusion or decommissioning.

6. Accountability

Implementation of a more clearly defined MSI framework would demonstrate that the government is taking steps to resolve accountability issues related to S&T expenditures and to ensure that decisions are made with the appropriate science-based information.[5] The framework should be consistent with the federal government's Management and Accountability Framework.

D. Priority-setting Criteria

MSI proposals should be evaluated on the following elements.

Scientific Excellence:

- Scientific peer review will be a central component of the framework. Scientific excellence is the basis of producing good and reliable new knowledge, and must be a central factor in decisions regarding MSIs. The justification of scientific excellence should include the quality of the research team and an assessment of the project's integration with and impact on the field of research and overall research system both in Canada and globally. It should also incorporate interdisciplinary elements where appropriate, as scientific advances increasingly occur at the interfaces of traditional scientific boundaries and the cross-fertilization of ideas and people enhance the benefits arising from the investment. The assessment of scientific excellence, in terms of new knowledge generated, must be undertaken by internationally recognized scientists and experts in the given field.

Economic, Social and Environmental Benefits:

- The justification of the proposal on the basis of scientific excellence should be accompanied by a delineation of the expected economic, social and environmental benefits for Canada, as well as any ethical and legal issues. Given the large investments required, decisions regarding MSIs are made not only for the good of science *per se* but also for the good of the country. International major science projects also endow considerable prestige to the participating countries.
- All anticipated economic benefits, such as job creation, market share, enhanced productivity, international trade, spin-offs and technological innovation, should be set out, along with the indicators (when possible) to measure them. Economic spillovers include both the money that will be generated by the project and the potential impacts of technology transfer and industrial innovation.
- The project's potential social benefits in terms of health, culture, public knowledge, environmental impacts etc., should also be defined.

[5]The Auditor General's December 2000 report discussed several aspects of decision-making and reporting processes regarding MSIs, including the need for complete and accurate information to Cabinet, cost overruns, the need for a framework, accountability, etc. The report is available at www.oag-bvg.gc.ca .

Impact on Highly Qualified Personnel:

- Highly trained scientists are essential in today's knowledge-based society. Nations that participate in major scientific ventures are able to attract and retain the highly qualified personnel that are drawn to such opportunities. Trainees get the opportunity to work with leading figures, and those who are trained at major science projects based in Canada are more likely to remain here to help ensure Canada's status as a leading nation in research and scientific development. Skilled people are required both in the design and ongoing operation of major science projects and these projects become instrumental in training a highly skilled workforce. Major science proposals must quantify the project's human resource impacts during both construction and operation.

Cost:

- The proposal must take into account estimates of the full lifetime costs of the project. In the case of facilities, this includes capital and construction costs, operations and maintenance, probable upgrades and expansion of operating costs, cost of access by individual users, contingencies, risks and decommissioning. Operating costs must also take into account inflation, future capital expansions or upgrades, and additional operating costs if the user community grows over the facility's lifetime. In the case of large cohort health studies, this would include sample follow-up, data archiving, storage of tissue samples, and processes for the adjudication of proposals to access these samples in the future. Similar to scientific assessments, a proposal should undergo a rigorous peer review of project execution.
- Contingency planning and costing are particularly difficult for large-scale novel projects with complex designs. One possibility, as suggested by the Auditor General (2000), is to do a project management and engineering analysis of the costs one year into the construction schedule when costs and scheduling estimates would be more accurate.

Risk Assessment and Management:

- MSI projects must be carefully considered in terms of the risks involved. A thorough evaluation of all types of risks, including scientific, technical, financial, security, environmental and others, must be undertaken.
    - Some major science projects have high inherent scientific and/or technical risk. Recognizing that scientific risk analyses may be imprecise in cases where something entirely novel is being proposed, a robust risk management system for this type of unique high-risk project should be developed based on worldwide best practices.
    - Other types of risk that require assessment include financial (e.g., cost overruns; partners dropping out); environmental (e.g., leaks/spills; disturbing natural

resources or wildlife habitats); worker and/or public health and safety (e.g., accidental exposure to chemicals or radioactive sources); and, security (e.g., changing national security standards). Additional risks, such as political and public perceptions, legal and regulatory, must also be assessed.

Project Management Oversight and Control:

- Each proposal should contain clear management, audit and oversight mechanisms consistent with best practices. It should delineate an oversight mechanism that would monitor progress on a multi-year basis and call for action if something unforeseen arises. Such unforeseen circumstances might include anything from budget changes (operations, contingency, etc.) to *force majeure* events. The monitoring mechanism should include responsibility for the project throughout its lifetime, including conclusion/decommissioning. These functions could be achieved by having an Oversight and Advisory Board (OAB) established by, and reporting to, the lead federal department or agency. The OAB should include external experts as well as representatives from all of the relevant funding agencies. For existing MSIs, the OAB role could be fulfilled by bodies such as the Board of Directors or Advisory Committee.
- The project should be managed by the most appropriate organization in terms of expertise and experience in the project's field. This organization may be a research institute, consortium, university, federal agency/department or a new entity. In any case, the governance of the project should involve funders, managers and users. In addition to the organization responsible for managing the project, a federal agency or department would have oversight of the project.

III. Options for an MSI Framework

A. Matrix of Framework Options

To illustrate a breadth of framework alternatives, a range of options (from distributed to centralized) for both process and funding mechanisms has been developed. The options are presented in the following matrix (Figure 1).

Process continuum: The process options range from Option 1 where existing agencies and departments retain responsibility for coordinating proposal development and securing project funding, to Option 3 where a central body is created to provide advice and direction on proposal development when the proposal moves beyond the capacity of a single department/agency to support it, and to make recommendations to Minister(s) regarding new projects, funding renewal and conclusion/decommissioning. All of the options propose the creation and annual publication of an overview document of past, current, proposed and future major science projects and their place in the context of national and international science.

Funding options: The funding options range from Option A, which calls for a small secretariat, to Option C, which entails an expanded secretariat and centralized funds for both proposal development and project funding.

The process and funding options can be combined to form seven framework models. These models are discussed below, starting with the recommended model (3A) and followed by descriptions of the alternative models. The recommended model was selected to reflect the feedback received on the initial discussion paper and to achieve the framework requirements outlined in Section II.C while minimizing additional bureaucratic burden.

Figure 1: Matrix of Process and Funding Options

		Decentralized	PROCESS	Centralized
		1	2	3
		MSIP publishes an annual overview document, "Outlook and Perspectives on MSIs in Canada," which casts past and ongoing investments, as well as the pipeline of approved, proposed and potential MSIs, in the context of Canadian and international science.		
		Proposals flow through departments and agencies and engage Cabinet process through existing channels.	The MSIP recommends to Minister(s) on Cabinet submissions regarding new project funding, operating fund renewal and project decommissioning. The MSIP would be advised by a scientific subcommittee.	
			Proposals flow through federal departments and agencies. MSIP and secretariat focus on the evaluation and prioritization of proposals that require Cabinet support.	Proposals receive advice and direction from the MSIP secretariat on proposal development. The secretariat plays a coordinating role as projects move beyond the capacity of one department or agency to support it. If a major science proposal receives backing from one or more departments or agencies, it is championed to the MSIP.
FUNDING	**A** Dedicated Secretariat	**1A**	**2A**	**3A**
	B Dedicated secretariat and proposal development funds. Projects funded from existing budgets and Cabinet submissions.	**N/A**	**2B**	**3B**
	C Expanded secretariat and central fund for proposal development and partial project funding.	**N/A**	**2C**	**3C**

B. Process Option 3

a) Framework Model 3A (Recommended Model)

Process:

- The MSIP secretariat plays a coordinating and advising role for proposals that have moved beyond the capacity of a single department/agency. The secretariat provides advice and direction on the development of proposals including the appropriate route a proposal should take; which departments or agencies should be involved, both in proposal development and eventual project funding; and, works closely with the involved departments and agencies as proposals work through the system. This process provides a lifecycle approach from proposal initiation to project approval. The MSIP secretariat is housed within the Office of the National Science Advisor.

- If a proposal is approved by the relevant departments/agencies, it is then championed by one of these to the MSIP. The champion department/agency becomes the Lead Federal Agency.
- The MSIP has two roles:
  - To publish an annual overview document, "Outlook and Perspectives on MSIs in Canada," which casts past and ongoing investments, as well as the pipeline of approved, proposed and potential MSIs, in the context of Canadian and international science; and,
  - To recommend to the appropriate Minister(s) new projects that require Cabinet submissions, [6] renewal of operating funds that require Cabinet submissions, and the decommissioning/conclusion of existing MSIs. The MSIP is advised by a standing scientific committee composed of eminent Canadian and foreign scientists.

Oversight and Advisory Board

- To ensure appropriate oversight and provide a link back into government decision making, each approved MSI would have an Oversight and Advisory Board (OAB). It is the responsibility of the Lead Agency to establish and maintain responsibility for the OAB once funding has been approved. However, to facilitate portfolio management by the MSIP, the OAB would submit annual reports on the progress and future directions of the MSI to the MSIP. If a Cabinet submission is necessary for the continued operation or upgrade of an MSI, the OAB would submit the request to the MSIP which, in turn, would make its recommendation to the Minister responsible for the Lead Federal Agency. For current MSIs, the OAB role could be fulfilled by existing Advisory Committees.

Role of the Lead Agency

- Before a proposal can be evaluated by the MSIP, the proposal must identify a Lead Agency. The Lead Agency, which assumes leadership of the proposal, may be any federal department or agency. The MSIP's initial and any subsequent funding recommendations are made to the Minister responsible for the Lead Agency who then brings it to Cabinet. Once a proposal has been approved, it is the responsibility of the Lead Agency to appoint the Oversight and Advisory Board.

[6] It should be noted that not all MSIs will require a Cabinet submission. While the project may exceed the financial resources of a single department or agency, it may be financially feasible if monies from two or more entities are combined, thus precluding the need for a Cabinet submission. Regardless of a project's need for a Cabinet submission, the secretariat would be involved in proposal development and coordination and the MSIP would incorporate it into the overview document.

Composition of the MSIP

- Presidents of the Canada Foundation for Innovation, Canadian Institutes of Health Research, Canadian Space Agency, Genome Canada, National Research Council, Natural Sciences and Engineering Research Council, Social Sciences and Humanities Research Council.
- Deputy Ministers of four science-based departments and agencies.
- Two international experts with experience in major science projects.
- Chaired by the National Science Advisor.
- Advised by a scientific subcommittee.

Role of the Federal Science-based Departments and Agencies

- Federal science-based departments and agencies, including granting councils and foundations, the National Research Council and ministerial departments such as Health Canada and Natural Resources Canada, will continue to play an essential role in the development, funding and implementation of MSIs. This process is designed to complement and build on, rather than replace, the existing strong working relationships that the departments/agencies have with their respective constituencies, and to ensure the coordination and collaboration of projects that have moved beyond the capacity of a single department/agency to fund or operate. The departments and agencies will continue to use their expertise to work with their constituent scientific communities to help them identify priorities within research fields and develop strategic views on potential major science projects. The departments and agencies will also continue to make their own independent funding decisions.

Development of the MSI Overview Document

The MSIP would be responsible for the development and periodic updating of an overview document, "Outlook and Perspectives on MSIs in Canada." This document would summarize the impact on the Canadian research system, budget requirements and lessons learned from past, ongoing and approved projects. It would also list the major science projects required over the next 20 years to maintain Canada's leading-edge research system and outline the rationale, projected lifecycle costs and timeline of each proposed project.

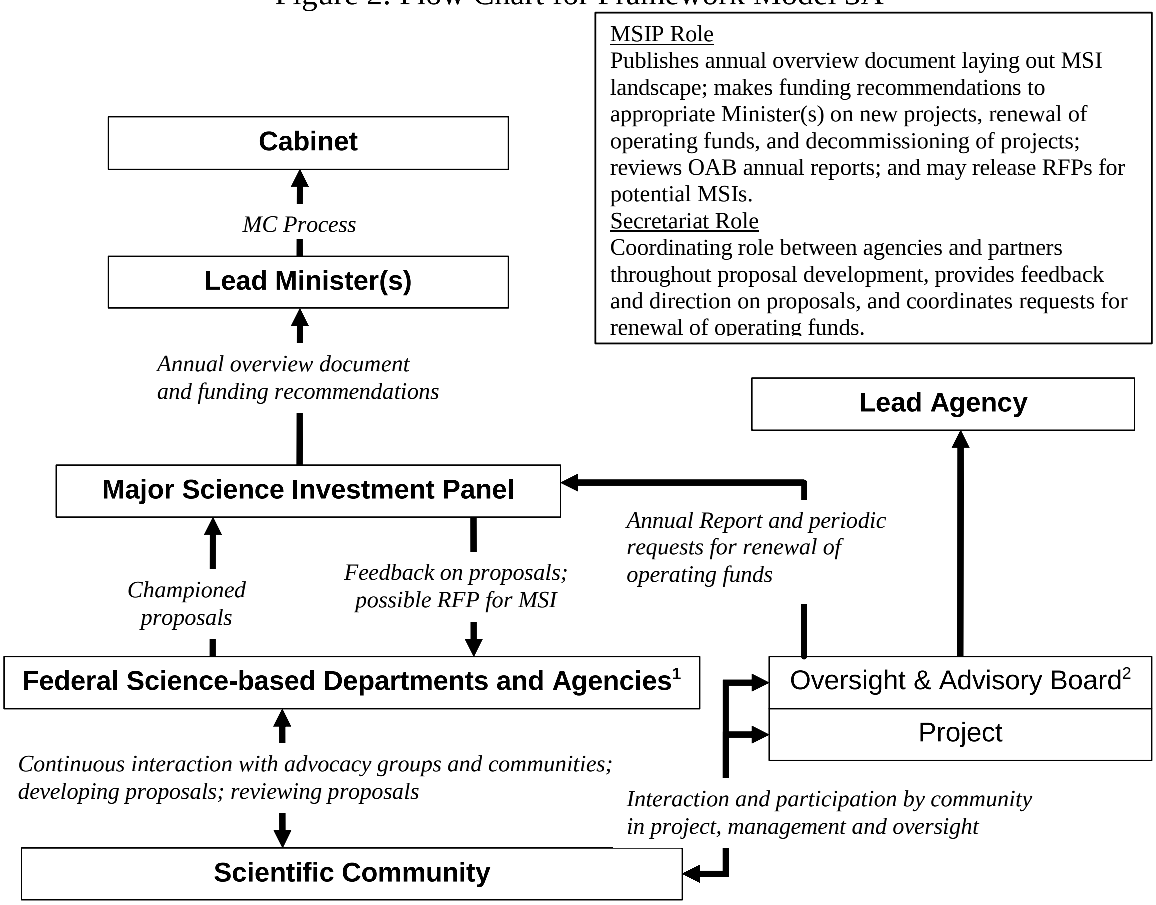
The overview document would not prioritize or recommend funding for individual projects but would inform policy makers of the MSI landscape so that they can better evaluate options and plan for MSI expenditures. The MSIP would conduct thorough consultations with the Canadian scientific and science policy communities and, when appropriate, internationally.

Rationale for Model 3A

Model 3A achieves the required objectives in that it:

- fulfills the requirements listed in Section II.C;
- allows for the systematic prioritization of a wide range of projects within the context of past, ongoing and proposed MSIs;
- links existing projects through the Oversight and Advisory Boards to the decision-making process to ensure a portfolio management approach;
- encourages the early involvement of the secretariat to facilitate a coordinated approach to proposal development and adequate stakeholder engagement; and,
- identifies a lead agency accountable for the project's implementation and operation.

Figure 2: Flow Chart for Framework Model 3A



1. Includes granting agencies and foundations, research agencies and ministerial departments
2. Role could be fulfilled by an existing body such as a Board of Directors or Advisory Board

b) Framework Model 3B:

Framework model 3B differs from 3A in that:

- The MSIP has a central fund to support the development of a select number of proposals. When project proponents initially approach the MSIP secretariat for advice and direction, they may also apply for funds from the MSIP for proposal development. Proponents would then be directed to seek approval from the appropriate departments and agencies. One of these would then champion the proposal to the MSIP.

c) Framework Model 3C

- The key difference in 3C from 3B is that the MSIP also has a central fund for project funding. Therefore, once the proposal has secured funding from existing departments and agencies and is championed to the MSIP, the MSIP can approve project funding rather than make recommendations to Minister(s) to provide the required funding.

C. Process Option 2

a) Framework Model 2A

- Proposals are developed by, and flow through, existing departments/agencies. If a proposal is approved by one or more of the departments or agencies and is deemed to require additional money through a Cabinet submission, one of the departments/agencies champions the proposal to the MSIP. The MSIP's role and composition is the same as in 3A.
- This model concentrates on the prioritization and funding recommendations made by the MSIP on proposals requiring a Cabinet submission. The role of the secretariat is focussed on facilitating this process rather than on the early engagement and coordination of proposal development.

b) Framework Models 2B, 2C

- As in Models 3B and 3C, 2B and 2C include central funds for proposal development and projects, respectively.

D. Process Option 1

a) Framework Model 1A

- MSI proposals flow through departments and agencies and engage the Cabinet process through existing channels when necessary. The role of the MSIP is to publish the annual overview document as described above. The MSIP composition is the same as above. The MSIP does not recommend to Ministers on project funding.

IV. Conclusion and Next Steps

The adoption of a framework for the evaluation, funding and oversight of major science investments in Canada will help to ensure that decisions are well-informed, follow best practices and involve a rational process. Benefits include higher-quality science, more effective use of public funds, greater clarity and transparency in decision making, fewer cost overruns and better management of projects. These, in turn, will translate into increased social, economic and environmental benefits to Canada from its major science investments.

This document is intended for discussion purposes at the October 3, 2005, MSI workshop organized by the National Science Advisor. The results of the workshop will be incorporated into a final document that will be submitted to the Science Deputy Ministers' Committee and the Committee of Presidents of Research Councils and Agencies before being presented to the Minister of Industry and the Prime Minister for consideration.

Appendix A: Composition of the Working Group

The development of this document was made possible through the contributions of the Working Group on Major Science Investments which included the following participants:

Canada Foundation for Innovation – Meg Barker, Director Planning and Outcome Assessment
Canadian Institutes of Health Research – Dr. Kelly VanKoughnet, Director, Research Planning and Resourcing
Industry Canada – Jim Valerio, Senior Advisor
National Research Council – Walter Davidson, Director, Large Facilities
Natural Sciences and Engineering Research Council – Pamela Moss, Portfolio Manager
Office of the National Science Advisor – Kevin Fitzgibbons, Executive Director
Office of the National Science Advisor – Christine Apold, Analyst
Statistics Canada – Michael Wolfson, Assistant Chief Statistician
Treasury Board Secretariat – Christine Duong, Senior Analyst
Editor – Dale Boyd

Appendix B: Overview of comments received on the Major Science Investments discussion paper

July 25, 2005

Background

The discussion paper, "A Framework for the Evaluation, Funding and Oversight of Canadian Major Science Investments," was distributed in early February 2005 to the Deputy Ministers of Science-based Departments and Agencies (SBDAs), Presidents of the Funding Agencies and Councils, and to the broader Canadian scientific community. The National Science Advisor requested that comments be submitted to his office by May 15, 2005. To date seventy-one responses have been received: thirteen from federal departments, twenty-three from universities, twenty from other organizations and fifteen from individuals. A list of submissions can be found in Annex I. Overall the paper was viewed positively and the National Science Advisor was applauded for tackling such an important issue. Comments are divided into the following themes:

- the definition and scope of major science investments (MSIs);
- the need for national science and technology priorities;
- governance and management of the framework;
- funding model; and
- project selection.

Definition and Scope of Major Science Investments

The most frequent comment, made by twenty-four respondents, was in support of broadening the definition of MSIs to include distributed networks and less-traditional investments particularly in the health and social sciences. Although the discussion paper referenced these elements, it was felt that the examples provided were too strongly focused on physics and astronomy. The only dissenting voices were the Canadian Institute for Neutron Scattering, the Coalition for Canadian Astronomy, and the National Research Council who felt that the definition should encompass capital-intensive investments only. There were also requests to include participation in international projects as potential MSIs if the project met the appropriate funding thresholds.

There were only five comments regarding the $100 M barrier. Health Canada and the Coalition for Canadian Astronomy were supportive, the University of Victoria thought the threshold was too low and the Council for Health Research considered that it was arbitrary and lacked sufficient rationale. The Social Sciences and Humanities Research Council argued that the threshold should be flexible since the extent to which an expenditure represents a major perturbation in the investment profile is very much field dependent. There were good arguments put forth to consider other criteria in addition to the sum lifetime cost of the project including the breakdown of operational versus capital funds and peak annual funding requirements. As well, seven respondents specifically mentioned that the reference to 3% of Canadian funding dedicated to MSIs was misleading, potentially inaccurate and detrimental to the argument for such a framework.

Need for National Science and Technology Priorities

The second most frequent comment from respondents was the need to place this process in the context of a clearly articulated, integrated national science and technology policy and priority-setting exercise for Canadian science. It will only be through a thorough analysis of national research priorities that strategic decisions can be made regarding MSIs. There were strong messages, particularly from the university community, that funding for MSIs should not adversely impact existing resource levels for granting councils or other research support such as CRCs and Indirect Costs of Research.

Governance and Management of the Framework

Overall, respondents expressed the view that the relationship between the proposed new governance structures and existing government processes should be clarified. For example, the following questions were raised:

- *How would recommendations from the Major Science Investment Panel (MSIP) be implemented?*
- *What would be the relationship to Cabinet and the MC process?*
- *How would a lead agency be selected and what roles or responsibilities would it play in moving a proposal forward?*
- *How would the role of the MSIP fit in with the future of CFI?*
- *What would be the precise role of the granting councils?*
- *What is the role of the National Science Advisor as an advocate relative to his role as a leader/manager of the process?*

Several respondents stated that the proposed process must have clear, strong links to existing government mechanisms in order to be effective.

Most comments on the governance structure centered on the MSIP's role and composition. Two respondents stated that the panel should be placed under the tri-council umbrella to ensure that existing expertise in the evaluation and prioritization of scientific proposals is effectively used. Three others recommended that proposals should first be vetted by the appropriate granting council before being championed to the MSIP or an equivalent body. The TRIUMF Board incorporated this pre-evaluative stage into a detailed alternative model. Proposals that are approved at the granting council level would then be championed to a high-level standing committee. This committee contrasts with the MSIP in that it would be chaired by an appropriate minister (currently this would fall to the Minister of Industry) and therefore has natural ministerial oversight. The TRIUMF Board recommended this model because a proposal would be examined in more depth before reaching the decision-making level and the model places a greater emphasis on securing government support for the best science rather than concentrating on prioritization within a specified funding envelope.

Regardless of the exact role of the MSIP within the framework of government, it was generally noted that the panel lacked sufficient scientific representation. It was suggested that the current composition could be bolstered by either adding leading national and international scientists or structuring a standing scientific committee to advise the panel. Others also recommended that leading Canadians from outside the research community should be incorporated to provide a challenge function. Finally, the need for provincial engagement and consultation was raised. Given that funding for MSIs is often contingent on financing from provincial sources, it was suggested that regional representation be considered for the MSIP. Questions were also raised regarding member selection and rotation.

A key point raised by several respondents was that the mechanism described in the paper focused on the approval of MSIs; however, it does not address operating fund renewal or the decommissioning of existing MSIs. To ensure a lifecycle approach to funding MSIs, mechanisms must be incorporated within the governance structure to deal with these issues.

Funding Model

Several respondents thought that the funding model needed clarification. The following questions were raised:

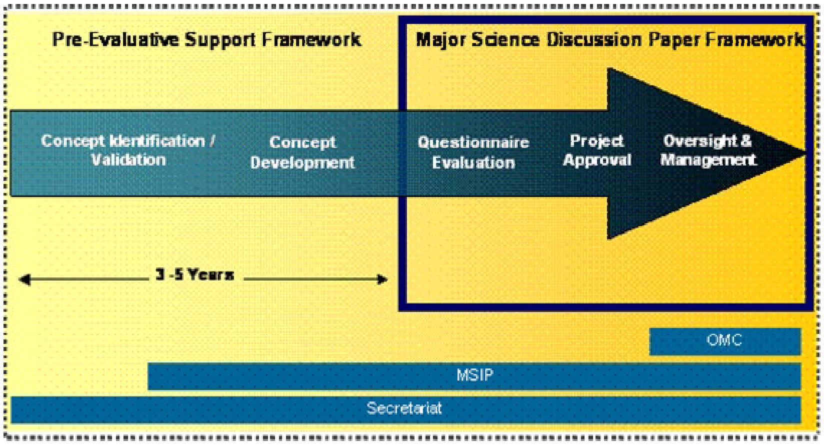
- *Where will money come from?*
- *Will all successful proposals go through the Cabinet process?*
- *Will decisions be binding on the granting councils?*
- *How will operating funds be approved and where will they come from?*
- *How will proposal development be funded?*
- *Will there be a pool of new money for the MSIP from which to fund projects?*

Most correspondents argued that without an injection of new money and/or a clear map of where funding would come from, the process would be in danger of becoming just another layer of bureaucracy and might raise unattainable expectations.

Project Selection

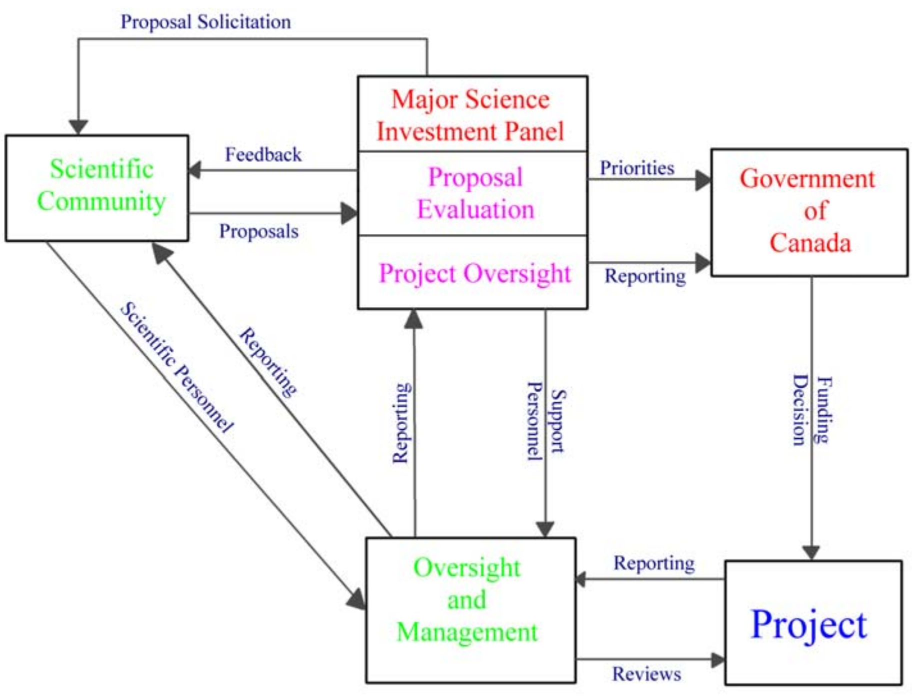
The majority of respondents who commented on the project selection process thought that there should be a multi-stage approval process where successful first-round applicants would be supported to develop final proposals. The secretariat should be structured and supported such that it can play a value-added role in the proposal development process. Figure 1 contains an interesting schematic suggested by the University of Calgary on how the infrastructure proposed in the framework could be leveraged across the pre-evaluative stage.

Figure 1: Staged time-line for the development of MSIs[7]



As previously mentioned some respondents were supportive of proposals first being vetted through the appropriate council or agency and then championed to the panel. An alternative flow chart to the one contained in Annex A of the discussion paper appears in Figure 2.

Figure 2: Modified Flow Chart[8]



While several specific modifications were suggested for Appendices B and C, there were a number of themes reiterated by multiple respondents. In addition to a peer review of

[7] Source: Dennis Salahub, Vice President (Research and International), University of Calgary, 2005.
[8] Source: Dominic Ryan, President, Canadian Institute for Neutron Scattering

scientific merit, a separate review of the project's budget, management structure and operation was called for. The "Leyman Reviews" of the US Department of Energy were held up as a useful model. It was also mentioned that the Canadian Academies of Science could play a potential role in the scientific peer review, although this is not their mandate.

Risk was also commented on a number of times. It was argued that the definition of risk needed to be more clearly defined and should include for example an assessment of the public reaction, as well as a separation between scientific risk, financial risk and external risk. Other comments included:

- a more absolute rating system to ensure comparison across years;
- a greater emphasis on peer review;
- impact assessment should include the opportunity costs of funding big science at the expense of small science;
- to what extent the facility/resource/initiative is required for progress in the specific field;
- the extent to which this investment is necessary for an acceptable return on previous capital investments;
- a need to weigh excellence and strategic relevance;
- an analysis of the international significance and novelty of the project;
- an evaluation of the ICT and network requirements;
- an analysis of linkages to other MSI;
- the inclusion of a human resources strategy;
- the development of a standardized proposal and budget framework; and
- results should be reported in a matrix of merit versus readiness.

Overall Assessment and Proposed Next Steps

Judging by the volume and tone of the responses received there is strong support for the development of an MSI framework. The benefits would include greater transparency, improved efficiency and effectiveness of decision making, and greater scientific, financial and project planning rigour. These elements were clearly identified as requiring improvement in the Auditor General's Report[9].

However, a number of issues and suggested changes highlighted in this overview need to be resolved. In order to address these issues more effectively, a working group comprised of senior advisors from Federal research agencies has been formed to review the comments in greater depth and to draft a second version that better reflects the input received.

The Presidents of Research Councils and Agencies as well as several of the correspondents recommended that a workshop be held for a review the framework before

[9] Auditor General of Canada, *Report of the Auditor General of Canada,* December 2000.

submitting it to government for consideration. This workshop will be held on October 3rd in Ottawa. The working group will report to the National Science Advisor who in turn will review the second draft of the framework with the Science Deputy Ministers' Committee and the Committee of Presidents of Research Councils and Agencies.

Time Frame

July	Drafting of 2nd version
August	Review of 2nd version by Science Deputy Ministers and Presidents of Councils and Agencies
September	Distribution of 2nd version to Science Community
October 3rd	Workshop - Ottawa
October	Drafting of final report and review by Science Deputies and Presidents
November	Submission of final report for consideration by government

Responses to Discussion Paper

Responses to Big Science Discussion Paper			
Submission #	**Date**	**Organization**	**Author**
		Government Departments	
1	17/Mar/05	AAFC	Leonard Edwards, DM
2	19/Apr/05	CFIA	Richard Fadden, President
3	22/Feb/05	CSA	David Kendall, DG, Space Science
4	25/Mar/05	CSA	Marc Garneau, President
5	12/May/05	Environment Canada	Karen Brown, Assistant DM
6	30/Mar/05	DFO	Larry Murray, DM
7	11/Apr/05	Health Canada	Hélène Gosselin, Associate DM
8	22/Feb/05	Health Canada	Morris Rosenberg
9	13/May/05	Ontario Ministry of Economic Development and Trade	Don Black, DM
10	13/May/05	NRC	Pierre Coulombe, President
11	11/Mar/05	NRCan	George Anderson, DM
		Granting Agencies	
12	10/Mar/05	CIHR	Alan Bernstein, President
13	06/Jul/05	SSHRC	Janet Halliwell, Vice-President
		Universities	
14	09/May/05	Bishop's University	J. Rittenhouse, Vice-Principal
15	11/May/05	Concordia University	Truong Vo-Van, Vice-Provost, Research
16	25/May/05	Dalhousie University	Ron O'Dor, Professor
17	25/May/05	G10 Vice-Presidents (Research)	R Gary Kachanoski (University of Alberta)
18	15/May/05	Laurentian University	Dr. Lietter Vasseur, Associate VP Research
19	02/May/05	McGill University	Jacques Hurtubise, Interim V.P. Research
20	10/May/05	McMaster University	Peter George, President and Vice-Chancellor
21	11/May/05	Mount St. Vincent University	Sheila Brown, President
22	13/May/05	Queen's University	Kerry Rowe, VP Research
23	09/May/05	Simon Fraser University	Colin Jones
24	01/Jun/05	Université du Québec à Montréal	Michel Jébrak, Vice-Recteur
25	13/May/05	Université de Sherbrooke	Pierre Labossière, Vice recteur à la recherche
26	15/May/05	University of British Columbia	David Dolphin, VP Research (Acting)
27	09/May/05	University of Calgary	Dennis Salahub, Vice President (Research & International
28	10/May/05	University of Manitoba	Grant M Hatch, Acting Associate Dean (Research)
29	31/Mar/05	University of New Brunswick	Gregory Kealey, VP (Research)
30	13/May/05	University of PEI	Kathrine Schultz, VP Research
31	05/May/05	University of Saskatchewan	Steven Franklin
32	18/May/05	University of Toronto	John Challis, V.P. Research
33	16/May/05	University of Victoria	David Turpin, President
34	16/May/05	University of Western Ontario	Ted Hewitt, V.P. Research and Inter
35	13/May/05	University of Waterloo, Institute for Quantum Computing	Raymond Laflamme, Director IQC
36	12/May/05	York University	Gordon G Shepherd, Director
		Other Organizations	
37	7/Jun/05	Association of Universities and Colleges of Canada	Claire Morris, President and CEO
38	05/May/05	Bechtel Corporation	O. Bedair
39	12/May/05	Canadian Asso. of Physicists	Mike Morrow, President
40	12/May/05	Canadian Astronomical Society	James E Hesser, President
41	12/May/05	Coalition for Canadian Astronomy	Gretchen Harris, Pekka Sinervo, Michael Jolliffe
42	11/May/05	Canadian Institute for Neutron Scattering	Dominic Ryan, President
43	29/Apr/05	Canadian Light Source Inc.	William Thomlinson, Exec. Director
44	30/Mar/05	Canarie	Andrew Bjerring, President and CEO
45	10/May/05	Council for Health Research in Canada	Deborah Gordon-El-Bihbety, President and CEO
46	13/May/05	C3.ca	
47	12/May/05	Institute of Particle Physics	William Trischuk, Director
48	25/Feb/05	Netera	Ken Hewitt, President
49	21/Feb/05	Oak Ridge National Laboratory	Thomas Mason
50	11/May/05	Partnership Group for Science and Engineering	Dr. Simon Hanmer, Chair
51	12/May/05	Perimeter Institute for Theoretical Physics	Howard Burton, Executive Director
52	24/May/05	Prime Minister's Advisory Council on Science and Technology	Jacquelyn Thayer Scott, Deputy Chair
53	01/Jun/05	Sudbury Neutrino Observatory Institute	SNO Institute Board
54	14/May/05	Sudbury Neutrino Observatory Institute	Art McDonald, Director
55	18/May/05	TRIUMF	Alan Shotter
56	28/Apr/05	United Kingdom	Sir David King, UK Science Advisor

Responses to Big Science Discussion Paper			
Submission #	**Date**	**Organization**	**Author**
		Individual Responses	
57	04/May/05	Alan Manson, Professor	University of Saskatchewan
58	15-May-05	Alexander Jablonski - Academia and Research Institution Liaison	Canadian Space Agency
59	26-May-05	Bjarni Tryggvason, Astronaut	Canadian Space Agency
60	9-Mar-05	D.D. Johnson- Professor Emeritus	University of Saskatchewan
61	11-Apr-05	Denis Rancourt- Professor	University of Ottawa
62	15/May/05	Donald Weaver	Dalhousie University
63	01/Mar/05	George Kalmus, UK	ACOT
64	09/May/05	James R Drummond- Researcher	University of Toronto
65	13/May/05	John G Spray	University of New Brunswick
66	30/Apr/05	K.W. Putt, Past President, Engineering Institute of Canada	K.W. Putt Consulting Inc.
67	02/May/05	Mary Anne White, Director, Institute for Research in Materials	Dalhousie University
68	03/Mar/05	Murray McLaughlin, President and CEO	Foragen Technologies
69	28/Feb/05	Dr. Philip Hultin, Associate Professor	University of Manitoba
70	12/Apr/05	RA Savidge, Professor	University of New Brunswick
71	27/May/05	Stephan Dupre	Former ACST member

Appendix C: Country Comparisons

1. United Kingdom[10]

MSI definition: The Large Science Facilities Strategic Road Map includes "facility projects" identified by members of Research Councils UK (RCUK) which meet one or more of the following criteria:

- Where there could be an international dimension to the proposed facility and therefore opportunity to share costs and develop relationships to benefit the UK science programme;
- Where the facility supports the requirements of research communities of more than one Research Council;
- Where the total investment in the build (capital expenditures) costs a Council more than £25 million or 10% of its annual grant-in-aid, whichever is less

Process for Approval:

- Individual Research Councils recommend a project be added to Large Science Facilities Road Map
- RCUK Executive Group adds project to Road Map
- Project is recommended for funding by RCUK Director-General to appropriate Ministers
- Progression towards funding and project completion through "Gateway" process

Road Map:

- Proposals are suggested by the Research Councils for submission into the Large Science Facilities Road Map. Although these can be suggested at anytime, there are deadlines for inclusion in a particular year's publication.
- The Road Map identifies prospective facilities that individual Councils believe are of strategic importance for UK science over the next 15 years. The Road Map is re-evaluated and published every two years.
- The RCUK Executive Group prepares a draft prioritization across subject areas according to Figure 1 (below). The exercise prioritizes projects for funding in the current or next Government spending review period (~5 years), and prioritizes more tentatively projects that may start mid-term (5-10 years) and far term (>10 years).
- The RCUK submits the draft prioritization to the Director-General of RCUK in the Office of Science and Technology (OST), who consults more widely before offering advice to Ministers.

Funding:

- Inclusion in the Road Map does not guarantee a project's funding. All projects are expected to proceed through the Gateway process (see below) to secure funding.

[10] Please visit the Office of Science and Technology's website for further details, www.ost.gov.uk

- Projects may be partly funded by the OST Large Facilities Capital Fund. To access this fund, projects must pass through a pre-Gateway Review and seek endorsement from the RCUK Executive Group following Gateway Review 1. A project must pass subsequent Ministerial and, in some cases, Treasury approval before the funding is formally committed and may be released.
- Individual Research Councils may decide to take a project forward that has not been formally prioritized if it is funded from within their own resources rather than from an additional allocation from the Science Budget. The individual Research Councils decide how far they wish to brief or consult the RCUK Executive Group on these projects.

Figure 1: UK Priority setting criteria for Large Facility Proposals

The criteria that the Research Councils and OST may apply to large facility proposals are set out below. Their relevance will vary according to the nature and phase of development of each project:

1. The scientific excellence and importance of the research delivered from the facility, the importance of the facility in delivering the science, and the overall match with the international standing of UK science;
2. The strength of the potential user group in the UK (including the opportunity for training and capacity building), and its breadth across subject areas and Research Councils;
3. The project's fit to the RCUK's and wider Government or national science strategy, including its impact on or contribution to other international collaborations;
4. Technical feasibility, and why the chosen technical solution is the best option;
5. The overall financial scale, including the whole-life, i.e. capital, operating, further development, and decommissioning costs of the facility, and how far the investment represents a significant element of the relevant Research Council's capital and resource budget lines;
6. The timescale of the project, the timeliness of the investment, and the impact on the UK of delay;
7. The extent to which the project would meet other regional, national and international needs, the interest and possible leverage from other potential funders, and the governance arrangements and other mechanisms to enable such participation;
8. Project and operational management arrangements, covering both construction and key aspects of the operation (e.g. data) and management of the facility once constructed;
9. The contribution to or from the UK's technology and industry base, and opportunities for exploitation;
10. The contribution to public confidence and engagement in science, during both construction and operation;
11. A suitable site, and environmental impact.

Some additional criteria, largely derivatives of those listed above, apply particularly, but not exclusively to the issue of hosting European or international-scale facilities:

12. The priority other countries attach to the project and their standing in that area of science;
13. The cost of participating in, but not hosting the facility;
14. Whether seeking to host the project would impinge on negotiations relating to other international collaboration;
15. The additional benefits of hosting an international facility, e.g.:
    a. contributions from other funders, and revenue from the expenditure and taxation of foreign nationals and from technology contracts for the facility;
    b. gaining scientific leadership and leverage;
    c. attracting international research talent;
    d. the development of clusters around the site;
    e. and how far these outweigh the premium typically paid by the host country.

Gateway Review Process:

All new procurement projects in civil central Government – including the Research Councils – are subject to the Office of Government Commerce Gateway process, which essentially comprises:

- Gateway Review 1 – business justification
- Gateway Review 2 – procurement strategy
- Gateway Review 3 – investment decision
- Gateway Review 4 – readiness for service
- Gateway Review 5 – benefits evaluation

Excerpts from UK Road Map – June 2003

Full text available at www.ost.gov.uk/research/funding/lfroadmap/index.htm

1. EXECUTIVE SUMMARY

This Large Facilities Strategic Road Map updates the first version of the Road Map which was published in June 2001. It is a tool by which Research Councils UK (RCUK) and its members can assess strategically the most expensive and complex scientific facilities with which UK researchers are or may wish to be involved. The road-map includes facility "projects" identified by members of RCUK as a priority for consideration which meet one or more of the following criteria:

- Where there could be an international dimension to the proposed facility and therefore opportunity to share costs and develop relationships to benefit the UK science programme;
- Where the facility supports the requirements of research communities of more than one Research Council;
- Where the capital investment is greater than the sum of £25 million, when it represents a significant element of an individual Research Council's budget line.

The Road Map is divided into the ten strategic areas listed below. The following paragraphs provide a brief synopsis of each. For further information see Section 3 or click on the hypertext links below.

Synchrotron radiation
Neutron scattering
High powered lasers
Radioactive particle beam facilities
Particle accelerators for particle physics
Astronomy and solar system science facilities
Fusion facilities
Ocean research vessels
Computing infrastructure
Major renewals, refurbishments and investments in Research Council Institutes

Synchrotron radiation is a major tool in many branches of physical and life sciences. Substantial programmes are funded at the Synchrotron Radiation Source (SRS) in CCLRC's Daresbury Laboratory and the European Synchrotron Radiation Facility (ESRF) in Grenoble. The UK's access to ESRF is not enough to meet the needs of UK scientists, and as the SRS is nearing the end of its useful life, the UK is constructing the new Diamond Synchrotron source at the CCLRC's Rutherford Appleton Laboratory, which will be operational by 2007. UK scientists require access to high brightness radiation at a range of wavelengths, to probe everything from biological molecules to quantum dots, and Diamond will be optimised to be complementary to the ESRF. Diamond will not be an optimal source of low energy radiation, nor will it have the capacity required to accommodate the UK's world-class Very Ultra Violet and Extreme Ultra Violet research communities, and the UK is developing the 4th Generation Light Source (4GLS) proposal which would provide a suite of ultra-high brightness, short pulse sources of spontaneous and stimulated synchrotron radiation. If approved, 4GLS might be operational by around 2010. At the short wavelength end of the spectrum, access to a sub-Angstrom X-ray free electron laser is likely to be required in the longer term.

Neutrons are an effective, and for many applications a unique, tool for probing the structure of matter. The UK has access to the world's most powerful reactor and accelerator based neutron sources – the Institut Laue Langevin (ILL) in Grenoble and ISIS at CCLRC's Rutherford Appleton Laboratory. In the short term, the UK intends to build on these two investments. With France and Germany, it has agreed to a ten-year extension of ILL (until 2013), and intends to support the "Millennium Programme" of capital investment at ILL to maintain the ILL at its world leading status. The UK has also agreed to develop a Second Target Station for ISIS, which will offer unique instrumentation allowing a new range of structural and dynamics studies of matter. In the longer term, the UK will need access to a Megawatt-class source, and there are a number of possible scenarios to achieving this, which will need to be evaluated in the medium term.

High power lasers enable the physics of matter at high densities and temperatures to be studied in a laboratory environment. They are of interest both to civil and defence related research, and several countries have developed military facilities with a component of open access for civilian research. In the UK, the principal facility is Vulcan at CCLRC's Rutherford Appleton Laboratory, whose power has been increased to 1 PW in 2003. Vulcan is likely to remain the primary facility for UK researchers, and a sustained and directed laser research programme would allow the UK to remain at the forefront of key science areas. In the nearer term, provision of high energy (kJ) beamlines would enable a much wider range of plasma parameters to be studied. Longer term, new technologies need to be developed to increase the intensity of the laser pulses. In the area of laser-driven fusion, there are opportunities for the UK to collaborate international partners (with Japan in the near term, and possibly with European partners in the long term leading to a potential European facility directed towards laser driven fusion).

Radioactive particle beams allow a number of fundamental studies to be carried out in nuclear physics and nuclear astrophysics, and to a lesser extent in other fields. UK scientists participate in many of the facilities around the world, gaining access on scientific merit. A previous option of developing a new facility within the UK has not been supported, as it was not considered to be of sufficiently high priority when compared with other potential investments. UK strategy is now focussing on enabling UK researchers to gain access to key facilities abroad and be involved in development programmes at those facilities – perhaps by trading access to UK based facilities in other fields.

The main particle physics project over the next 5-10 years is the Large Hadron Collider (LHC) at CERN, which is a major part of the PPARC particle physics portfolio during this period. Beyond that, three particle accelerator facilities are likely to be needed over the next 15-20 years. Firstly, a high-energy linear electron-positron collider with energy between 0.5 and 1.0 TeV is needed to make precision studies of the discoveries at the LHC. Secondly, an intense neutrino source ('neutrino factory') is needed to study the properties of the neutrino mixing matrix. Thirdly, a higher energy collider with a centre of mass energy well above the TeV scale is likely to be needed to test the new theories developed from the LHC and linear collider, and illuminate the physics at even higher energy scales. This might be a higher energy linear electron-positron collider, or it could be a muon collider which might also be needed at lower energy to make complementary studies, in particular of the Higgs sector. If the UK is also to benefit from the technology developed for these advanced facilities, it is important that the UK be fully involved in the design and construction of the machine as well as of the detectors, even if these facilities are not built in the UK. In future, partnerships of nations or groups of nations making major contributions in kind, rather than cash, could be the favoured mechanism.

Within **astronomy**, 8-metre class optical/infra-red telescopes will dominate observational studies for the next decade, and UK scientists currently have access via Gemini and the European Southern Observatory's Very large Telescope. For the future, three classes of astronomical facilities will be essential: large space telescopes operating at wavelengths inaccessible from the ground, large interferometers in space and on the ground, and extremely large (50-metre plus) ground-based optical/infra-red telescopes. UK scientists currently have access to the Very Long Baseline Interferometer radio array and the Newton XMM X-ray space telescope. Over the next decade, these will be complemented by a millimetre/sub-millimetre array (ALMA), the James Webb Space Telescope (successor to Hubble) and a space based gravitational radiation observatory (LISA). R&D is under way for 50-metre plus telescopes and a Square Kilometre Array radio interferometer. The UK is well placed to contribute to these projects, but needs to invest in R&D in the short to medium term. In **solar systems science**, the UK participation comes primarily through our membership of the European Space Agency (ESA). A new ESA planetary programme called Aurora is planned for 2005-2015, and the UK is well placed to make a significant impact.

Facilities for UK researchers in magnetic-confined **fusion** are currently provided at the UK Atomic Energy Authority's Culham Science Centre, which is host for the European JET project as well as the UK's own spherical tokamak facility MAST. The next generation fusion facility, the International Tokomak Experimental Reactor (ITER), is likely to be agreed before the end of 2004, with construction taking around 10 years, and costs in the region of £2.5 billion. ITER will not be located in the UK, and European participation in ITER may mean insufficient funding is available to operate JET. UK efforts in the near term are therefore likely to concentrate on major participation in ITER, and continued experimentation with MAST. Significant research in materials is needed in parallel to ITER if fusion power is to be realised on a fast track, and there is a proposal for an international fusion materials irradiation facility (IFMIF) at around £300 million, although resources in all the main countries will be tight. If IFMIF does proceed, the UK will want to be involved, and UK participation could range from contributing to experiments in the detailed designed phase to hosting the design team or even IFMIF itself.

To maintain the UK's world-class strengths in oceanography, and marine geology and geophysics, UK scientists need access to high quality **oceanographic research vessels**. Currently, UK researchers have access to two dedicated NERC research ships, the RRS Charles Darwin and the RRS Discovery, and to an international pool of ships and equipment via NERC's barter arrangements with other countries. The replacement to the RRS Charles Darwin, which is nearing the end of its useful life, will be delivered by 2006, costing in the region of £35 million. The RRS Discovery will reach the end of its economic life by 2010, and a replacement will be required, costing perhaps £60 million.

Computing infrastructure requirements are growing rapidly, and expensive high performance computing facilities are needed to meet research challenges across several disciplines. The UK currently has two major cross-disciplinary facilities. HPCx, procured in 2002, has a sustained capability of 3.4 Tflop/s, upgraded to 6 Tflop/s by July 2004 and to 12 Tflop/s by November 2006. The CSAR service began in 1998 and runs to 2006. It has two main systems, with sustained performances of 671 Gflop/s and 316 Gflop/s, and a new service with a sustained performance of 1 Tflop/s is scheduled for September 2003. In the future, it is likely that high performance machines with different architectures will be required. At least one facility a factor of 8 greater than the initial phase of HPCx by around 2005 is desired, doubling after 2 years and doubling again two years later. The Research Councils are looking to collaborate with other Government agencies to share future facilities.

A number of **major renewals, refurbishments and investments in Research Council Institutes** are required over the coming years to ensure that UK scientist shave access to top laboratory facilities.

- The *Laboratory of Molecular Biology*, an institute of the MRC, is one of the world's leading laboratories. The laboratory building was designed to meet the needs of molecular biology of the 1960s. It is over-crowded and inadequately ventilated. Its congested site, low ceilings, small rooms, and network of central load bearing concrete pillars severely limit the scope for modernisation and expansion. Such modernisation and expansion is needed to retain the laboratory's world leading position, and for this a new building is required. It is hoped that the £90 million project could be completed around 2008.

- The *Pirbright Laboratory*, part of the Institute for Animal Health, which is funded primarily by BBSRC and DEFRA, needs a new enclosed complex to meet modern international biosecurity standards. Without this it could lose its status as an international reference centre for major animal diseases. The new facility would cost around £40 million, and would take three years to build.

- To maximise the value of the new Diamond synchrotron (see above), a *research complex* is proposed, with both new scientific and living facilities for visiting scientists. The total cost of the project would be around £40 million. Part of this infrastructure would need to be ready at the same time as Diamond in 2007, with the rest phased in over time.

- The *Halley station* in Antarctica, operated by the British Antarctic Survey, a NERC Institute, provides a vital platform to conduct globally significant research across a range of sciences and provides a presence required by the UK Government in British Antarctic Territory. The Halley station is located on the Brunt Ice Shelf in Antarctica. Due to the movement of the ice shelf and snow accumulation, the station has to be periodically replaced (this will be the sixth replacement since 1956). The total costs of the new Halley Station (including its final dismantling, obligatory under the Antarctic Treaty) will be around £34M. The work must be completed by 2010.

4. SUMMARY OF ACTUAL AND POTENTIAL PROJECTS IN THE ROADMAP

Synchrotron radiation

DIAMOND Synchrotron Core facility and initial beamlines
Additional DIAMOND beamlines
4th Generation Light Source (initially a Test Bed and Design Study)
Free Electron Lasers

Neutron Scattering

Institut Laue Langevin renewal and Millennium Programme upgrade
ISIS Second Target Station – core facility and new beamlines
Next generation neutron source for Europe – possibilities include:
New 5MW + 5MW short and long pulse source (the "European Spallation Source")
New long pulse only source, >5MW
MW upgrade to ISIS

High Powered Lasers

Upgrades to Vulcan

Radioactive Particle Beams

Identify options for UK scientists in facilities overseas

Particle physics

Large Hadron Collider at CERN
Electron-positron linear collider
Muon collider
Neutrino factory (initially MICE)

Astronomy and Solar System Science

Atacama Large Millimetre/submillimetre Array (ALMA)
James Webb Space Telescope
Laser Interferometer Space Antenna (LISA)

R&D for 50-metre plus optical/infra-red telescopes, Square Kilometre Array (SKA) and X-ray Evolving Universe Spectroscopy (XEUS)
Euopean Space Agency (ESA) Aurora Programme
Extension to ESA MOSAIC programme

Fusion

International Tokomak Experimental Reactor (ITER)
Mega Amp Spherical Tokomak (MAST) upgrades
International Fusion Materials Irradiation Facility (IFMIF)

Oceanographic research vessels

Replacement for RRS Charles Darwin
Replacement for RRS Discovery

Computing Infrastructure

HPCx upgrades
1 Tflop/s system addition to CSAR
Future multi-Tflop/s high performance computing provision

Renewals, refurbishments and investments in Research Council Institutes

New building for the Laboratory of Molecular Biology (LMB)
Refurbishment of the Pirbright Laboratory at the Institute for Animal Health (IAH)
Research Complex to sit alongside Diamond synchrotron
Replacement of the Halley Research Station in Antartica

2. United States' National Science Foundation (NSF)[11]

MSI Definition: Acquisition, construction, commissioning, and upgrading of major research equipment, facilities and other capital assets that cost more than several tens of millions of dollars.

Current Process for Approval:

- Large facility proposals originate in the scientific community. NSF program officers and staff support these initiatives by providing funds for meetings and workshops that facilitate the scientific community's internal evaluation and maturation of these concepts. By the time a proposal is received by the NSF, ideas, alternatives, partnerships, cost and timeline estimates have been thoroughly examined.
- On receipt by the NSF, large facility proposals are subjected to a rigorous external peer review that focusses on intellectual merit and broad impacts.
- Successful proposals are recommended for further review by the Major Research Equipment and Facilities Construction (MREFC) panel that comprises the NSF assistant directors and office heads and is chaired by the NSF deputy director. The MREFC review panel evaluates the merit of a proposed project and then ranks it against other proposals under consideration. Projects that are not highly rated according to the criteria below (see Figure 3) are returned to the initiating directorates and may be reconsidered later. Highly rated projects are placed in priority order by the panel in consultation with the NSF director.
- From the MREFC panel recommendations, the NSF director selects candidate projects to be considered by the National Science Board (NSB). The NSB's Committee on Programs and Plans (CPP) takes the lead in reviewing a proposed project and makes recommendations to the NSB for inclusion in future budget requests and approving project implementation.
- Once the NSB has approved a project for funding, the director may recommend the project for inclusion in a future budget request to the Office of Management and Budget (OMB). The budget request is passed by the NSB and then a rank-ordered list of projects is presented to the OMB. The list of major projects in the budget may be modified during negotiations between the OMB and NSF. During that process, other parts of the executive branch, such as the White House Office of Science and Technology Policy, may provide input on the projects included in the budget.
- Finally, the NSF submits a priority list of projects to Congress as part of its budget submission.

Funding:

- Projects are funded through the NSF budget process. In 1995, the NSF created the MREFC account to support the "acquisition, construction, commissioning,

[11] Drawn from *Setting Priorities for Large Research Facility Projects supported by the National Science Foundation*, The National Academies Press, 2004.

and upgrading of major research equipment, facilities and other capital assets" that cost more than several tens of millions of dollars. The MREFC 2004 request was $202 million – about 15% of the tools budget and 3.7% of the NSF's total request.

Ongoing Management:

- There is a Deputy Director, Large Facility Projects, located within the Office of Budget, Finance and Award Management who provides management and oversight of all large projects from conceptualization through operation.

Recent National Academies Recommendations:

A recent review of the NSF's priority setting for large research facility projects by the NAS published the following recommendations:

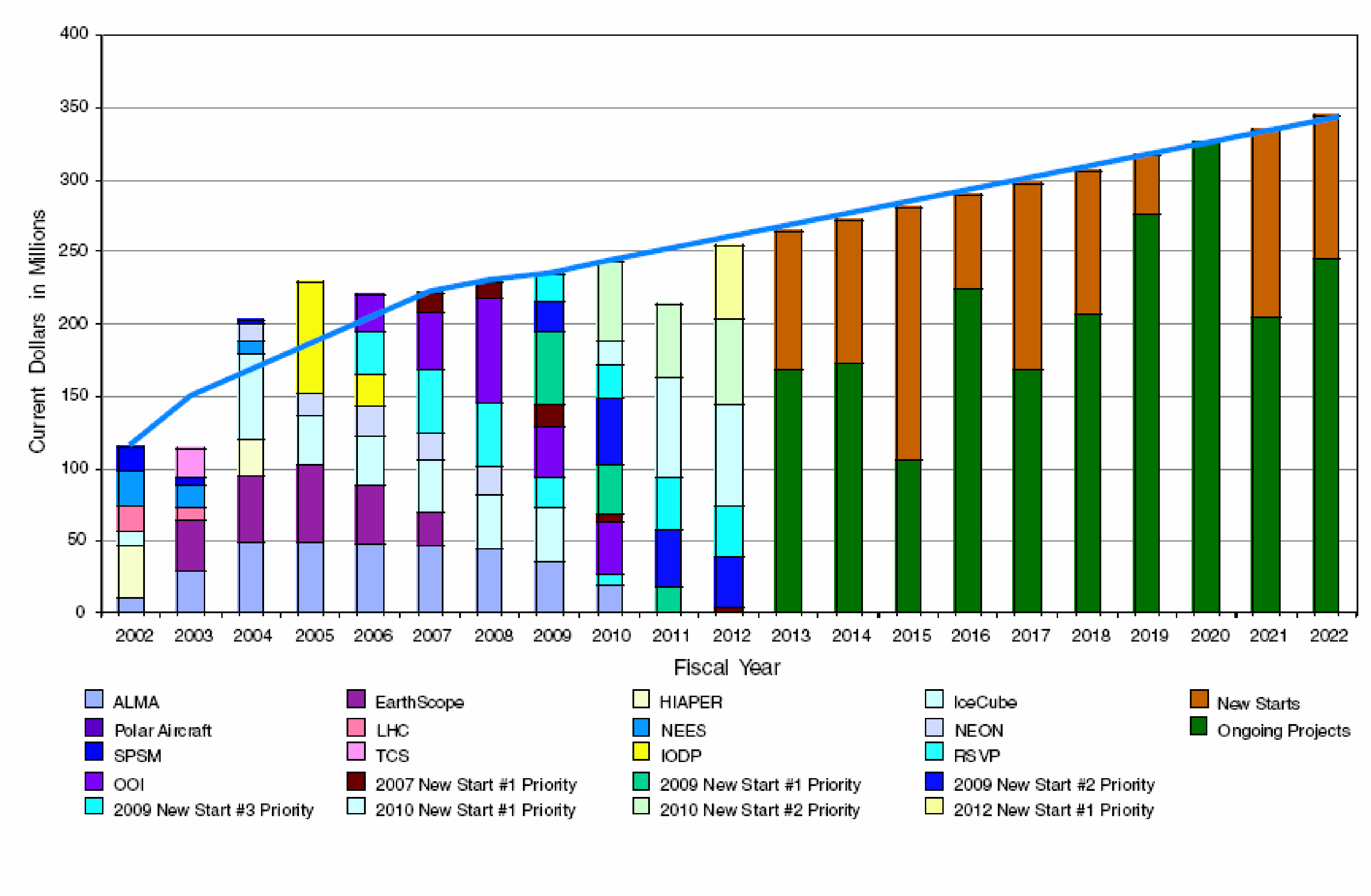
1. The NSB should oversee a process whereby the NSF produces a roadmap for large research facility projects that it is considering for construction over the next 10-20 years.
2. The NSF, with the approval of the NSB, should base its annual MREFC budget submission to Congress on the roadmap and should include: proposed yearly expenditures over the next 5 years for committed projects and for projects that will start in that period; rank ordering of proposed new starts; and rationale behind the proposed budget, project ranking and any differences between the budget submission and roadmap.
3. NSF should enhance project pre-approval planning and budgeting to develop a clear understanding of the project's technical definition or scope of work and implementation plan including periodic independent reviews of the project's progress relative to the original construction plan; and the creation of an oversight committee to monitor facility operations.
4. The Office of Science and Technology Policy in the Executive Office of the President should have a substantial early role in coordinating roadmaps across agencies and with other countries.

Roadmap:

Central to the NAS recommendations is the creation of a roadmap for large research facility projects under consideration for construction over the next 10-20 years. According to the NAS report, the roadmap should:

- Be based on broad inputs from the scientific community;
- Take into consideration the need for continued funding of existing projects, and should provide a set of well-defined potential new project starts for the near term (0-10 years);
- Reflect a reasonable projection of the large research facility budget over the next 2 decades. The roadmap is not a guarantee of funding but rather a plan for the development of NSF's large research facility program. Figure 2 shows an example of a 20-year budget roadmap.

Figure 2: NAS example of a 20-year budget for large facility projects



- Rank projects based on the criteria listed in Figure 3. Projects on the 10-20 year scale will necessarily be less well defined and ranked qualitatively, to yield a vision of the future rather than a precise funding agenda;

Figure 3: Criteria for Developing Large Facilities Roadmaps and Budgets

Overlapping categories of criteria should guide the preparation of the large facilities roadmap and NSF's annual budget submissions. As shown in Figure 1, scientific and technical quality must be at the core of these criteria. Because these are large facility projects, they must have the potential to have a major impact on the science involved; otherwise, they should not reach the next step. The rankings show what we would expect to happen first within a field, then within a directorate of NSF, and then across NSF. The criteria from earlier stages must continue to be used as the ranking proceeds from one stage to the next.

First Ranking: Scientific and Technical Criteria Assessed by Researchers in a Field or Interdisciplinary Area

- Which projects have the most scientific merit, potential, and opportunities within a field or interdisciplinary area?
- Which projects are the most technologically ready?
- Are the scientific credentials of the proponents of the highest rank?
- Are the project-management capabilities of the proposal team of the highest quality?

Second Ranking: Agency Strategic Criteria Assessed Across Related Fields by Using the Advice of Directorate Advisory Committees

- Which projects will have the greatest impact on scientific advances in this set of related fields taking into account the importance of balance among fields for NSF's portfolio management in the nation's interest?
- Which projects include opportunities to serve the needs of researchers from multiple disciplines or the ability to facilitate interdisciplinary research?
- Which projects have major commitments from other agencies or countries that should be considered?
- Which projects have the greatest potential for education and workforce development?
- Which projects have the most readiness for further development and construction?

Third Ranking: National Criteria Assessed Across All Fields by the National Science Board

- Which projects are in new and emerging fields that have the most potential to be transformative? Which projects have the most potential to change how research is conducted or to expand fundamental science and engineering frontiers?
- Which projects have the greatest potential for maintaining US leadership in key science and engineering fields?
- Which projects produce the greatest benefits in numbers of researchers, educators, and students enabled?
- Which projects most need to be undertaken in the near term? Which ones have the most current windows of opportunity, pressing needs, and international or interagency commitments that must be met?
- Which projects will have the greatest impact on current national priorities and needs?
- Which projects have the greatest degree of community support?
- Which projects will have the greatest impact on scientific advances across fields taking into account the importance of balance among fields for NSF's portfolio management in the nation's interest?

Ranking projects across disciplines is inherently not an exact science; nevertheless, these criteria, as illustrated by the questions, provide a framework for a discussion of why one project is accorded a higher priority than another and a mechanism for the discussion to be as objective as possible in ranking projects across fields. Within the ranking categories, the questions might change as government wide initiatives and unexpected occurrences shift priorities. Similarly, at times, some questions might have greater weight than others in the judgment of the NSB. The key element is for the questions and weighting to be identified before the ranking process begins and for a clear rationalization to be provided when proposed large research facility projects are ranked.

3. Australia[12]

MSI Definition:
Australia's National Collaborative Research Infrastructure Strategy (NCRIS) Advisory Committee uses the term "capabilities" rather than "infrastructure" to recognize that enhancing capacity in a given area of research may require a range of infrastructure investments, collaboration in international initiatives and the development of related human capital and networks. These capabilities are not limited to major science projects and cover a broader investment size.

Strategic Roadmap of Potential Research Infrastructure Investments:

The National Collaborative Research Infrastructure Strategy (NCRIS) is providing $542M over seven years to provide researchers with major research facilities, supporting infrastructure and networks necessary for world-class research. Although it will address major science projects, it has a broader scope covering smaller as well as major science investments. To help identify appropriate areas for investment, a strategic roadmap is under development. It will identify a number of "capabilities" that are judged to be priorities because of their potential to drive excellence across one or more strategically important fields of research and innovation in the medium to long term.

A discussion document was released in November 2004 which, amongst other things, provided a draft outline of the Strategic Roadmap. A Capability Scoping Document, which draws on stakeholder feedback and identifies the range of potential "capabilities" that could be included in the Roadmap, was published in June 2005. A prioritized short-list of capabilities will be produced by early 2006 and provide the basis for the first round of NCRIS funding allocations.

[12] Documents produced by the National Collaborative Research Infrastructure Strategy Advisory Committee, available at www.dest.gov.au/sectors/research_sector/policies_issues_reviews/key_issues/ncris

4. Germany[13]

Over the past 20 years, the BMBF has set up *ad hoc* groups to recommend priorities for funding large facilities whenever the need arose. Such recommendations go to the minister, who makes final decisions (subject to discussion with the Finance Ministry and Cabinet when appropriate).

In 2000, the BMBF asked the Science Council (an independent government advisory body) to review nine proposals for large basic research facilities (cost > €15M). The Science Council established a working group to conduct this evaluation which included scientists from universities and research establishments in Germany, the United States and Switzerland as well as individuals involved in and representing national and international scientific administrations. The group established six subpanels composed of 57 external experts, including 37 international participants.

The working group conducted a science policy appraisal of the proposals based partly on individual expert assessments of the scientific quality of each large-scale facility. The facilities were placed in the following categories: unconditional support, conditional support and those requiring further development. The Science Council's response also provided recommendations on the structure, funding and future assessment of large-scale facilities in Germany.

The following criteria for the science policy appraisal were drawn directly from the Science Council's report,

"The Science Council first carried out an expert assessment of each large-scale facility for basic scientific research listed by the BMBF and then, in a second step, placed the individual facilities and the respective expert assessments in an overall science policy context. The individual expert assessments of the large-scale facilities were carried out by various sub-panels. The main focus of the assessments was on

- the probability of fundamentally new insights or the possibilities of decisive scientific advances which could only be achieved with the large-scale facility,
- the large-scale facility's technical feasibility and the degree of technical innovation,
- the scientific and technical competence of the institutions involved,
- the already existing or anticipated acceptance of the (potential) users from immediately relevant and from neighbouring areas of expertise, and
- the fulfilment of various objectives of importance for research (transfer, international perspectives, promoting young scientists).

A science policy appraisal of the large-scale facilities was carried out by the Science Council building upon the assessments of the scientific quality of the individual facilities and taking the following aspects into account:

- Scientific potential of the research programme
- Fulfilment of science and technology policy goals as formulated 10 general "theses on the significance of large-scale facilities for basic scientific research.
- Degree of maturity of the technical concept and, linked to it, the possible timeframe for implementing the individual facilities

[13] Drawn from *Statement on Nine Large-scale Facilities for Basic Scientific Research and on the Development of Investment Planning for Large-scale Facilities,* 2003. Available at http://www.wissenschaftsrat.de/texte/5385-02.pdf

- The context of further national and international scientific development of the research fields to which they belong and their interaction with other disciplines."

Recommendations for future large-scale science facility assessments:

MSI Definition

The Science Council stated "Decisions on procurement above a cost limit of €50 - €100M which will be used by several institutions and are important for large sections of the scientific community must be based on funding recommendations made from a suitably broad perspective." and "It makes sense to continue to entrust this task to the Science Council".[14]

The 2002 Science Council assessment was the first appraisal of a wide range of large-scale facilities from a scientific and research-policy point of view. It recommended that this process represents an effective way to conduct these assessments and that future proposals be assessed according to uniform scientific and research policy criteria including the following points,

- "It is important to not only examine the procurement of specific facilities, but also to discuss the importance of and the prospects for the research areas concerned.
- Procurements should be considered that are not only supervised by universities but also by non-university research institutions.
- The expert assessment should be conducted in a structured framework that offers as much scope for comparison as possible.
- If necessary, the Science Council can continue to act in an advisory capacity beyond the initial assessment."

[14] "Statement on nine large-scale facilities for basic scientific research and on the development of investment planning for large-scale facilities", Pg. 74.

5. European Union

In planning for the Framework Program 7 (FP7), the EU's chief instrument for funding scientific research and technological development, a recent EU working document (2004)[15] recommended a more strategic approach to the construction and upgrades of major research infrastructure. It proposed that FP7 require the development of a vision and a roadmap for research infrastructure in Europe over the next 10 to 20 years. The European Strategy Forum on Research Infrastructures (ESFRI), mandated in 2002 to "support a coherent approach to policy-making on research infrastructures in Europe, and to act as an incubator for international negotiations about concrete initiatives," was well suited to develop this Road Map.

Purpose of the Roadmap

The Roadmap will provide an overview of major research infrastructure needs over the next 10-20 years. It will not prioritize or recommend on funding or location of proposed major research infrastructures, but will serve as a basis to make decisions and establish funding priorities. Projects vary in size depending on the field of research. The preliminary list published by ESFRI in April 2005[16] included 23 projects with costs ranging from less than €100 million to more than €1 billion. In a number of cases, the projects consist of a network of facilities located in several countries.

Criteria

Specific criteria established by ESFRI for projects to be considered for the Roadmap are defined in their Communication of December 2004[17].

> A number of criteria will be used to select the research infrastructure projects that will be able to enter in the European Roadmap. Some criteria may have to be tailored to the specific situation of the field; for instance, the financial threshold in the Steering Group "Physical sciences and Engineering" will differ from the one in the Steering Group "Social Sciences and Humanities".
>
> The criteria can be classified into several categories:
> **General criteria**
> The infrastructure projects to be included should:
> - comply with the general definition given above;
> - be new infrastructures or major upgrades of existing ones.
>
> **Scientific / Strategic criteria**
> The infrastructure projects should:
> - correspond to a real need for the development of the field in Europe;
> - be supported by the appropriate scientific community at European level;
> - be of pan-European interest;
> - be multi-user facilities offering an open access (physical or virtual) for scientists from all over Europe;

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[15] *Working Document on THE RESEARCH INFRASTRUCTURES IN FP7*, ftp:/ftp.cordis.lu/pub/infrastructures/docs/rifp7_workingdoc_291004_en.pdf
[16] *The ESFRI List of Opportunities*, ftp://ftp.cordis.lu/pub/era/docs/esfri_list_opportunities_290305.pdf
[17] *European Roadmap for Research Infrastructures ESFRI* http:www.lnl.infn.it/~nupecc/esfri%20Roadmap_171204.pdf

- be relevant at international level.

Technical and financial criteria

The infrastructure projects should:

- be timely and mature;
- be technologically feasible;
- open new possibilities or offer improved technological performance;
- have evaluated construction and operating costs;
- offer good possibilities for European partnership and commitment of major stakeholders. [18]

Consultation

To prepare the Roadmap, ESFRI has set up three Steering Groups covering: Physical Sciences and Engineering; Biological and Medical Sciences; and, Social Sciences and Humanities. The countries represented in ESFRI and the European Commission were invited to nominate a delegate to each Steering Group.

The Steering Groups review the following material:

- Existing roadmaps at national or European levels in relevant fields;
- Foresight studies made by the European Science Foundation (ESF) and the Global Science Forum (GSF) of the OECD;
- Recommendations by advisory bodies such as EURAB or the NREN Policy Committee;
- Contracts or studies supported by the European Commission;
- Information or submissions from formal organizations within the scientific and industrial communities; and,
- Solicit the views of important stakeholders in the field of research infrastructures, such as EIROforum (a collaboration of major European intergovernmental research organizations).

ESFRI's Steering Groups have the option of creating dedicated Expert Groups to address identified gaps. These may be needed for fields lacking organized scientific communities, as well as interdisciplinary or newly emerging fields. Members of Expert Groups are nominated by Member States and the European Commission. They may include non-European experts. Contrary to the situation in the Steering Groups, the members of an Expert Group are not considered to be the delegate of a research minister. The Steering Groups present their results and advise the ESFRI.[19]

Funding

Funding for projects identified on the Roadmap may come from a variety of sources including the European Commission, Member Countries and research councils.

[18] "European Roadmap for Research Infrastructures ESFRI" http://www.lnl.infn.it/~nupecc/esfri%20Roadmap_171204.pdf

[19] "European Roadmap for Research Infrastructures- ESFRI Communication" http://www.lnl.infn.it/~nupecc/esfri%20Roadmap_171204.pdf