A Review of Reports on Selected LARGE FEDERAL SCIENCE FACILITIES

Management and Life-Cycle Issues

Terrence K. Kelly
Aaron Kofner
Parry M. Norling
Gabrielle Bloom
David M. Adamson
Megan Abbott
Mark Wang

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PREFACE

ABOUT THIS ANALYSIS

The federal government manages and operates several large-scale research facilities of various types. The purpose of this study is to help the Office of Science and Technology Policy (OSTP) of the Executive Office of the President examine the issues surrounding the planning, operation, and management of selected large scientific facilities and to identify key areas in need of oversight or coordination by OSTP through the National Science and Technology Council (NSTC). In consultation with OSTP, a Science and Technology Policy Institute research team at RAND identified and studied several recent reports on the planning and management of such facilities. The ultimate aim of this work was to identify lessons that would be of value to the federal government as it builds, manages, and retires these facilities in the future. This RAND report summarizes each of the reviewed reports and synthesizes their key findings and recommendations.

This report should be of interest to those involved with the management or oversight of large federal research facilities and to scientists and technical staff who use these facilities for research.

A logical next step would be to conduct an analysis of the policies governing the development, operations, and maintenance of the collective large-scale federal scientific facilities, which constitute a significant portion of the federal scientific base. Although such an analysis is beyond the scope of this study, it could yield valuable insights into the conduct and potential of federally supported science

and technology efforts and lead to significant improvements in those efforts.

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- supports OSTP and other Executive Branch agencies, offices, and councils
- helps science and technology decisionmakers understand the likely consequences of their decisions and choose among alternative policies
- helps improve understanding in both the public and private sectors of the ways in which science and technology can better serve national objectives.

In carrying out its mission, the Institute consults broadly with representatives from private industry, institutions of higher education, and other nonprofit institutions.

Inquiries regarding the Science and Technology Policy Institute may be directed to:

Helga Rippen
Director
RAND Science and Technology Policy Institute
1200 South Hayes Street
Arlington, VA 22202-5050
Phone: (703) 413-1100 X5574
e-mail: stpi@rand.org
Web: http://www.rand.org/scitech/stpi

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SUMMARY

Funding and maintaining infrastructure to support the conduct of science have long been central components of federal research and development policy. In particular, the federal government manages and operates several large-scale research facilities of various types that enable scientific inquiry in a range of fields in which the United States seeks to retain global leadership, including high-energy physics, astronomy, and, increasingly, the life sciences.

These facilities pose complex management challenges throughout their life cycles, from initial planning for their creation, through operation and upgrades, to retirement and environmental cleanup. Constructing such facilities requires extensive planning and foresight. Program and facility managers frequently have to adapt to changes in the scientific fields they support, changes in their user communities, and changes in the policy and funding environments in which they compete for resources.

STUDY PURPOSE AND SCOPE

The purpose of this study is to help the Office of Science and Technology Policy (OSTP) examine the issues surrounding the planning, operation, and management of selected large scientific facilities and to identify key areas in need of oversight or coordination by OSTP through the National Science and Technology Council

(NSTC).[1] Our ultimate aim was to identify lessons that would be of value to the federal government as it builds, manages, and retires these facilities in the future.

To identify these lessons, RAND's Science and Technology Policy Institute (S&TPI) examined 20 reports on studies of, or related documents about, major science facilities and drew conclusions based on the findings and recommendations of the expert panels that produced this collection of documents.[2] The material presented here represents S&TPI's synthesis of the findings and recommendations in those reviewed documents. This report distills from those 20 reviewed documents lessons learned about the following issues of particular interest to OSTP and makes recommendations to the extent that they are supported by the documents RAND reviewed:[3]

- Issues regarding facility management effectiveness and efficiency
- Issues regarding accessibility of facilities to scientists
- Issues that affect the quantity and quality of scientific output
- Workforce (both technical and managerial) issues
- Issues of facility life-cycle management, including facility
  - planning and construction
  - instrumentation
  - modernization and modification
  - shutdown or retirement.

These topics clearly are not mutually exclusive and were not uniformly addressed in the reviewed reports. Most reports focused on operations, management, and upgrades for existing facilities, and

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[1]This report was limited to facilities owned, operated, or funded by the federal government. No generalization to private-sector scientific facilities is implied by the findings in this report.

[2]This collection of reports is not comprehensive, but rather is a sampling of reports that focused on certain types of large scientific facilities.

[3]We explicitly addressed these items when writing the "Findings and Recommendations" sections of Chapters Three through Twenty.

paid scant attention to the retirement of facilities and only slightly more attention to facilities planning and construction.

The scope of this project, as well as time and resource constraints, did not permit a comprehensive review of reports on all types of large scientific facilities. In particular, reports on classified facilities (e.g., those that produce materials for nuclear weapons) and some types of high-energy physics facilities (e.g., particle accelerators) were not included in this review.[4] In fact, the reports on Department of Energy (DOE) facilities were limited to those run by the DOE Office of Science.

SYNTHESIS OF THE REVIEWED REPORTS' FINDINGS AND RECOMMENDATIONS

The following general observations should be helpful in understanding the issues surrounding the planning, funding, management, and operation of large scientific facilities.

Facility Missions

- U.S. facilities are generally specialized, with little overlap in their capabilities and missions. The reports we reviewed contained no call for closing facilities to remove redundancy or for any other reason. The panels that prepared the reports generally found that each facility is contributing in its own way to science.
- There is a great deal of overlap and competition between U.S. and international facilities in the areas of neutron scattering and synchrotron sources. National prestige and scientific leadership were cited as reasons for upgrading existing U.S. federal facilities or building new ones, but technical capability and timely and convenient access by a growing user community are also of great

[4]However, a discussion of these facilities was included in a General Accounting Office (GAO) report to the Chairman of the Committee on Governmental Affairs of the U.S. Senate entitled *Department of Energy: Opportunity to Improve Management of Major System Acquisitions,* which is reviewed in Chapter Three of this report. Other reports covering these specific types of facilities, individually or as a group, were not otherwise reviewed due to budget and time restrictions.

importance to the continued evolution of multi-user, multi-program facilities.

- Although U.S. facilities are specialized, many of them are developing a broader, multi-purpose, diverse, and even interdisciplinary research program due to developments in the life sciences in particular. Facilities that had once been the exclusive domain of physicists and material scientists now have much broader user communities.

Access and Usage

- The increased breadth and diversity of research programs introduce increased difficulty in allocating access to facilities in a manner that seems equitable to all users. For example, prioritizing synchrotron beam-time allocation between a materials-science and a life-science experiment is controversial because it is difficult to compare their merits across disciplines.
- Maintenance, staffing, and instrumentation decisions have strongly affected, and in many cases limited, facilities usage. It is important to note that these decisions represent deliberate choices in which trade-offs have been made—e.g., to defer maintenance, to decrease support staff, or to not instrument beamlines in order to reduce funding requirements.

Adapting to Change

- The life expectancy of facilities can be extended significantly through doing facility upgrades, developing broader research programs, and conducting low-cost improvements and robust maintenance.
- The long time frames and uncertainty in building new facilities are often mentioned as justification for shorter-term upgrades, low-cost improvements, and maintenance funding.
- Discoveries motivate new research and experiments, which in turn require new instrumentation or facility capabilities. Assertions that U.S. science requires the building of new facilities need

to be weighed against the gains that can be realized through facility upgrades and other such changes.

ASSESSMENT ISSUES

The panels that produced these reports used a wide range of methodologies and approaches to reach their conclusions. In particular, some panels primarily reviewed documents, while others solicited expert input or visited facilities. Also, the degree of internal user-group input varied compared with the degree of input from external users or scholars from other fields.

Although the reviewed reports covered many different facilities of several types, they contain a surprising number of common concerns and suggestions. In particular, the General Accounting Office (GAO) report to the Chairman of the Committee on Governmental Affairs of the U.S. Senate on DOE major systems acquisitions (discussed in Chapter Three)[5] and the Cooperative Stewardship report[6] (discussed in Chapter Five) contain excellent summations of issues and solutions that cover a wide variety of facilities.

In the following sections, we address OSTP's specific concerns (as listed earlier under "Study Purpose and Scope") regarding the funding and management of federal science facilities.

MANAGEMENT OF ONGOING OPERATIONS

This section addresses management efficiency and effectiveness, workforce issues, scientific access to experimental stations within these facilities, and maximizing scientific output. It includes key findings and recommendations gleaned from the reviewed reports and synthesized by the S&TPI research team.

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[5]General Accounting Office, *Department of Energy; Opportunity to Improve Management of Major System Acquisitions*, Washington, D.C.: GAO, GAO/RCED-97-17, 1996 (available at http://www.science.doe.gov/SC-80/sc-81/PDF/rc97017.pdf).

[6]Committee on Developing a Federal Materials Facilities Strategy, *Cooperative Stewardship: Managing the Nation's Multidisciplinary User Facilities for Research with Synchrotron Radiation, Neutrons, and High Magnetic Fields,* Washington, D.C.: National Academy Press, 1999 (available at http://books.nap.edu/html/cooperative_stewardship).

Important to the understanding of the discussion that follows is the fact that many large scientific facilities work concurrently in two modes—operating the overall facility and operating the experimental stations within the facility. The first mode involves the core operations, maintenance, and modernization of the facility, including the provision of some level of technical assistance to the experimental stations, whereas the second mode typically includes the development, installation, use, and upgrade of the instruments needed to conduct experiments.

Personnel Issues

Personnel issues concerning both the numbers and quality of managerial and technical staff are sufficiently similar across federal government agencies with large scientific facilities to warrant attention from the Executive Office of the President. This is not a high-visibility issue, but it has the potential to negatively affect scientific productivity at federal facilities. OSTP, through the NSTC, should monitor this aspect of the nation's scientific health on a routine basis using well-defined goals and metrics.[7]

Funding

The findings of the Cooperative Stewardship report, which are covered in Chapter Five, were validated by the other reviewed reports: (1) A single agency should fund core operations and maintenance (the "stewardship model") because relying on multiple agencies to fund core functions can lead to shortfalls if agency missions change or if appropriations subcommittees of the Congress disagree on priorities; (2) funding for instrumentation and experimental stations should come from user groups as well as from the steward agency and should be coordinated by an interagency body; and (3) OSTP, through the NSTC, should work with the federal agencies representing this increasingly diverse user community to ensure adequate management and funding of instrumentation and experimental sta-

[7]This recommendation is limited to federal government facilities; no assertion is made about facilities that are not owned, operated, or funded by the government. Furthermore, the NSTC will need to define the metrics and goals for managing this issue.

tions. The Office of Management and Budget should play a key role in this interagency coordination process.

Access

OSTP, through the NSTC, should coordinate the development of a streamlined, transparent, and standardized set of legal and administrative practices and a process for implementing those practices at federally owned facilities. In doing so, care is needed to make sure new, nontraditional users become familiar with how access and resource allocation decisions are made.

Life-Cycle Planning

In planning for new facilities, particularly unique or first-of-a-kind facilities, flexibility in expectations for life-cycle costs is necessary. This is not to say that "anything goes," but rather that realistic proposals, based on the best cost estimates, must be updated at set periods by competent management teams. Furthermore, despite long-term planning for future facilities, capability upgrades and modernization should be explicitly considered in life-cycle planning given that the reviewed reports clearly indicate that those steps will be needed.

CONCLUSION: THE NEED FOR GREATER COORDINATION AND NEXT STEPS

In managing and planning the collective base of large scientific facilities, it is clear that interagency coordination led by an authoritative body able to convene suitable interagency meetings and set policy is critical. No single agency has a complete perspective on all ongoing efforts and plans and can make well-informed objective recommendations on priorities, funding, and other systemic issues. As the entity within the Executive Office of the President charged with coordinating and setting government-wide science and technology policy, OSTP (through the NSTC) has the potential to bring the disparate players together to identify and resolve national-level issues. Therefore, OSTP is the logical candidate to lead this process.

A document of the scope of this report can explore only a few general themes and present a few specific recommendations. Nevertheless, these themes and recommendations, coupled with a robust NSTC process to oversee and provide guidance to agencies owning large scientific facilities, should yield significant improvements in the planning, operation, and management of large U.S. science facilities.

A logical next step would be to conduct an analysis of policies governing the development, operations, and maintenance of the collective large-scale federal scientific facilities, which constitute a significant portion of the federal scientific base. Although this analysis is beyond the scope of this study, it could yield valuable insights into the conduct and potential of federally supported science and technology efforts and lead to significant improvements in both.

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ACRONYMS

AAS	American Astronomical Society
ALS	Advanced Light Source
ANL	Argonne National Laboratory
ANS	Advanced Neutron Source
APS	Advanced Photon Source
BESAC	Basic Energy Sciences Advisory Committee
BioSync	Structural Biology Synchrotron Users Organization
BNL	Brookhaven National Laboratory
CAMD	Center for Advanced Microstructure and Design
CAT	Collaborative Access Team
CESR	Cornell Electron Storage Ring
CHESS	Cornell High Energy Synchrotron Source
DOE	U.S. Department of Energy
EIS	Environmental impact statement
eV	Electron volt
FPIH	*Facility Project Implementation Handbook*
FPM	Facility project manager

GAO	General Accounting Office
GeV	Giga-electron volts (billion electron volts)
GO	General Observer
HFBR	High Flux Beam Reactor
HFIR	High Flux Isotope Reactor
HST	Hubble Space Telescope
HTP	Hubble Treasury Program
ILL	Institut Laue-Langevin (Grenoble, France)
IPNS	Intense Pulsed Neutron Source (ANL)
ISIS	Rutherford Appleton Laboratory Pulsed Spallation Source (Oxford, United Kingdom)
IWG	Interagency Working Group
keV	Kilo-eV (thousand electron volts)
LANL	Los Alamos National Laboratory
LANSC	Los Alamos Neutron Science Center
LFP	Large facility project
LIGO	Laser Interferometer Gravitational Wave Observatory
LSC	LIGO Scientific Collaboration
meV	Milli-eV (thousandth of an electron volt)
MeV	Mega-eV (million electron volts)
mm	Millimeter
MMA	Millimeter Array
MSA	Major system acquisition
MW	Megawatt
NASA	National Aeronautics and Space Administration
NCNR	NIST Center for Neutron Research

NIH	National Institutes of Health
NIST	National Institute of Standards and Technology
NML	National Magnet Laboratory
NOAO	National Optical Astronomy Observatory
NRAO	National Radio Astronomy Observatory
NRC	National Research Council
NSB	National Science Board
NSF	National Science Foundation
NSLS	National Synchrotron Light Source
NSTC	National Science and Technology Council
OBES	Office of Basic Energy Services (DOE)
OMB	Office of Management and Budget
ORNL	Oak Ridge National Laboratory
OSTP	Office of Science and Technology Policy
PRT	Participating Research Team
PSS	Pulsed Spallation Source
R&D	Research and development
S&E	Science and engineering
SIRTF	Space Infrared Telescope Facility
SNS	Spallation Neutron Source
SSRL	Stanford Synchrotron Radiation Laboratory
S&TPI	Science and Technology Policy Institute
STScI	Space Telescope Science Institute
TAC	Telescope Allocation Committee
UVOIR	Ultraviolet-optical-infrared