2016 LARGE FACILITIES WORKSHOP SUMMARY REPORT

National Science Foundation

May 24-26, 2016
Smithsonian Institution
Washington, DC

Contents

1 Introduction

1.1 Purpose

The Large Facilities Workshop is an annual event hosted by NSF's Large Facilities Office (LFO). The workshop is a collaborative forum for NSF's Large Facilities community intended to provide participants with continuous learning and information sharing opportunities. Desired outcomes to advance the NSF mission of scientific research at Large Facilities include:

- Sharing knowledge and experience with best practices and common challenges that arise for both NSF and its Large Facilities.
- Discussing new initiatives and engaging the Large Facilities community for input.
- Demonstrating project management, operations, new policy initiatives, and business-related tools and techniques.
- Expanding our community of practice and connecting Large Facility colleagues to share information, experience, and expertise.

The workshop is held every year, with even year workshops in the Washington, DC area and odd year workshops in the field at a Large Facility.

1.2 Format

The agenda and presentations from the workshop are included in Appendices A and D and available on the 2016 NSF LFW webpage. The list of participants and an overview of the range of participants are included in Appendix B and Section 3.

The workshop content targeted the following kinds of professionals:

- Project managers, estimators, schedulers, and controllers
- Principal Investigators and scientists
- Planners, architects, engineers, and construction managers
- Cooperative agreement and contracting officers
- Business professionals
- Policy and oversight stewards
- Facility operations, maintenance, and property managers

The agenda was structured to provide a diverse selection of relevant topics for the Large Facilities community along multiple tracks, including a dedicated business track. Various approaches for information sharing were used, with plenary presentations plus break-out sessions featuring presentations, panels, and roundtable discussions. The workshop was also structured to present NSF's evolving oversight approach at a high level, followed by more detailed discussions of key elements. Recommendations from the *National Academy of Public Administration (NAPA) Panel Report on NSF Use of Cooperative Agreements to Support Large Scale Investment in Research* were also presented. The overall NAPA recommendations were then linked to individual break-out sessions, including sequenced sessions where solutions from other federal agencies were first presented then later followed by roundtable discussions soliciting feedback from the community for development of NSF guidance. Speakers were encouraged to present and elicit “Best Practices” or “Actionable Recommendations” which were then captured by dedicated note takers.

NSF was proud to co-sponsor the 2016 workshop with the Smithsonian Institution and showcase highlights from our similar missions. The workshop took place on the National Mall at the Smithsonian S. Dillon Ripley Center. The Smithsonian also generously arranged three behind the scenes tours of their newest construction and renovation projects, including unopened exhibits and museums:

- Major exhibit renovations at the National Air and Space Museum
- Construction and exhibit design at the new National Museum of African American History and Culture
- Major renovations and historic preservation of the Arts and Industries Building

2 Presentation Highlights

This section provides very brief summaries of the presentations, including their purpose, major points, and discussions. Any key takeaways from interactive discussions that can be characterized as "Best Practices" or "Actionable Recommendations" are also noted. Where possible, organizations responsible for following up on any actions are also identified. This section is intended to summarize and supplement the detailed, expert slide presentations included in Appendix D and available on the 2016 NSF LFW webpage, not transcribe all comments and discussions. More detailed but rough notes on the various viewpoints expressed during the discussions are available and may be requested from LFO. These notes will be used by LFO to help inform the Action Recommendations.

2.1 Tuesday May 24, 2016

Welcome, Opening Remarks

Speakers: Matt Hawkins (Head, Large Facilities Office (LFO), NSF), Nancy Bechtol (Director, Facilities, Smithsonian Institution)

NSF and the Smithsonian Institution welcomed attendees, gave an overview of the workshop, and discussed their respective large facilities portfolios. Open discussion and collaboration among organizations was encouraged as well as promulgating any actionable recommendations and best practices from attendees.

Laser Interferometer Gravitational Wave Observatory (LIGO): The Inside Story

Speaker: Mike Landry (Detection Lead Scientist, California Institute of Technology, LIGO Hanford Observatory)

Advanced LIGO began operations in 2015 with spectacular results, detecting gravitational waves in the first month! The presentation discussed highlights and best practices from initial proposal of the LIGO Hanford and Livingston Observatories through their path to discovery, including construction, advanced instrumentation, testing, transition to operations, and first detection.

Best Practices:

- Proposal for observatories clearly identified that initial detection instruments were at the frontiers of technology and that upgraded detectors must be accommodated in the future.
- 10x increase in instrument sensitivity was >10x harder.
- Adopted "checklist manifesto" using lists with a minimum set of things to do, akin to aviation style checklists.
- Importance of safety, supported through checklists, hazards analyses, and stop work orders.
- Importance of quality assurance for hardware and software.
- Advanced LIGO increased organizational hierarchy over LIGO but delegated authority and responsibility downward to increase decision making speed.

- Find ways to discover potential installation and coordination issues as early in a project as possible, e.g., testing and commissioning of second observatory included more parallel efforts while implementing lessons learned from first observatory.
- Continuity of key personnel: much of the staff that operated LIGO was involved with Advanced LIGO construction and now operation.

Transforming Concepts Into Reality: Project Management Insights from NASA's Goddard Space Flight Center

Speaker: Dave Mitchell (Director, Flight Projects Directorate, NASA Goddard Space Flight Center)

Helped broaden NSF's community of practice with personal experience and perspective on project management from NASA science mission projects. Highlights included reflections on the development of the MAVEN mission to Mars which launched in November 2013 and arrived at the Red Planet in September 2014.

Best Practices:

- Need schedule and budget contingency to mitigate risks.
- Need to manage technical reserves and design margin to mitigate impacts to design, mission performance, and schedule.
- Need to manage schedule sensitivities and deadlines, e.g., launch windows.
- Complex designs may need unique or one-of-a-kind facilities and support equipment.
- Major unplanned events often require a project "stand-down" and re-plan.
- Importance of communicating project scope and contingency management when involved in partnerships with outside organizations.
- Requirements creep, both in the science and engineering areas, must be minimized to stay on schedule and within budget.
- Facilitate wide open communication – listen and share the good, the bad and the ugly.
- Establish, maintain, and implement an executable baseline – develop clear, stable objectives/requirements from the outset; establish clean interfaces; track changes, implement corrective actions when necessary; and maintain effective configuration control.
- Rigorous tracking of metrics (cost, schedule, technical) is critical to keeping leadership aware of negative trends in order to react early.
- Proper early project staffing – brought the schedule lead, financial manager, and Earned Value Management (EVM) lead onboard at the beginning of the project to design a Work Breakdown Structure (WBS)-based schedule and EVM system.
- Stability of leadership and continuity of key personnel through the project lifecycle is critical.
- Push to get front line managers in the project office that have strong hardware development experience.
- Match heritage system with heritage people since not all documentation is available.
- Wisely structured competitions yield the most suitable team to complete the project.
- Perform periodic reviews to capture and implement lessons learned.
- Managing a green project better than a red project – have to start explaining the project rather than managing the project.

Actionable Recommendations:

- Perform independent cost and schedule reviews 6 months prior to Preliminary Design Review as these provided significant benefit. [ACTION: LFO will provide additional expectations in draft Large Facilities Manual (LFM) section 4.2.]

NSF and the Federal Budget

Speaker: Michael Sieverts (Division Director, Budget Division, NSF),

An overview of the federal budget process was provided to provide additional context and perspective for how the NSF budget and the Major Research Equipment and Facilities Construction (MREFC) budget requests fit into the overall process. The budget planning timeline was presented and the community was informed of current events related to the FY17 budget request and provided links to additional resources.

"Lightning Talks" from Large Facilities

Speakers: Demian Bailey (Project Manager, Regional Class Research Vessel, Oregon State University), Andy Adamson and Scott Kleinman (Associate Director Operations and Associate Director Development, Gemini Observatory), Mike Carrancho (Deputy Director, Engineering and Design Division, Office of Planning, Design and Construction, Smithsonian Facilities), Joel Brock (Director, Cornell High Energy Synchrotron Source), Jamie Allan (Program Director, Integrated Ocean Drilling Program, GEO, NSF), Rick Farnsworth (Senior Program Manager, National Ecological Observatory Network), John Kelly (Program Director, Arecibo Observatory), Murray Stein (Director of Marine Operations / Marine Superintendent, University of Alaska Fairbanks)

Speakers highlighted recent accomplishments and challenges from a cross section of NSF and Smithsonian facilities. Session served an opportunity to share and collaborate with the community.

Best Practices:

- Need to be nimble to handle different funding scenarios.
- University teams are often still used to "grad students and duct tape"; cultural shift to more rigorous project management and systems engineering approaches is challenging.
- Renovation and retrofit projects present unique cost and schedule risks.
- Buy down risks up front when possible, e.g., via advanced procurements.
- Emphasize and carefully evaluate the unique aspects of each facility.
- Make facilities sustainable via green initiatives.

Actionable Recommendations:

- NSF: Consider setting goals during design and reporting requirements during operations for "uptime metrics" (e.g., % time and costs for operations, maintenance, idleness). [ACTION: LFO will consider providing additional information via the LFM.]

Business Practices Roundtable Part I: Making Sense of Audits and Reviews

Facilitators: Florence Rabanal (Large Facilities Advisor, LFO, NSF), Anna-Lee Misiano (Grants and Agreements Officer, DACS/CSB, NSF), Charlie Zeigler (Cost Analyst, DIAS, NSF)

Provided overview of the common types of audits and reviews, including the purpose and personnel involved. Engaged participants to gather input and ideas for improvement and identify areas where NSF clarification or assistance is needed.

Best Practices:

- Clarify in communications the specific type of review and audit being conducted.

Actionable Recommendations:

- NSF: Clarify and communicate the scope and timeline for completion of audits and reviews. [ACTION: LFO will consider providing additional information via the LFM and/or website.]
- NSF: Disseminate best practices and lessons learned from audits and reviews to the large facilities community to allow continuous improvement. [ACTION: LFO will compile major issues identified over the last 5 years for distribution to the community. LFO will have "BSR Hot Topic" presentations at annual LFW.]

GAO – Schedule Assessment Guide & Cost Estimating and Assessment Guide

Speaker: Jason Lee (Assistant Director, Applied Research and Methods, US Government Accountability Office)

Provided an overview of GAO Cost Estimating and Assessment Guide and the GAO Schedule Assessment Guide, focusing on best practices to facilitate integrated project planning and management. Discussed the characteristics of a reliable, high-quality cost estimate. Discussed the characteristics of a reliable, high-quality schedule. Identified how to participate in update to the GAO cost estimating guide.

Best Practices:

- The steps and best practices in the GAO cost guide can be organized into the four characteristics of a reliable, high-quality cost estimate: Comprehensive, Well-Documented, Accurate, Credible.
- Include life-cycle costs in estimates – they are typically much higher than construction costs.
- Importance of WBS to organize the estimate and clearly determine whether costs are double-counted or omitted.
- The GAO Cost Guide presents 8 types of independent cost reviews; any of the review types meets the intent of the GAO guide to get an independent check on the estimate.
- An independent cost estimate (ICE) is the most rigorous review type; reconciliation of the ICE with the project estimate helps ensure estimate is Credible and Accurate.
- A Well-Documented estimate can be quickly recreated by an analyst unfamiliar with the program and yield the same result.
- Importance of including ground rules and assumptions and accuracy range when presenting estimate to management, not just presenting the point estimate.
- The GAO Schedule Guide presents four characteristics of a reliable, high-quality schedule: Comprehensive, Well-Constructed, Credible, and Controlled.

- Importance of resource-loading schedules.

Actionable Recommendations:
- GAO can provide material they use in cost and schedule assessments (e.g., lists of requested documents; interview questions; record of analysis templates; MS Excel workbooks for assessing MS Project files; MS Project filters, tables and views for assessing MS Project files; Primavera P6 workbooks and filters (still under development)). [ACTION: LFO has received available GAO material and will post publically on LFO website.]
- GAO can provide training on the cost and schedule guides. [ACTION: LFO will consider options for GAO training into the professional training, experience, and qualification guidance being developed and discussed further below.]

Smithsonian Institution – Building Information Modeling & Asset Management

Speaker: Mike Carrancho (Deputy Director, Engineering and Design Division, Office of Planning, Design and Construction, Smithsonian Facilities)

Provided an overview of the Smithsonian's recent initiative to use data rich Building Information Modeling technology for design, construction, and lifecycle management of capital assets.

Best Practices:
- Find out how all stakeholders could use a system before writing requirements.
- Justify adoption of new systems by the value they offer, not based on arbitrary criteria like counts or area.
- Make the results widely available within the organization.
- Consider security of information from the outset.
- BIM is becoming widely used standard practice for lifecycle management of capital assets.
- BIM is a very useful tool for project visualization and reviews, providing 3D interactive models, with immersive virtual reviews under development.

Organizational Climate Studies – Experience from NSF's Advanced Cyberinfrastructure Projects

Speaker: Lizanne DeStefano (Georgia Tech Center for Education, Integrating Science, Mathematics, and Computing)

Presented methods for assessing organizational climate based on experience within the Extreme Science and Engineering Discovery Environment (XSEDE) and Blue Waters supercomputing projects. Stressed importance of collecting and acting upon feedback to create a positive work atmosphere and a high performing organization focused on continuous improvement.

Best Practices:
- Consider use of organizational climate studies and similar tools to get feedback for improvement.
- Involve an institutional review board when designing surveys and evaluation protocols.
- Have performance measures to identify promising or problematic trends.
- Use logic models to map processes and help identify potential problems and solutions.
- Encourage feedback and clearly demonstrate and communicate resulting improvements.

Business Systems Reviews (BSR) Hot Topics

Speaker: Florence Rabanal (Large Facilities Advisor, LFO, NSF)

Discussed recurring BSR observations on property and equipment management. Solicited community stakeholder feedback on property management expectations, requirement, and challenges.

Best Practices:

- Importance of well-organized and comprehensive repositories for key information (e.g., warranties, maintenance).

Actionable Recommendations:

- NSF: Highlight property and equipment capitalization requirements to recipients with construction projects. [ACTION: LFO will consider options for highlighting existing guidance.]
- NSF: Provide guidance to recipients on how to report equipment that is used for multiple projects. [ACTION: LFO will consider options for providing additional guidance.]
- NSF: Provide examples of best practices for reporting work in progress and construction in progress. [ACTION: LFO will consider options for providing additional examples.]
- NSF: Work with NSF Property Office and discuss where LFO or other NSF-wide Large Facility stakeholders might partner and assist in the processing of property-related requests. [ACTION: LFO will consider options for facilitating property-related requests.]

2.2 Wednesday May 25, 2016

NSF Future Investments, NAPA Report, and Evolving Oversight

Speaker: Matt Hawkins (Head, LFO, NSF)

Presented summary of Dr. Cordova's "NSF Ideas for Future Investments" presented to the National Science Board in May. Noted NSF initiative to lower the threshold for MREFC expenditures for "mid-scale research infrastructure" below $100M, including appropriate modification of processes, to increase the flexibility for science projects.

Provided an overview of the National Academy of Public Administration (NAPA) Panel Report on NSF Use of Cooperative Agreements to Support Large Scale Investment in Research. The NAPA report supported NSF use of cooperative agreements and provided recommendations intended to improve NSF's oversight and project management practices for large facility construction projects. Requested community input to facilitate implementation of recommendations and inform forthcoming guidance within our Large Facilities Manual. Discussed initiative to develop a community of practice for documenting, sharing, and implementing lessons learned. Discussed initiative to implement requirements for project management experience, certification, and training.

Best Practices:

- Importance of clearly communicating when new initiatives apply to Large Facilities construction and/or operation.

Smithsonian Institution – Lessons Learned Database and Implementation

Speaker: Jim Yuengert (Smithsonian Institution (SI), Office of Planning, Design and Construction)

Described Smithsonian's recent development of an electronic database and process for collecting and implementing lessons learned throughout their community. Shared examples from Mathias Lab Construction and Cooper Hewitt Smithsonian Design Museum Renovation. The interactive discussions helped inform NSF of ways to develop a lessons learned database.

Best Practices:

- Culture change is challenging – make a leadership priority and emphasize open communication and constructive learning environment.
- Keep the system simple including required background information.
- Leverage existing systems and business processes.
- Document lessons as they come up, don't wait until the end of the project.
- Capture key words to allow searching and trending.
- Find ways to act on lessons to reinforce their value.

Cyberinfrastructure (CI) Scoping Roundtable

Facilitator: Bill Miller (Division of Advanced Cyberinfrastructure, CISE, NSF)

Reviewed outcomes from the December 2015 NSF-sponsored workshop on "Cyberinfrastructure for NSF Large Facilities," which brought together the topic of cyberinfrastructure and the topic of large facilities for the first time. Discussed the NSF goals to have a deeper understanding of CI needs within and external to facilities, foster dialogue and collaboration, and create a dynamic CI ecosystem.

Best Practices:

- Proactively engage other organizations to facilitate partnering in big data issues.
- Continually communicate NSF capabilities for data analytics.

Integrated Cost-Schedule Risk Analysis

Speaker: David Hulett (Principal, Hulett & Associates)

Provided overview of advanced integrated cost and schedule risk analysis.

Best Practices:

- Carefully consider correlation and multiplicative effects of risks, they can affect time and cost and multiple activities.
- Carefully consider systemic risks.
- Add costs as time-dependent and time-independent resources.
- Interview personnel for good risk data.
- Prioritize risk-mitigation actions and commit to them.

The NSF Cybersecurity Center of Excellence: Large Facilities Cybersecurity Resources

Speaker: James Marsteller (Information Security Officer, Pittsburgh Supercomputing Center)

Provided overview of the Center of Trustworthy Scientific Cyberinfrastructure (CTSC), including CTSC mission, past work with large facilities, key resources and events of interest to large facilities. Highlighted CTSC efforts to improve situational awareness for large facilities.

Best Practices:

- Build and maintain highly effective cybersecurity programs appropriate for the science mission and responsive to evolving risks and requirements.
- Highly effective programs require budget for personnel and tools, clearly defined rules for governance, situational awareness, and engagement with the NSF cybersecurity community.

DOE Project Management Career Development Program

Speaker: Linda Ott (DOE Office of Project Management Oversight & Assessments)

Described DOE's Project Management Career Development Program (PMCDP). Included discussion of the value proposition of investing in project management skillset development, DOE's reason for establishing PMCDP, lessons learned, the value of tracking and measuring Federal Project Directors (FPDs), and the status of PMCDP and FPD certification a decade later.

The session provided an example of an existing federal program that was successfully implemented for developing project managers. Laid the ground work for Thursday roundtable discussion of how to develop a similar program for NSF and our large facility community. The session also touched on two main tenets of the NAPA report, qualifications of project managers and building a community of practice.

Best Practices:

- Devise or select a program for federal employees compliant with Federal Acquisition Certification for Program and Project Managers (FAC-P/PM).
- Have a program that is rigorous, fair, and useful, but still flexible.
- Include elements of training, continuous learning, demonstrated experience, performance, leadership and communication skills, and peer superior reviews.
- Distance learning as valuable as classroom learning for most introductory classes; however, asynchronous deliveries (pre-recorded classes) are not as effective since students may "fast forward" through the content.
- Newsletter keeps the community engaged in current offerings and future directions.

Transition to Operations – Panel

Panel: Carol Wilkinson (Large Facilities Advisor, LFO, NSF), Mike Landry (Detection Lead Scientist, California Institute of Technology, LIGO Hanford Observatory), Derek Ross (Deputy Director, Construction Division, Office of Planning, Design and Construction, Smithsonian Facilities), Steve Ellis (Program Director, BIO, NSF)

The panel discussed approaches for transitioning into operations, including lessons learned from their recent projects. Differences in the projects required different approaches to transitioning (e.g., two observatories, distributed networks of observatories, standalone building), but the different approaches still had many common best practices. The interactive discussions helped inform NSF's development of additional guidance on transitioning into operations. No slides were used during the panel discussion.

Best Practices:

- Need clear delineation of how and when a project will exit the Construction Stage and enter the Operations Stage.
- Need this clear delineation defined early in project development to set scope, cost, and schedule.
- Define requirements, roles, and responsibilities in a Transition to Operations Plan.
- Each project should determine the most appropriate transition approach for their unique circumstances.
- Importance of thorough and real time documentation for as-built configurations, proof of commissioning, testing, inspection, and acceptance.

- Be mindful of warranty periods and need for operations and maintenance manuals.
- Multi-disciplinary project teams – design, construction, science, operations, maintenance – with frequent in person communication can help drive Construction Stage to completion.
- Management of staff during any overlap period is critical – good communications, clear expectations, same standards – don't "throw it over the wall".

Business Practices Roundtable Part II: New Initiatives

Facilitators: Jeff Lupis (Division Director, DACS, NSF)

Provided additional background and context for recent initiatives to further review recipient financial information, cost information (award budgets and incurred costs), management fee, and to explain the "how, what and when" of new incurred cost audits. Community input was requested on business practices and oversight to improve processes.

Best Practices:

- Clearly communicate standardized guidance to help ensure facility compliance and proper NSF oversight.

2.3 Thursday May 26, 2016

NASA Evolvable Mars Campaign Development

Speakers: Stephen Hoffman (SAIC), Larry Toups (Johnson Space Center, NASA)

Provided an overview of the concept of operations, requirements, and organizational structure to pioneer an extended human presence on Mars. Described challenges associated with a harsh, distant, and uncertain environment. Described technology development and project management framework for projects that require new technologies and flexible approaches in uncertain environments.

Best Practices:

- Provide clear linkage of current investments in large scientific research facilities to future capability needs.
- Develop facility management approaches that work best for the unique research, operations, and maintenance requirements.
- If your project has unique technical risks and uncertainties, develop evolvable phased approaches, multi-use and flexible designs, and built in margin.
- Importance of mockup and testing for proving new systems.
- Look broadly for analogs of projects.
- Need to manage schedule sensitivities and deadlines, e.g., launch windows.
- Correlate tasks in each phase to logistics constraints.
- Use Technology Readiness Assessment Guides (e.g., NASA, DOE, DOD, forthcoming GAO Guides) to manage projects requiring cutting-edge technologies.

Actionable Recommendations:

- NSF: Consider use of Technology Readiness Assessment Guides. [ACTION: LFO will consider adding technology readiness guidance to the LFM.]

Large Facilities: Environmental Compliance and Permitting and Lessons Learned

Speaker: Caroline Blanco (Assistant General Counsel - Environment, OD/OGC, NSF)

Discussed need for large facility recipients to obtain permits and NSF responsibilities for environmental compliance. Discussed challenges faced by NSF and recipients when trying to meet their respective obligations, which can result in schedule delays and increased costs. Highlighted recent challenges from Daniel K. Inouye Solar Telescope (DKIST) and National Ecological Observatory Network (NEON) and presented strategies for effective and efficient risk mitigation.

Best Practices:

- Start early and be transparent.
- Clearly define NSF and recipient roles.
- NSF bears responsibility for environmental compliance while the project must obtain any necessary permits.
- Use NSF provided checklist to help NSF decide what kind of environment reviews, if any, must follow.

- Engage the public on a personal level and understand the local culture before holding public meetings.

Smithsonian Institution – Science Exhibit Highlights

Speaker: Elizabeth Musteen (Chief of Exhibit Production, Office of Exhibits, National Museum of Natural History, Smithsonian Institution (SI))

Discussed highlights and lessons learned from the design and construction of some of the newest and most exciting Smithsonian science exhibits, including the Sant Ocean Hall, Kenneth E. Behring Family Hall of Mammals, Butterflies and Plants: Partners in Evolution, the Behring Family Rotunda, and the Annenberg Hooker Hall of Geology, Gems and Minerals.

Best Practices:

- Act as a visitor advocate when developing education and public outreach displays, put yourself in their shoes.
- Use on-line and other technologies to make education engaging and interactive, and readily accessible after leaving the exhibit.
- Simplify displays while still engaging and informing visitor.

Earned Value Management – Certification or Verification? – Roundtable Review

Facilitator: Carol Wilkinson (Large Facilities Advisor, LFO, NSF)

Discussed NSF initiatives to establish guidelines and requirements for Earned Value Management Systems (EVMS) used for evaluating construction project status and management. Other federal agencies have established EVMS requirements, with varying ranges of rigor, depth of inspection, and involvement by external EVM professionals, based on the 32 guidelines from Electronic Industries Alliance (EIA) Standard 748. Participants provided thoughts and experiences on the impacts and benefits of EVMS evaluation. Discussion will inform development of NSF EVM guidance and requirements for the LFM.

Best Practices:

- Importance of ensuring good data in and out of the EVMS.
- EIA-748 is the standard for EVMS guidelines.
- If EVM is not valuable to a project, then it is not well implemented.
- The requirements for EVM can be tailored and structured to the particular project.
- Validation of EMVS should include review and acceptance for compliance with EIA-748.
- Validation methods are tailored and structured to the particular federal agency.

Evaluating Facilities-based Education and Public Outreach Activities

Speaker: John Taber (Director of Education and Public Outreach, Incorporate Research Institutions for Seismology (IRIS))

Discussed the IRIS education and public outreach activities, highlighting recent evaluation methods.

Best Practices:

- Having an evaluation plan prior to designing educational materials focuses efforts on generating highest quality outreach and education.
- Collaborative Impact Analysis Method and metrics helped improve activities and provide richer reporting of impacts.

Smithsonian Institution – Astrophysical Observatory Projects

Speaker: Steve Groh (Program Manager, Office of Planning, Design and Construction, Smithsonian Facilities), Marc Tartaro (Design Manager, Office of Planning, Design and Construction, Smithsonian Facilities)

Provided overview of telescope planning, design, construction, and maintenance from Smithsonian Astrophysical Observatory work in Hawaii, Arizona, Greenland, and Chile with a focus on the impacts of remote and austere environments.

Best Practices:

- Early planning and attention is critical for addressing common challenges to astrophysical observatories.
- Carefully consider addressing common challenges: extreme climatic conditions, facility complexity, leased properties and sites, Native American lands, natural habitats, 24/7/365 operations, aging infrastructure, fiscal planning cycles, funding constraints, competitive science, tight deadlines, maintenance, and decommissioning.

Community of Practice Roundtable

Facilitator: Ivan Graff (Large Facilities Advisor, LFO, NSF)

Held discussion to help develop a community of practice for sharing, documenting, and implementing lessons learned. Etienne Wenger, who coined the term in 1991, defines communities of practice as "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly." Discussion focused on how recipients and others have formed their own communities of practice and the best features of these communities. Discussed links to NAPA recommendations. Gained insights into community preferences for the architecture, function, interface, and population or usage requirements for a lessons learned database. The interactive discussions helped inform NSF of ways to expand our community of practice and develop a lessons learned database.

Best Practices:

- Develop template for lessons learned collection; make it simple, user-friendly, automated.

- Provide ability to categorize lessons for tracking, filtering, text searching, e.g. key words, categories.
- Thoughtfully consider how or if a lesson learned becomes policy; trends lend themselves to policy while one offs go into best practices or procedures rather than policy.
- Collect lessons learned in real time and make available for discussion.
- Collect lessons learned from the entire team, not just from managers.
- Make sure lessons are applicable to other projects.
- Include both positive and negative lessons learned.

Large Facilities Manual (LFM) – New Guidance on Cost Estimating and Analysis

Speaker: Kevin Porter (Large Facilities Advisor, LFO, NSF)

Provided overview of draft LFM guidance for cost estimating and analysis. Requested community input on guidance and noted public comment period. Discussed links to NAPA recommendations.

Best Practices:

- Follow GAO Cost Estimating and Assessment Guide.
- Properly designed cost model data sets can facilitate presentation of costs in various ways, e.g., by WBS and NSF budget category.

Broadening and Improving Science User Communities: The Roles of National User Facility Organization (NUFO) & NSF

Panel: Susan White-DePace (Executive Administrator, NUFO), Dave Morrissey (Associate Director of Operations, National Superconducting Cyclotron Laboratory), Carol Wilkinson (Large Facilities Advisor, LFO, NSF)

Shared experiences forming and managing science user communities with multiple agency and international partners. Provided an overview of the NUFO mission, activities, and facilities and benefits of involvement to users and facilities. Discussed NSCL external user organization and discussed links to NAPA recommendations.

Best Practices:

- Science user communities can facilitate sharing of best practices, professional development, public awareness, unified messaging, and policy change.
- Communication with users is critical; have a web presence and a single point of contact.

Project Management Personnel Development & Certification Roundtable

Facilitator: Ivan Graff (Large Facilities Advisor, LFO, NSF)

Discussed initiative to develop and implement requirements for project management training, experience, and certification. Discussed the costs and benefits and applicability of different types of certifications available to the public and reviewed options for implementation. Discussed links to NAPA recommendations. Attendees provided substantive input. The interactive discussions helped inform NSF development of qualification requirements for inclusion in the LFM and cooperative agreements.

Best Practices:
- PIs at least need "awareness" of project management principles and practices to work better with the PM.
- Important "people skills" for a good PM include being able to run a meeting, conflict resolution, making decisions, and public speaking – these cannot be readily taught or confirmed.

Business Practices Roundtable Part III: New Initiatives

Facilitators: Jeff Lupis (Division Director, DACS, NSF), Jemal Williams (Grants and Agreements Officer, DACS/CSB, NSF)

Continued previous discussions with focus on management fee. Discussed links to NAPA recommendations. Attendees provided substantive input. The interactive discussions helped inform NSF review of the management fee guidance in the LFM.

Best Practices:
- Allowing organizations to request and receive a fee helps ensure competition among qualified organizations for large facility construction and operations.
- Eliminating management fee would deny awardees the ability to recover ordinary and necessary expenses not otherwise reimbursable.

3 Participant Summary Data

Appendix D contains a list of the 165 registered workshop participants. NSF's Large Facilities were well represented. Outreach to other federal agencies and organizations to build our community of practice was also successful. A cross section of different professionals were represented. Overall attendance exceeded expectations.

Organizations & Professions

	Large Facilities	NSF	Other Agencies & Organizations	TOTAL
Business Professionals	27	19	2	48
Project/Operations Managers, Program Officers	15	25	18	58
Executive	20		5	25
Scientists	10		6	16
Other	8	7	3	18
TOTAL	80	51	34	165

Facility Participation

Academic Research Fleet
Alaska Region Research Vessel
Arecibo Observatory
Atacama Large Millimeter Array
Cornell High Energy Synchrotron Source
Daniel K. Inouye Solar Telescope
GEMINI Observatory
Geodesy Advancing Geosciences and EarthScope
Ice Cube
JOIDES Resolution, International Ocean Discovery Program
Large Hadron Collider, Compact Muon Solenoid (CMS) Detectors
Large Hadron Collider, A Toroidal LHC Apparatus (ATLAS)
Large Synoptic Survey Telescope
Laser Interferometer Gravitational-Wave Observatory
National Center for Atmospheric Research
National Ecological Observatory Network
National High Magnetic Field Laboratory
National Optical Astronomy Observatory
National Radio Astronomy Observatory
National Solar Observatory
National Superconducting Cyclotron Laboratory
Natural Hazards Engineering Research Infrastructure
Ocean Observatories Initiative
Regional Class Research Vessel
Seismological Facilities for the Advancement of Geoscience and EarthScope
United States Antarctic Program

Other Agencies and Organizations

Smithsonian Institution
Government Accountability Office
Department of Energy
NASA
Idaho National Laboratory
US Army Corps of Engineers
SURA/Jefferson Lab
National Center for Supercomputing Applications
Pittsburgh Supercomputing Center
Georgia Tech Center for Education, Integrating Science, Mathematics, and Computing
Embassy of China
Canada Foundation for Innovation
National User Facility Organization / Argonne National Laboratory
Federal Science Partners
SAIC
Hulett & Associates
KForce Government Solutions
ALEX-Alternative Experts, LLC

4 Survey Results Summary

Feedback on the workshop was requested both online each day and in person at the end of the three days. Data from online survey results is included in Appendix C. Some key takeaways are presented below and will be addressed to continuously improve future workshops.

Topics:

- More broadly solicit input for future topics, e.g., via listserv, online chat forums, surveys, and suggestion boxes.
- More sessions focused on topics relevant to operating facilities.
- Consider having recipient-only sessions with facilitators to allow more open communication.
- Identify topics earlier and establish annual topics.

Attendance:

- Consider making attendance mandatory in awards.
- Consider providing single-day or videoconferencing participation.

Miscellaneous:

- Provide additional time and opportunities for introductions, interaction, and communication among participants, e.g., between sessions, via interactive sessions, at the end of the day.
- Provide larger meeting rooms with more space for participants; plan for surge capacity.

Actionable Recommendations:

- Develop ways to more broadly solicit input for future topics. [ACTION: LFO will pursue options for the 2017 LFW.]
- NSF: Identify topics earlier and establish annual topics. [ACTION: LFO will identify topics, including annual topics, further in advance of the 2017 LFW.]

5 Overall Conclusions & Actionable Recommendations

Overall the workshop was successful and provided a constructive and collaborative environment for NSF's Large Facilities and other government agencies and partners. New initiatives were highlighted and rich interactive discussions will help inform development of future guidance. Many Best Practices were shared with the community. Many Actionable Recommendations were identified as summarized below and will be considered by NSF. NSF's Large Facility community of practice was expanded. Feedback of the overall workshop was collected and will help improve future workshops.

Actionable Recommendations:

- Perform independent cost and schedule reviews 6 months prior to Preliminary Design Review as these provided significant benefit. [ACTION: LFO will provide additional expectations in draft LFM section 4.2.]
- NSF: Consider setting goals during design and reporting requirements during operations for "uptime metrics" (e.g., % time and costs for operations, maintenance, idleness). [ACTION: LFO will consider providing additional information via the LFM.]
- NSF: Clarify and communicate the scope and timeline for completion of audits and reviews. [ACTION: LFO will consider providing additional information via the LFM and/or website.]
- NSF: Disseminate best practices and lessons learned from audits and reviews to the large facilities community to allow continuous improvement. [ACTION: LFO will compile major issues identified over the last 5 years for distribution to the community. LFO will have "BSR Hot Topic" presentations at annual LFW.]
- GAO can provide material they use in cost and schedule assessments (e.g., lists of requested documents; interview questions; record of analysis templates; MS Excel workbooks for assessing MS Project files; MS Project filters, tables and views for assessing MS Project files; Primavera P6 workbooks and filters (still under development)). [ACTION: LFO has received available GAO material and will post publically on LFO website.]
- GAO can provide training on the cost and schedule guides. [ACTION: LFO will consider options for GAO training into the professional training, experience, and qualification guidance being developed and discussed further below.]
- NSF: Highlight property and equipment capitalization requirements to recipients with construction projects. [ACTION: LFO will consider options for highlighting existing guidance.]
- NSF: Provide guidance to recipients on how to report equipment that is used for multiple projects. [ACTION: LFO will consider options for providing additional guidance.]
- NSF: Provide examples of best practices for reporting work in progress and construction in progress. [ACTION: LFO will consider options for providing additional examples.]
- NSF: Work with NSF Property Office and discuss where LFO or other NSF-wide Large Facility stakeholders might partner and assist in the processing of property-related requests. [ACTION: LFO will consider options for facilitating property-related requests.]
- NSF: Consider use of Technology Readiness Assessment Guides. [ACTION: LFO will consider adding technology readiness guidance to the LFM.]
- Develop ways to more broadly solicit input for future topics. [ACTION: LFO will pursue options for the 2017 LFW.]
- NSF: Identify topics earlier and establish annual topics. [ACTION: LFO will identify topics, including annual topics, further in advance of the 2017 LFW.]

Appendix A: Agenda

National Science Foundation & Smithsonian Institution
2016 Large Facilities Office Workshop

Washington, DC

Tuesday, May 24 – Thursday, May 26, 2016

Agenda

Tuesday, May 24

8:00 – 9:15 AM	**Registration, Light Refreshments** Foyer 3111A, Room 3112
9:15 – 9:45 AM	**Welcome, Opening Remarks** Speakers: Matt Hawkins (Head, Large Facilities Office (LFO), NSF), Nancy Bechtol (Director, Facilities, Smithsonian Institution) Description: Welcome by NSF and Smithsonian, overview of the workshop, NSF and Smithsonian large facilities portfolios, and outcomes from 2015 Workshop. Room 3111
9:45 – 10:45 AM	**Laser Interferometer Gravitational Wave Observatory (LIGO): The Inside Story** Speaker: Mike Landry (Detection Lead Scientist, California Institute of Technology, LIGO Hanford Observatory) Description: LIGO began operations in 2015 with spectacular results, detecting gravitational waves in the first month! Highlights from transitioning into operations and lessons learned from their path to discovery. Room 3111
10:45 – 11:00 AM	**Break**
11:00 – 12:00 PM	**Transforming Concepts Into Reality: Project Management Insights from NASA's Goddard Space Flight Center** Speaker: Dave Mitchell (Director, Flight Projects Directorate, NASA Goddard Space Flight Center) Description: Personal experience and perspective on project management from NASA science mission projects. Highlights include reflections on the development of the MAVEN mission to Mars which launched in November 2013 and arrived at the Red Planet in September 2014. Room 3111
12:00 – 1:00 PM	**Working Lunch** Room 3111
1:00 – 2:00 PM	**Breakout Session #1**
2:00 – 2:15 PM	**Break**
2:15 – 3:15 PM	**Breakout Session #2**
3:15 – 3:30 PM	**Break**

3:30 – 4:30 PM	**Breakout Session #3**
5:00 PM	**Shuttle Buses Depart Ripley Center for Renaissance Washington, DC Downtown Hotel**
6:00 – 8:00 PM	**Reception, Renaissance Washington, DC Downtown Hotel**

Breakout Session #1 (Choose 1 of 2)

1. **"Lightning Talks" from Large Facilities**

Speakers: Demian Bailey (Project Manager, Regional Class Research Vessel, Oregon State University), Andy Adamson and Scott Kleinman (Associate Director Operations and Associate Director Development, Gemini Observatory), Mike Carrancho (Deputy Director, Engineering and Design Division, Office of Planning, Design and Construction, Smithsonian Facilities), Joel Brock (Director, Cornell High Energy Synchrotron Source), Jamie Allan (Program Director, Integrated Ocean Drilling Program, GEO, NSF), Rick Farnsworth (Senior Program Manager, National Ecological Observatory Network), John Kelly (Program Director, Arecibo Observatory), Murray Stein (Director of Marine Operations / Marine Superintendent, University of Alaska Fairbanks)
Description: Speakers highlighting recent large facility accomplishments and challenges.
Room 3111

2. **Business Practices Roundtable Part I: Making Sense of Audits and Reviews**

Facilitators: Florence Rabanal (Large Facilities Advisor, LFO, NSF), Anna-Lee Misiano (Grants and Agreements Officer, DACS/CSB, NSF), Charlie Zeigler (Cost Analyst, DIAS, NSF)
Description: Overview of the common types of audits and reviews and discuss how they fit together. Participants will share strategies for being responsive in an audit and identify areas where NSF clarification or assistance is needed.
Room 3035

Breakout Session #2 (Choose 1 of 2)

1. **GAO – Schedule Assessment Guide & Cost Estimating and Assessment Guide**

Speaker: Jason Lee (Assistant Director, Applied Research and Methods, US Government Accountability Office)
Description: An overview of GAO schedule and cost estimating guides, focusing on best practices and updates, to facilitate integrated project planning and management.
Room 3111

2. **Smithsonian Institution – Building Information Modeling & Asset Management**

Speaker: Mike Carrancho (Deputy Director, Engineering and Design Division, Office of Planning, Design and Construction, Smithsonian Facilities)
Description: Overview of SI's recent initiative to use data rich Building Information Modeling technology for design, construction, and lifecycle management of capital assets.
Room 3035

Breakout Session #3 (Choose 1 of 2)

1. **Organizational Climate Studies – Experience from NSF's Advanced Cyberinfrastructure Projects**

Speaker: Lizanne DeStefano (Georgia Tech Center for Education, Integrating Science, Mathematics, and Computing)
Description: Methods for assessing organizational climate and benefits to other large facilities projects based on experience within the Extreme Science and Engineering Discovery Environment (XSEDE) and Blue Waters supercomputing projects.
Room 3111

2. **Business Systems Reviews (BSR) Hot Topics**

Speaker: Florence Rabanal (Large Facilities Advisor, LFO, NSF)
Description: Overview of recurring BSR observations on property and equipment management. Opportunity for information sharing, asking outstanding questions, understanding what to avoid. Attendees will be encouraged to share their challenges and solutions to aligning with NSF expectations. As time permits, highlights of new BSR process initiatives will be presented, such as the oversight tracking system and annual planning.
Room 3035

Wednesday, May 25

8:00 – 9:15 AM	**Registration, Light Refreshments** Foyer 3111A, Room 3112
9:15 – 10:45 AM	**NSF Future Investments, NAPA Report, and Evolving Oversight** Speaker: Matt Hawkins (Head, LFO, NSF) Description: The presentation will begin with a summary of Dr. Cordova's "NSF Ideas for Future Investments" presented to the National Science Board in May. It will then segway into an overview of the National Academy of Public Administration (NAPA) Panel Report on NSF Use of Cooperative Agreements to Support Large Scale Investment in Research. The NAPA recommendations support NSF use of cooperative agreements with recommendations are intended to improve NSF's oversight and project management practices for large facility construction projects. Key recommendations include (1) developing a community of practice for documenting, sharing, and implementing lessons learned, and (2) implementing requirements for project management experience, certification, and training. Community input is requested to facilitate implementation of recommendations and inform forthcoming guidance within our Large Facilities Manual. Room 3111
10:45 – 11:00 AM	**Break**
11:00 – 12:00 PM	**Breakout Session #1**
12:00 – 1:00 PM	**Working Lunch** Room 3111
1:00 – 2:30 PM	**Breakout Session #2**
2:30 – 4:00 PM	**Smithsonian Tours** Major Exhibit Renovations at the National Air and Space Museum Construction and Exhibit Design at the National Museum of African American History and Culture Major renovations and historic preservation of the Arts and Industries Building

Breakout Session #1 (Choose 1 of 3)

1. **Smithsonian Institution – Lessons Learned Database and Implementation**

Speaker: Jim Yuengert (Smithsonian Institution (SI), Office of Planning, Design and Construction)
Description: Highlights from SI's recent development of an electronic database and process for collecting and implementing lessons learned throughout a community. SI will share examples from Mathias Lab Construction and Cooper Hewitt Smithsonian Design Museum Renovation.
Room 3111

2. **Cyberinfrastructure (CI) Scoping Roundtable (Bill Miller)**

Facilitator: Bill Miller (Division of Advanced Cyberinfrastructure, CISE, NSF)
Description: This follow-up to the December 2015 NSF-sponsored workshop on "Cyberinfrastructure for NSF Large Facilities" will review outcomes from that workshop, and invite additional input, in areas such as

anticipated future needs, ways of increasing innovative collaboration between the CI and facilities communities, and leveraging of existing shared CI resources. The roundtable will provide helpful input to NSF in its efforts to plan future opportunities.
Room 3037

3. **Integrated Cost-Schedule Risk Analysis**

Speaker: David Hulett (Principal, Hulett & Associates)
Description: Expert overview of integrated cost and schedule risk analysis and contingency calculation methods which form the basis of the risk management chapters in the Guide to the Project Management Body of Knowledge (PMBOK© Guide) and the Large Facilities Manual.
Room 3035

Working Lunch

1. **The NSF Cybersecurity Center of Excellence: Large Facilities Cybersecurity Resources**

Speaker: James Marsteller (Information Security Officer, Pittsburgh Supercomputing Center)
Description: Brief overview of the Center of Trustworthy Scientific Cyberinfrastructure (CTSC), including CTSC mission, past work with large facilities, key resources and events of interest to large facilities. Details on a CTSC effort to improve situational awareness for larger facilities will be highlighted.
Room 3111

Breakout Session #2 (Choose 1 of 3)

1. **DOE Project Management Career Development Program**

Speaker: Linda Ott (DOE Office of Project Management Oversight & Assessments)
Description: Highlights from DOE's Project Management Career Development Program (PMCDP). Includes discussion of the value proposition of investing in project management skillset development, DOE's reason for establishing PMCDP, lessons learned, the value of tracking and measuring Federal Project Directors (FPDs), and the status of PMCDP and FPD certification a decade later.
Room 3111

2. **Transition to Operations – Panel**

Panel: Carol Wilkinson (Large Facilities Advisor, LFO, NSF), Mike Landry (Detection Lead Scientist, California Institute of Technology, LIGO Hanford Observatory), Derek Ross (Deputy Director, Construction Division, Office of Planning, Design and Construction, Smithsonian Facilities), Steve Ellis (Program Director, BIO, NSF)
Description: A panel led discussion of lessons learned during transition to operations, with focus on recent projects.
Room 3037

3. **Business Practices Roundtable Part II: New Initiatives**

Facilitators: Jeff Lupis (Division Director, DACS, NSF)
Description: Additional background and context for recent initiatives to further review recipient financial information, cost information (award budgets and incurred costs), management fee, and to explain the "how, what and when" of new incurred cost audits. Community input is requested on business practices and oversight. Links to NAPA recommendations.
Room 3035

Thursday, May 26

8:00 – 9:15 AM	**Registration, Light Refreshments** Foyer 3111A, Room 3112
9:15 – 10:45 AM	**NASA Evolvable Mars Campaign Development** Speakers: Stephen Hoffman (SAIC), Larry Toups (Johnson Space Center, NASA) Description: Developing a concept of operations, requirements, and project management structure for an evolving and flexible phased construction and start-up project to pioneer an extended human presence on Mars. Room 3111
10:45 – 11:00 AM	**Break**
11:00 – 12:00 PM	**Breakout Session #1**
12:00 – 1:00 PM	**Working Lunch** Room 3111
1:00 – 2:00 PM	**Breakout Session #2**
2:00 – 2:15 PM	**Break**
2:15 – 3:45 PM	**Breakout Session #3**
3:45 – 5:00 PM	**Workshop Feedback to NSF** Facilitator: Kevin Porter (Large Facilities Advisor, LFO, NSF) Description: Informal opportunity to provide direct feedback to LFO immediately after the workshop. Room 3031

Breakout Session #1 (Choose 1 of 3)

1. **Large Facilities: Environmental Compliance and Permitting and Lessons Learned**

Speaker: Caroline Blanco (Assistant General Counsel - Environment, OD/OGC, NSF)
Description: Large facility awardees must often obtain permits. NSF must also meet its environmental compliance responsibilities. Occasionally, NSF and its awardees encounter challenges in meeting their respective obligations, which can result in schedule delays and increased costs. Discussion will highlight recent challenges from DKIST and NEON and present strategies for effective and efficient risk mitigation.
Room 3111

2. **Smithsonian Institution – Science Exhibit Highlights**

Speaker: Elizabeth Musteen (Chief of Exhibit Production, Office of Exhibits, National Museum of Natural History, Smithsonian Institution (SI))
Description: Highlights and lessons learned from the design and construction of some of the newest and most exciting Smithsonian science exhibits, including the Sant Ocean Hall, Kenneth E. Behring Family Hall of Mammals, Butterflies and Plants: Partners in Evolution, the Behring Family Rotunda, and the Annenberg Hooker Hall of Geology, Gems and Minerals.
Room 3031

3. **Earned Value Management – Certification or Verification? – Roundtable Review**

Facilitator: Carol Wilkinson (Large Facilities Advisor, LFO, NSF)
Description: NSF is establishing guidelines and requirements for Earned Value Management Systems (EVMS) used for evaluating construction project status and management. Other federal agencies have established EVMS requirements, with varying ranges of rigor, depth of inspection, and involvement by external EVM professionals, based on the 32 guidelines from EIA Standard 748. Participants will provide thoughts and experiences on the impacts and benefits of EVMS evaluation to inform development of NSF EVM guidance and requirements for the 2017 revision to the LFM. Links to NAPA recommendations.
Room 3035

Working Lunch

1. **Evaluating Facilities-based Education and Public Outreach Activities**

Speaker: John Taber (Director of Education and Public Outreach, Incorporate Research Institutions for Seismology (IRIS))
Description: Brief overview of the IRIS education and public outreach activities, highlighting recent evaluation methods.
Room 3111

Breakout Session #2 (Choose 1 of 3)

1. **Smithsonian Institution – Astrophysical Observatory Projects**

Speaker: Steve Groh (Program Manager, Office of Planning, Design and Construction, Smithsonian Facilities), Marc Tartaro (Design Manager, Office of Planning, Design and Construction, Smithsonian Facilities)
Description: Overview of telescope planning, design, construction, and maintenance from Smithsonian Astrophysical Observatory work in Hawaii, Arizona, Greenland, and Chile with a focus on the impacts of remote and austere environments.
Room 3111

2. **Community of Practice Roundtable**

Facilitator: Ivan Graff (Large Facilities Advisor, LFO, NSF)
Description: Discussion to help develop a community of practice for sharing, documenting, and implementing lessons learned. Etienne Wenger, who coined the term in 1991, defines communities of practice as "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly." Discussion will focus on how recipients and others have formed their own communities of practice and the best features of these communities. Links to NAPA recommendations.
Room 3031

3. **Large Facilities Manual (LFM) – New Guidance on Cost Estimating and Analysis**

Speaker: Kevin Porter (Large Facilities Advisor, LFO, NSF)
Description: Overview of draft LFM guidance for cost estimating and analysis. Participants may provide input. The draft is also available for public comment. Links to NAPA recommendations.
Room 3035

Breakout Session #3 (Choose 1 of 3)

1. **Broadening and Improving Science User Communities: The Roles of National User Facility Organization (NUFO) & NSF**

Panel: Susan White-DePace (Executive Administrator, NUFO), Dave Morrissey (Associate Director of Operations, National Superconducting Cyclotron Laboratory), Carol Wilkinson (Large Facilities Advisor, LFO, NSF)
Description: The panel will share their experiences forming and managing science user communities with multiple agency and international partners. Includes an overview of the NUFO mission, activities, and facilities and benefits of involvement to users and facilities. NSF large facilities community is invited to provide insights during community discussion. Links to NAPA recommendations.
Room 3111

2. **Project Management Personnel Development & Certification Roundtable**

Facilitator: Ivan Graff (Large Facilities Advisor, LFO, NSF)
Description: Discussion to help develop and implement requirements for project management training, experience, and certification. Discussion will consider the benefits and applicability of different types of certifications available to the public and review options for implementation. Links to NAPA recommendations.
Room 3031

3. **Business Practices Roundtable Part III: New Initiatives**

Facilitators: Jeff Lupis (Division Director, DACS, NSF), Jemal Williams (Grants and Agreements Officer, DACS/CSB, NSF)
Description: Continuation of “Business Practices Roundtable Part II: New Initiatives” with focus on community input. Links to NAPA recommendations.
Room 3035

TUESDAY - 5/24	Room 3111	Room 3035	
8:00			Registration, Light Refreshments
9:15	Opening Remarks		
9:45	Opening Plenary - LIGO		
			Break
11:00	Opening Plenary - NASA		
12:00	Working Lunch Speaker TBD		
1:00	Lightning Talks	Business Roundtable I - Audits & Reviews	
2:00			Break
	GAO Cost and Schedule Guides	Smithsonian - BIM & Asset Management	
3:00			Break
	Organization Climate Studies	BSR Hot Topics	
4:00			
5:00			Hotel Shuttle
6:00			Reception - Rennaisance Hotel
7:00			
8:00			

WEDNESDAY - 5/25	Room 3111	Room 3037	Room 3035	
8:00				Registration, Light Refreshments
9:15	NSF Future Investments, NAPA Report, and Evolving Oversight			
				Break
11:00	Smithsonian Lessons Learned Database	CI Scoping Roundtable	Integrated Cost-Schedule Risk Analysis	
12:00	Working Lunch Cybersecurity & CTSC			
1:00	DOE Project Management Career Development	Transition to Operations Panel	Business Roundtable II - New Initiatives	
2:00				
				Smithsonian Tours
3:00				
4:00				
5:00				
6:00				
7:00				

THURSDAY - 5/26	Room 3111	Room 3031	Room 3035	
8:00				Registration, Light Refreshments
9:15	NASA Evolvable Mars Campaign Development			
				Break
11:00	Environmental Compliance and Permitting	Smithsonian Science Exhibits	EVM Roundtable	
12:00	Working Lunch Education and Public Outreach & IRIS			
1:00	Smithsonian - Astrophysical Observatory Projects	Community of Practice Roundtable	LFM Cost Estimating & Analysis Guidance	
2:00				Break
	Sciences Communities: The Role of NUFO	PM Personnel Certification Roundtable	Business Roundtable III - New Initiatives	
3:00				
4:00		Workshop Feedback to NSF		
5:00				
6:00				
7:00				

Appendix B: Participant Information

National Science Foundation

2016 Large Facilities Office Workshop

May 24-26, 2016

Participants List

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2016 Large Facilities Office Workshop

May 24-26, 2016

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2016 Large Facilities Office Workshop

May 24-26, 2016

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May 24-26, 2016

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2016 Large Facilities Office Workshop

May 24-26, 2016

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2016 Large Facilities Office Workshop

May 24-26, 2016

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2016 Large Facilities Office Workshop

May 24-26, 2016

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2016 Large Facilities Office Workshop

May 24-26, 2016

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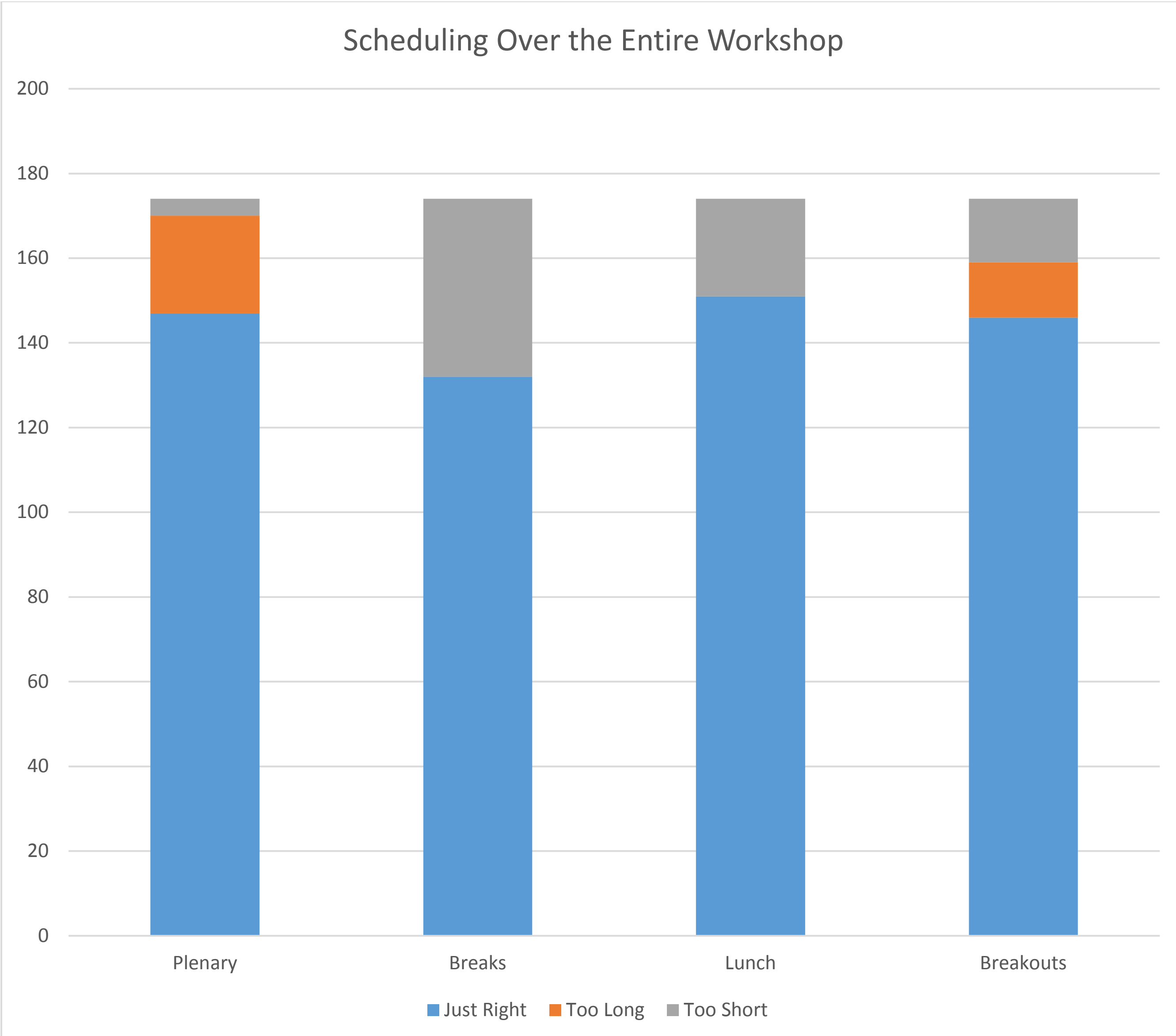
Appendix C: Survey Data & Metrics

Session Title	Percentage Agree: I found the presentation informative	I understood the presenter(s)	I view the topic as important	The presentation seemed well organized	The presenter(s) considered my comments or answered my questions	AVERAGE
Business Practices Roundtable Part I: Making Sense of Audits and Reviews	74%	75%	98%	55%	65%	73%
Business Practices Roundtable Part II: New Initiatives	67%	96%	97%	63%	70%	79%
Business Practices Roundtable Part III: New Initiatives	75%	75%	95%	69%	64%	75%
Business Systems Reviews (BSR) Hot Topics	59%	77%	93%	56%	63%	69%
Community of Practice Roundtable	100%	100%	86%	100%	100%	97%
Cyberinfrastructure Scoping Roundtable	78%	89%	89%	83%	100%	88%
DOE Project Management Career Development Program	73%	91%	69%	64%	60%	71%
Earned Value Management Certification or Verification Roundtable	89%	100%	100%	89%	83%	92%
Environmental Compliance and Permitting	94%	100%	90%	94%	100%	96%
Evaluating Facilities-based Education and Public Outreach Activities	70%	83%	83%	57%	43%	67%
GAO Schedule Assessment Guide & Cost Estimating and Assessment Guide	77%	79%	88%	77%	71%	78%
Integrated Cost-Schedule Risk Analysis	53%	50%	95%	54%	56%	62%
Large Facilities Manual (LFM) New Guidance on Cost Estimating and Analysis	83%	87%	100%	83%	86%	88%
Laser Interferometer Gravitational Wave Observatory (LIGO): The Inside Story	88%	86%	76%	92%	60%	80%
Lightning Talks from Large Facilities	79%	84%	85%	73%	73%	79%
NASA Evolvable Mars Campaign Development	92%	92%	68%	92%	92%	87%
NSF Cybersecurity Center of Excellence: Large Facilities Cybersecurity Resources	87%	97%	90%	93%	82%	90%
NSF Future Investments, NAPA Report, and Evolving Oversight	95%	97%	97%	90%	84%	92%
Organizational Climate Studies Experience from NSF's Advanced Cyberinfrastructure Projects	64%	92%	68%	84%	78%	77%
Project Management Insights from NASA's Goddard Space Flight Center	94%	97%	89%	92%	84%	91%
Project Management Personnel Development & Certification Roundtable	91%	91%	88%	82%	88%	88%
Smithsonian Institution Astrophysical Observatory Projects	75%	100%	67%	75%	100%	83%
Smithsonian Institution Building Information Modeling & Asset Management	65%	65%	58%	76%	82%	69%
Smithsonian Institution Lessons Learned Database and Implementation	64%	64%	100%	64%	80%	74%
Smithsonian Institution Science Exhibit Highlights	100%	100%	78%	83%	100%	92%
The Roles of National User Facility Organization (NUFO) & NSF	82%	82%	79%	76%	90%	82%
Tour: Arts and Industries Building	90%	90%	60%	70%	90%	80%
Tour: National Air and Space Museum	94%	94%	83%	89%	94%	91%
Tour: National Museum of African American History and Culture	100%	100%	100%	100%	100%	100%
Transition to Operations Panel	71%	94%	84%	82%	80%	82%

Most Popular	
Tour: National Museum of African American History and Culture	100%
Community of Practice Roundtable	97%
Environmental Compliance and Permitting	96%
NSF Future Investments, NAPA Report, and Evolving Oversight	92%
Earned Value Management Certification or Verification Roundtable	92%
Smithsonian Institution Science Exhibit Highlights	92%
Project Management Insights from NASA's Goddard Space Flight Center	91%
Tour: National Air and Space Museum	91%
NSF Cybersecurity Center of Excellence: Large Facilities Cybersecurity Resources	90%
Large Facilities Manual (LFM) New Guidance on Cost Estimating and Analysis	88%
Cyberinfrastructure Scoping Roundtable	88%
Project Management Personnel Development & Certification Roundtable	88%
NASA Evolvable Mars Campaign Development	87%
Smithsonian Institution Astrophysical Observatory Projects	83%
Transition to Operations Panel	82%
The Roles of National User Facility Organization (NUFO) & NSF	82%
Laser Interferometer Gravitational Wave Observatory (LIGO): The Inside Story	80%
Tour: Arts and Industries Building	80%
Lightning Talks from Large Facilities	79%
Business Practices Roundtable Part II: New Initiatives	79%
GAO Schedule Assessment Guide & Cost Estimating and Assessment Guide	78%
Organizational Climate Studies Experience from NSF's Advanced Cyberinfrastructure Projects	77%
Business Practices Roundtable Part III: New Initiatives	75%
Smithsonian Institution Lessons Learned Database and Implementation	74%
Business Practices Roundtable Part I: Making Sense of Audits and Reviews	73%
DOE Project Management Career Development Program	71%
Business Systems Reviews (BSR) Hot Topics	69%
Smithsonian Institution Building Information Modeling & Asset Management	69%
Evaluating Facilities-based Education and Public Outreach Activities	67%
Integrated Cost-Schedule Risk Analysis	62%



Scheduling Over the Entire Workshop
200
180
160
140
120
100
80
60
40
20
0
Plenary
Breaks
Lunch
Breakouts
Just Right
Too Long
Too Short

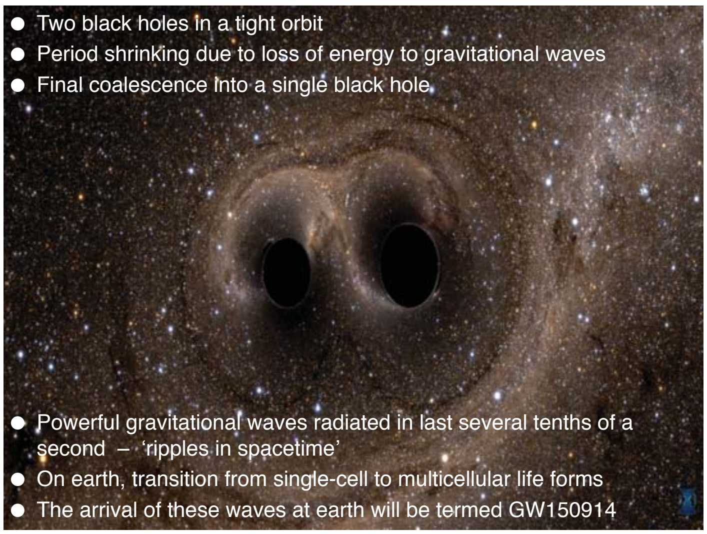
Appendix D: Presentations

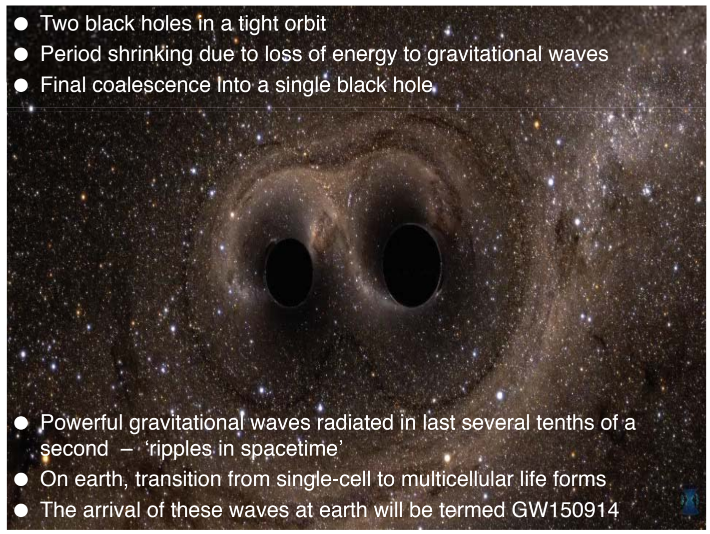
D.1 Tuesday May 24, 2016

Laser Interferometer Gravitational Wave Observatory (LIGO) : The Inside Story

M. Landry
LIGO Hanford Observatory/Caltech
for the LIGO and Virgo Scientific Collaborations

NSF Large Facilities Workshop 24 May 2016





Outline

- A timeline of GW150914
- Some history of gravitational waves, and experiments
- Initial LIGO, the Advanced LIGO Project, LIGO Operations
  - » The experiments
  - » The phases and transitions, some problems and some lessons
- The Event itself, GW150914
- Some results and conclusions

100 years ago

- General Relativity is published in 1915 by former patent clerk, now Professor, A. Einstein
- First paper indicating that gravitational waves (GW) in 1916
  - » Contains an algebraic error, leading Einstein to think that no energy is carried by GWs
- Second paper in 1918 corrects this error, but Einstein indicates that the effect is of no practical interest since the effect is too small to be detected

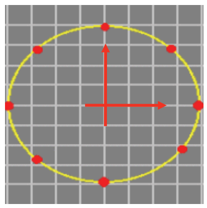
Meanwhile….

- The gravitational waves from the binary black-hole merger cross Gacrux, a star in the Southern Cross

Gravitational waves

- Distortions in space-time, generated by changing quadrupole moments such as in co-orbiting objects, spinning asymmetric objects
- Interact weakly with matter - even densest systems transparent to gravitational waves
- An entirely new phenomenon with which to explore the universe

Physically, gravitational waves are *strains*: $h = \dfrac{\Delta L(f)}{L}$

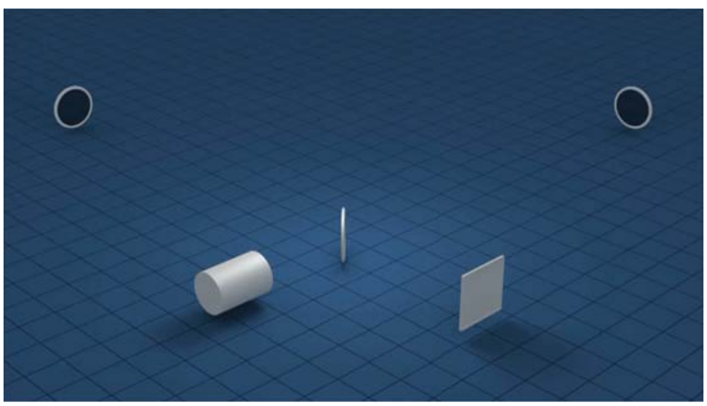


A half-century ago

- Gertsenstein and Pustovoit, 1963: theoretical study of using laser interferometry to detect GWs (Russian)
- Others re-invent the notion – among them Joe Weber, who pioneered experimental searches for GWs, in developing 'acoustic bar' sensors
- In 1972, Rainer Weiss publishes an internal MIT report
  - » Sets the concept and scale of LIGO
  - » This roadmap contains also noise sources and how to manage them
- Interest grows in Max Planck Garching (Germany), U. Glasgow, Caltech in this interferometric technique
- GW150914 passes HR 2225 in Canis Major

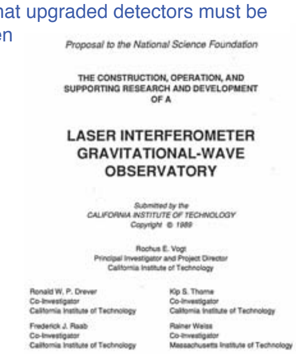
Rainer Weiss

Michelson interfometers



Two decades ago

- Caltech and MIT propose to the NSF to establish Observatories
- Proposal states clearly that the initial detectors only have a chance of detections, and that upgraded detectors must be accommodated and foreseen



Proposal to the National Science Foundation

THE CONSTRUCTION, OPERATION, AND SUPPORTING RESEARCH AND DEVELOPMENT OF A

LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY

Submitted by the CALIFORNIA INSTITUTE OF TECHNOLOGY
Copyright © 1989

Rochus E. Vogt
Principal Investigator and Project Director
California Institute of Technology

Ronald W. P. Drever
Co-Investigator
California Institute of Technology

Kip S. Thorne
Co-Investigator
California Institute of Technology

Frederick J. Raab
Co-Investigator
California Institute of Technology

Rainer Weiss
Co-Investigator
Massachusetts Institute of Technology

Two decades ago

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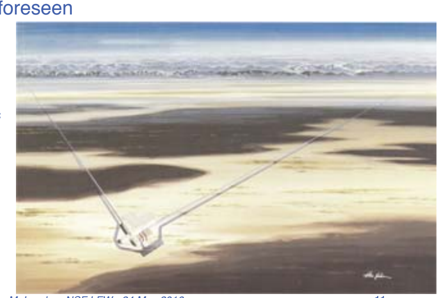


- Artist's conception of what an observatory might look like
- GW150914 passing 82 Eridani…

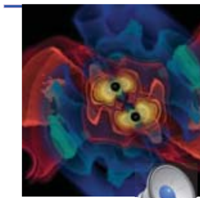
LIGO Laboratory: two observatories, Caltech and MIT campuses

- Mission: to develop gravitational-wave detectors, and to operate them as astrophysical observatories
- Jointly managed by Caltech and MIT; responsible for operating LIGO Hanford and Livingston Observatories
- Requires instrument science at the frontiers of physics fundamental limits

LIGO Scientific Collaboration

- 900+ members, 80+ institutions, 17 countries

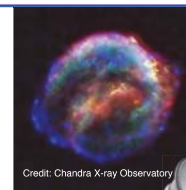
Astrophysical sources of gravitational waves



Credit: AEI, CCT, LSU

Coalescing Compact Binary Systems: Neutron Star-NS, Black Hole-NS, BH-BH

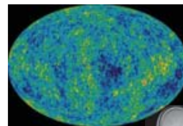
- Strong emitters, well-modeled,
- (effectively) transient



Credit: Chandra X-ray Observatory

Asymmetric Core Collapse Supernovae

- Weak emitters, not well-modeled ('bursts'), transient
- Also: cosmic strings, SGRs, pulsar glitches



NASA/WMAP Science Team

Cosmic Gravitational-wave Background

- Residue of the Big Bang
- Long duration, stochastic background

Casey Reed, Penn State

Spinning neutron stars

- (nearly) monotonic waveform
- Long duration

Within 10 years

- Advanced LIGO is funded in 2006: an upgrade of all components, 10x better sensitivity

- Initial LIGO deinstallation Oct 20, 2010, installation starts for Advanced LIGO after
  - » GWs from the BH-BH cross Alpha Centauri, the closest star, just 4.4 light years away

Advanced LIGO support

- NSF-supported (~$205M MREFC phase)
  - » Caltech as awardee, MIT and Caltech sharing responsibility institutionally, organizationally, scientifically, and technically
  - » Several US LSC institutions supported on subcontracts from LIGO Lab in Project phase (all US-supported aLIGO work to be on aLIGO MREFC)
- Foreign contributions – from experienced collaborators
  - » Germany – Pre-stabilized laser (value ~$14M incl. development)
  - » United Kingdom – Test mass suspensions and some test mass optics (value ~$14M incl. development)
  - » Australia – alignment sensors, optics, and suspensions (value ~ $1.7M incl. development)

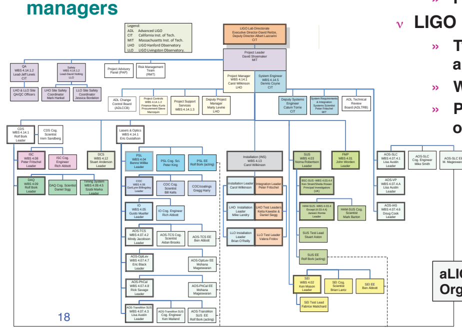
LIGO Pre-Project Organization Structure

'Flat' organization typical of many academic institutions

- Shallow management tree
  - » Top level only one or two reports away
  - » From 10 to 30+ direct reports per manager (~170 FTE)
- Authority and responsibility held by a few at the top
  - » Little delegation of budget, hiring, mission, and priority decisions
  - » Technical staff not burdened by bureaucratic responsibilities

aLIGO Project Organization Chart

Project organization is hierarchical, with several tiers of managers



aLIGO Project Management Organization Chart

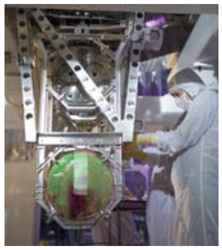
- **Authority and responsibility delegated downwards**
  - » **Fewer direct reports**
- **LIGO becomes strongly matrixed**
  - » **Two thirds of lab staff works on aLIGO project assignments**
  - » **With new hires - 280 employees**
  - » **Permanent staff will return to operations**

10X more sensitive, >10X harder…

- 14 unique fabricated parts
- 68 fabricated parts total
- 165 total including machined parts and hardware

Test mass suspension
From Initial LIGO

- 188 unique fabricated parts
- 1569 fabricated parts total
- 3575 total including machined parts and hardware



Test mass suspension
From Advanced LIGO

Key Installation elements

- People
  - » Steady state science running: ~40 people at each of the sites. At install peak ~90 people @ LHO, less at LLO
  - » Included technicians, engineering, scientists, project controls, facilities, management, i.e. everything
  - » Installation staff launched each day with coordination meeting
  - » Also includes riggers/millwrights operating under $3.3M time and materials (T&M) contract. Introduced to LIGO science to stress our unique needs (precision and contamination control, vs. speed)
- Safety
  - » Checklists
  - » Hazard Analyses
  - » Stop work

Weld repairs

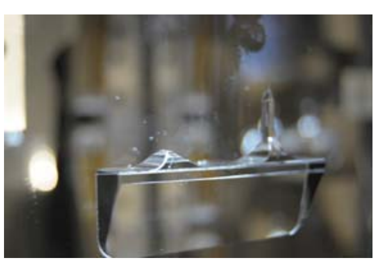
Assembly issue

- Unauthorized weld repairs detected visually in some seismic plates; underscores need for good QA
- Investigated with contractor and x-rays
- At issue is trapped volumes and virtual leaks
- Concluded new parts were required

Fiber breakage

Install issue

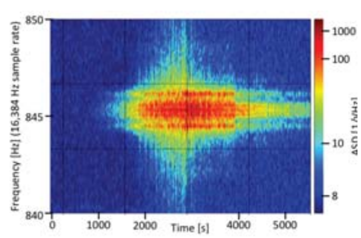
- ITMY fibers broken in shaking incident induced by code bug
- Stop work called; code fixed/reviewed, testing restarted
- Underscores need for code reviews and testing



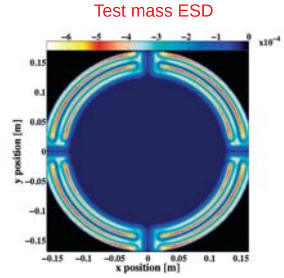
Active acoustic mode damping

Commissioning issue

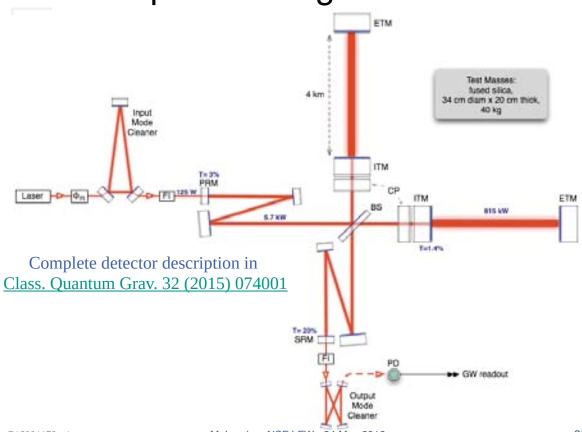
- Active damping using the electro-static drive, or ESD on the test masses



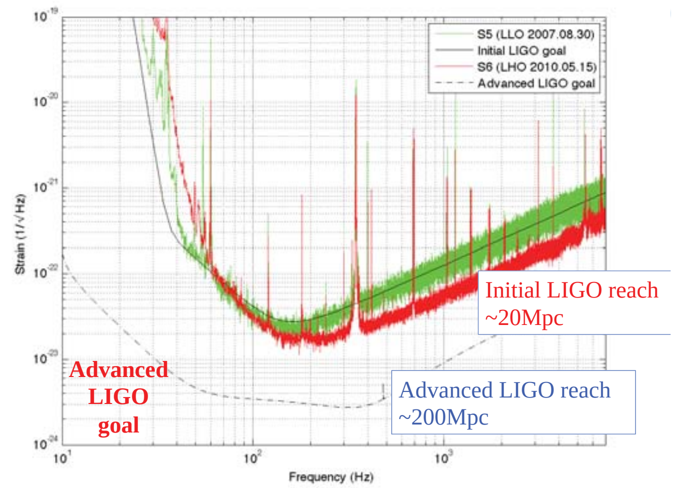
Test mass ESD

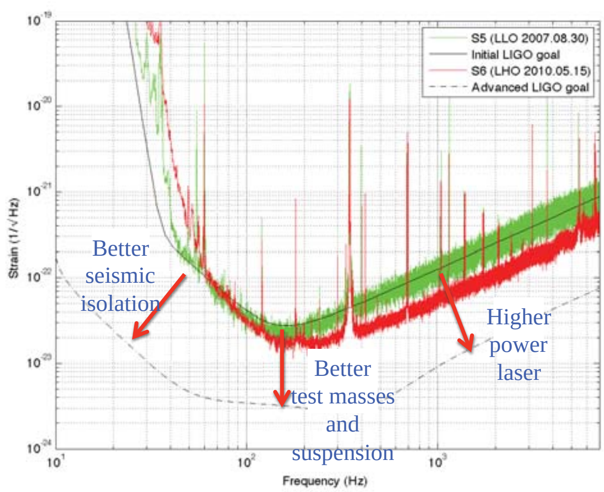


Optical configuration



Complete detector description in
Class. Quantum Grav. 32 (2015) 074001





Seismic Isolation

Ground Motion at 10 [Hz] ~ 10^{-9} [m/rtHz]

$$\Delta L = h\, L \sim 10^{-19}\, m / Hz^{1/2}$$

Need 10 orders of magnitude

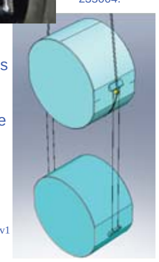
Test masses are suspended from 7 stages of active and passive vibration isolation

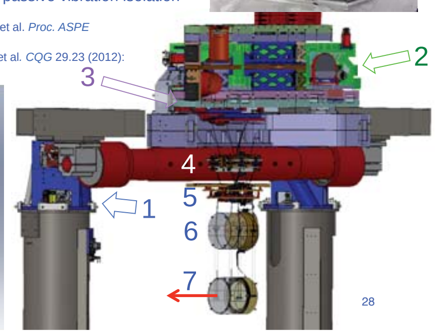
Matichard, F., et al. *Proc. ASPE* (2010)

Aston, S. M., et al. *CQG* 29.23 (2012): 235004.

Last two stages are monolithic to improve Brownian noise

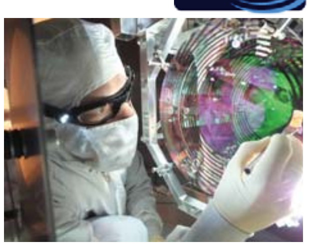
Cumming, A. V., et al. *CQG* 29.3 (2012): 035003.





Test Masses

- Heavy Mirrors → Insensitive to photon pressure from high power
- Test mass coating brownian noise dominates strain sensitivity in the most sensitive region (~100 [Hz])
- Larger Mirrors → Increase Spot Size: Average over more surface area



Diameter	**34 cm**
Thickness	**20 cm**
Mass	**40 kg**
$1/e^2$ Beam Size	**5.3-6.2 cm**

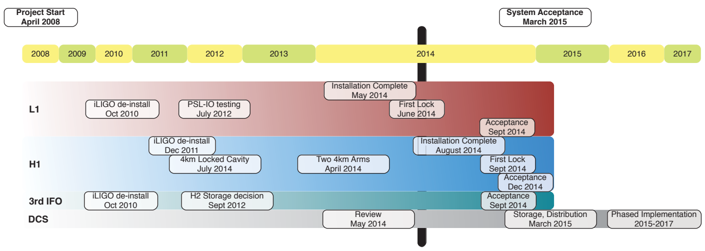
Harry, G. M., *et al.* *CQG* 27.8 (2010) 084006

200W Nd:YAG laser

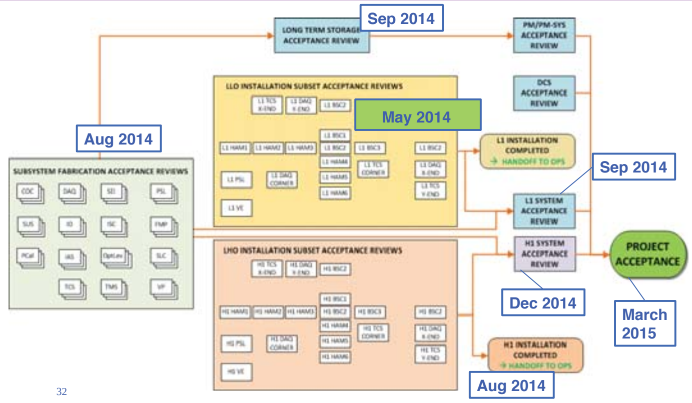
Designed and contributed by Max Planck Albert Einstein Institute

- Stabilized in power and frequency – using techniques developed for time references
- Uses a monolithic master oscillator followed by injection-locked rod amplifier
- Delivers the required shot-noise limited fringe resolution

Project Schedule Highlights



Acceptance



Transition to operations

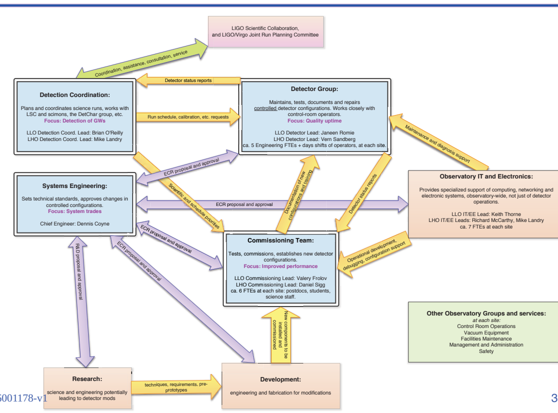
aLIGO Project:

- Subsystem installation and testing.
- Integrated testing, leading to locked whole detector, ready for Ops acceptance.
- Data computing and storage installation.
- Training and documentation.

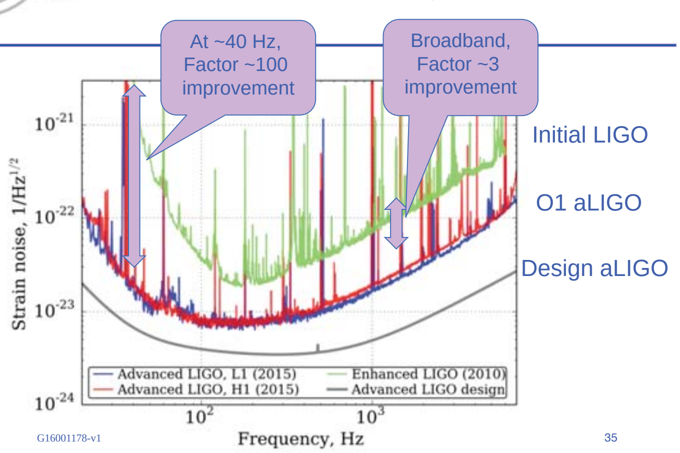
Operations:

- Assembling of new teams and groups.
- Adapting and inventing operations and maintenance plans.
- Maintenance of detector components after installation complete.
- Commissioning detectors that are accepted.

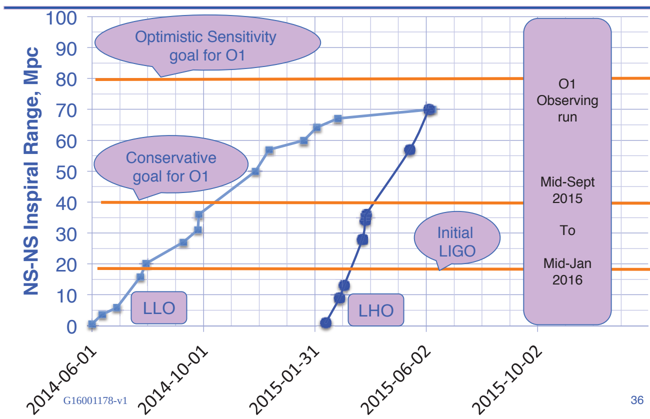
OPS functional groups



Sensitivity for first Observing run O1



Sensitivity Commissioning of aLIGO after completion of installation

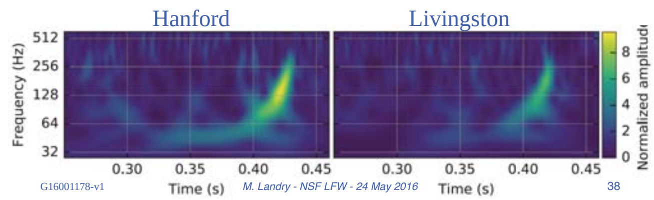


GW150914

- Early morning of Sep 14, at each LIGO site, only an operator and a couple of scientists are present
- Scientists and grad students make final electronic logs and leave site

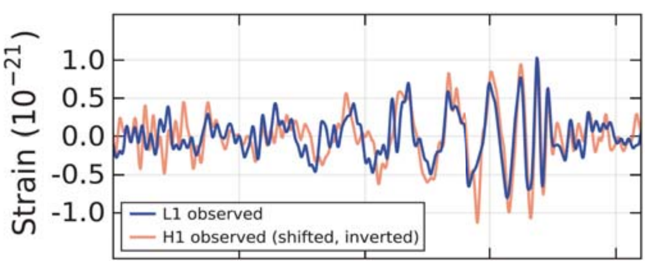
GW150914

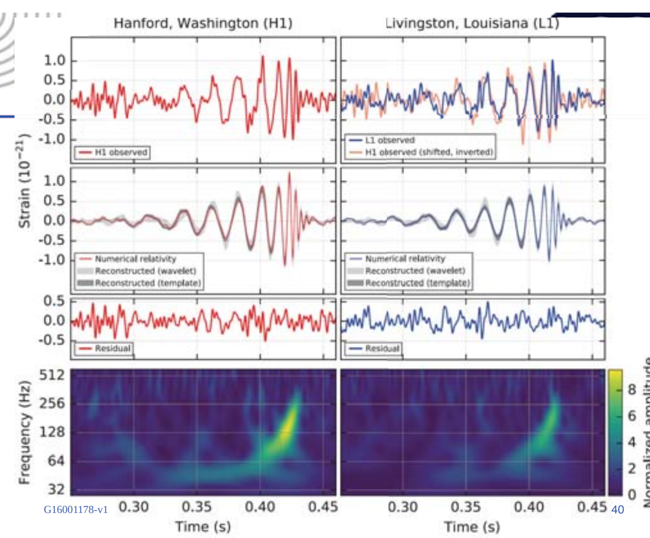
- Early morning of Sep 14, at each LIGO site, only an operator and a couple of scientists are present
- Scientists and grad students make final electronic logs and leave site
- GW150914 passes through Livingston site at 09:50:45 UTC, and 6.9ms later, through the Hanford site (02:50:45 Pacific time)
- Within 3 minutes it is detected by online search codes

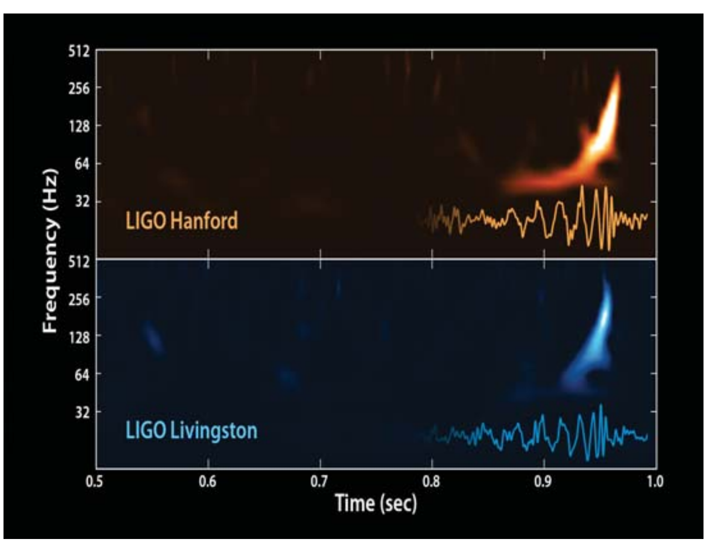


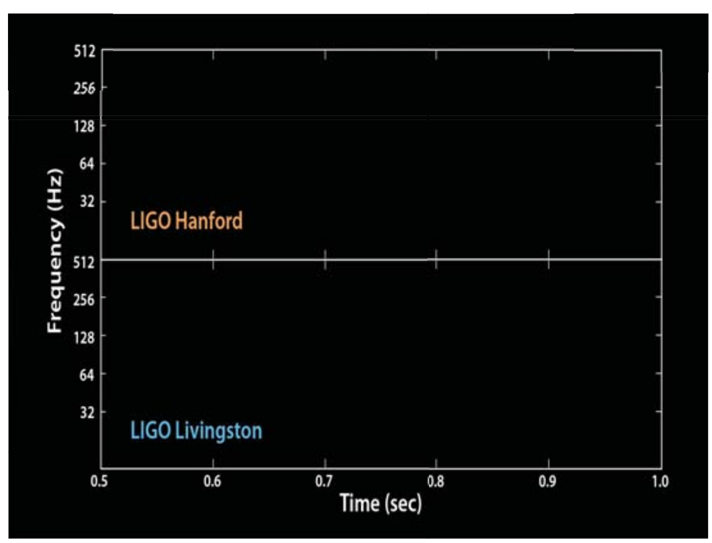
Time series

- Within ~15m, postdocs at AEI see the trigger in our GW database, suspect it is either a signal or an injection
- By 9am Pacific we know it is not a blind injection: we freeze the sites for a month, poll the sites, begin accumulating background data…



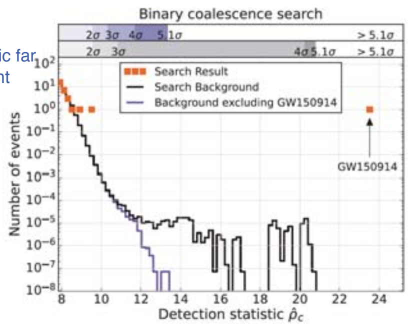






Detection confidence

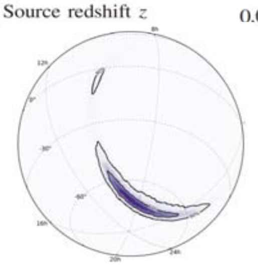
- First seen with a 'burst' on-line detection system, but best statistical confidence measure obtained with a template search based on GR, and numerical solutions
- 'Off-source' background built up using non-physical time slides (>10 msec)
- Equivalent of 600,000 years of background used
- GW150914 had detection statistic far larger than any background event
- False Alarm rate <1/203,000 years, corresponding to 5.1σ.
- A very large SNR in quiet data.



G16001178-v1

Source characteristics

Primary black hole mass	$36^{+5}_{-4} M_\odot$
Secondary black hole mass	$29^{+4}_{-4} M_\odot$
Final black hole mass	$62^{+4}_{-4} M_\odot$
Final black hole spin	$0.67^{+0.05}_{-0.07}$
Luminosity distance	410^{+160}_{-180} Mpc
Source redshift z	$0.09^{+0.03}_{-0.04}$



- 3 $M_\odot$ radiated in GWs; 36 + 29 = 62....+3
- Degeneracy in position and distance (only 2 detectors… need Virgo!)
  - In the Southern Hemisphere, an annulus with some preference in angle
- Alerted EM partners, a group of over 60 telescope collaborations for follow-up
- Can determine a rich set of conclusions due to
  - 'time trace' of amplitude of strain,
  - Absolute calibration of the instrument in strain, and
  - Excellent match to GR

G16001178-v1 ... 45

More info: papers.ligo.org

LIGO
Laser Interferometer Gravitational-Wave Observatory

Observation of Gravitational Waves from a Binary Black Hole Merger

Abstract:

On September 14, 2015 at 09:50:45 UTC the two detectors of the Laser Interferometer Gravitational-Wave Observatory simultaneously observed a transient gravitational-wave signal. The signal sweeps upwards in frequency from 35 to 250 Hz with a peak gravitational-wave strain of 1.0×10^{-21}. It matches the waveform predicted by general relativity for the inspiral and merger of a pair of black holes and the ringdown of the resulting single black hole. The signal was observed with a matched-filter signal-to-noise ratio of 24 and a false alarm rate estimated to be less than 1 event per 203 000 years, equivalent to a significance greater than 5.1σ. The source lies at a luminosity distance of 410^{+160}_{-180} M_{pc} corresponding to a redshift $z = 0.09^{+0.03}_{-0.04}$. In the source frame, the initial black hole masses are $36^{+5}_{-4} M_\odot$ and $29^{+4}_{-4} M_\odot$, and the final black hole mass is $62^{+4}_{-4} M_\odot$, with $3.0^{+0.5}_{-0.5} M_\odot c^2$ radiated in gravitational waves. All uncertainties define 90% credible intervals. These observations demonstrate the existence of binary stellar-mass black hole systems. This is the first direct detection of gravitational waves and the first observation of a binary black hole merger.

Download Paper

Related Papers:

- LIGO-P1500229: Observing gravitational-wave transient GW150914 with minimal assumptions
- LIGO-P1500269: GW150914: First results from the search for binary black hole coalescence with Advanced LIGO
- LIGO-P1500218: Properties of the binary black hole merger GW150914
- LIGO-P1500217: The Rate of Binary Black Hole Mergers Inferred from Advanced LIGO Observations Surrounding GW150914
- LIGO-P1500262: Astrophysical Implications of the Binary Black-Hole Merger GW150914
- LIGO-P1500213: Tests of general relativity with GW150914
- LIGO-P1500222: GW150914: Implications for the stochastic gravitational-wave background from binary black holes
- LIGO-P1500248: Calibration of the Advanced LIGO detectors for the discovery of the binary black-hole merger GW150914
- LIGO-P1500238: Characterization of transient noise in Advanced LIGO relevant to gravitational wave signal GW150914
- LIGO-P1500227: Localization and broadband follow-up of the gravitational-wave transient GW150914
- LIGO-P1500271: High-energy Neutrino follow-up search of Gravitational Wave Event GW150914 with IceCube and ANTARES
- LIGO-P1500237: GW150914: The Advanced LIGO Detectors in the Era of First Discoveries

Analyses in companion papers

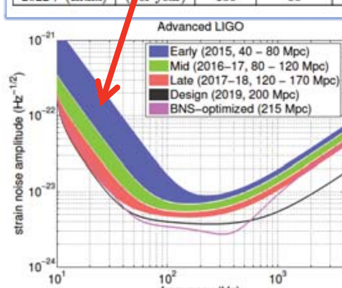
- Effects due to GR-violations in GW150914 are limited to less than 4% (see the Tests of GR paper)
- Electromagnetic followup made by astronomy partners (see Localization & Follow-up paper)
- Expected rate of BBH mergers (see the Rates paper)
  - 2-400 $\mathrm{Gpc}^{-3}\mathrm{yr}^{-1}$
- Limit on the mass of the graviton (Testing GR):
  $$m_g \leq 1.2 \times 10^{-22}\ \mathrm{eV/c^2} \text{ at } 90\% \text{ confidence}$$
- GW150914 demonstrates heavy stellar mass black holes can form in binaries and merge within a Hubble time; requires weak massive-star winds, possible in low metalicity environments (see the Astrophysical implications paper)

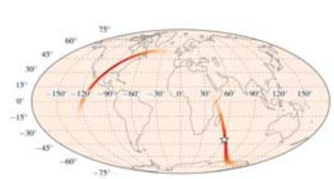
47

Observing Scenario, focus on NS-NS Binaries

http://arxiv.org/abs/1304.0670

Epoch	Estimated Run Duration	$E_{GW} = 10^{-2} M_\odot c^2$ Burst Range (Mpc) LIGO	Virgo	BNS Range (Mpc) LIGO	Virgo	Number of BNS Detections	% BNS Localized within 5 deg²	20 deg²
2015	3 months	40 – 60	–	40 – 80	–	0.0004 – 3	–	–
2016–17	6 months	60 – 75	20 – 40	80 – 120	20 – 60	0.006 – 20	2	5 – 12
2017–18	9 months	75 – 90	40 – 50	120 – 170	60 – 85	0.04 – 100	1 – 2	10 – 12
2019+	(per year)	105	40 – 80	200	65 – 130	0.2 – 200	3 – 8	8 – 28
2022+ (India)	(per year)	105	80	200	130	0.4 – 400	17	48





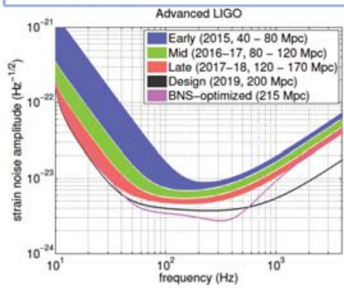
Localization of source, Hanford and Livingston LIGO detectors, First science run at end 2015

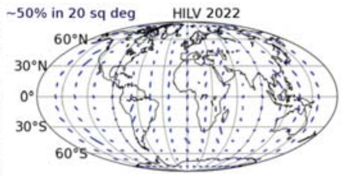
48

LIGO Observing Scenario, focus on NS-NS Binaries

http://arxiv.org/abs/1304.0670

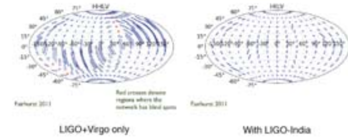
Epoch	Estimated Run Duration	$E_{GW} = 10^{-2} M_{\odot} c^2$ Burst Range (Mpc) LIGO	Virgo	BNS Range (Mpc) LIGO	Virgo	Number of BNS Detections	% BNS Localized within 5 deg^2	20 deg^2
2015	3 months	40 – 60	–	40 – 80	–	0.0004 – 3	–	–
2016–17	6 months	60 – 75	20 – 40	80 – 120	20 – 60	0.006 – 20	2	5 – 12
2017–18	9 months	75 – 90	40 – 50	120 – 170	60 – 85	0.04 – 100	1 – 2	10 – 12
2019+	(per year)	105	40 – 80	200	65 – 130	0.2 – 200	3 – 8	8 – 28
2022+ (India)	(per year)	105	80	200	130	0.4 – 400	17	48





Localization of source,
Hanford, Livingston, Virgo, India detectors,
Observing 2022

LIGO India is a GO, after several years of delay



Cabinet

Cabinet grants 'in-principle' approval to the LIGO-India mega science proposal

The Union Cabinet chaired by the Prime Minister Shri Narendra Modi has given its 'in principle' approval to the LIGO-India mega science proposal for research on gravitational waves. The proposal, known as LIGO-India project (Laser Interferometer Gravitational-wave Observatory in India) is piloted by Department of Atomic Energy and Department of Science and Technology (DST). The approval coincides with the historic detection of gravitational waves a few days ago that opened up of a new window on the universe to unravel some of its greatest mysteries.

The LIGO-India project will establish a state-of-the-art gravitational wave observatory in India in collaboration with the LIGO Laboratory in the U.S. run by Caltech and MIT.

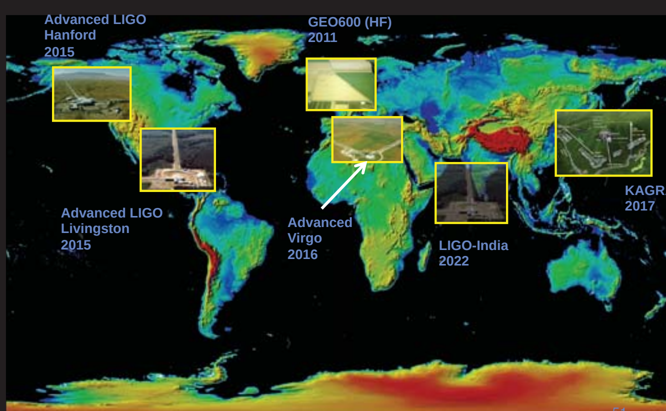
The project will bring unprecedented opportunities for scientists and engineers to dig deeper into the realm of gravitational wave and take global leadership in this new astronomical frontier.

LIGO-India will also bring considerable opportunities in cutting edge technology for the Indian industry which will be engaged in the construction of eight kilometre long beam tube at ultra-high vacuum on a levelled terrain.

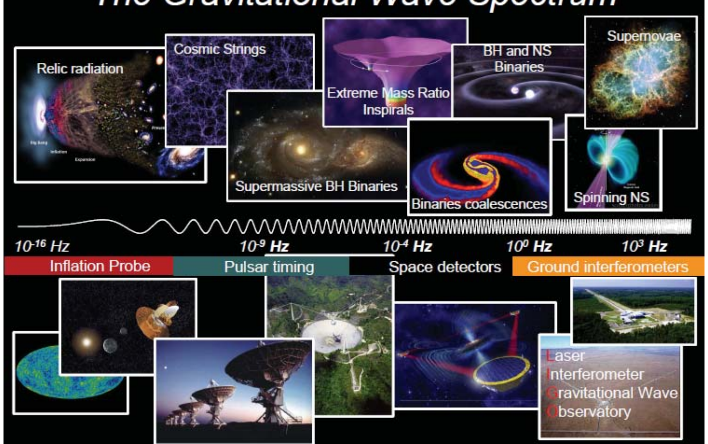
The project will motivate Indian students and young scientists to explore newer frontiers of knowledge, and will add further impetus to scientific research in the country.

***

The advanced GW detector network: 2015-2025



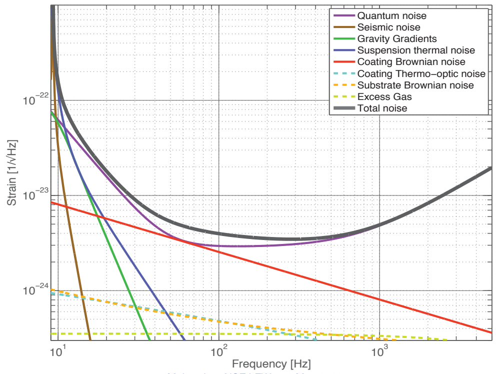
The Gravitational Wave Spectrum



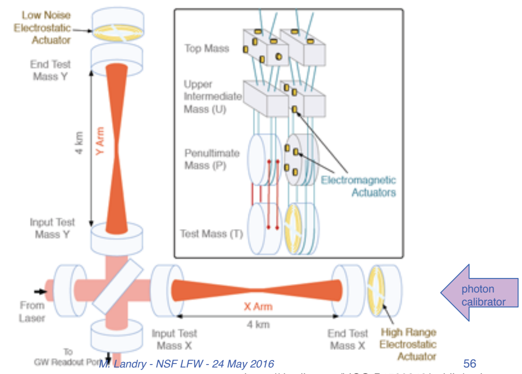
LIGO Scientific Collaboration

Extra slides

Principal noise terms



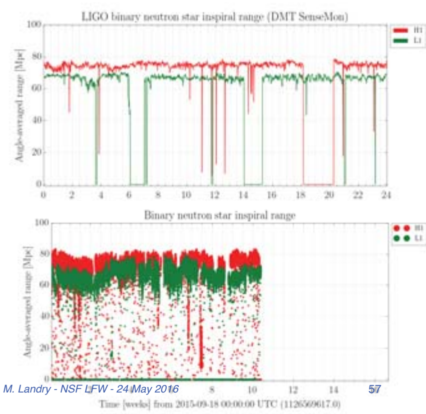
End mirror ("test mass") quadruple-pendulum suspensions



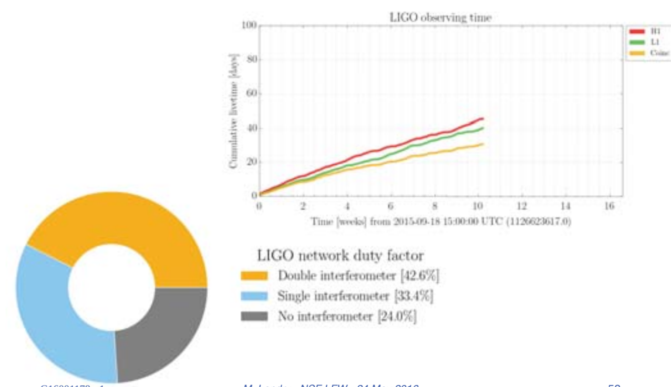
https://dcc.ligo.org/LIGO-P1500248/public/main

LIGO range

LIGO range into space for binary neutron star coalescence (Mpc)

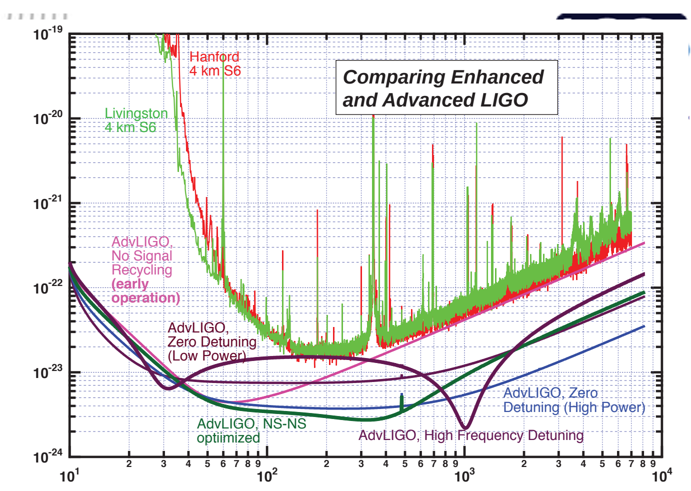


LIGO up time



Expected data rates

- LIGO will produce, in raw science frames, ~ 10 MB/s ~ 840 TB/day ~ 300 TB/year per IFO.
- For 2 IFOs, with trend and RDS data included, we will generate on the order of 1 Petabyte of data per year total, per copy. (And we'll keep dual copies of all data, with one copy at the observatories and one copy at Caltech.)



Staff

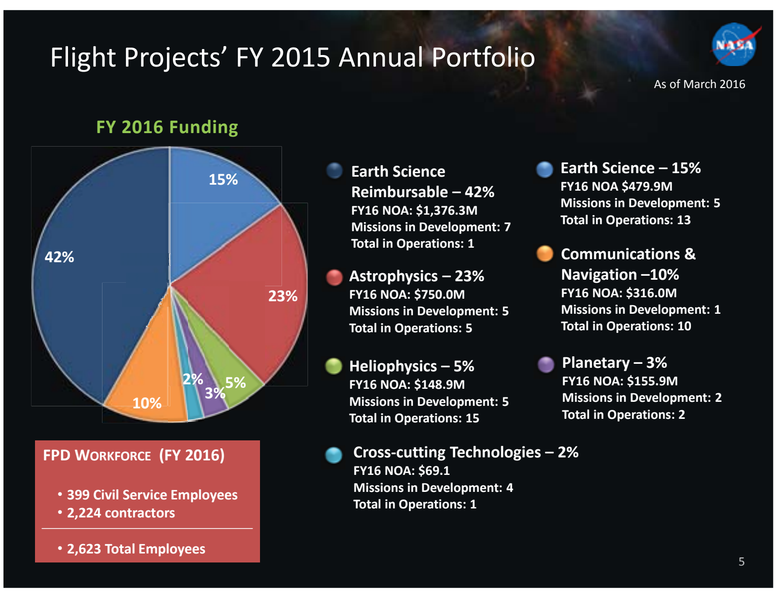
- Steady state science running: ~40 people at each of the sites
- At the peak of Advanced LIGO install ~90 people @ LHO, fewer at LLO owing to single interferometer
- Includes technicians for assembly and clean and bake, engineering, scientists, project controls, facilities, management, i.e. everything
- Also includes riggers/millwrights operating under $3.3M time and materials (T&M) contract. Expertise in rigging, pipefitting, sheet metal, etc. Flexibility in numbers (currently 4 at LHO, 2-3 part time at LLO)
- Visitors: Lab and LSC visitors to sites. LSC on sub-contract


National Aeronautics and Space Administration
Goddard Space Flight Center
Transforming Concepts Into Reality: Project Management Insights from NASA's Goddard Space Flight Center
David Mitchell
Director of Flight Projects Directorate
Presentation to the National Science Foundation and Smithsonian Institution at the 2016 Large Facilities Office Workshop
May 24, 2016


Humanity's Big Questions
How do We Survive and Thrive?
Translate the knowledge and technologies derived from these areas of exploration to practical applications today.
Why are We Here?
What is Out There?
2


NASA GSFC Installations
• GSFC Greenbelt, MD
• GSFC Wallops Flight Facility, VA
• IV&V Facility, WV
• Goddard Institute for Space Studies, NY
• Ground Stations at White Sands Complex, NM
Wallops Flight Facility
White Sands Complex
Independent Verification and Validation Facility
Greenbelt Campus
Goddard Institute for Space Studies
3


Our People
Technicians/Other 6%
Clerical 5%
Scientists & Engineers 61%
Professional/ Administrative 28%
GSFC Workforce
Total Civil Servants: 3,400
Total Contractors : 6,400
Total Workforce: 9,800
4


Flight Projects' FY 2015 Annual Portfolio
As of March 2016
FY 2016 Funding
15%
42%
23%
10%
2%
3%
5%
Earth Science Reimbursable – 42%
FY16 NOA: $1,376.3M
Missions in Development: 7
Total in Operations: 1
Earth Science – 15%
FY16 NOA $479.9M
Missions in Development: 5
Total in Operations: 13
Astrophysics – 23%
FY16 NOA: $750.0M
Missions in Development: 5
Total in Operations: 5
Communications & Navigation –10%
FY16 NOA: $316.0M
Missions in Development: 1
Total in Operations: 10
Heliophysics – 5%
FY16 NOA: $148.9M
Missions in Development: 5
Total in Operations: 15
Planetary – 3%
FY16 NOA: $155.9M
Missions in Development: 2
Total in Operations: 2
Cross-cutting Technologies – 2%
FY16 NOA: $69.1
Missions in Development: 4
Total in Operations: 1
FPD WORKFORCE (FY 2016)
• 399 Civil Service Employees
• 2,224 contractors
• 2,623 Total Employees
5

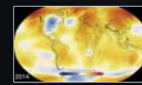

GSFC: A Diverse Mission Portfolio
6

Looking to the Future

2015 Accomplishments

MAVEN Mission Reveals Speed of Solar Wind Stripping Martian Atmosphere

First Global Precipitation Maps from GPM



NASA, NOAA Find 2014 Warmest Year in Modern Record

DSCOVR Discovers Moon Photo-bombing Earth

Sounding Rocket Launches

Goddard Open House Attracts Record Crowd of 20,000

Wallops Flight Facility Marks 70 Years

President Park Geun-hye Visits NASA Goddard

Celebrating 25 Years of Hubble

Liftoff for MMS Mission's Quadruplet Satellites

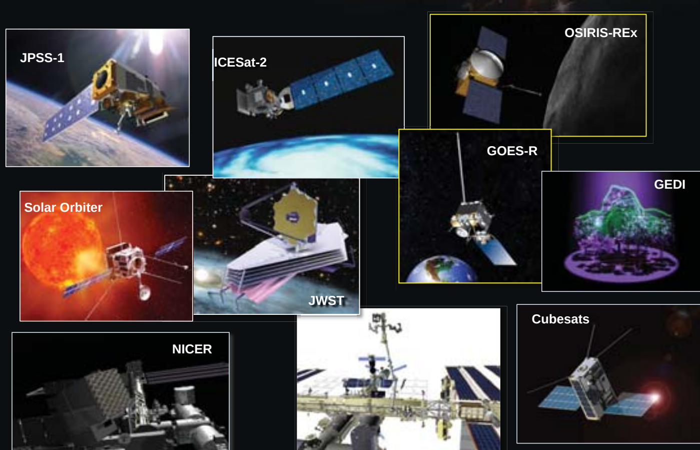
Mars' Moon Phobos is Slowly Falling Apart

Fermi Satellite Detects First Gamma-ray Pulsar in Another Galaxy

Webb Telescope Mirror Assembly Begins at Goddard

SMAP Launches January 2015

Upcoming Launches and Future Missions

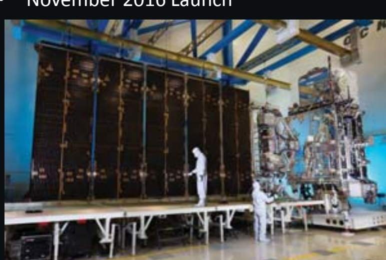


Accomplishments - OSIRIS REx

- Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS REx) asteroid sample return mission completing environmental testing
  - Launch in September 2016

Accomplishments - GOES-R Satellite

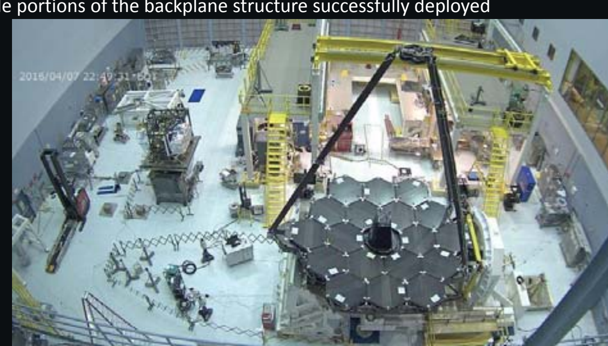
- Geostationary Operational Environmental Satellite "R" Series (GOES-R) is a collaborative program between NOAA and NASA to develop the next generation GOES environmental satellites (follow-on to GOES-N/O/P)
- GOES-R completed mass properties, sine vibe, shock, dynamic interaction test, and launch vehicle adapter match mate
- November 2016 Launch



GOES-R in Sine Vibe at LMSSC in Littleton, CO

Accomplishments - JWST

- James Webb Space Telescope (JWST) is a deployable infrared telescope, passively cooled, with 6.5 meter diameter segmented adjustable primary mirror designed to study the origin and evolution of galaxies, stars, and planetary systems
- Primary mirror installation is complete
- Integrated Science Instrument Module underwent third and final cryogenic test.
- Side portions of the backplane structure successfully deployed



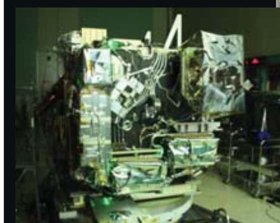
Launch: October 2018

Accomplishments – JPSS

- Joint Polar Satellite System 1 (JPSS 1) spacecraft will sustain continuity of and enhance NOAA's Earth observation analysis and forecasting capabilities from global polar-orbiting observations
- Pre-Environmental Review successfully completed on March 30, 2016
  - On track for January 2017 launch

Accomplishments – ICESat-2

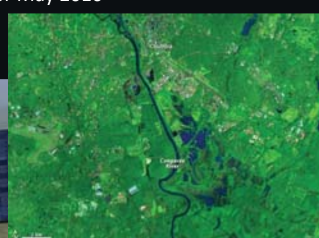
- Ice, Cloud, and Land Elevation Satellite (ICESat-2) is designed to collect altimetric measurements of the Earth's surface, optimized to measure the heights and freeboard of polar ice and global vegetation canopy.
- Project undergoing integration and test
- Launch: October 2017



ATLAS Instrument

New Missions for GSFC – LANDSAT 9

- LANDSAT 9 is in Phase A
- Designed to provide continuity in the multi-decadal land surface observations to study, predict, and understand the consequences of land surface dynamics
  - Mission Definition Review scheduled for May 2016



Flooding Near Columbia, South Carolina

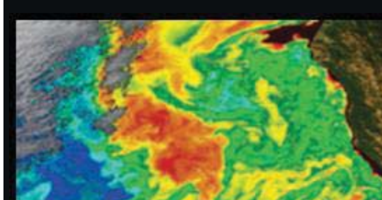
New Missions for GSFC - WFIRST

- Wide Field Infrared Survey Telescope (WFIRST) is a NASA observatory designed to settle essential questions in the areas of dark energy, exoplanets, and infrared astrophysics
- WFIRST Mission Concept Review successfully completed in December 2015
- Key Decision Point A was held in January 2016

Baseline WFIRST Image

New Missions for GSFC - PACE

- Pre-Aerosol, Clouds, and Ocean Ecosystem (PACE) mission will make global ocean color measurements to provide extended data records on ocean ecology and global biogeochemistry (e.g., carbon cycle) along with polarimetry measurements to provide extended data records on clouds and aerosols
- PACE completed Mission Concept Review in March 2016

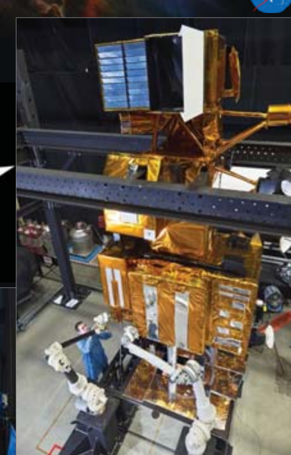


New Missions for GSFC – Restore-L

- Restore-L will robotically refuel a Government–owned satellite in low Earth orbit (LEO)
- Restore-L Satellite Mission Preliminary Design Review held in December 2016
- Restore-L Mission Concept Review held April 7-8, 2016

Restore Servicing Vehicle (RSV) (bottom, with conceptual Bus shown) mated to notional client (top)

Sen. Barbara Mikulski Officially Opens New Robotic Operations Center



Development work at GSFC with Landsat 7 as case study

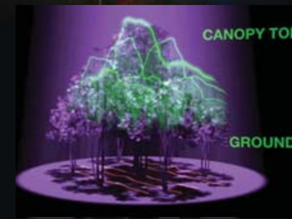
International Space Station Utilization

- **Neutron star Interior Composition ExploreR (NICER)** study of neutron stars through soft X-ray timing
- Completed Pre-Environmental Review and is in integration and test
- Launch in January 2017

- **Raven** (relative navigation tech demo) launches to the International Space Station in November 2016

International Space Station Utilization

- The Total and Spectral Solar Irradiance Sensor (TSIS-1) mission will provide absolute measurements of the total solar irradiance (TSI) and spectral solar irradiance (SSI), important for accurate scientific models of climate change and solar variability



- The scientific goal of the **Global Ecosystem Dynamics Investigation Lidar (GEDI)** is to characterize the effects of changing climate and land use on ecosystem structure and dynamics to enable radically improved quantification and understanding of the Earth's carbon cycle and biodiversity
- **Global Ecosystems Dynamics Investigation (GEDI)** is in Phase B Preliminary Design Review held in March 2016

PROJECT UNIQUE CHALLENGES

Unique Flight Project Challenges

- Problems and challenges arise even on the most well planned projects
- Need both schedule and budget reserve to address unknown unknowns
  - Need reserves to actively manage issues and concerns to minimize cost and schedule impacts
  - Need reserves to mitigate risks
- Need to manage technical reserves and design margins
  - Exceeding technical reserves and design margins may force re-designs, affect mission performance requirements, and/or deplete cost and schedule reserves

Challenges - Schedule

- Meeting planetary windows bring hard deadlines
  - May need to wait months or years for next launch opportunity

Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS Rex) completing environmental testing – Shipped to Cape Canaveral on May 20, 2016 – Launch window September 3 – October 12, 2016

Challenge – Complex Design (1 of 2)

- Satellites with complex designs and/or large scale pose unique challenges
  - Drives schedule and cost

James Webb Space Telescope (JWST)

Challenge – Complex Design (2 of 2)

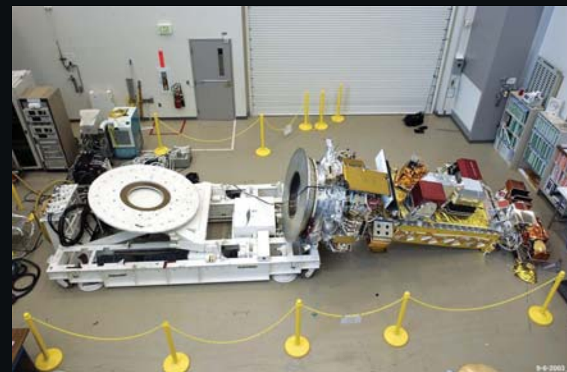
- Satellites with complex designs may need unique or one-of-a-kind facilities and support equipment
- Ground systems can also have complex designs and/or unique challenges

New vibration facility for James Webb Space Telescope (JWST)

JWST thermal vacuum testing to occur at JSC

Challenges – Mishaps

- Major unplanned events often requiring a project "stand-down" and re-plan

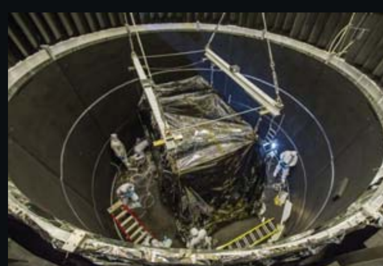


Spacecraft mishap during integration

Challenges – Facility Conflicts

- Schedule conflicts between projects using integration and test facilities
  - May require building new facilities
  - May require taking hardware to outside facilities

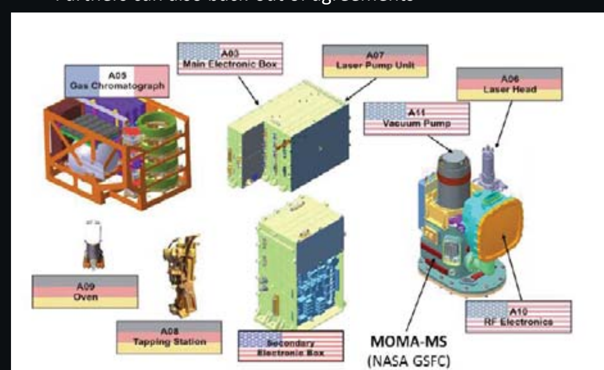
- ➢ MMS conflict with JWST required MMS to go to Naval Research Laboratory for Thermal Vacuum testing
- ➢ Facility conflicts also drove MMS to build their own cleanroom facility



- ➢ JWST Integrated Science Instrument Module being lowered into the GSFC Space Environment Simulator Thermal Vacuum chamber

Challenges – Outside Partnerships

- Partnerships with outside organizations can drive funding and schedule beyond the control of the GSFC project manager
- Partners can also back-out of agreements



GSFC contribution to European ExoMars mission: Mars Organic Molecule Analyzer Mass Spectrometer (MOMA-MS)

ExoMars mission recently slipped launch 2 years from 2018 to 2020

Challenges – Procurement Delays

- Delays in awarding procurements can increase cost, as well as decrease schedule margins

JPSS 2, 3, and 4 spacecraft experienced a delayed start as a result of a procurement protest

Challenges – Hardware Issues

- Hardware issues can cause cost increases, schedule delays, re-designs, and re-plans
  - Parts issues
    - Parts not available
    - Long lead items don't meet mission schedule
    - Parts may require test program
  - Hardware issues
    - Poor workmanship
    - Failure during testing
    - Behind schedule
    - Exceeded budget
    - Unexplained test results
    - Late deliveries

Late hardware deliveries from suppliers

Challenges – Changing Requirements

- There will be reasons to change requirements after they are baselined — budget cuts, changes in funding profiles, system upgrades, unplanned changes in an interface, or changes in a regulation or a standard, etc.
- Requirements creep, both in the science and engineering areas must be minimized to stay on schedule and within budget

Landsat Data Continuity Mission (LDCM) - The Thermal Infrared Sensor (TIRS) instrument drove schedule

Challenges – Launch Vehicle Schedule

- Delays in launch vehicle schedules use up funding and schedule reserves
- Project manager needs to incorporate schedule and cost margin in budget for normal launch delays of a few weeks or months
  - May need to re-plan and request more funding from Headquarters for longer delays
- Launch vehicle failures tend to cause long launch delays, as well as, backlogs in the manifest

MAVEN Launch on ATLAS V on November 18, 2013

DSCOVR launch on Falcon 9 rocket from Kennedy Space Center on February 11, 2015

Challenges – On Orbit Events

- Orbital events can cause a loss of mission
- STEREO mission experienced problems in October 2014
  – Lost communications with one of the two spacecraft while in extended operations
- Defense Meteorological Satellite Program (DMSP 19) broke up in orbit in February 2015
  – Exploded while in a sun-synchronous polar orbit leaving a large debris field
- Micrometeoroid impact to the MMS 4 spacecraft but all instruments and the spacecraft are still functioning
- NASA monitors space debris and performs collision risk conjunction assessments (CARA)
  – Routinely needs to move satellites to avoid collisions

STEREO Satellites during Spin Test

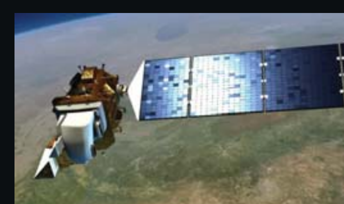
Challenges – Stakeholders

- Key stakeholders often drive launch dates and funding, as well as ownership of mission between agencies
- Stakeholders include Congress, Office of Management and Budget, science communities, and other agencies
- Outcomes are often out of the control of the center and project manager

Deep Space Climate Observatory

Triana mission originally scheduled to launch in 2003 (NASA mission) → Storage from 2001 to 2013 / Several attempts to revive mission → DSCOVR mission (formerly Triana) confirmation in 2013 with launch in 2015 (joint NASA/NOAA mission)

Same instruments/measurements – different prime mission focus (earth science to solar storm warning)



Landsat 9: Stakeholders driving launch readiness date

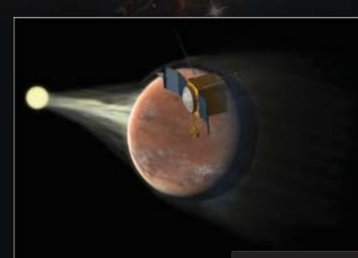
MAVEN

Mars Atmosphere and Volatile EvolutioN (MAVEN) Mission

MAVEN's Lessons Learned

The MAVEN Project's Journey

From proposal days…



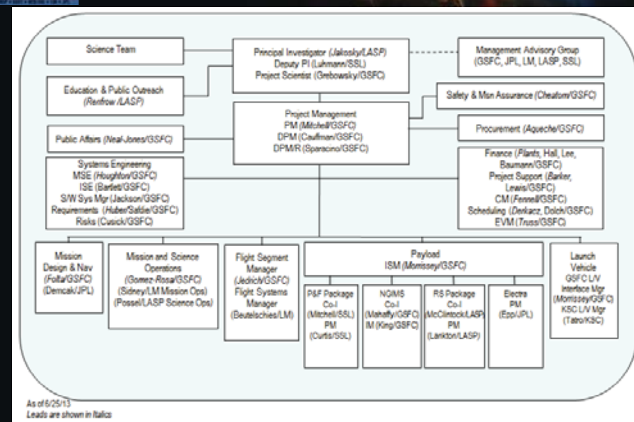
… to Science at Mars

All major milestones, including launch, achieved on the schedule originally proposed in 2008 – and under budget!

Historical Perspective

- The concept which became MAVEN was hatched in 2003 by one scientist from the University of Colorado/Boulder (eventual Principal Investigator [PI]) and two scientists from the University of California/Berkeley
- The MAVEN PI asked Goddard to join the team in 2005. The MAVEN proposal was submitted in response to NASA Headquarters' Scout II Announcement of Opportunity in 2006
- MAVEN was one of 20 Step-1 proposals. Two were selected for a more-detailed feasibility or Phase A study
- Following the competitive Phase A study, MAVEN was selected to move forward to flight in 2008
- After a 1-year "risk reduction phase," MAVEN transitioned to a 4-year development phase for launch. MAVEN was confirmed in 2010
- MAVEN was included in the government shutdown in October 2013, less than 7 weeks from launch. Launch-preparation activities were restarted after 2 days
- MAVEN launched on November 18, 2013. This was the first day of its 3-week launch period, and it launched at the first opportunity at the start of its 2-hour firing window that day. MAVEN entered Mars orbit on September 21, 2014
- MAVEN launched on schedule, under budget, and with the full technical capability that was intended

Project Organization at Launch



- Project resides within GSFC's Flight Projects Directorate, Planetary Science Projects Division
- Support from GSFC internal organizations, as well as NASA Headquarters, Jet Propulsion Laboratory, Kennedy Space Center, and industry partners is key
- Note that MAVEN is a University of Colorado at Boulder-Laboratory for Atmospheric and Space Physics PI-led mission, with project management coming from GSFC

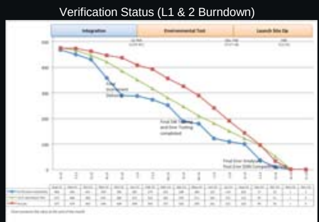
Major Partner Institutions

Project Management: Principles to Success

1. Establish a clear and compelling vision
   - Create a clearly defined vision of the future that serves to inspire and motivate the project team which in turn provides an important first step in paving the road toward project success
2. Secure sustained support "from the top"
   - Develop effective working relationships with key stakeholders at all levels
3. Exercise strong leadership and management
   - Identify and develop other leaders and technical staff within the organization, define clear lines of authority and demand accountability
4. Facilitate wide open communication
   - Listen and share the good, the bad and the ugly
5. Develop a strong organization
   - Design and align culture, rewards, and structure
6. Manage risk/seek opportunities
   - Employ a continuous and evolving risk-management process
   - Look forward then exploit opportunities to reduce cost or schedule requirements through agile principles
7. Establish, maintain, and implement an executable baseline
   - Develop clear, stable objectives/requirements from the outset; establish clean interfaces; track changes, implement corrective actions when necessary; and maintain effective configuration control

Lessons Learned from the MAVEN Journey

- Rigorous tracking of metrics (cost, schedule, technical) is critical to keeping leadership aware of negative trends in order to react early



	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12
Cum SPI	0.94	0.95	0.95	0.95	0.96	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98
Cum CPI	1.03	1.02	1.01	1.00	1.00	1.00	1.01	1.01	1.01	1.02	1.02	1.02	1.03

1/31/13

	MAVEN Critical Milestones	Need Date
1	NGIMS FM ready for Environmental Testing (GSFC)	1/7/13
2	NGIMS Vibration Test Complete (GSFC)	2/7/13
3	Delivery of SWEA Paylaod to LM (SSL)	3/21/13
4	Deliver NGIMS Payload to LM (GSFC)	3/25/13
5	Flight TAME Controller Available to ATLO	2/1/13
6	C&DH #1 DTCI-U Flight Spare available to ATLO (LM)	2/3/13
7	Magnetics Swing Test (ATLO)	1/10/13
8	Begin S/C Modal Survey Test (ATLO)	2/4/13
9	Re-Install TAME (ATLO)	2/5/13
10	FSW Build 5.0 Available (LM)	3/18/13
11	Begin S/C Acoustics Test (ATLO)	2/8/13
12	Begin S/C Sine Vibe Test (ATLO)	2/27/13
13	Install SWEA to Spacecraft (ATLO)	3/28/13
14	Install NGIMS to Spacecraft (ATLO)	4/1/13
15	Begin ORT 1 Test (GDS)	4/17/13
16	Begin S/C EMI/EMC Test (ATLO)	4/19/13
17	S/C Self Test #7	4/25/13
18	Begin SVT/MOI (Off-Nominal) Tests (ATLO)	5/1/13
19	Lost in Time Test (LM)	5/3/13
20	Begin Thermal Vac Test (ATLO)	5/22/13
21	Power Performance Test (ATLO)	6/11/13
22	Begin ORT 2 Launch Nominal Test (GDS)	6/12/13
23	Payload Final Performance Test (ATLO)	6/21/13
24	Dry Spin Balance Test Complete (ATLO)	7/9/13

1 - Reviewing TAME PWB coupons to determine useability
2 - SWEA is diagnosing issues with high voltage discharges.SWEA was decoupled from the PFP package and to be shipped separately.
3 - DTCI Fabrication delayed
4 - EMI/EMC Test moved to accommodate NGIMS delivery
5 - FSW 5.0 delayed to accommodate additional changes

Review	Review Held / Scheduled	Actions	Submitted	% Submitted	Closed	% Closed
RSS PER	4/10/12	5	5	100%	5	100%
PFP PER	5/22/12	7	7	100%	7	100%
NGIMS PER	10/15/12	2	2	100%	2	100%
Spacecraft PER	1/29/13	5	3	60%	3	60%
SIR	6/25/12	4	4	100%	4	100%
Electra HRCR (JPL internal)	6/21/12	0	n/a	n/a	n/a	n/a
RSS PSR	10/24/12	1	1	100%	1	100%
PFP PSR	10/30/12	1	1	100%	1	100%
NGIMS PSR	TBD	TBD	-	-	-	-
Observatory PSR	7/16/13	TBD	-	-	-	-
MOS/GDS Peer Review	6/5/12	0	n/a	n/a	n/a	n/a
MOR	11/13/12	14	8	57%	6	43%
ORR/FOR	8/13/13	TBD	-	-	-	-
Totals		39	31	79%	29	74%

Lessons Learned: Planning and Scheduling

- From Phase A, top-level schedules established key milestones (Preliminary Design review, Critical Design Review, System Integration Review, Launch Readiness Date, etc.) that all organizations could use for lower level planning and pricing purposes
- It is critically important to get out of the starting blocks quickly with proper project staffing. Brought the schedule lead, financial manager, and Earned Value Management (EVM) lead onboard at the beginning of the project to design a Work Breakdown Structure (WBS)-based schedule and EVM system – costs and schedule were monitored together
- Held early face-to-face meetings with organizations supplying schedule and EVM data to set expectations and assess institutional capabilities. This created a collaborative environment

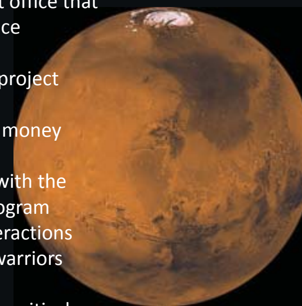
Lessons Learned: Schedule Execution

- All schedules were reviewed 30, 60, and 90 days ahead
- During each shift of key integration and test events, the product lead met with the team, quality control representatives, and the scheduler to review planned and completed activities and status
- During mission integration and test
  - At the beginning and end of every shift, team reviewed the daily and hourly schedule to prepare and execute assignments
  - Daily schedule briefings were held. The team focused on tasks scheduled for the coming days and weeks. Problems were addressed, identifying workarounds to save schedule
- The project team acted with the mindset of "schedule is king" during every phase of the mission. The team had to, given the constrained planetary launch period

November 18, 2013

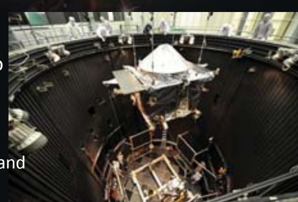
Lessons Learned from the MAVEN Journey

- Stability of leadership through the project lifecycle is critical
- Push to get front line managers in the project office that have strong hardware development experience
- Maintain a sense of urgency throughout the project lifecycle even if your mission does not have a constrained planetary launch period. Time is money
- Communicate, communicate, communicate with the project office, the PI, partner institutions, program office and NASA HQ; regular face-to-face interactions are critical. You/your team have to be road warriors
- Transparency and openness with your team is critical. You want to hear about concerns early, not days before or after launch



Lessons Learned from the MAVEN Journey

- Fight for sufficient cost reserves at the outset of the mission (and sufficient up-front funding and carryout). These cost reserves will be needed to address many of the unknowns during development
  - Pressure to cut bid price during the competitive phase was rebuffed by the Principal Investigator and the Project Manager
  - Descoped two instruments shortly before final proposal submission to ensure proper reserves
  - Execution is much more efficient when the project remains green throughout development rather than going yellow or red
- Resist requirements creep, both in the science and engineering areas
  - A solid mission was proposed and we stuck to it even under pressure from various corners (e.g., add a camera, add a student instrument, add a "free" foreign instrument)



Lessons Learned from the MAVEN Journey

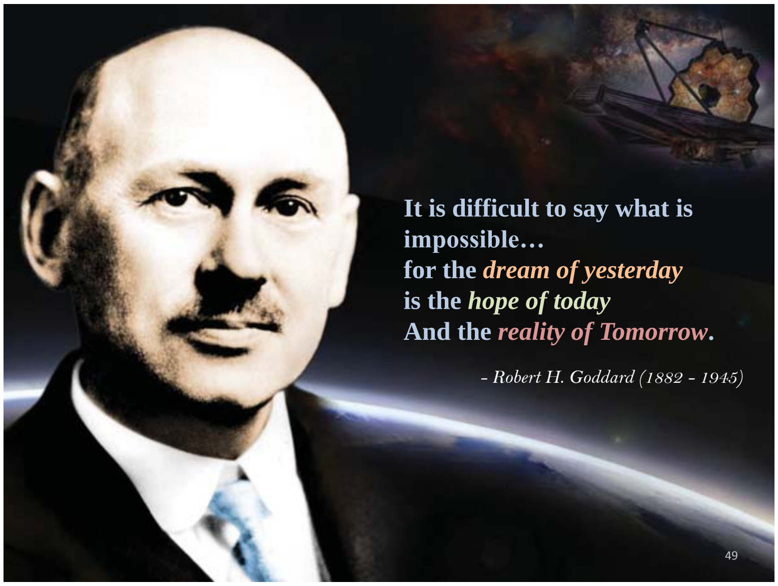
- Transition into integration, test, and on-orbit operations (Phase CDE) on a project is a large effort. For a planetary project, any loss of schedule is critical. In an effort to expedite the CDE proposal process, the spacecraft contractor opened the lower level internal subsystem reviews to the Project prior to submittal of the Phase CDE proposal. The result was a delivered proposal that contained no surprises
- Negotiate partner institution Phase C-E contracts before the Confirmation Review - MAVEN retired a significant cost growth risk and bounded the overall scope of effort
- The spacecraft contractor and Project Office personnel traveled extensively together to kickoff meetings at vendor facilities. These meetings set expectations on how we wanted the vendors to operate
- Heritage systems help but just as importantly you need the matching "heritage people" building the hardware (this isn't always possible)
  - In one case, a technician who built circuit boards for previous instruments retired and the replacement tech did not implement the correct high-voltage workmanship techniques because they hadn't been documented

Lessons Learned from the MAVEN Journey

- Spending money early to retire risk significantly reduced late surprises and overruns
- There was a large amount of interest from external parties that impacted "normal" work. Be prepared for significant data requests, questions, audits. Staff accordingly
- Brought the Joint Cost/Schedule Confidence Level (JCL) independent review team into the mix with the project 6 months before the Preliminary Design Review (PDR). This was significant in relieving any disconnects in the run up to Mission PDR and Confirmation Review

Lessons Learned from the MAVEN Journey

- The first lesson in planning is that you can't plan for everything. We encountered plenty of issues on MAVEN that required us to assess the impacts and move forward with Plan B. Surprises along the way:
  - Two instruments were delivered months late, during the year of launch
  - Application of a new material in a heritage system (MetGlas) and impacts in I&T. Must fully evaluate new materials and their application prior to use
  - Sequestration, with imposition of a travel cap in FY 2012 that threatened MAVEN's approach to conducting business
  - FY 2014 furlough beginning 7 weeks before scheduled launch and how we preserved MAVEN's full launch period
  - Removal of an instrument at the launch site for rework back at Goddard (the "Cannot Duplicate Problem" that surfaced again during launch preparations at KSC, and forced a late, tough decision)
  - Comet Siding Spring – truly an "unknown unknown" when we bid the mission in 2008. This comet was discovered in January 2013 and drove a significant amount of analysis and mitigation planning and implementation for the October 2014 encounter
- Find opportunities to team build at frequent intervals and schedule in lessons learned opportunities during every phase of development


It is difficult to say what is impossible…
for the dream of yesterday
is the hope of today
And the reality of Tomorrow.
- Robert H. Goddard (1882 - 1945)
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Questions?

NSF and the Federal Budget

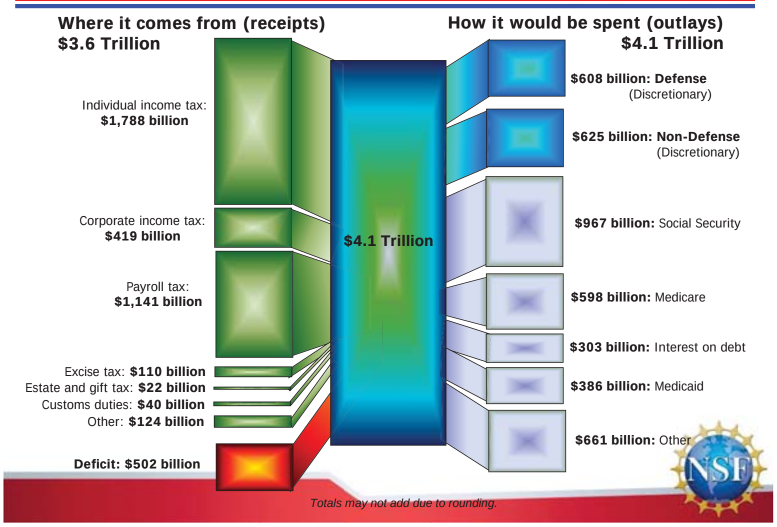
Michael Sieverts
Division Director, Budget Division
Office of Budget, Finance, and Award Management
U.S. National Science Foundation

Main Topics

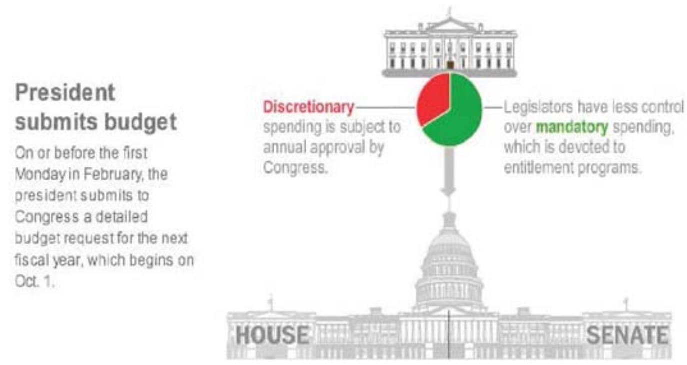
- Federal Budget: Some Basics
- NSF Budget Process
- NSF Appropriations
- Current Events

Spending America's Income

Broad revenue and spending categories in President Obama's fiscal 2017 budget:



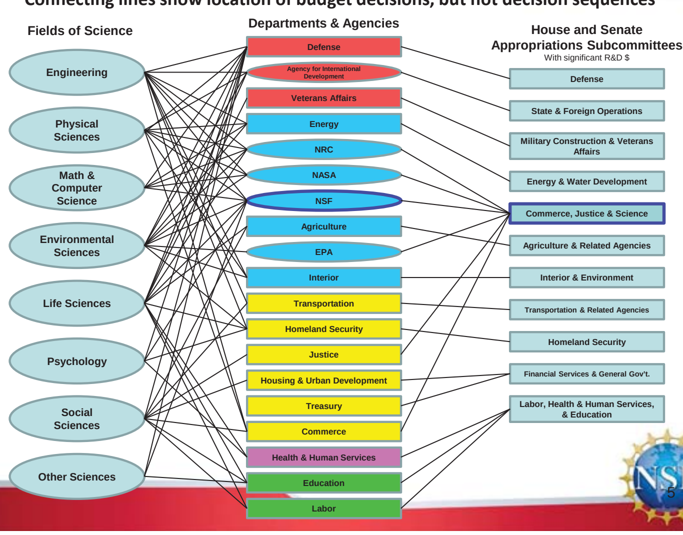
Totals may not add due to rounding.



Source: Washington Post: http://www.washingtonpost.com/wp-srv/special/politics/federal-budget-process/noFlash.jpg

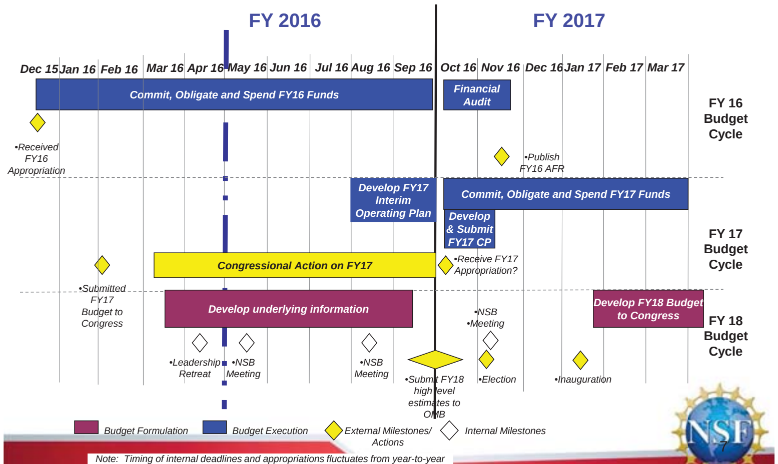
Fields of Science and Executive and Legislative Decision Units

Connecting lines show location of budget decisions, but not decision sequences



Overview of Budget Process

Budget Planning Timeline



What is the “budget”?

- Congressional Justification
  - Justification of Estimates of Appropriations to the Congress
- NSF:
  - 2 pages of appropriations language
  - ~570 pages of “justification”
- Know your pages
  - http://www.nsf.gov/about/budget/

NSF Budget

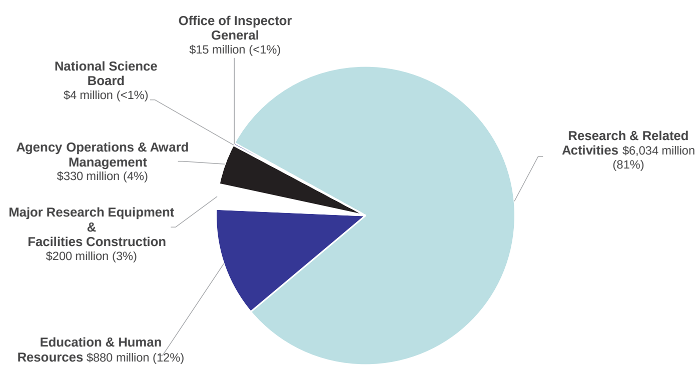
NSF Total Budget (FY 2016): $7.463 billion

NSF receives funding in six appropriations to finance its mission

Programmatic Activities
- Research and Related Activities (R&RA)
- Education and Human Resources (EHR)
- Major Research Equipment and Facilities Construction (MREFC)

Administrative & Management Activities
- Agency Operations and Award Management (AOAM)
- National Science Board (NSB)
- Office of Inspector General (OIG)

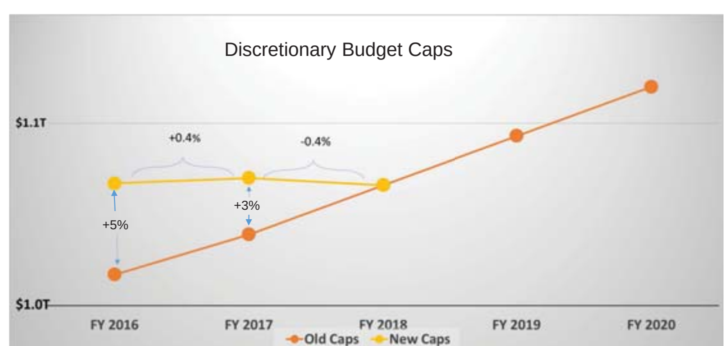
NSF BUDGET STRUCTURE
FY 2016 Appropriations by Account - $7,463 million



Program Accounts

- R&RA & EHR:
  - Major Directorates and Offices.
  - ~93% of Total Appropriation for NSF
- MREFC:
  - Major facility projects
  - ~3% of Total Appropriation for NSF

Current Events:
Bipartisan Budget Act of 2015 (P.L. 114-74)



National Science Foundation
FY 2017 Budget Request to Congress
(Dollars in Millions)

Account	FY 2016 Estimate	FY 2017 Request - Discretionary	FY 2017 Request Discretionary over FY 2016 Estimate		FY 2017 Request - Mandatory	FY 2017 Request - Total	FY 2017 Request Total over FY 2016 Estimate	
			Amount	Percent			Amount	Percent
Research & Related Activities	$6,034	$6,079	$46	0.8%	$346	$6,425	$392	6.5%
Education & Human Resources	880	899	19	2.1%	54	953	73	8.3%
Major Research Equipment & Facilities Construction	200	193	(7)	-3.6%	-	193	-7	-3.6%
Agency Operations & Award Management	330	373	43	13.0%	-	373	43	13.0%
National Science Board	4	4	*	0.2%	-	4	*	0.2%
Office of Inspector General	15	15	*	0.3%	-	15	*	0.3%
Total, NSF	$7,463	$7,564	$101	1.3%	$400	$7,964	$501	6.7%

Totals may not add due to rounding.
* denotes amounts <$500K.

What is meant by mandatory funding?

- Different category of Federal spending than NSF typically sees
- Also known as "direct spending"
- GAO Definition: budget authority that is provided in laws other than appropriations acts
- Most commonly associated with entitlement programs (Social Security, Medicare, etc.) but also supports R&D
- *Not subject to discretionary caps*
- In FY 2017, the Administration is seeking legislation to provide mandatory funding for NSF on a one-time basis

Congressional Action to Date

- FY 2017 Budget Hearings in the House
  - House Appropriations, Subcommittee Commerce, Science, Justice March 16, 2016
  - House Committee on Science, Space & Technology March 22, 2016
- Senate markup on April 21, 2016
- House subcommittee markup on May 17, 2016
- Congress not considering Administration's proposal for new mandatory funding

Senate Mark-up

National Science Foundation
FY 2017 Senate Markup: Comparison to FY 2017 Request (Discretionary) and FY 2016 Estimate
(Dollars in Millions)

Account	FY 2016 Estimate	FY 2017 Request-Discretionary	FY 2017 Senate	FY 2017 Senate over FY 2016 Estimate		FY 2017 Senate over FY 2017 Request-Discretionary	
				Amount	Percent	Amount	Percent
Research & Related Activities	$6,034	$6,079	$6,034	-	-	-$46	-0.8%
Education & Human Resources	880	899	880	-	-	-19	-2.1%
Major Research Equipment & Facilities Construction	200	193	247	46	23.1%	53	27.7%
Agency Operations & Award Management	330	373	330	-	-	-43	-11.5%
National Science Board	4	4	4	-	-	*	-0.2%
Office of Inspector General	15	15	15	*	0.3%	-	-
Total, NSF	$7,463	$7,564	$7,510	$46	0.6%	-$54	-0.7%

Totals may not add due to rounding.
* denotes amounts <$500K.

House Mark-up

National Science Foundation
FY 2017 House Markup: Comparison to FY 2017 Request (Discretionary) and FY 2016 Estimate
(Dollars in Millions)

Account	FY 2016 Estimate	FY 2017 Request-Discretionary	FY 2017 House	FY 2017 House over FY 2016 Estimate		FY 2017 House over FY 2017 Request-Discretionary	
				Amount	Percent	Amount	Percent
Research & Related Activities	$6,034	$6,079	$6,079	$45	0.7%	-	-
Education & Human Resources	880	899	880	-	-	-19	-2.1%
Major Research Equipment & Facilities Construction	200	193	87	-113	-56.5%	-106	-54.9%
Agency Operations & Award Management	330	373	340	10	3.0%	-33	-8.8%
National Science Board	4	4	4	*	-	-	-
Office of Inspector General	15	15	15	*	-	-	-
Total, NSF	$7,463	$7,563	$7,405	-$58	-0.8%	-$158	-2.1%

Totals may not add due to rounding.
* denotes amounts <$500K.

Appropriations: Noteworthy Items

SENATE

- Third Regional Class Research Vessel
- GAO review of projects funded via MREFC account
  - Based on GAO review of NASA projects
- NSB report re: facilities O&M
- AOAM funding insufficient to cover relocation to Alexandria

HOUSE

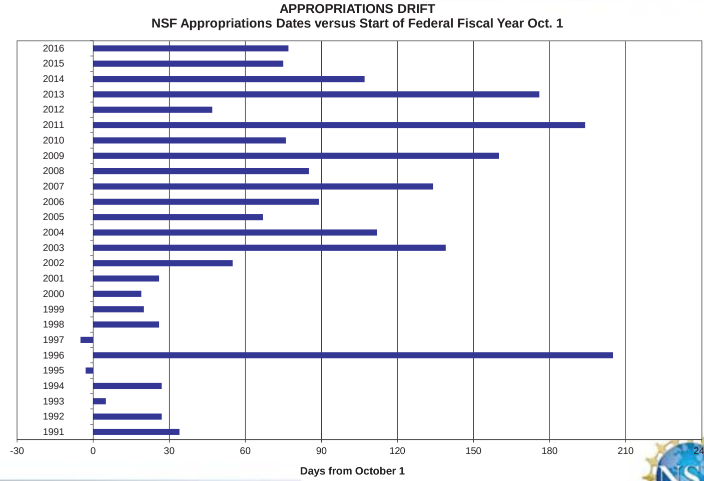
- No details yet
- No Regional Class Research Vessel funding

Outlook

- ➢Uncertainty – Potential Outcomes….
  - Appropriations enacted by Oct. 1

    -- OR --

  - Continuing resolution until after election or inauguration



For More Information

NSF Budgets – Budget and Performance link at bottom of nsf.gov
http://www.nsf.gov/about/budget/
http://www.nsf.gov/about/performance/

NSF Budget Primer -
http://collaboration.inside.nsf.gov/bfa/Budget/Budget%20Process%20Primer/01_Primer_Introduction.aspx

NSF Budget Internet Information System (BIIS) - http://dellweb.bfa.nsf.gov/

NSF Enterprise Information System (EIS) –
http://budg-eis-01/eisportal/default.aspx

NSF Program and Financial Coding Manual FY 2016
https://inside.nsf.gov/tools/toolsdocuments/Inside%20NSF%20Documents/NSF%20Manual%2021.pdf

Lightening Talks

National Science Foundation
Large Facilities Workshop
May 24, 2016

RCRV

Regional Class Research Vessel

NSF LARGE FACILITIES WORKSHOP

UNOLS Glosten OSU

RCRV

Status Update✔

- Passed CDR/PDR/BSR/Acquisition Review
- FDR in October
- NSB recommended 2 vessels based on Decadal Survey. NSF has $106M in FY17 Pres Bud.

NSF Off Ramps/Stage Gates

✔ 1 Determination to Award Phase I
✔ 2A Approval of CDR
✔ 2B Approval of Post-CDR Funding (Dec 2013)
✔ 3 Funding for PDR Appropriated (Feb 2014)
✔ 4A Approval of PDR
✔ 4B Approval for inclusion in MREFC Budget
5A Approval of SY Selection
5B Approval of FDR
6A Determination of Adequate Funding
6B Approval of Post-FDR Funding
7 Determination of Adequate Out-Year Funding

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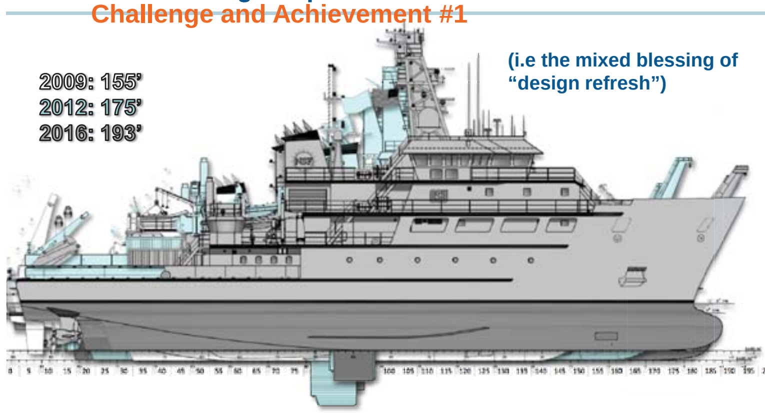
RCRV

Establishing Scope: RCRV Over Time

Challenge and Achievement #1

(i.e the mixed blessing of "design refresh")



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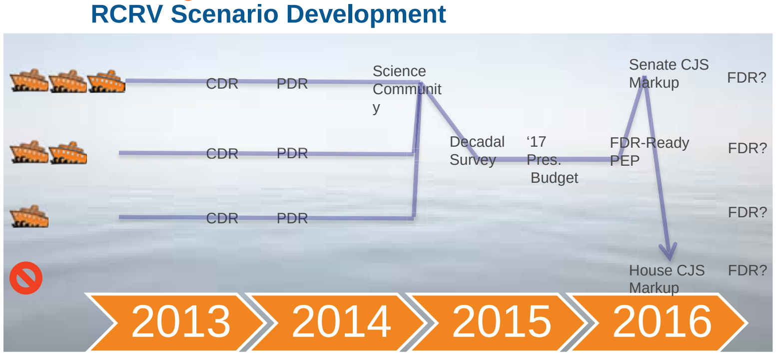
RCRV

Challenge and Achievement #2

RCRV Scenario Development



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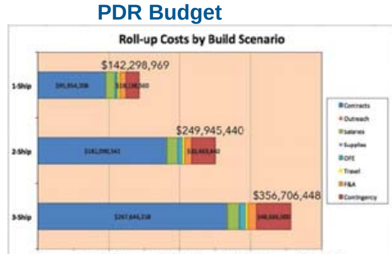
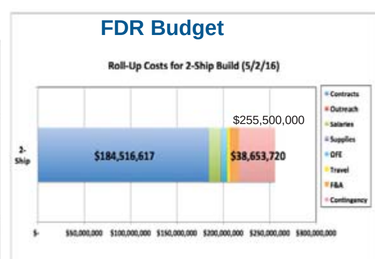
RCRV

Budget Progression

PDR Budget



FDR Budget



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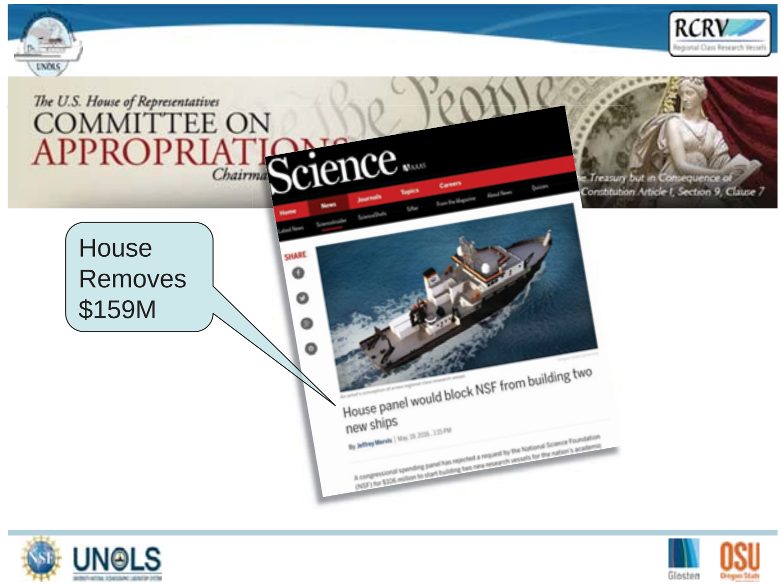
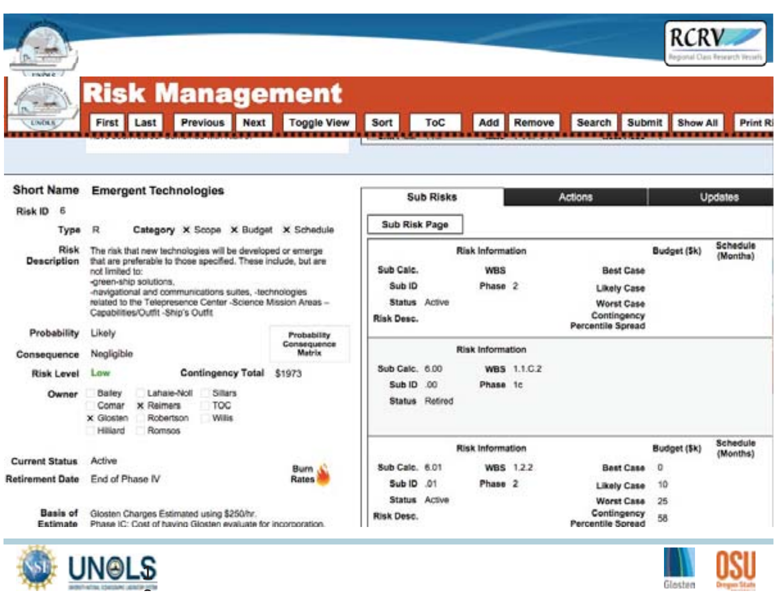
RCRV
United States Senate Committee on
APPROPRIATIONS
PROFESSIONAL MARINER
Oregon State seeks shipyard to build new research vessel
Science
RFI Released May 2nd
Senate Added $56M
U.S. Senate calls for building three, not two, new regional research vessels
UNOLS
Glosten
OSU


RCRV
The U.S. House of Representatives
COMMITTEE ON APPROPRIATIONS
Science
House Removes $159M
House panel would block NSF from building two new ships
UNOLS
Glosten
OSU


RCRV
Bridge Mock Up
UNOLS
Glosten
OSU


RCRV
Model Testing
• Cavitation-free to 11 kts
• No evidence of bubble sweep down under simulated survey conditions
UNOLS
Glosten
OSU


RCRV
Risk Management
First
Last
Previous
Next
Toggle View
Sort
ToC
Add
Remove
Search
Submit
Show All
Short Name Emergent Technologies
Risk ID 6
Type R
Category Scope Budget Schedule
Sub Risks
Actions
Updates
Sub Risk Page
Probability Likely
Consequence Negligible
Risk Level Low
Contingency Total $1973
Current Status Active
Retirement Date End of Phase IV
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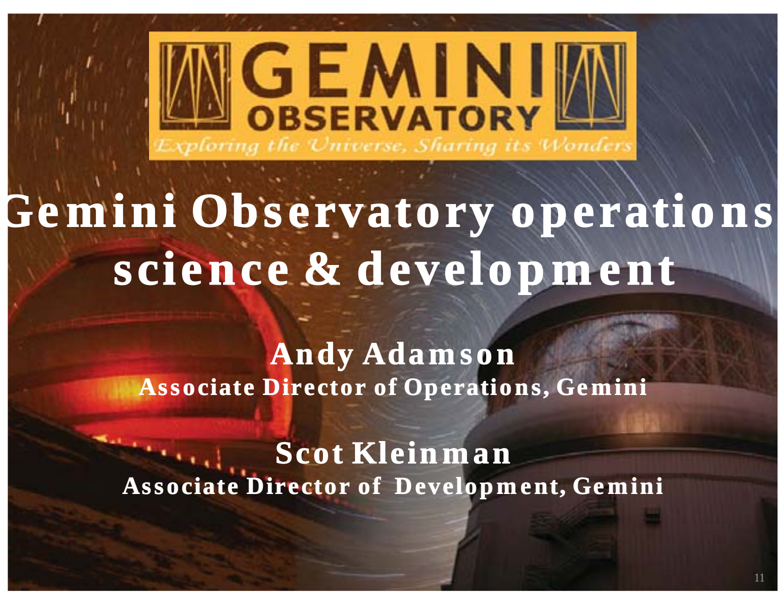
GEMINI OBSERVATORY
Exploring the Universe, Sharing its Wonders
Gemini Observatory operations science & development
Andy Adamson
Associate Director of Operations, Gemini
Scot Kleinman
Associate Director of Development, Gemini
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Gemini Observatory:
Operating twin 8m telescopes
on Mauna Kea and Cerro Pachon:
providing access to the entire sky

The International Partnership

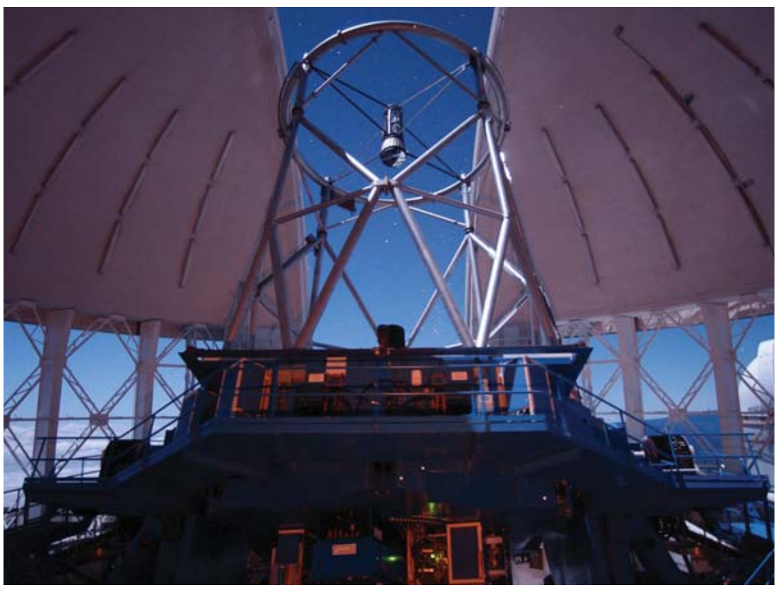
International Agreement *2016-2021* includes as partners:
USA, Canada, Brazil, Argentina, and Chile

Shares **2016-2021:**
(Budget **~27+x $M/year**)

US 70 %
CA 20 %
BR 7 %
AR 3%
AUS+KOR +x%

KASI (Korea) is a limited-term partner since *2015*, aspiring to become a full partner

Australia did not remain a full partner beyond *2015*, but is continuing in *2016* as limited-term partner



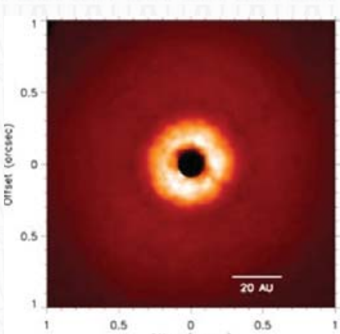
Proposing for time at Gemini

The regular proposal: *once per semester*, through the national Time Allocation Committees (TAC)
for regular proposals — 70%

Large & Long Programs: *once per year*, through the Large Program TAC
for large and/or long **ambitious** proposals — 20%

Fast turnaround programs: *once per month*, 'peer reviewed', no TAC
for short, rapid, immediate and/or follow-up proposals — 10%

Recent Science Highlights



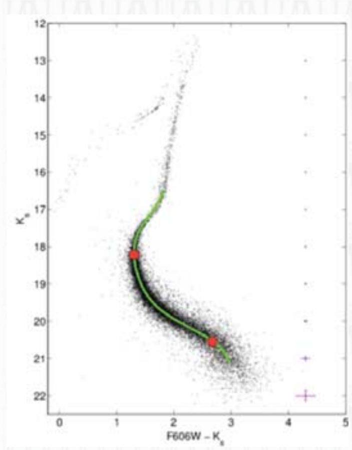
TW Hydrae
1.2 micron (near-infrared)
Polarized intensity image from GPI

Rapson et al. 2016
- GPI probes w/in 10AU of TW Hydrae
- Comparison with simulations suggests 0.2M Jupiter planet at 21A

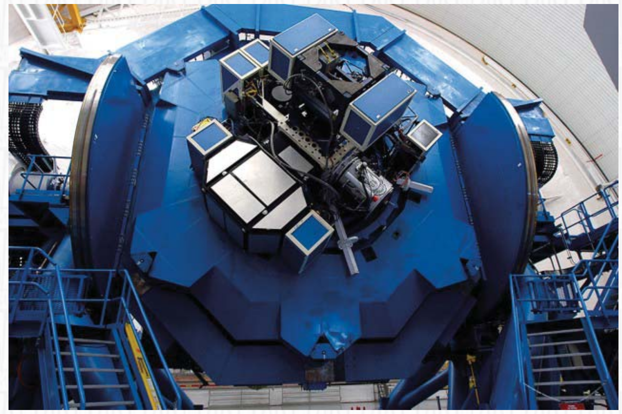
Recent Science Highlights

Turri et al. 2015
- Globular cluster NGC 1851
- Around 16,000 stars
- Depth and precision allow combination with HST
- Double subgiant branch
- Main sequence "knee" reddening- and distance-independent age

GeMS/GSAOI
Multiconjugate, laser-supported AO



Gemini Instruments



Engaging the Community

Bring your Projects
Apply for Long and Large, Fast Turnaround, or standard TAC; Upgrade a current instrument, or build part or all of a new one

Bring your Instrument
Contact us if you would like to bring a Visiting Instrument or propose for our new projects and initiatives

Bring yourself
Rediscover the advantages of classical observing and mitigate weather loss with Priority Visiting Observing

Bring your Student
Give your student the extra boost of motivation by taking her/him along and we'll chip in to pay for it!

Bring your Code
Share your reduction/analysis code or just expertise on our new User Forum. Win observing time.

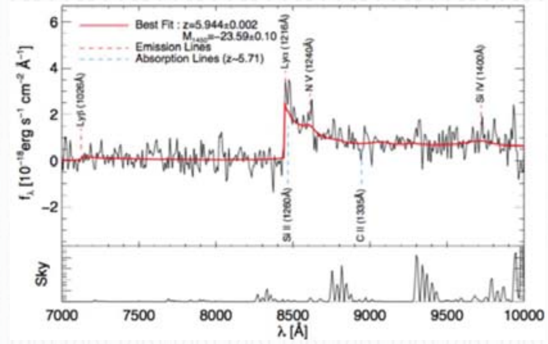
Contracting Issues

- Negotiations typically drag on longer than hoped
- Approval process through oversight and NSF takes a long time
- Sometimes difficult to take advantage of opportunities while adhering to procurement requirements
- Reserves, contingency, risk mitigation funds: a moving target in policy, but critical for projects
- Typical university teams still used to grad students and duct tape; hard to move to more rigorous project management and systems engineering approaches

… and one more thing

Very interested in how you do resource planning for both current and future operations and projects in your organizations.

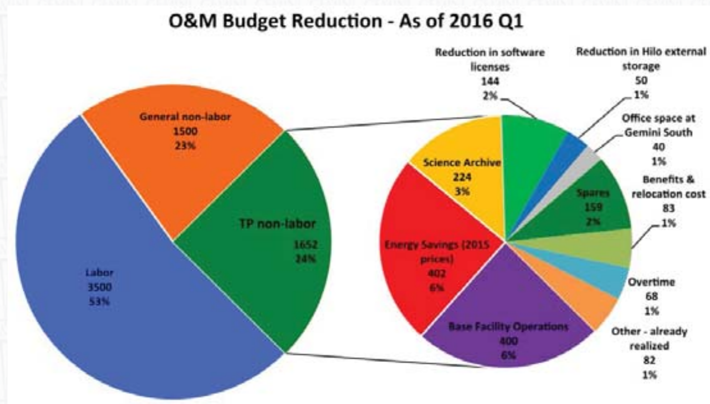
Recent Science Highlights



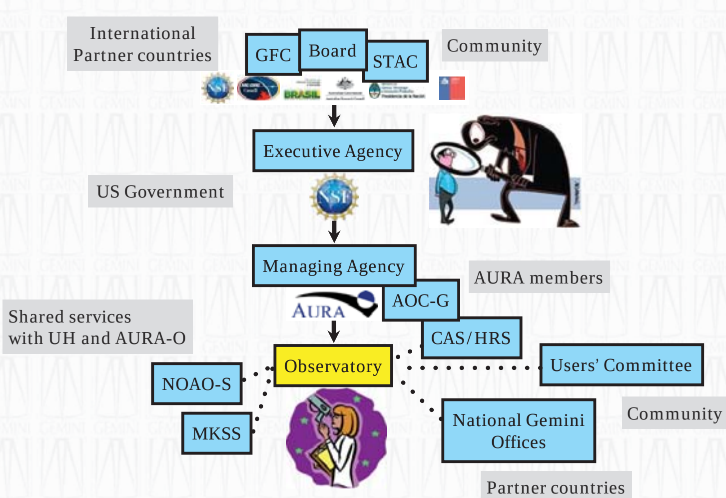
Kim et al. 2015 • first publication from Korean participation in Gemini partnership • GMOS-S spectroscopy confirm source as quasar, and redshift • sample from Infrared Medium-Deep Survey • not enough quasars for cosmic reionization, even considering candidates as well as confirmed quasars in the survey

Gemini North runs from Hilo since November

UK withdrawal: 25% budget reduction



The Governance



Lightning Talk

Integrated
Cost-Schedule
Risk Analysis

Mike Carrancho, P.E.
Smithsonian Institution
NSF Large Project Workshop 24 May 2016

Integrated Cost-Schedule Risk Analysis

Smithsonian

National Air & Space Museum

- *Very Large, complex, renovation project*
- *Complete HVAC replacement*
- *Complete stone envelope and primary weather barrier replacement*
- *Museum to remain open and operational during project*
- *"Like rebuilding a 747 while in flight" Ret. Gen J. Dailey*

Cost Risks & Impacts

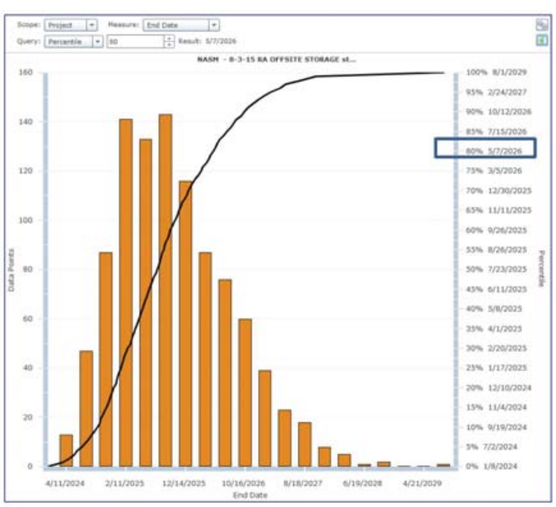
Top Cost Risk Drivers			
No.	**Risk Description**	**Cost Impact**	**Time Impact (days)**
1	Congressional approval of funding amount may be less than requested	$24,306,400	96
2	Uncertainty	$22,178,500	121
3	Client initiated/requested changes	$18,246,100	75
4	Impact of delayed funding for any particular sequence (construction)	$13,917,700	59
5	Stone Risk - Production (Fabrication and Inspection)	$8,495,210	96
6	Contractor's construction management team may not be competent to manage project of this complexity	$7,996,700	21
7	Major design defect or error	$4,963,780	6
8	Lack of laydown & staging areas requiring close in off site storage for construction for GC	$4,773,020	13
9	Lack of adequate SI "Supervision and Administration" budget	$4,407,350	0
10	Proposed schedule for de-mount/deinstallation of 3-5 months may be insufficient.	$4,202,490	27

Schedule Risks & Impacts

Top Schedule Risk Drivers			
No.	**Risk Description**	**Time Impact (days)**	**Cost Impact**
1	Uncertainty	121	$22,178,500
2	Congressional approval of funding amount may be less than requested	96	$24,306,400
3	Stone Risk - Production (Fabrication and Inspection)	96	$8,495,210
4	Client initiated/requested changes	75	$18,246,100
5	Planned 24 hour construction operations will have negative impact (morale, fatigue, union grievances, tying up supervisors time) - from collections movement perspective.	66	$2,553,200
6	Impact of delayed funding for any particular sequence (construction)	59	$13,917,700
7	Proposed schedule for re-mount/reinstallation of 10-12 months may be insufficient.	31	$740,064
8	Proposed schedule for de-mount/deinstallation of 3-5 months may be insufficient.	27	$4,202,490
9	Contractor's construction management team may not be competent to manage project of this complexity	21	$7,996,700
10	Protest from unsuccessful bidders	19	$984,379

Cost Probabilities

Schedule Probabilities



Questions

Mike Carrancho, PE

Smithsonian Institution
Deputy Director, Office of Planning, Design and Construction
CarranchoM@si.edu

CHESS Highlights

Joel D. Brock, Director
Cornell High Energy Synchrotron Source (CHESS)
joel.brock@cornell.edu

CHESS is supported by the NSF and the NIH/NIGMS under NSF award DMR-1332208

CHESS at a Glance

- NSF stewarded, national user facility providing synchrotron x-ray facilities to an international, multidisciplinary user community.
- Located on central campus of Cornell University, Ithaca, New York
- Our X-ray facilities are optimized for high-flux, high-energy applications in: Materials Research, Life Science, Engineering, Biology, Physical Sciences, and Cultural Heritage.
- Over 1,300 user visits, 800 unique visitors each year
- 11 experimental stations
- > 3600 hours per year of x-ray operations.
- >$20M/year in funding
- ~75 FTEs, ~150 people on payroll
- 60 undergraduates per year participate in laboratory research.
- X-ray Beam time awarded via competitive proposal process
  – Proposals rated by (domain science) experts
  – ~ 60% success rate
  – ~1 publication / day of operations

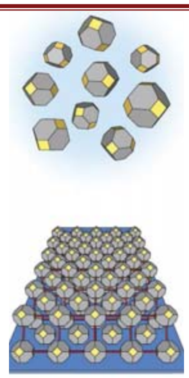
Nanocrystal self-assembly sheds its secrets: a new approach gives a real-time look
Tisdale (MIT) DMR-1332208

The transformation of simple colloidal particles — bits of matter suspended in solution — into tightly packed, beautiful lace-like meshes, or superlattices, has puzzled researchers for decades. Pretty pictures in themselves, these tiny superlattices, also called quantum dots, are being used to create more vivid display screens as well as arrays of optical sensory devices. The ultimate potential of quantum dots to make any surface into a smart screen or energy source hinges, in part, on understanding how they form.

Through a combination of techniques including controlled solvent evaporation and synchrotron X-ray scattering, the real time self-assembly of nanocrystal structures has now become observable *in-situ*. The findings were reported in the journal Nature Materials in a paper by Assistant Professor William A. Tisdale and grad student Mark C. Weidman, both at MIT's Department of Chemical Engineering, and Detlef-M. Smilgies at the Cornell High Energy Synchrotron Source (CHESS) [1].

To make the nanoscale movies (see third page), the group took advantage of a CHESS-developed experimental chamber and a recently developed dual detector setup with two fast area detectors, while environmental conditions were changed during the formation of superlattices. Using lead sulfide nanocrystals, they were able to conduct simultaneous small-angle X-ray scattering (capturing the structure of the superlattice) and wide-angle X-ray scattering (capturing atomic scale orientation and alignment of single particles) observations during the evaporation of a solvent.

"We believe this was the first experiment that has allowed us to watch in real time and in a native environment how self-assembly occurs," Tisdale says. "These experiments would not have been possible without the experimental capabilities developed by Detlef and the CHESS team." [2]



(top) Illustration of randomly oriented nanocrystals in solution.

(bottom) Illustration of two layers of the atomically aligned bcc nanocrystal superlattice on the substrate, where the bcc (110)SL plane is parallel to the substrate

[1] Mark C. Weidman, Detlef- M. Smilgies, and William A. Tisdale, "Kinetics of the self-assembly of nanocrystal superlattices measured by real-time in situ X-ray scattering," Nat Mater advance online publication (2016).

[2] Text quoting an MIT report by Michael Patrick Rutter; https://mitei.mit.edu/news/nanocrystal-self-assembly-sheds-its-secrets

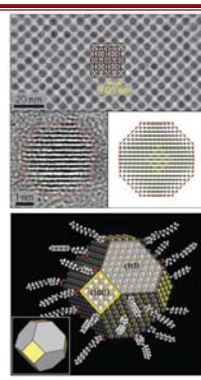
Nanocrystal self-assembly sheds its secrets: a new approach gives a real-time look
Tisdale (MIT) DMR-1332208

Science - What was found? What is new?
- Demonstrated the first experiment to view in real time and in a native environment how self-assembly occurs
- Developed a new method to observe self-assembly of nanocrystals using controlled solvent evaporation and synchrotron X-ray scattering
- The discovery will lead to refined models for self-assembly of a wide range of organic soft materials.

Impact - Why is it important?
- The broader adoption of nanocrystals into energy conversion technologies has been limited by the lack of knowledge about how they self-assemble
- These tiny superlattices, also called quantum dots, are being used to create more vivid display screens as well as arrays of optical sensory devices.
- The ultimate potential of quantum dots to make any surface into a smart screen or energy source hinges, in part, on understanding how they form
- This new findings will enable direct manipulation of resulting superlattices, with the possibility of on-demand fabrication and the potential to control the formation of related soft materials such as proteins and polymers and materials needed for new technologies

Why did this research need CHESS?
- CHESS-developed experimental chamber and a recently developed dual detector setup with two fast area detectors was needed to control environmental conditions during the formation of superlattices.
- The CHESS D1 experimental station has high-flux, wide energy-bandpass x-ray optics and can support multiple simultaneous fast 2D detectors and a fast data-acquisition compute farm to capture time-resolved kinetics of the in-plane and out-of-plane molecular ordering

Work supported by an Energy Frontier Research Center (DOE-BES), made use of MRSEC Shared Experimental Facilities at MIT (NSF DMR-08-19762), a NSF Graduate Research Fellowship (1122374), and CHESS (DMR-1332208).



(top) TEM image of a bcc superlattice of the nanocrystals with a superimposed [100]SL view of four unit cells with a lattice constant of 9.05 nm. Inset (left) shows a high-resolution TEM image of a single nanocrystal in which the atomic planes are visible and the corresponding nanocrystal model (right) that leads to this pattern.

(bottom) Atomic model of the nanocrystals used in this study highlighting a hexagonal (111)NC face and a square (100)NC face. The ligand coverage density has been decreased for the image to better show the nanocrystal core.

[1] Mark C. Weidman, Detlef- M. Smilgies, and William A. Tisdale, "Kinetics of the self-assembly of nanocrystal superlattices measured by real-time in situ X-ray scattering," Nat Mater advance online publication (2016).

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Nanocrystal self-assembly sheds its secrets: a new approach gives a real-time look
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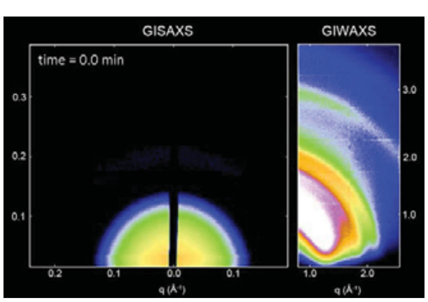


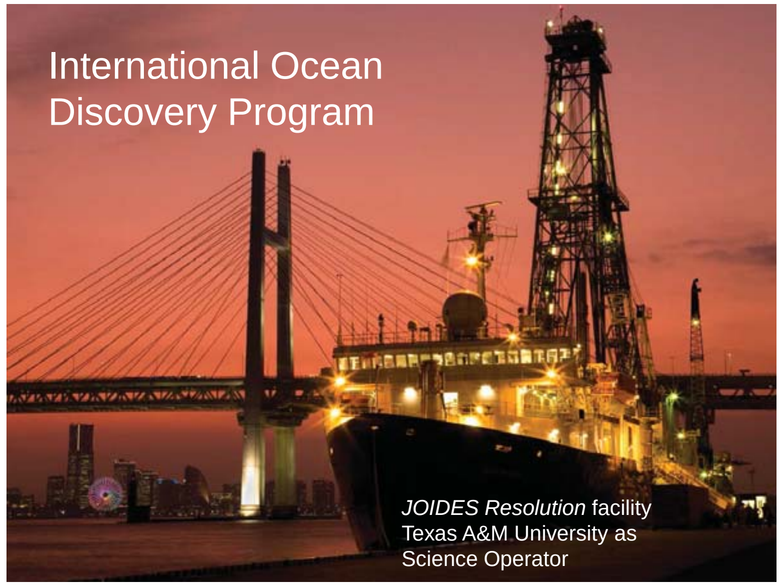
Time-resolved X-ray scattering reveals the transition from a disordered colloid to a highly ordered superlattice. a–h, Temporal evolution of GISAXS (square panels) and GIWAXS (vertical panels) patterns during the in situ measurement of nanocrystal self-assembly. The GISAXS patterns show the transition from a colloidal suspension to an fcc superlattice to a bcc superlattice via contraction of the c axis. The white circles on the left halves of the GISAXS patterns are the predicted scattering locations for the superlattice parameters indicated above each image. The GIWAXS patterns show the early onset of orientational alignment as well as the shape transformation of the 200NC scattering peak.

The Future: optimizing for high-flux, high-energy x-rays CHESS-U

Funding (awaiting public announcement by Governor Cuomo)
- **New York State's Upstate Revitalization Initiative (URI)**
- **$15M over 3 years (completion 12/31/2018)**
- **Goal is regional economic development (job creation and retention in Southern Tier) – public/private partnerships**

Capital Project – optimize for high-flux, high-energy x-rays
- **Single particle beam operation**
- **Increase storage ring energy from 5.3 → 6.0 GeV**
- **Increase storage ring current from 100 → 200 mA**
- **Decrease storage ring emittance**
- **Increase number of undulator sources from 2 to 10**
- **(re)build/upgrade 6 x-ray beamlines and experimental stations**

end



Scientific Ocean Drilling

Largest and longest running international research program dedicated to exploring Earth's history and structure

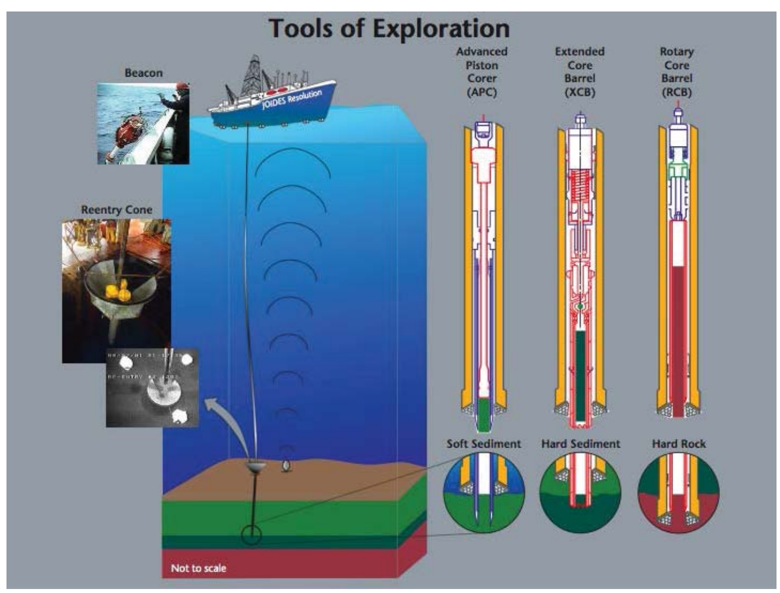
- Project Mohole: 1958-1966
- Deep Sea Drilling Project (DSDP): 1968-1983
- Ocean Drilling Program (ODP): 1985-2003
- Integrated Ocean Drilling Program (IODP): 2003-2013
- International Ocean Discovery Program (IODP): 2013-2023

IODP Member Countries

Australia	Germany	Norway
Austria	Iceland	Portugal
Belgium	India	South Korea
Canada	Ireland	Spain
China	Italy	Sweden
Denmark	Japan	Switzerland
France	Netherlands	United Kingdom
Finland	New Zealand	United States

The International Ocean Discovery Program: Multiple Platforms

JOIDES Resolution — *Chikyu* — **Mission Specific Platforms**

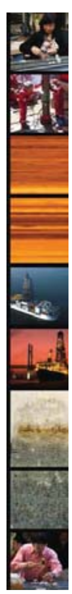


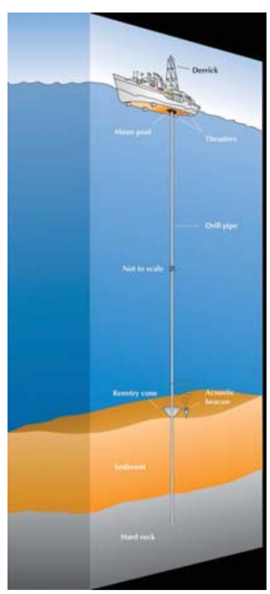
The *JOIDES Resolution* is a $1300 m^2$ floating laboratory…

…and a floating university

Major Accomplishments of Scientific Ocean Drilling

- Confirmation of the Seafloor Spreading Hypothesis
- Discovered that the Mediterranean Sea completely dried repeatedly ~5 million years ago
- Recovered direct evidence that a bolide impact caused the mass extinction that killed off the dinosaurs
- Recovered an intact section of the upper oceanic crust
- Recovered first samples of gas hydrates from continental margins
- Discovered that deep ocean waters flow vigorously through the crust (world's largest aquifer)
- Discovered that the deep seafloor hosts abundant microbial life.



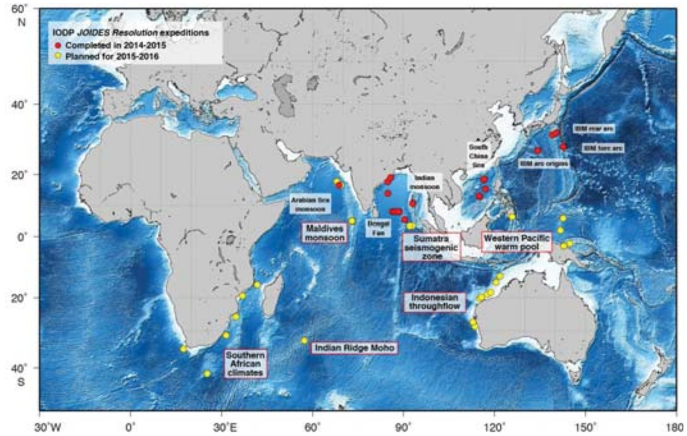


JR Facts

- **Owned:** Overseas Drilling Limited, Inc.
- Built 1978 as exploration vessel *Sedco/BP* 471
- Converted to science research in 1985
- Rebuilt 2009; facility is reliable- breakdown contract rate 0-2% 2009 -2016

- **Length:** 143 m (471 ft)
- **Drill pipe:** 5" and 5.5" tapered string
- **Drill string capacity:** >9 km (~30,000 ft)
- **Deepest hole penetration:** 2111 m (6924 ft)
- **Shallowest water:** 35.5 m (123 ft)
- **Deepest water:** 5980 m (19,614 ft)
- **Most core on single cruise:** 8003 m (26,250 ft)
- **Total core recovered:** >230 km (>146 miles)

JOIDES Resolution Recent and Upcoming Expeditions



Richard Farnsworth PhD PMP
Senior Program Manager

Battelle/NEON

March 3, 2016

National Ecological Observatory Network

- Battelle was recently selected by the National Science Foundation (NSF) to assume management of the construction and initial operations of the NEON observatory
- Battelle began transition in Mid-March
  - Transitioning key staff to Battelle Ecology Inc.
  - Ensuring smooth transition of permitting, contracts, etc.
  - Continuing construction and Operations
  - Expect to complete transition of Observatory by June 2016

NEON is a continental-scale observation system for examining ecological change over time.

Battelle Mission and Purpose

Our mission: To translate scientific discovery and technology advances into societal benefits

Gordon Battelle, Founder

- Nonprofit, charitable trust formed in 1925
- Profits reinvested in science & technology and in charitable causes, making the world better for generations to come

Project Sikuliaq

NSF Builds a Ship With Capabilities Like No Other!

Schedule Change Highlights

- Following Final Design Review there were five major areas that could potentially cause Project schedule changes
  - Funding to continue the project – Accelerated from FDR because the Project was "shovel ready" when American Recovery and Reinvestment Act of 2009 funding became available, no impact on Project schedule.
  - Shipyard Contract Award – Accelerated from FDR because of availability of ARRA funding, no impact on Project schedule.
  - Delivery of Owner Furnished Z-Drives to the Shipyard – Accelerated from FDR because of shortened lead time for gear sets, no impact on Project schedule.
  - Shipyard Execution and Ship Delivery Date
  - Post-delivery trials

Shipyard Execution and Ship Delivery Date

- Original contract delivery date – 22 January 2013
- Actual delivery date – 06 June 2014
- Two shipyard contract modifications that contractually extended delivery a total of 197 days:
  - Mod 34 added 185 days due to lengthening of the ship – 26 July 2013
  - Mod 50 added 12 days due to OFE Z-drive issue – 07 August 2013
- Shipyard was 303 days late with delivery of the ship:
  - Significantly protracted shipyard tests and trials
  - Shipyard paid $2,250,000 in liquidated damages (maximum allowed by the contract) for late delivery

Change Orders

- Decided to:
- Increase length to 6 feet to increase reserve buoyancy
- Change from Steel to Aluminum structure above 02 deck
- Eliminate elevator service above 01 deck
- Other weight savings: light-weight joinery, steel reductions
- VCG is below the line, including full icing and science loads

Post-Delivery Trials

- Late delivery and two funded science cruises in late 2014 reduced time for warm water trials and pushed piston coring trials off until 2016.
- Plan for post-delivery shipyard availability was reduced in scope necessitating a second post-delivery shipyard availability in late 2015:
  - Timeline for original post-delivery shipyard period was too early
  - Funded science cruises in the Arctic in summer/fall 2015 didn't allow for extending the post-delivery shipyard period
- Complexity of the ship required more time for fully testing the systems than originally planned.
- Replacement A-frame schedule and timeline for discovery of post-delivery issues from trials necessitated second post-delivery shipyard period.

The Greening of R/V Sikuliaq

- Bottom Coating
- Waste Incinerator
- Integrated Power Plant
- Waste Heat Recovery System
- Biodegradable Lubricants
- Double Bottom Hull
- State of the Art MSD
- Ballast Water Management System
- Specialized Hull Configuration and Propulsion

The Greening of R/V Sikuliaq

Shrinking a Ship's Environmental Footprint

THE END

UNIVERSITY OF ALASKA FAIRBANKS

America's Arctic University

The National Science Foundation

2016 NSF Large Facilities Workshop

Making Sense of Audits and Reviews

Business Roundtable I

May 24, 2016

Anna-Lee Misiano, (amisiano@nsf.gov) *Division of Acquisition and Cooperative Support*

Florence Rabanal (frabanal@nsf.gov), *Large Facilities Office*

Eddie Whitehurst, (ewhitehu@nsf.gov) *Division of Acquisition and Cooperative Support*

Charlie Zeigler, (czeigler@nsf.gov) *Division of Institute and Award Support*

Presentation Goal, Objectives and Agenda

GOAL: TO IMPROVE OUTCOME of REVIEWS/AUDITS

OBJECTIVES:

- Outline various types of Audits/Reviews
- Explain the overall purpose of each [Audit/Review]
- Identify the Business Owners associated with [Audit/Review]
- Highlight key interactions amongst Business Owners
- Engage stakeholders to gather input and ideas

PRESENTATION SCOPE and Content

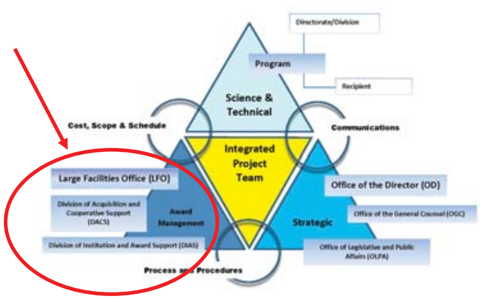
- Defines Audits/Reviews broadly as "a careful/methodical check or review of something";
- Recognizes the necessity of [audits/reviews] and fiduciary responsibilities inherent to the stewardship of Federal funds.
- Covers administrative business of audits/reviews of NSF Large Facility Portfolio, and NOT audits/reviews associated with project management (e.g., EVM, contingency) or scientific/technical components
- Presents an overview of "what, why and who", NOT the details of "how"
- Complements related (more detailed) held in Business Roundtable II and III discussions.

Engaging Stakeholders

- How could NSF's communication and documentation strategies be adjusted to improve [external stakeholder] understanding of the variety of audits/reviews?
  - Importance
  - NSF Resources for Questions and Guidance
  - NSF Coordination
- What are major challenges to employing suggested strategies for audit/review interactions?
- What steps could NSF take to further facilitate Recipient-implementation of the suggested improvement strategies for audits/review?

KEY [NSF] ASSURANCE MEMBERS/ AWARD MANAGEMENT:

Division of Acquisition and Contract Support, the Division of Institution and Award Support, and the Large Facilities Office



AUDITS/REVIEWS: OVERVIEW BY TYPE

AUDIT/REVIEW TYPE	SIMPLIED DESCRIPTION	BUSINESS OWNER
	STATUTORY	
Single Audit (A-133)	*ANNUALLY*, to provide assurance to the US federal government as to the management and use of such funds by recipients such as states, cities, universities, and non-profit organizations	Independent certified public accountant (CPA)
OIG-led/contracted	*RISK-BASED,* to promote efficiency and effectiveness, through assessment of internal controls, financial management, information technology, and other systems that affect the operation of Agency programs. To investigate fraud, misuse of funds, and other violations of laws and regulations.	NSF Office of Inspector (OIG)
Improper Payments	*ANNUALLY*, to identify for reducing improper payments	NSF Division of Financial Management (DFM)
	POST-AWARD MONITORING	
ADVANCED: focus on developing a reasonable assurance that institutions managing the higher-risk awards possess adequate policies, processes, and systems to properly manage federal awards		
Business Systems Review	*RISK-BASED,* to provide oversight/assurance of the suite of business systems (people, processes, and technologies) that supports the administrative management of a Facility (http://www.nsf.gov/pubs/2013/nsf13100/nsf13100.pdf)	NSF Large Facilities Office (LFO)

AUDITS/REVIEWS: OVERVIEW BY TYPE

AUDIT/REVIEW TYPE	SIMPLIED DESCRIPTION	BUSINESS OWNER
POST AWARD MONITORING, Cont.		
ADVANCED: focus on developing a reasonable assurance that institutions managing the higher-risk awards possess adequate policies, processes, and systems to properly manage federal awards		
Advanced Monitoring Desk Review & Site Visit	*RISK-BASED*, to assess the extent that an awardee maintains a control environment within which awards are likely to be administered in compliance with Federal financial and administrative regulations and NSF agreement provisions (http://www.nsf.gov/bfa/dias/caar/docs/factsheet_desk.pdf)	NSF Division of Institution and Award Support (DIAS)
BASELINE: focus on post-award actions and financial transactions for most awards and verify that awardee institutions implement awards in compliance with federal regulations and the terms and conditions of NSF award agreements		
Award Expenditure Transaction Testing	*RISK-BASED*, reveal potential financial anomalies, inaccurate expenditure reporting, or evidence of a possible misunderstanding of, or non-compliance with, federal cash management requirements and/or NSF guidelines.	NSF Division of Financial Management (DFM)
Grants and Agreements Monitoring	ONGOING, reveal a misunderstanding of, or non-compliance with, federal regulations and the terms and conditions of NSF awards	NSF Division of Grants and Agreements (DGA)
Active Payment/ACM$ Screening	ONGOING, focused on daily, monthly, quarterly, and annual transactional activity.	NSF Division of Financial Management (DFM)
Program Income	ONGOING, to verify that awardee institutions are properly reporting program income in accordance with NSF's policies.	NSF Division of Financial Management (DFM)

AUDITS/REVIEWS: OVERVIEW BY TYPE

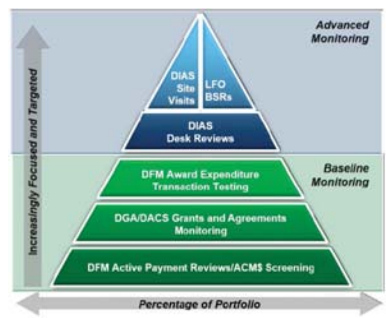
AUDIT/REVIEW TYPE	SIMPLIED DESCRIPTION	BUSINESS OWNER
MREFC LIFE-CYCLE BASED		
PRECONSTRUCTION STAGES: to assess whether [costs] they are reasonable and realistic as the design matures in preparation for the eventual construction award and subsequent operations awards		
High-Level Cost Analysis #1	Post CDR…to only frame the initial parametric cost estimate, ensure coordination with the other NSF assurance divisions and offices, and identify areas of further refinements with the cost book and PEP that are necessary during the Preliminary Design Phase… "	Division of Acquisition and Cooperative Support (DACS)
Cost Analysis #2	POST PDR, "…to give confidence in the Not-To-Exceed estimated Total Project Cost (TPC)… also identify areas of further refinement with the cost book and PEP that are necessary during the Final Design Phase."	Division of Acquisition and Cooperative Support (DACS)
Cost Analysis #3	~90-180 DAYS PRIOR to PLANNED AWARD DATE, "…to give confidence in making the actual award for construction based on the best-available cost information, including updated cost proposal information received during the Final Design Phase."	Division of Acquisition and Cooperative Support (DACS)
Independent Cost Estimate Review/s	AD HOC, To assess, through independent mechanisms, the credibility of the [Large Facility's] cost estimate.	Large Facility Office (LFO)
Accounting System	PRIOR TO MAKING CONST AWARD, "…to assess and determine if awardee and subawardee accounting systems are adequate for use with cost reimbursement type agreements ."	Division of Acquisition and Cooperative Support (DACS)

AUDITS/REVIEWS: OVERVIEW BY TYPE

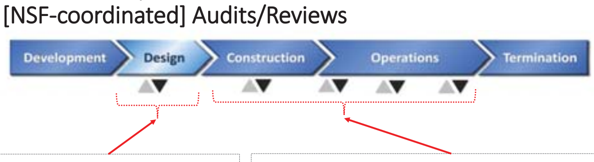
AUDIT/REVIEW TYPE	SIMPLIED DESCRIPTION	BUSINESS OWNER
MREFC LIFE-CYCLE BASED, Cont.		
CONSTRUCTION AND OPERATION STAGES: to assess whether [costs] they are reasonable and realistic as the design matures in preparation for the construction award and subsequent operations awards		
Business Systems Review	*RISK-BASED*, to provide oversight/assurance of the suite of business systems (people, processes, and technologies) that supports the administrative management of a Facility (http://www.nsf.gov/pubs/2013/nsf13100/nsf13100.pdf)	NSF Large Facilities Office (LFO)
Accounting System, Other Business Systems	PRIOR TO MAKING CONST/OPS AWARD, "…to assess and determine if awardee and subawardee accounting systems are adequate for use with cost reimbursement type agreements ."	Division of Acquisition and Cooperative Support (DACS)
Cost Incurred Audit	AT LEAST ANNUALLY, AWARD [>$100M], "to assure the existence of adequate controls which will prevent or avoid waste, fraud, and abuse and inefficient practices."	Division of Acquisition and Cooperative Support (DACS)
Budget Review	ALL AWARD ACTIONS> $10M, over all award years funded at that time. Ensure budgeted costs are reasonable and realistic to accomplish project scope.	Division of Institution and Award Support (DIAS)
Indirect Cost Rate Negotiation	GENERALLY ANNUALLY, with provisional to final indirect cost rates. Where NSF acts as cognizant Federal agency, review of indirect cost pool expenses may include transaction testing.	Division of Institution and Award Support (DIAS)

NSF Post Award Monitoring

- Baseline monitoring, executed in the course of post-award administration, seeks to verify that awardee institutions implement awards in compliance with federal regulations and the terms and conditions of NSF award agreements.
- NSF's advanced monitoring activities focus on developing a reasonable assurance that institutions managing the higher-risk awards possess adequate policies, processes, and systems to properly manage federal awards.



MREFC Life-Cycle Based View: [NSF-coordinated] Audits/Reviews



- **COST ANALYSES, immediately following** Conceptual Design Review, Preliminary Design Review and Final Design Reviews.
- **REVIEW OF INDEPENDENT COST ESTIMATE** , prior to completion of second cost analysis. Other internal NSF cost analyses may be used.
- **BUSINESS SYSTEMS REVIEW,** ideally conducted during CDR phase and prior to PDR, if employed

- **BUSINESS SYSTEMS REVIEW,** ideally prior to transition to Operations, in addition to periodically Operations Phase, if employed
- **ACCOUNTING SYSTEM and OTHER BUSINESS SYSTEMS,** prior to entering any large facility Construction or Operations [>$100M] Cooperative Agreements
- **COST INCURRED AUDIT,** at least annually for award [>$100M], "to assure the existence of adequate controls which will prevent or avoid waste, fraud, and abuse and inefficient practices."
- **BUDGET REVIEW,** ALL AWARD ACTIONS> $10M, over all award years funded at that time. Ensure budgeted costs are reasonable and realistic to accomplish project scope.
- **INDIRECT COST RATE NEGOTIATION,** GENERALLY ANNUALLY, with provisional to final indirect cost rates. Where NSF acts as cognizant Federal agency, review of indirect cost pool expenses may include transaction testing.

Strategies for Improving Audit and Review Interactions and Outcomes

- ROLES AND RESPONSIBLITIES
  - Identify single point of contact/dedicated person, in appropriate organizational role
  - Coordinate, coordinate, coordinate Organization-wide
  - Maintain routine and open communication with your auditors/reviewers
- PLANNING
  - Plan ahead, don't wing it
  - Create deliberate internal and external communication strategies, include routine interactions
  - Provide staff training
- DOCUMENTATION
  - Organize well packaged and externally-oriented materials
  - Avoid the extremes, "too much, too little"
  - Provide easy and timely access
  - Assure underlying systems are robust

Engaging Stakeholders

- How could NSF's communication and documentation strategies be adjusted to improve [external stakeholder] understanding of the variety of audits/reviews?
    - Importance
    - NSF Resources for Questions and Guidance
    - NSF Coordination
- What are major challenges to employing suggested strategies for audit/review interactions?
- What steps could NSF take to further facilitate Recipient-implementation of the suggested improvement strategies for audits/review?

GAO

GAO's Cost and Schedule Assessment Guides

U.S. Government Accountability Office

Applied Research and Methods

Cost Engineering Sciences

Jason T Lee, Assistant Director

May 2016

GAO

Agenda

- The role of GAO
- GAO Cost Guide and the characteristics of a reliable cost estimate
- GAO Schedule Guide and the characteristics of a reliable schedule
- How is the government performing?
- Proposed updates to the Cost Guide
- Reliability assessment example for a large-scale infrastructure project

GAO

The Role of GAO in Government

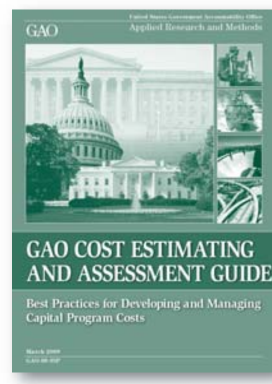
Known as the investigative arm of Congress, GAO exists to support Congress in meeting its constitutional responsibilities. To that end, GAO works to

- Help improve the performance of federal government
- Ensure government agencies and programs are accountable to the American people
- Examine the use of public funds, and
- Evaluate federal programs by providing analyses and recommendations to help Congress make informed oversight and funding decisions

GAO

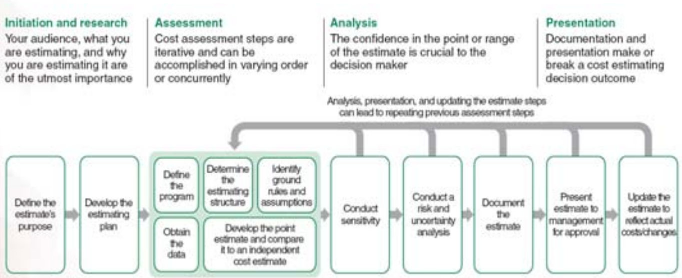
Cost Estimating and Assessment Guide

- Drafted 2005-2007, published in 2009
- Outlines GAO's criteria for assessing cost estimates during audits
- Contains 20 chapters with supporting appendixes
- Chapters 1-17: developing credible cost estimates and the 12-step cost estimating process for developing high quality cost estimates
- Chapters 18-20 address managing program costs once a contract has been awarded and discuss Earned Value and risk management
- Also provides case studies of prior GAO audits to show typical findings related to the cost estimating process



GAO

A Reliable Process for Developing Credible Cost Estimates



Source: GAO.

GAO

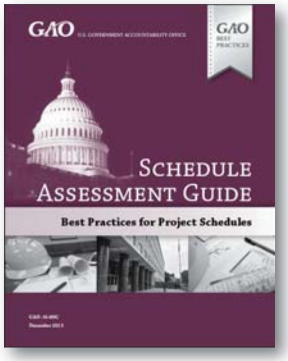
Characteristics of Reliable Cost Estimates

Are all costs included?	Is the estimate unbiased?	What is the uncertainty?	Can the estimate be recreated?
Comprehensive	**Accurate**	**Credible**	**Well Documented**
• Develop the estimating plan • Determine the estimating approach	• Develop the point estimate • Compare the point estimate to an independent estimate • Update the estimate with actual costs	• Create an independent cost estimate • Conduct sensitivity analysis • Conduct risk and uncertainty analysis	• Define the program • Identify ground rules and assumptions • Obtain data • Document the estimate • Present estimate to management

GAO

Schedule Assessment Guide

- Drafted 2010-2015, exposure draft published May 2012
- Final publication December 2015
- Outlines GAO's criteria for assessing master schedules
- Contains chapters for each of the 10 best practices plus supporting appendixes
- Also provides case studies of prior GAO audits to show typical findings related to the scheduling process



GAO

Four Characteristics of a Reliable Schedule

Is all effort included?	Is the network logical?	What is the uncertainty?	Is progress measured?
Comprehensive	**Well Constructed**	**Credible**	**Controlled**
• Capture all activities • Assign resources to all activities • Establish durations for all activities	• Sequence all activities • Confirm the critical path • Confirm reasonable float (slack)	• Confirm vertical and horizontal traceability • Conduct a schedule risk analysis	• Update the schedule with progress • Maintain a schedule baseline

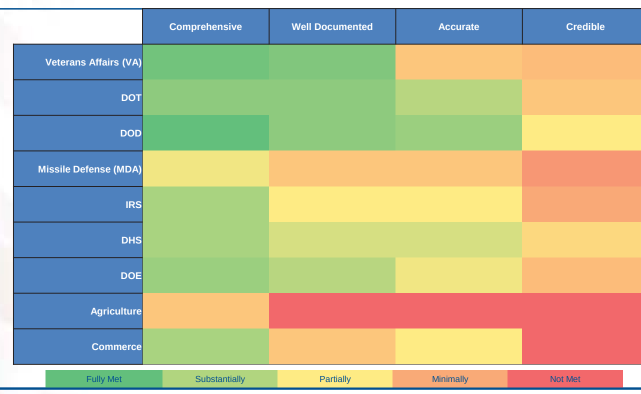
GAO

How Is the Government Performing?

The extent to which agencies are adhering to cost and schedule best practices

GAO

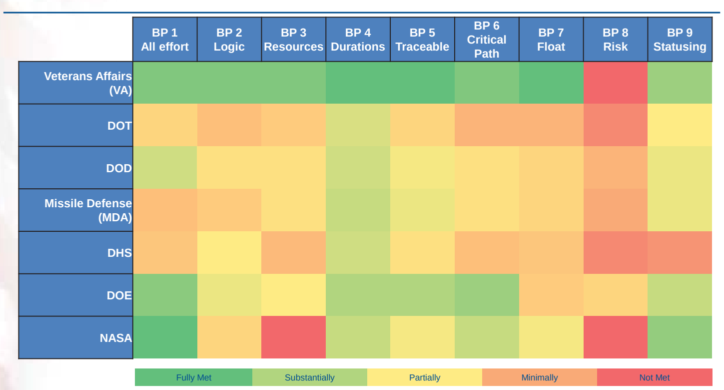
How is the government performing in developing cost estimates?



Data based on agencies and departments with three or more GAO cost estimate assessments

GAO

How is the government performing in developing and maintaining schedules?



Results reflect agencies and departments with three or more GAO schedule assessments

GAO

Some Proposed Cost Guide Updates

- Integration with and references to the
  - GAO Schedule Assessment Guide (GAO-16-89G)
  - GAO Standards for Internal Control (GAO-14-704G)
  - GAO Technology Readiness Assessment Guide (expected summer 2016)
  - GAO Federal Agile Software Guide (issue date TBD)
- Improved definitions and descriptions of several best practices and their mappings to the 12 steps and 4 characteristics
- Applicability of best practices to all types of capital programs
- Appendixes: risk breakdown structures, spreading contingency dollars through the WBS; updated laws and guidance

Invitation to Participate in Further Updates and Discussion about Best Practices

GAO invites interested parties to meet with us and other experts to discuss further updates to the cost and schedule guides so that the guides continually reflect best practices.

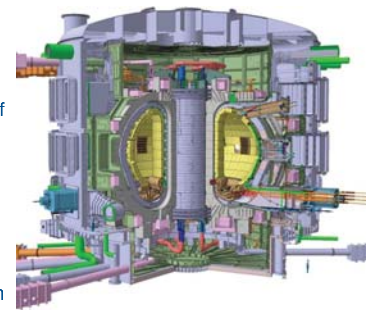
If interested, please e-mail your contact information to:

Jason T Lee – leejt1@gao.gov

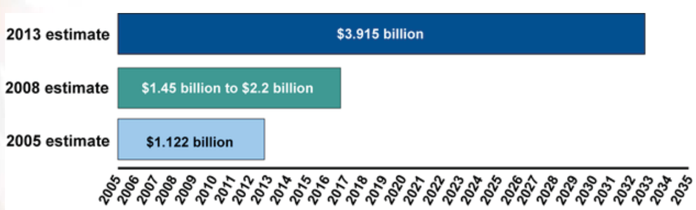
Karen Richey - richeyk@gao.gov

International Thermonuclear Experimental Reactor (ITER) Project: Background

- ITER is an international research facility being built in France to demonstrate the feasibility of fusion energy.
- Other countries involved in ITER include Russian Federation, Japan, European Union, People's Republic of China, Republic of Korea, and India.
- The United States has committed to providing about 9 percent of ITER's construction costs through contributions of hardware, personnel, and cash, and DOE is responsible for managing those contributions, as well as the overall U.S. fusion program.
- GAO reviewed costs and schedules in 2014 (GAO-14-499)



ITER: Cost estimates of U.S. Contribution



Source: GAO analysis of DOE data. | GAO-14-499

ITER: Key Findings

- ***Cost:*** Estimate of U.S. contribution has grown by almost $3 billion
- ***Schedule:*** Estimated completion date has slipped by 20 years
- ***Causes:*** 1) refined design and requirements of U.S. hardware; 2) changes to the international schedule; 3) changes to ITER design; 4) U.S. funding constraints and associated inflation; 5) increased ITER construction costs
- Assessment:
  - U.S. schedule estimates substantially meet best practices
  - U.S. cost estimates substantially meet best practices, but only partially meet Credible because they did not develop a sensitivity analysis or independent cost estimate
  - DOE has been unable to set a cost and schedule baseline in part because the international schedule has not been set

ITER: Recommendations

- Revise U.S. ITER Project Office to develop a sensitivity analysis for the cost estimate and compare to an independent cost estimate
- Develop proposal describing what actions are necessary to create a reliable international schedule and improve ITER Organization program management
- Once ITER Organization creates a reliable master schedule, use that schedule to update the U.S. schedule
- Develop strategic plan to address DOE's fusion program priorities

Conclusion

- The GAO Cost Guide and Schedule Guides provide criteria to evaluate many types projects
- The GAO Cost Guide and Schedule Guides can serve as the basis for agency project control guidance
- GAO recommendations have been aimed at improving oversight to keep projects on cost and schedule.

GAO

Thank you- Any Questions?

Guides Available Online:

- GAO Cost Estimating and Assessment Guide: http://www.gao.gov/products/GAO-09-3SP
- GAO Schedule Assessment Guide: http://www.gao.gov/products/GAO-16-89G

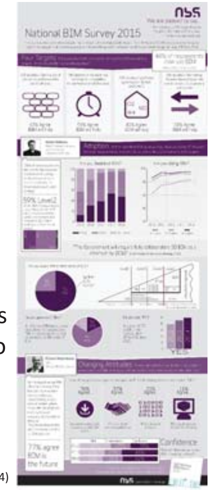
Mike Carrancho, P.E.
Smithsonian Institution
NSF Large Project Workshop 24 May 2016

Smithsonian

BIM for the ASSET Lifespan

Consider This:

- 92% believe it will be 'de facto' design standard in 3 years
- Only 25% of US owners have 'very high involvement' in BIM
- 75% of these stated that the AEC team used BIM when it wasn't required by the owner
- UK is a leader in BIM with over 98% of owners having some involvement in BIM compared to 59% in the US



(Sources: NBS National BIM survey, 2015; McGraw Hill Constructon, 2014)

SF BIM Program Timeline

- 2013: Planning for BIM
  - Market and industry survey
  - Use Case Analysis, SI staff and AEs
  - In-house BIM Technician
- 2014: BIM Pilots, Standards and Wiki Sites
  - Identified major upcoming design project
  - Developed draft language for SOW
  - Create BIM templates & Guidance
  - BIM Viewer and Model Checker recommendations
  - Develop internal BIM Wiki sites using MS Sharepoint
- 2014 – 2015:
  - Updated AE Center, public facing website
  - Refine BIM guidelines and design deliverable requirements through pilot project feedback
  - Implement BIM Viewer
  - Focus on Asset replacement workflows
- 2015 – 2016:
  - Developing AE Scope of work language
  - Developing Div 1000 construction specification language
  - Implement Model Checker

3

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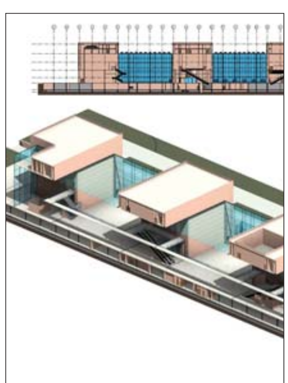
Establishing a BIM Foundation

SF BIM: Begin with the End in Mind

Required Outcomes of using BIM
- BIM usefulness required long after design and construction
- Asset management
- Portable for maintenance and operations personnel
- Accessible at multiple user levels across the institution

During Design
- Incorporate specific BIM design review capabilities
- Address multiple user capabilities: equipment & skills
- Develop standards for AE to follow

During Construction
- Define 'As-Built BIM'
- Asset management
- Integration with Computerized Facility Maintenance System (Tririga Facility center)

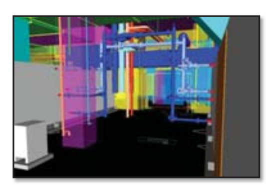


NASM - BUILDING SECTION

Use Cases

Capital Program
- Introduce use of 2D and 3D (low detail) to visualize location and extent of capital project areas

Design
- More efficient access to accurate as-builts, shop drawings



Facilities Management
- Support ***preventative maintenance*** through visualization of work tasks and asset location

Energy Management
- Introduce geospatial component to existing power and water usage analysis

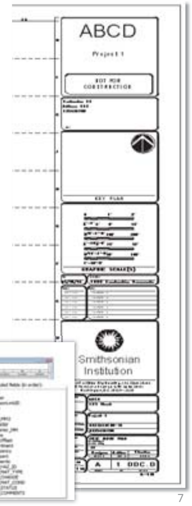
Smithsonian Gardens
- Support geospatial analysis of exterior spaces

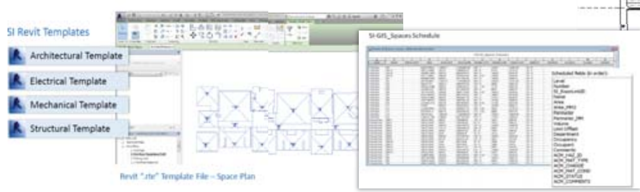
Historic Preservation
- Identify rooms and spaces of historic importance

Data Framework

SI BIM Templates

- Provides a standardized Revit work environment to foster consistency in BIM development– for both AEC project teams and internal SI initiatives
- Support SI spatial data management by providing SI data fields and geometry for rooms and floors, and standard attributes
- Standardize model development, BIM guidelines and CAD exports with National CAD Standard and SI document conventions, standardize views and naming conventions
- Provide SI-specific asset data parameters and schedule views for O&M

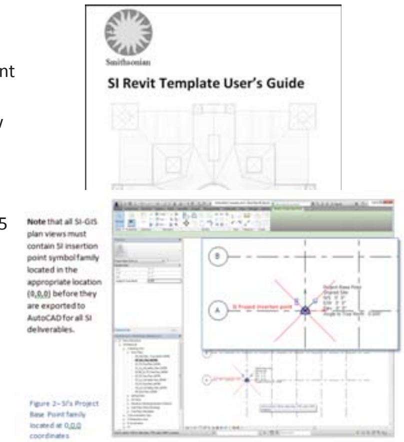




Guidance & Standards

Revit Template User's Guide

- Guidance for AEC project teams (primarily)
- Develop consistent model development across projects (and in-house)
- Not a tutorial – expect reader to know Revit
- Walks the user through Smithsonian minimum standards
- Based on National CAD Standard (v5) 5
- Customized title blocks, syntax for SI
- Identifies "Best Practices" (items not required)



Data Framework

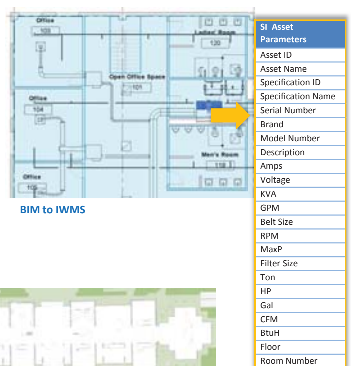
FM BIM: Data Development

IWMS/CAFM

- Provide critical asset data, *"ready"* for Tririga Facility Center Upload
- Focus: less data and higher quality

GIS

- BIM exchanges CAD geometry + data attributes for rooms and spaces



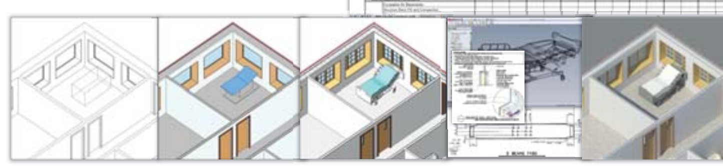
SI Revit templates organize data to be developed in the project BIM, and delivered to SI at project turnover, exported to GIS and IWMS

Guidance & Standards

Guidance for BIM Deliverables

Level of Development Guide *(DRAFT)*

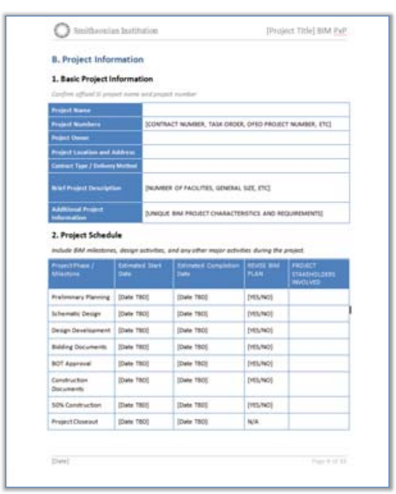
- SI has developed a guidance framework for the level development required for BIM deliverables
- BIM LOD will be identified early in the project (passed on to the team to detail in the project BIM PxP)
- The **Scope of Work** of the project ultimately defines the BIM requirements



Guidance & Standards

BIM Project Execution Plan (PxP)

- A living document populated and updated by the project team
- Clarifies and maintains the project BIM development process for the owner, and the team
- Provides a vetting process for any changes made in the BIM development process



Smithsonian Institution [Project Title] BIM PxP

B. Project Information

1. Basic Project Information

Project Name	
Project Numbers	[CONTRACT NUMBER, TASK ORDER, OFEO PROJECT NUMBER, ETC]
Project Owner	
Project Location and Address	
Contract Type / Delivery Method	
Brief Project Description	[NUMBER OF FACILITIES, GENERAL SIZE, ETC]
Additional Project Information	[UNIQUE BIM PROJECT CHARACTERISTICS AND REQUIREMENTS]

2. Project Schedule

Include BIM milestones, design activities, and any other major activities during the project.

Project Phase / Milestone	Estimated Start Date	Estimated Completion Date	REVISE BIM PLAN	PROJECT STAKEHOLDERS INVOLVED
Preliminary Planning	[Date TBD]	[Date TBD]	[YES/NO]	
Schematic Design	[Date TBD]	[Date TBD]	[YES/NO]	
Design Development	[Date TBD]	[Date TBD]	[YES/NO]	
Bidding Documents	[Date TBD]	[Date TBD]	[YES/NO]	
BOT Approval	[Date TBD]	[Date TBD]	[YES/NO]	
Construction Documents	[Date TBD]	[Date TBD]	[YES/NO]	
50% Construction	[Date TBD]	[Date TBD]	[YES/NO]	
Project Closeout	[Date TBD]	[Date TBD]	N/A	

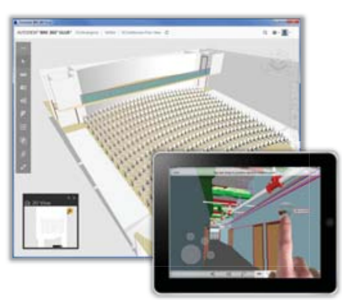
[Date]

Plan

Supporting SI BIM Project Reviews

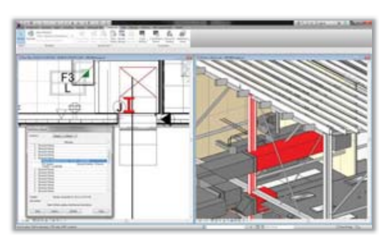
BIM Viewers

- Provides a means to review developing project models by SI users who are not Revit experts
- Offers versatile methods for viewing BIM: PDFs, mobile devices



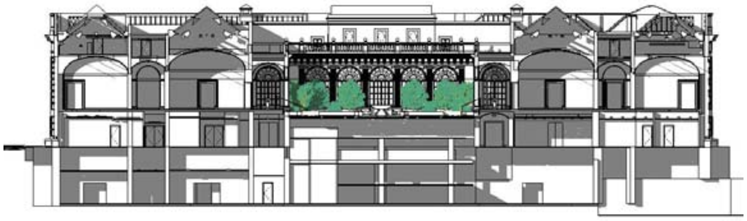
Model Checkers

- Provides an automated means to check a BIM against a customized rule set
- Useful by SI and by their project consultants



How will it all work?

BIM data improvement over time



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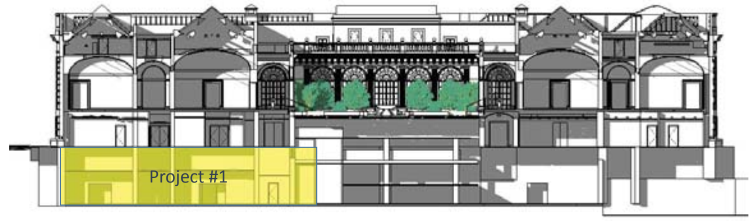


How will it all work?

BIM data improvement over time

How will it all work?

BIM data improvement over time

Building Information Management Portal

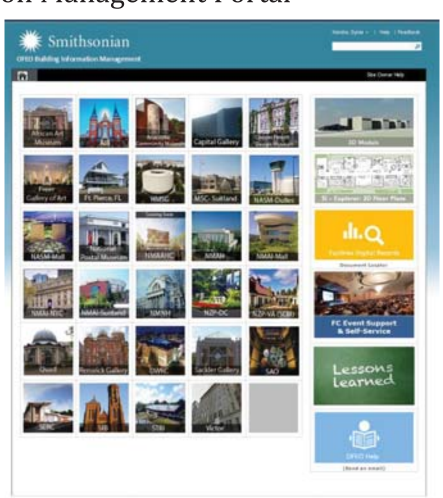
BIM "Wiki"

Develop a go-to source for information about SI facilities

- Highly visual
- Collaborative web-based environment
- Leveraging SI's SharePoint expertise

Provide links and information from *existing* SI systems

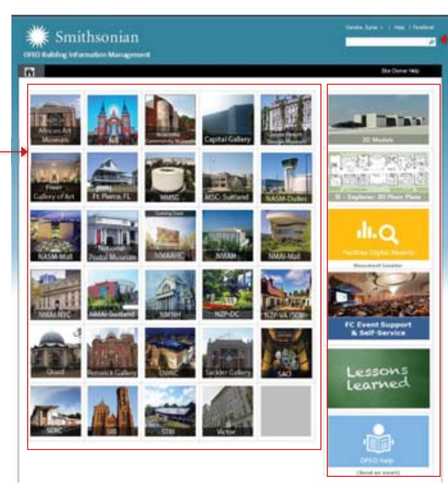
- No new data, just a clearinghouse for existing systems
- SI campus specific
- Simplifies access to critical facilities information



BIM "Wiki" – Home Page

Top level page – access to all building pages and support documentation

Access:
Individual Building Wikis



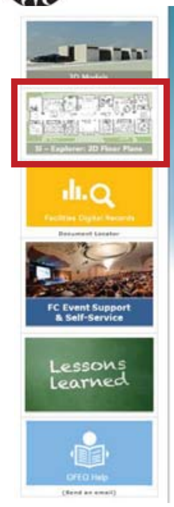
Search

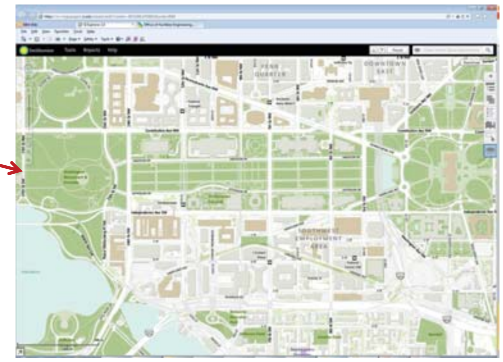
Access:
Top level access to OFEO systems

3D Models

Direct Download of Autodesk Revit Files

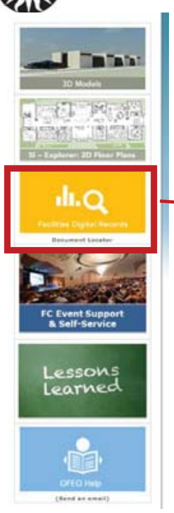
SI Explorer – GIS Mapping & Viewer





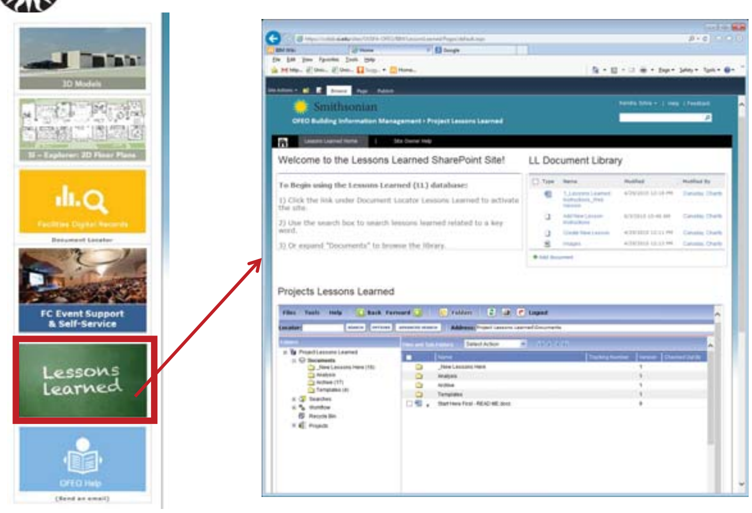
Visualize 2D drawings and sites

Document Locator

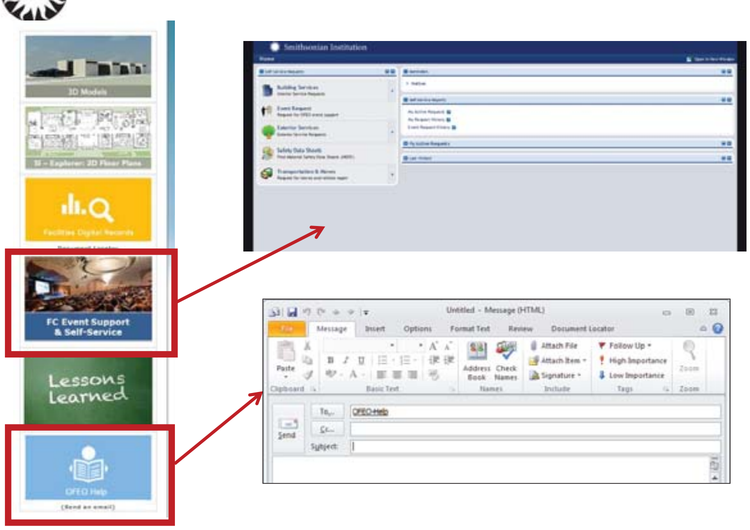


A different way of getting to document locator
- - same data

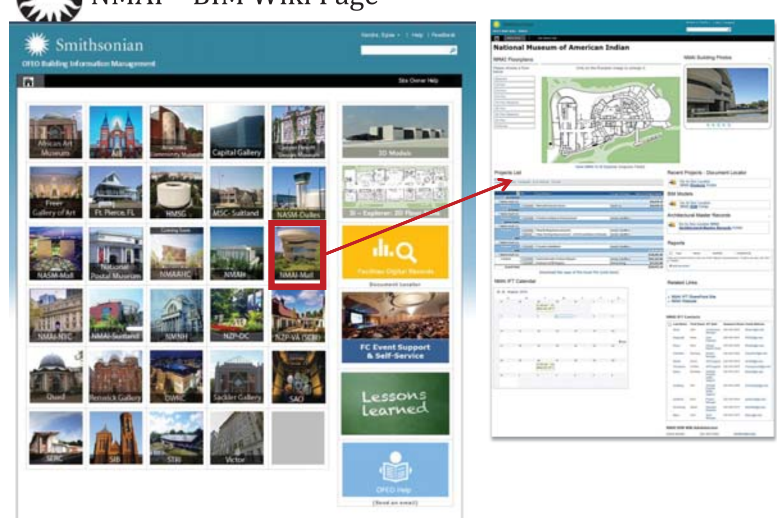
Lessons Learned



Other OFEO resources



NMAI – BIM Wiki Page



Building - Home Page (NMAI)

SharePoint functions

Building Photos

Views of floor plans

Document Locator: Building specific shortcuts to Projects, BIM, Architectural Master Records

Projects List (Excel download – live link to MOPS)

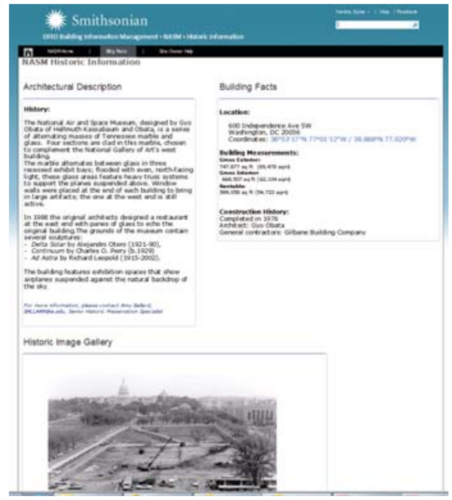
Reports

Related links

NMAI IFT Calendar

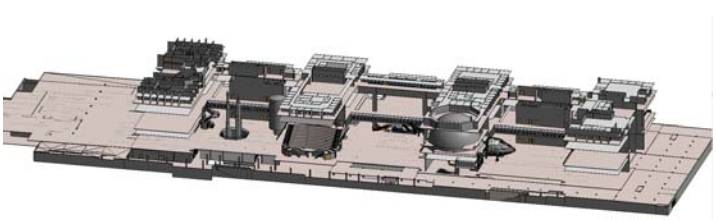
NMAI IFT contacts

Architectural History – second tab



Future Plans

- More templates – life safety and security templates
- BIM Viewer – easy to use -- to facilitate early project visualization by clients and reviewers
- Model Checker to assist both contractors and SI staff in verifying data accuracy – especially in complex deliverables.



Questions

Mike Carrancho

Smithsonian Institution

Deputy Director, Office of Planning, Design and Construction

CarranchoM@si.edu

July 22, 2016

Organizational Climate Studies and Other Evaluation Strategies: Experience from NSF's Advanced Cyberinfrastructure Projects

Lizanne DeStefano, Georgia Institute of Technology
Lorna Rivera, University of Illinois at Urbana-Champaign

XSEDE
Extreme Science and Engineering Discovery Environment

NSF

Three Evaluation Strategies

- Climate Study
- Dashboard Display of KPIs and area metrics
- Logic Models

NSF XSEDE

July 22, 2016

Annual Climate Study

Lizanne DeStefano, Georgia Institute of Technology
Lorna Rivera, University of Illinois at Urbana-Champaign

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Extreme Science and Engineering Discovery Environment

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Purpose of the Climate Study

Support XSEDE's organizational health by providing data over time to:

- Better understand current working conditions
- Recognize successes and areas of concern
- Develop responses to improve working conditions
- Improve workplace efficiency and satisfaction

NSF XSEDE

Method

- Annual on-line Survey to all XSEDE staff and leadership
  - Core items
  - XSEDE specific items
  - May/June administration
- Disaggregation by Level 2, 3, site, FTE, length of employment
  - Special requests by L2 and L3 managers
- EXTENSIVE dissemination and interaction around results
- Documentation of XSEDE response to results
  - Quarterly Meetings

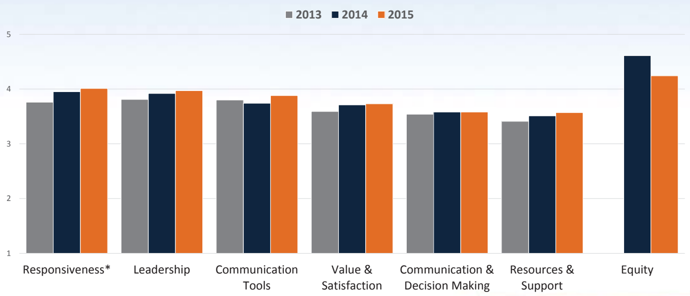
NSF XSEDE

Six Climate Indices

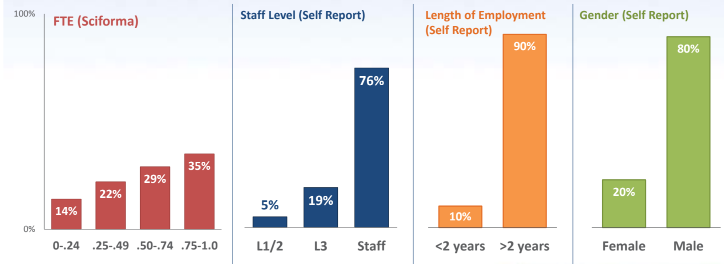
- Responsiveness
- Leadership
- Communication Tools
- Values and Satisfaction
- Communication and Decision-making
- Resources and Support
- Equity

NSF XSEDE

Index Scores Over Time (Scale 1 – 5)

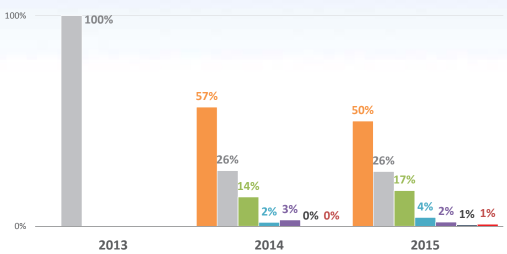


2015 Respondent Demographics



2015 Respondent Demographics Continued

Racial/ethnic diversity: Note that totals may not equal 100% since respondents could select more than one category.



2013 Recommendation: Promote staff directory on main XSEDE staff wiki page. Consider adopting a universal online document storage and collaboration solution.

2014-2015 XSEDE Response: Complete reorganization of wiki. Retirement and replacement of Sciforma in XSEDE2.0. Expansion of Communication Tools dimension in 2015 Climate Study.

Climate Study Results

Survey Item	Mean 2013	Mean 2014	Mean 2015
Q1A. The XSEDE staff wiki helps me find information across the project.	-	**3.26***	**3.58****
Q1C. The XSEDE staff wiki contains information that is useful to me and my work.	-	-	3.82
Q1E. The XSEDE staff wiki helps me to communicate effectively with other XSEDE staff.	3.04	2.99	3.18

Scale: Strongly Disagree (1) to Strongly Agree (5) * *p* < .05, ** *p* < .01, *** *p* < .001

Range of comparable projects 2.83 to 3.74

"The wiki reorganization has helped me find things outside my level 3 WBS area"

"…It would also help to expand the use of good collaborative tools to a more complete integrated tool suite, e.g., integrated wiki/issue system/source control/code review system.

2013 Recommendation: Maintain detailed FTE assignments, coordinate with local supervisors, and regularly recognize outstanding work.

2014-2015 XSEDE Response: Detailed FTE assignments included in PY5 and XSEDE2.0 planning budgets. Internal newsletter highlights of staff work.

Climate Study Results

Survey Item	Mean 2013	Mean 2014	Mean 2015
Q7A. I am satisfied with the balance between my work for XSEDE and my work on other projects.	**3.33***	3.54	**3.59***
Q7D. I am satisfied with how my program area is managed.	**3.57****	3.75	**3.93****

Scale: Strongly Disagree (1) to Strongly Agree (5) * *p* < .05, ** *p* < .01, *** *p* < .001

"I work for an XSEDE partner. I feel that my interactions with XSEDE staff are very good."

"…Perhaps there should be annual performance reviews, and the Level 3's could shift funds between people and institutions based on who is actually delivering."

Range of comparable projects 2.83 to 3.74

2013 Recommendation: Establish explicit procedures including time limits for XSEDE decision making.

2014-2015 XSEDE Response: Expanded communication & decision making dimension in 2014 Climate Study and again in 2015. All hands meetings implemented at sites. Retirement of projects lacking desired outcomes.

Climate Study Results

Survey Item	Mean 2013	Mean 2014	Mean 2015
Q3A. XSEDE's decision making process is efficient.	-	2.93	2.96
Q3B. I understand how decisions are made within the organization.	-	-	3.04
Q3C. I have input in decision making that relates to my work.	-	-	3.77
Q3D. When decisions are made, they are effectively communicated back to me.	-	-	3.55

Scale: Strongly Disagree (1) to Strongly Agree (5)

Range of comparable projects 2.83 – 3.74

" "Communication during and after decision making by senior leadership is better than before, but overall still not nearly good enough…However, I have confidence that the senior leadership is addressing this problem and headed in the right direction."

2014 Recommendation: Conduct deeper investigations of organizational climate as it relates to equity with staff from all groups.

2014-2015 XSEDE Response: Expanded equity dimension in 2015 Climate Study. Diversity speaker at June 2015 quarterly meeting.

Climate Study Results

Survey Item	Mean 2013	Mean 2014	Mean 2015
Q2b. I feel that XSEDE staff treat each other equally regardless of gender.	-	4.41	4.38
Q9. How often do you experience discrimination by other XSEDE staff?†	-	4.83	4.80

Scale: Strongly Disagree (1) to Strongly Agree (5)
†Note Q9 has been reverse coded as 1 (Almost Always) to 5 (Never).

"I'm sure that there is unconscious bias like with any human enterprise. I haven't personally seen anything I could point to as a clear case of discrimination, but different people can interpret the same event differently."

Range of comparable projects not available

July 22, 2016

Pilot TEOS Area Metrics Tableau Dashboard Demonstration

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XSEDE
Extreme Science and Engineering Discovery Environment

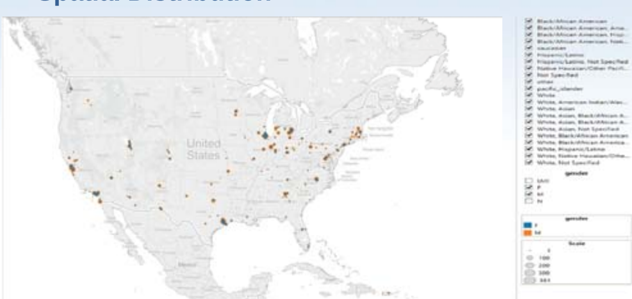
XSEDE has a complex system of KPIs and area metrics

- Dashboard was developed to provide real time access to metrics for L1, L2, and L3 and program managers.
  - Easy quarterly and annual reporting
  - Consistent definitions and data pulls
  - Promotes longitudinal analysis
  - Better understand user base
  - Promote data based decision-making and transparency

L2 Area Metrics Sample

Cumulative and Quarterly Data

Spatial Distribution

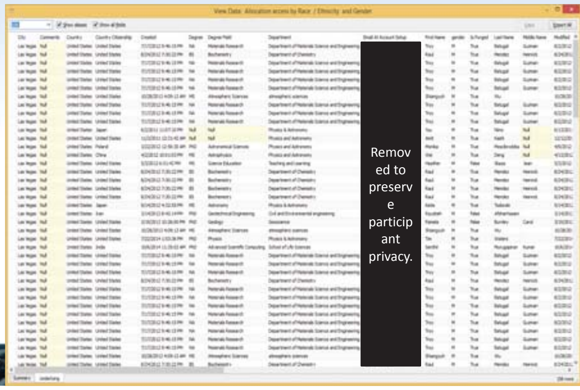


L2: Area Metrics

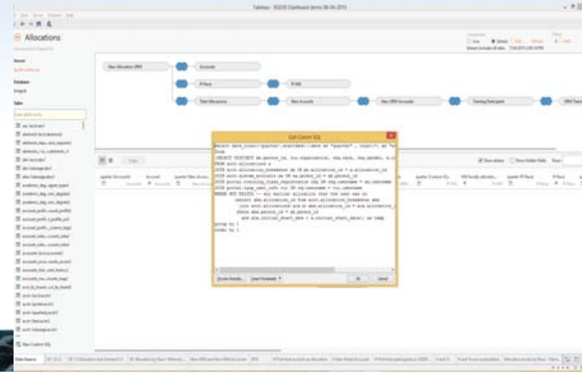
Cumulative and Quarterly Data

	Project Year / Project Quarter															
	PY 1				PY 2				PY 3				PY 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
% New Account (Total New Accounts / Cumulative Total)	28%	21%	39%	17%	15%	17%	28%	16%	18%	9%	10%	19%	8%	6%	8%	5%
New Non URM	327	338	925	481	527	750	1,706	1,158	1,607	786	1,087	2,387	1,172	904	1,262	965
New Racial / Ethnic minorities, Women and MSI.	172	144	543	274	272	360	799	590	797	435	507	1,391	606	440	616	423
Total New accounts	499	482	1,468	755	799	1,110	2,505	1,748	2,404	1,221	1,594	3,778	1,778	1,344	1,878	1,388
Cumulative Total	1,799	2,281	3,749	4,504	5,303	6,413	8,918	10,666	13,070	14,291	15,885	19,663	21,441	22,785	24,663	26,051

Underlying Data



Underlying Queries



July 22, 2016

Logic Models

Lizanne DeStefano, I-STEM, UIUC
Lorna Rivera, I-STEM, UIUC
Michael Culbertson, I-STEM, UIUC

XSEDE
Extreme Science and Engineering Discovery Environment

Logic Models represent intended program operation

- Make program components and processes explicit
- Identify different understandings and promote consensus
- Clarify points for intervention and evaluation

Allocations are an important metric in XSEDE

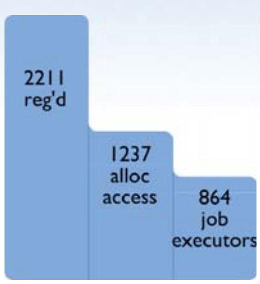
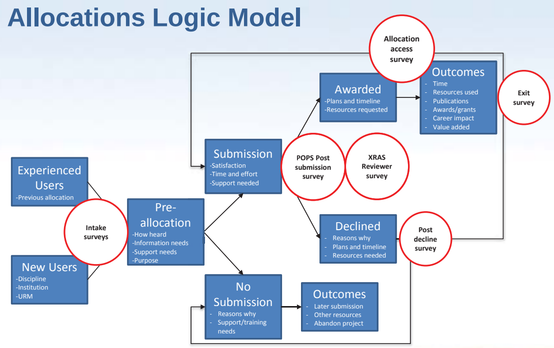


Figure 1. Training Registrants as of February 2013

Allocations Logic Model



Surveys

Table 1. Survey suite related to allocations

Items on…	Intake	POPS Post Submission	XRAS Reviewer	Allocation Access	Exit	Declined
Computational experience	X	X		X	X	X
Training needs	X			X	X	X
Access/use of other computational resources	X			X	X	X
Champion interaction	X			X	X	X
Demographics	X	X		X	X	X
Submission process		X				
Review process			X			X
New portal account	X					
Allocation plans				X		
Allocation achievements					X	
Alternative plans						X

Discussion

- Are the annual Climate Study and other strategies useful for promoting continuous improvement and a positive working environment within XSEDE?
- Are these findings useful or applicable to other large NSF investments?
  - Communication & decision making in virtual organizations
  - New staff orientation needs
  - Less than .50 FTE

Discussion

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2016 NSF Large Facilities Workshop

Property and Equipment Management

Business Systems Review, Annual Hot Topic

May 24, 2016

Florence Rabanal, (frabanal@nsf.gov) *Large Facilities Office*

BACKGROUND AND DRIVERS: Property and Equipment Management

- **BROAD NEED: (remain competitive) Government needs to understand US investments in research and development infrastructure**
- **"LOCAL" REALITY: (limited funds) Agencies need to make the most effective use; prevent waste and abuse as stewards of Federal taxdollars.**
- **NSF EXPERIENCE:** Retrospective analysis of results from NSF's Business Systems Reviews (Post Award Monitoring) suggests there is a need for to strengthen current assurance and oversight (associated with the Large Facility portfolio) through proactive measures which could involve documentation or activities.

Goal, Objectives and Agenda

GOAL: TO STRENGTHEN CURRENT ASSURANCE AND OVERSIGHT [Property/Equipment Management] ACTIVITIES ASSOCIATED WITH THE NSF LARGE FACILITY PORTFOLIO

TODAY'S OBJECTIVES:

- Provide background and driver for NSF/LFO effort.
- Outline various components related to property/equipment management.
- Identify the Business Owners associated with information components.
- Highlight key interactions amongst Business Owners
- Engage stakeholders, leverage experience and gather input.

PRESENTATION: Scope and Content

- Covers property and equipment; government-owned, real and personal
- Presents an overview of "what, why and who", NOT the details of "how"
- Highlights frequently observed "challenges"
- Assumes a fiduciary responsibility as stewards of taxpayer dollars

Stakeholder Engagement

- How does NSF's management approach align with your experience and understanding of roles and responsibilities?
- What do you see as the major challenges to employing property/equipment requirements as articulated in the NSF guidance and requirements documentation?
- Are Recipient expectations clearly outlined in the cooperative agreements?
- Are there opportunities for NSF to clarify its communication on property/equipment management? If so what and how should they be addressed?

PROPERTY/EQUIPMENT NSF STAKEHOLDERS: OVERVIEW of RESPONSIBILITIES

COMPONENT	BUSINESS OWNER	SUMMARY OF SELECT RESPSONSBILITIES
NSF Property Management Program	NSF Director of the Office of Information and Resources Management (OIRM)	• Agency Administration of Property Management Program
Implementation of NSF Property Management Program	NSF Division of Administrative Services	• Government-owned Property: Maintains records of accountability; Familiarizes NSF awardees with their responsibilities; Conducts site reviews, inspections, and evaluations of the use and control systems and evaluates the adequacy of related property records • Liaisons with and prepares reports for the General Services Administration and other Federal agencies; coordinates disposition of in the custody of NSF and its awardees • Excess Property: Coordinates the acquisition of personal property for NSF contractors and awardees; Manages the reutilization of excess government property in accordance with applicable law and regulation • Conducts appropriate liaison with NSF Program Offices to ensure sound property receipt, safeguarding, and disposal
NSF Accounting and Financial Statements	NSF Division of Financial Management	• Develops and provides guidance on depreciation and asset accounting standards (as required by regulation); • Maintains ledger control for capitalized property; • Provides guidance and assistance with the review and interpretation of financial statements from NSF awardees, as they pertain to property, plant and equipment.

PROPERTY/EQUIPMENT NSF STAKEHOLDERS: OVERVIEW of RESPONSIBILITIES

COMPONENT	BUSINESS OWNER	SUMMARY OF SELECT RESPSONSBILITIES
Grants/Cooperative Agreement Provisions	Division of Grants and Agreements, and Division of Acquisition and Cooperative Support (DACS)	• Incorporate provisions designed to protect Government interest relating to real and personal property acquired or furnished under NSF contracts, grants, and agreements, and report these provisions as required by regulation; • Ensure that NSF's central computer databases accurately denote those contracts, grants, and agreements in which Government-owned property has been placed in the custody of the awardee
GOE Acquisition Transfer or Disposal	Heads of Organization (*e.g*, Assistant Directors as Senior Official Directorates, and Division Directors *etc.*)	• Making appropriate recommendations with respect to the acquisition, transfer, or disposal of Government-owned property for use under NSF contracts or grants managed by their offices.
Post Award Monitoring and Assurance of Large Facility Portfolio Awards	Large Facilities Office	• Provide a assurance/verification that the administrative [property and equipment management] policies and procedures are written, conform to OMB requirements and NSF award expectations, and are used to manage the business needs of the Facility.
Agency Policy and Guidance Large Facilities Portfolios	Large Facilities Office	• Develop and issuing NSF policy and guidance on the large facility planning and management, which includes property/equipment management.
Agency Policy/Grants and Agreements	Division of Institution and Award Support	• Developing, implementing and issuing proposal and award policy which includes property/equipment management.

NSF PROPERTY/EQUIPMENT Management: Select Business Activities and Information Sharing

COMPONENT	BUSINESS "ACTIVITY"
GOVERNMENT-OWNED EQUIPMENT (GOE) SUBMISSIONS	Government-wide Planning
WORK IN PROGRESS/CONSTRUCTION IN PROGRESS (WIP/CIP) SUBMISSIONS	External (OMB, GSA etc.) Reporting for Initiatives
ANNUAL INVENTORY SUBMISSIONS (Real and Personal Property)	Technical Program Planning and Competition
	Agency Administrative Post Award Monitoring
	Agency Financial Statements
	Audits of Agency Process and Programs
	Recipient Administration of Research Awards

Observed Challenges with Property/Equipment Management

- General view that property/equipment management = inventory
- End-users (Facility) are often not involved/engaged with inventory-type or reporting activities (Central Services)
- Planning and budgeting often excludes or delays maintenance in lieu of research.
- Documentation is sparse, especially with key documentation on maintenance, warranties, surveys etc.
- Well organized and comprehensive repositories for key information (e.g., warranties, maintenance) is often lacking and disconnected (e.g., budget, finance and acquisition).
- Staffing is not always aligned with workload
- Automation and computing tools not fully leveraged

Appendix D: Presentations

D.2 Wednesday May 25, 2016

NATIONAL SCIENCE FOUNDATION

NSF IDEAS FOR FUTURE INVESTMENT

2016 Large Facilities Workshop – May 25, 2016
Matthew Hawkins
Head, LFO

Dr. France A. Córdova
Director, National Science Foundation
May 6, 2016

NSF Ideas for Future Investment

RESEARCH IDEAS

- Harnessing Data for 21st Century Science and Engineering
- Shaping the New Human – Technology Frontier
- Understanding the Rules of Life: Predicting Phenotype
- The Quantum Leap: Leading the Next Quantum Revolution
- Navigating the New Arctic
- Windows on the Universe: The Era of Multi-messenger Astrophysics

PROCESS IDEAS

- Growing Convergent Research at NSF
- Mid-scale Research Infrastructure
- NSF 2050

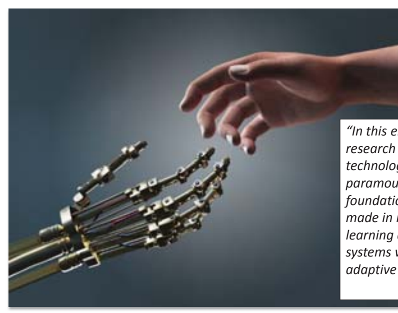
Harnessing Data for 21st Century Science and Engineering

"...develop a national-scale initiative aimed at fundamental data science research, research data cyberinfrastructure, and the development of a 21st century data-capable workforce."

"The cyberinfrastructure ecosystem must be robust, open, and science-driven, and capable of mining data delivered by our large-scale facilities."

Dr. Córdova

Shaping the New Human — Technology Frontier



"In this emerging techno-world, research examining this human-technology frontier becomes paramount. We would build on foundational investments we've made in research in machine learning and efficient engineered systems with cognitive and adaptive capabilities."

Dr. Córdova

Understanding the Rules of Life

Predicting Phenotype

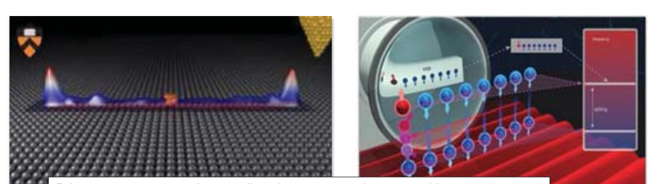
"To understand the "rules of life" will require convergence of research across biology, computer science, mathematics, the physical sciences, behavioral sciences and engineering."

"How can computational modeling and informatics methods enable the data integration needed to predict complex living systems?"

Dr. Córdova

The Quantum Leap

Leading the Next Quantum Revolution



"The new quantum revolution will exploit quantum phenomena like superposition, entanglement, and squeezing to enable the next wave of precision sensors, and more efficient computation, simulation, and communication. NSF would invest in research that addresses the manipulation of quantum states, and the control of material-light interactions, involving physicists, mathematicians and engineers."

Dr. Córdova

Navigating the New Arctic

"NSF would establish an observing network of mobile and fixed platforms and tools across the Arctic to document biological, physical and social changes, and invest further in theory, modeling and simulation of this changing ecosystem and its broader effects on the planet."

Dr. Córdova

Windows on the Universe

The Era of Multi-messenger Astrophysics

"We have come to a special moment in understanding our universe: for the first time we can explore its mysteries in the electro-magnetic regime, the particle regime, and the gravitational wave regime. NSF is the agency that uniquely can do this with ground based observatories…"

"With so much potential for discovery, we must increase our investment in the large number of potential U.S. users, in exploiting the big data that these observatories are producing, and in increasing the sensitivity of these and other ground-based facilities."

Dr. Córdova

Growing Convergent Research at NSF

"Convergence is a relatively new way of thinking about bringing people with their disciplinary knowledge together to address grand challenges."

"The convergent approach would frame challenging research questions at inception, and foster the collaborations needed for successful inquiry. NSF is well-positioned to foster convergence because of its deep connections to all fields of science and engineering."

Dr. Córdova

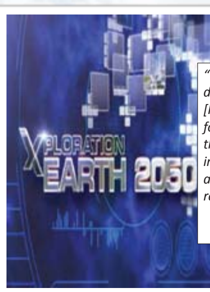
Mid-scale Research Infrastructure

"You are now familiar…with the limitation of our MREFC process with respect to funding opportunities that cost between several M$ and 100 M$."

"Lowering the threshold for MREFC expenditures, with appropriate modification of processes, would increase the flexibility for excellent science to be done across the agency."

Dr. Córdova

NSF 2050

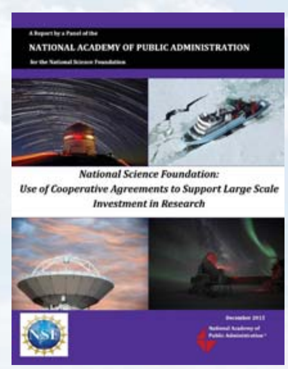


"With this initiative NSF would dedicate a special fund now [FY18?], to invest in bold foundational research questions that are large in scope, innovative in character, originate outside of any particular directorate, and require a long-term commitment."

Dr. Córdova

NAPA Study Implementation

- Study commissioned by NSF in early 2015
- Evaluate NSF's use of Cooperative Agreements for Large Scale Research Infrastructure Investments
- Final Report received December 17, 2015
- Implementation now underway



Business Practices
Cost Analysis, Cost Estimating, Contingency, and Management Fee

- Exceptions to recommendations from pre-award cost analyses reviewed by the Large Facilities Office and forwarded to the Chief Financial Officer for final determination (3.1) – **COMPLETE (Internal NSF Standard Operating Guidance)**
- Clarify the Large Facilities Manual (LFM) requiring Recipients to follow the guidance in the GAO Cost Estimating and Schedule Assessment Guides when developing cost estimates (4.2) – **COMPLETE (2016 Revision to the LFM: "*should*" to "*shall*")**
- Evaluate the impacts of eliminating management fee (4.3) – **UNDER CONSIDERATION/IN PROGRESS**

Business Practices
Cost Analysis, Cost Estimating, Contingency, and Management Fee

- Retain control of a portion of contingency funds (4.1) - **COMPLETE (Internal NSF Standard Operating Guidance)**
  - Internal documentation of decision process which is based on risks (Recipient & Project)
  - Documentation of NSF-approved contingency budget and allocations to the Recipient in the award notice and the cooperative support agreement (CSA).
  - **No change to Recipient processes** in Project Execution Plan (CCB, NSF approval thresholds, etc.)
  - In compliance with the Uniform Guidance ("Known-Unkowns", Part of award, Recipient manages)
  - Recipient to manage/report against both the total contingency budget and the allocations to-date.

"Contingency" is NOT a dirty word!

However…Beware of the term "Reserve" (drawing down and holding funds "just in case") since this is **NOT allowed** under the Uniform Guidance. NSF itself does not have a mechanism for (nor does it fund) "Management Reserve" (See LFM).

Project management knowledge and skills

- Identify NSF project management skill requirements by role and develop/implement required project management training/workshops (6.7) – **IN PROGRESS**
- Require Recipient project managers be certified in project management and specify the minimum experience thresholds in the cooperative agreement (6.8) – **UNDER CONSIDERATION/IN PROGRESS (Breakout Session)**
- Formally establish "communities of practice" to share best practices and implement a "lessons learned" requirement for all MREFC projects (6.9) – **IN PROGRESS (Breakout Session)**

Planning, oversight & accountability
Roles and responsibilities

- Establish and publish a joint NSF-NSB duties and responsibilities document(6.1) – **IN PROGRESS**
- (1) Authorize LFO to hire two additional FTEs; and (2) Revise MREFC Panel charter changing the LFO Head status to a full-voting member (6.5) – **COMPLETE**
- Re-scope the MREFC Panel to include review of projects in the development and construction stages (6.2) **– IN PROGRESS**

Planning, oversight & accountability
Roles and responsibilities

- Identify/codify project management and financial management expertise and explicitly add the requirements to the criteria for selection of external reviewers (6.3) – **IN PROGRESS**
- Establish a FACA advisory committee for the Director to use as a sounding board for objective insight on large research projects (6.4) – **IN PROGRESS**
- Evaluate development/uses the NSF Facility Plan and how it aligns with the agency's strategic planning processes (6.6) – **IN PROGRESS**

Large Facilities Manual (LFM)

- Current version dated June 2015
- Annual Review and Up-date Cycle
- 2016 Revision out for public comment:

Federal Register: https://www.gpo.gov/fdsys/pkg/FR-2016-05-09/pdf/2016-10793.pdf

LFO Website: https://www.nsf.gov/bfa/lfo/lfo_documents.jsp

NSF Documentation Related to Large Facilities:
- ✓ Proposal and Awards Policy and Procedures Guide (PAPPG)
- ✓ Large Facilities Manual (LFM)
- ✓ Business Systems Review (BSR) Guide
- ✓ NSF Internal Standard Operating Guidance – *"Consult with PO or G&AO"*

New Policies and Procedures

- Cost Analysis – New Section 4.2 of the LFM (Cost Model, BoE & Proposal Format – **Breakout Session**)
- Incurred Cost Audit Tool **(Breakout Session)**
- Obligations and Allocations of Budget Contingency (NAPA)
  - No change in Recipient practices per the LFM
  - NSF holding up to 100% until need justified (See 2016 revision of LFM)
- Management Fee > Under Review
  - Policy published in June 2015 LFM still in effect

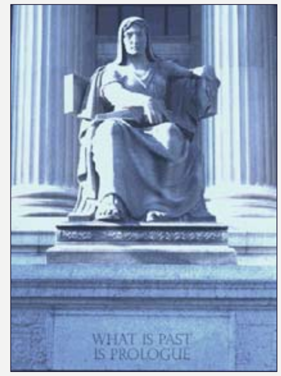
QUESTIONS & DISCUSSION?

SMITHSONIAN LESSONS LEARNED PROGRAM

SI-NSF LARGE FACILITIES WORKSHOP
MAY 25, 2016

LESSONS OF HISTORY

"What is past is prologue."



"Those who do not learn from history are doomed to repeat it."

- Santayana

CAN YOU AFFORD **NOT** TO LEARN FROM PAST EXPERIENCE?

"Insanity is doing the same thing over and over and expecting different results."

- Ben Franklin

SMITHSONIAN LESSONS LEARNED PROGRAM AGENDA

- Program Evolution
- Lessons Learned Process
- Lessons
- Comments/Questions

SMITHSONIAN LESSONS LEARNED PROGRAM PROGRAM EVOLUTION

- CII – 2007 Research Team Co-Chair
  - State of the industry
  - Jump-start guide
- Facilities Unit Goal - 2013
  - Form Task Force
  - Survey
  - Develop plan

SMITHSONIAN LESSONS LEARNED PROGRAM PROGRAM EVOLUTION

Lessons Learned Process Elements

- Leadership
- Culture
- Lesson Collection
- Lesson Analysis
- Lesson Implementation
- Resources
- Maintenance and Improvement

SMITHSONIAN LESSONS LEARNED PROGRAM
PROGRAM EVOLUTION

2014 Pilot Program

- Data Base Selection and Development
- ID Pilot Projects
- Collections Templates and Methods

SMITHSONIAN LESSONS LEARNED PROGRAM
COLLECTION

- **Collection Template**
  - Lesson Learned
  - Background
  - Executive Action
  - Admin Info

- **Data Base**
  - Existing Document Locator DB
  - BIM Wiki Site
  - Searchable

SMITHSONIAN LESSONS LEARNED PROGRAM
COLLECTION

Collection Process

- Specific Projects
  - From Integrated Facilities Teams
  - Project Type and Phase
  - Museum Input
  - Contractor and Consultant Input
- Individual collection

SMITHSONIAN LESSONS LEARNED PROGRAM
ANALYSIS

Analysis teams

- 5-6 volunteers from SI Facilities staff
- Review 20 lessons
- Sort into action folders
- Develop suggested Executive Action

SMITHSONIAN LESSONS LEARNED PROGRAM
ANALYSIS

Action Folders

- Review Panel
- External Action
- Change to tech requirements
- Change to Process
- Pre-project Checklist
- Newsletter
- Return/Rewrite
- No Action - Archive

SMITHSONIAN LESSONS LEARNED PROGRAM
IMPLEMENTATION

Implementation Presentations

- Senior Leadership Briefings
- 12 lessons
- Document decisions
- Track actions

SI Facilities Quarterly Newsletter

- Three lessons
- Credit submitters!

SMITHSONIAN LESSONS LEARNED PROGRAM ACCOMPLISHMENTS

- 270 lessons collected
- 210 lessons analyzed
- 27 lessons presented for implementation

SMITHSONIAN LESSONS LEARNED PROGRAM LESSONS

Cooper Hewitt Museum Renovation

- Design exhibits concurrently with infrastructure
- Install stand-alone temporary fire alarm system
- Closely coordinate museum re-opening dates

SMITHSONIAN LESSONS LEARNED PROGRAM LESSONS

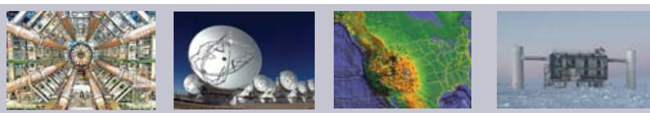
Mathias Lab Construction

- Coordination of drawings; more attention required
- Never assume that all previous HAZMAT abatement has been completed. Cheaper to test and confirm.

- Sustainability initiatives don't necessarily lead to customer satisfaction.

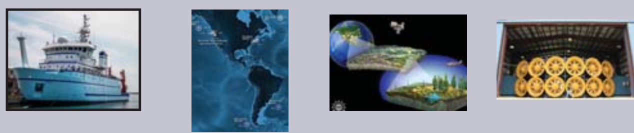
SMITHSONIAN LESSONS LEARNED PROGRAM LESSONS

Questions?



Large Facilities & Cyberinfrastructure

Follow-up from December 2015 workshop



Bill Miller

Science Advisor
Division of Advanced Cyberinfrastructure (ACI)
CISE Directorate
National Science Foundation

WLMiller@nsf.gov

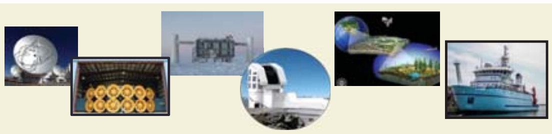
NSF Large Facilities Workshop, May 25, 2016

Cyberinfrastructure (CI)

- Science-related computational and data capabilities, resources and services that serve the research and education end-users (generally, outward facing).
  - Computing, software, data infrastructure, workflows, portals, networking, and related workforce…
  - Distinguish from Information Technology (IT): not science related, part of business operations to benefit facility's own personnel.
  - Some elements like cybersecurity may span CI and IT.
- Facility CI (in-house capabilities)…
  - vs. external shared research CI
  - vs. commercial resources (e.g. cloud).

Facilities and Shared Research CI

Facility CI Capabilities



Products & Services

Portals, Data, Software, Analysis tools

External

"Middleware" CI Services

- Data Services – Access, Discovery, Analytics, Semantics
- Science APIs, Portals, Gateways
- Workflow systems and other CI

Computing Resources

NSF-supported CI ecosystem | campus, regional resources | commercial cloud | international

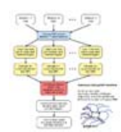
Networks

National/International Research and Education Network

LIGO science enabled by shared research cyberinfrastructure (CI)

Open Science Grid

Pegasus HTCondor



XSEDE STAMPEDE

Computing

- **Open Science Grid (OSG):** High throughput parallelized event searches of 100,000 models for neutron binary star mergers, black holes,…
- **Comet** (SDSC) and **Stampede** (TACC) **HPC** computations, via **XSEDE** allocations system**.**

Workflows

- **Pegasus** and **HTCondor**: create, distribute, monitor OSG jobs, manage data transfers, analyze LIGO data.

Networking

- NSF-funded upgrade from 10Gbps to 100Gbps WAN enabled huge gains in throughput.

NSF programs: Data Building Blocks (DIBBs), Software Infrastructure (SI2), Campus Cyberinfrastructure Network Infrastructure and Engineering (CC*NIE, DNI), and others. OSG and Pegasus also supported by the DOE.

NSF's goals

- **Gain a deeper understanding of cyber needs <u>within</u> and <u>external to</u> large facilities to support large scale science.**
  - Identify needs, gaps and trends that can guide future NSF investments.
- **Foster dialog and collaboration <u>among large facilities</u> and <u>with the CI community</u>.**
  - Exchange practices, success cases, and technology awareness, trends.
  - Maximize use of existing CI resources, minimizing duplication of effort.
  - Develop new partnerships to address challenges, and inspire new R&D.
- **Ultimately: Create a dynamic *national CI ecosystem*** that supports the changing needs of the research community.

Cyberinfrastructure for NSF Large Facilities Workshop

December 1st, 10 a.m. – 6:00 p.m. & December 2nd, 8:30 a.m. to 2:30 p.m., 2015
Westin Arlington Gateway, Arlington, VA

http://idies.jhu.edu/symposium/cyberinfrastructure-ci-for-nsf-large-facilities-workshop/

Organizers

Workshop Chair:
Alex Szalay, Johns Hopkins University

Program Committee:
- Christine Borgman, University of California, Los Angeles
- Peter Couvares, Syracuse University
- Brian Glendenning, National Radio Astronomy Observatory
- Kerstin Lehnert, Columbia University
- Chuck Meertens, UNAVCO
- Manish Parashar, Rutgers University

Goal was to "create a forum for direct interaction between the NSF large facilities and CI developer community"

75 participants from over 45 institutions, large facilities, and CI resources.

Some take-homes from the workshop

Issues raised

- CI workforce – recruitment, retention, finding expertise and partners
- Dealing with data – discoverability, sharing, archiving/curation…
- Software – computational codes, analysis, visualization, integrated workflows
- Accessing best practices, guides, consultative processes (like for cybersecurity)
- Deciding when to build in-house vs. outsourcing or leveraging existing resources
- Interoperability, re-use, accessing/using external resources
- Disconnect between facility lifetime (long) and external CI lifecycles (shorter)
- User needs for analysis tools, computational resources and other services.
- New trends – e.g. streaming data to advance computing

Next steps?

- Additional workshops – exploring CI needs/challenges in specific areas
- Incentivizing community building, partnerships, collaboration and exchange, among facilities and with CI projects
- Identifying new ways of leveraging existing shared CI resources and capabilities

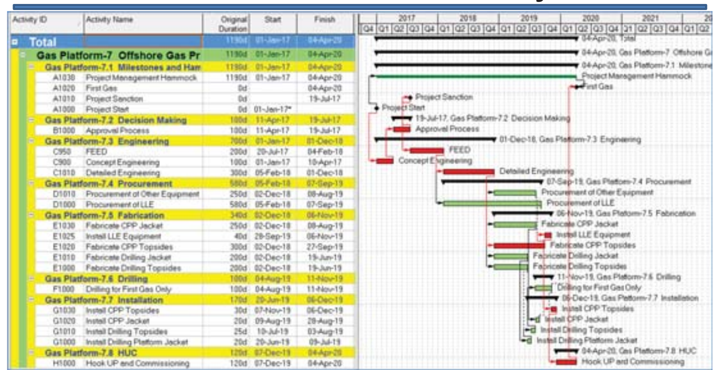
http://trustedci.org/2016summit/

Quantitative Cost-Schedule Risk Analysis in the 2015 LFM

2016 National Science Foundation Large Facilities Workshop May 25, 2016

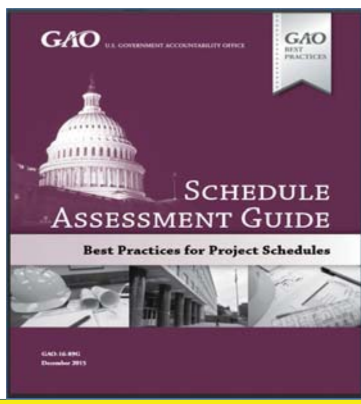
David T. Hulett, Ph.D., FAACE
Hulett & Associates, LLC
Los Angeles, CA

Example Schedule: Offshore Gas Production Platform Project



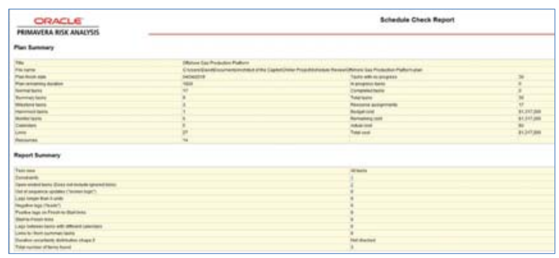
This is not the model I used for the LFM. That one is lost to the computer gremlins.

Test the Schedule against GAO 10-point Scheduling Best Practices



http://www.gao.gov/products/GAO-16-89G

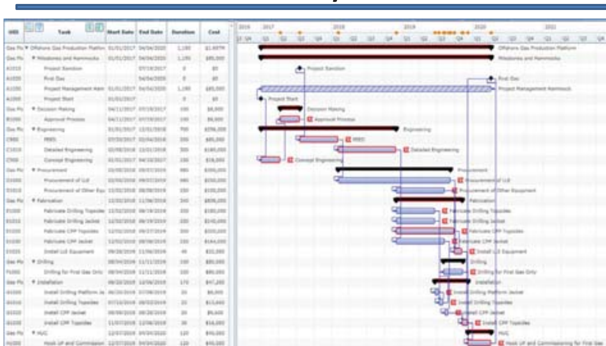
Third-Party Software Can Help in Testing the Quality of the Schedule



Oracle Primavera Risk Analysis Schedule Check Report

Deltek Acumen FUSE

Import to Integrated Cost-Schedule Risk Analysis Software



39-month $1.7 billion Project

Using Booz Allen Hamilton Polaris©
http://www.boozallen.com/consulting/products/polaris

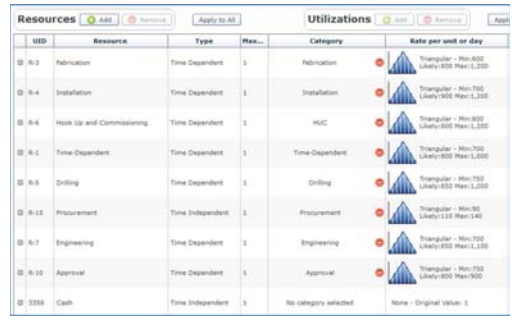
Adding Uncertainty to Activity Durations and Resource Quantities by Reference Ranges

- Uncertainty in schedule duration is similar to "common cause" variation related to six sigma process control concepts developed by Walter Shewhart and championed by Edwards Demming
- "Common cause variability is a source of variation caused by unknown factors that result in a steady but random distribution of output around the average of the data …. Common cause variation is also called random variation, noise, non-controllable variation … " (http://www.isixsigma.com/dictionary/common-cause-variation/)

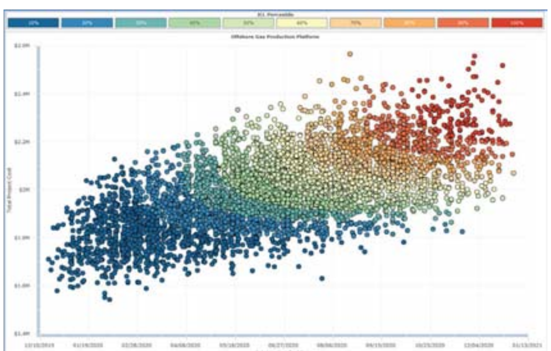
Uncertainty to Activity Durations by Reference Ranges

These represent uncertainty parameters for the entire activity class (engineering, procurement, fabrication…). To achieve that while using the specified ranges on each activity within the class, these uncertainty values must be correlated 100%

Resource usage Uncertainty Ranges

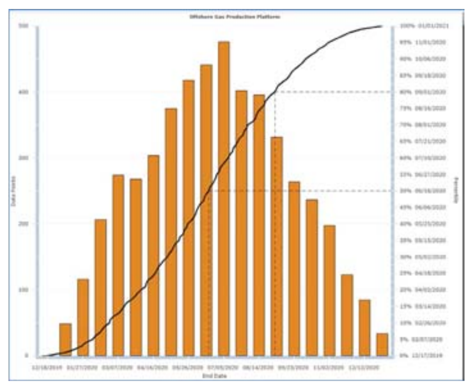


Scatterplot: Effect of Uncertainty on Durations and Resources



Correlation Finish Date – Cost calculated at 62%. Upward slope reflects effect of uncertain durations on cost

Effect of Uncertainty on Finish Date

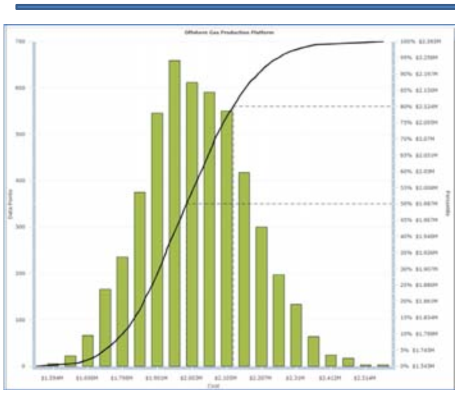


Deterministic Finish Date 4/4/20

P-80 Finish Date 9/1/20

Effect = + 5 months

Effect of Uncertainty on Project Cost



Baseline = $1.69 billion

P-80 cost = $2.12 billion

Over cost = $427 million or 25%

Add Project-Specific Risks

- Risk is similar to "special causes" in six sigma
- "… special cause variation is caused by known factors that result in a non-random distribution of output…Special cause variation is a shift in output caused by a specific factor such as environmental conditions or process input parameters. It can be accounted for directly and potentially removed…" (http://www.isixsigma.com/dictionary/variation-special-cause/)
- Hence, pre-mitigated risks are the subject of risk mitigation workshops

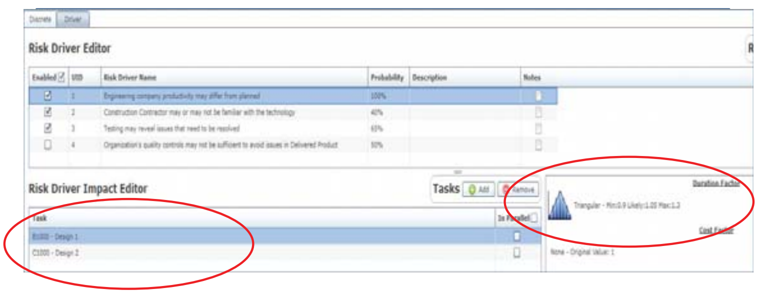
Risk Drivers (1)

- Each identified risk has a probability that it will occur with some effect on time or cost
- If the risk occurs it affects activities' durations and costs
  - If time-dependent resources (labor, rented equipment) it will vary the daily burn rate
  - If time-independent resources (equipment to be installed, material) it will affect the entire cost directly

Risk Drivers (2)

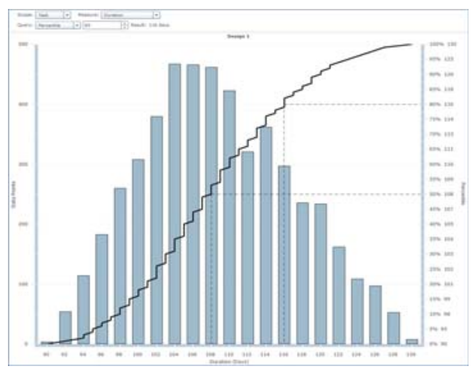
- A risk may affect multiple activities
- Activities may be affected by multiple risks
- If a risk driver occurs it has a multiplicative effect on the durations of the activities it affects
  - Multiplier < 1.0 ➔ shorter duration, opportunity
  - Multiplier > 1.0 ➔ longer duration, threat
- Multiplier is chosen at random from input distribution (usually 3-point estimate, triangle)

Introducing Risk Drivers that Cause Additional Variation in the Simulation



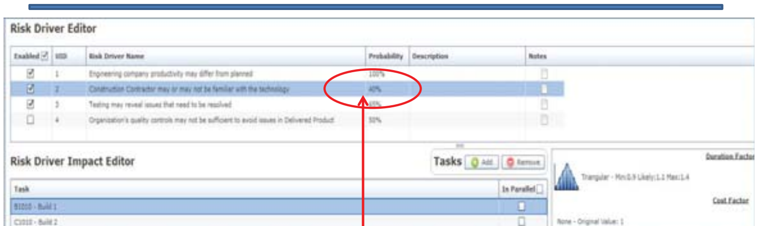
Four risk drivers are specified. The first is a general risk about engineering productivity, which may be under- or over-estimated, with 100% probability. It is applied to the two Design activities

100% Likely Risk Driver's Effect on Design Duration



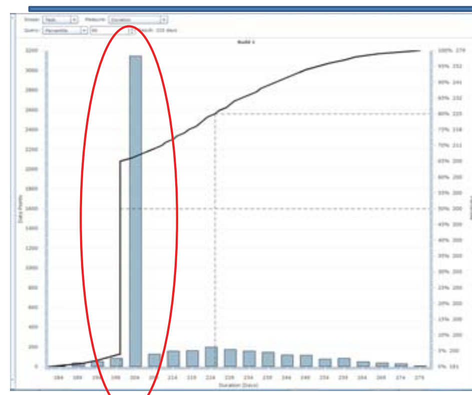
With a 100% likely risk the probability distribution of the activity's duration looks like a triangle. Not any different from placing a triangle directly on the activity

Risk Driver with Risk at < 100% likelihood



With this risk, the Construction Contractor may or may not be familiar with the technology, the probability is 40% and the risk impact if it happens is .9, 1.1 and 1.4. It is applied to the two Build activities

With a 40% Likelihood, the "Spike" in the Distribution Contains 60% of the Probability

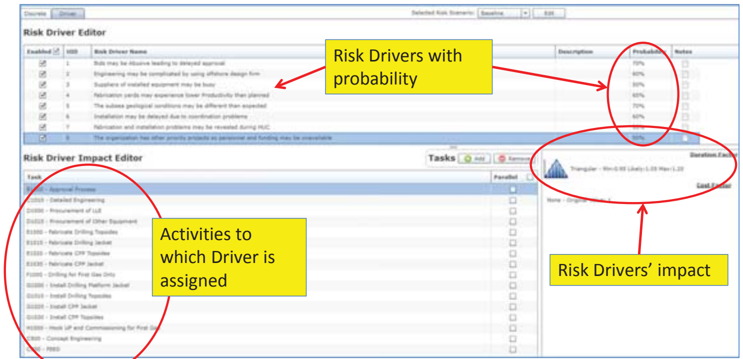


Here is where the Risk Driver method gets interesting. It can create distributions that reflect:

- Probability of occurring
- Impact if it does occur

Cannot represent these two factors with simple triangular distributions applied to the durations directly

Using Risk Drivers Method



Risk Factors Model How Correlation Occurs Coefficients are Calculated (1)

Risk Probability = .5,
Range .95, 1.05, 1.15

Activity 1 | Activity 2

Correlation = 100%

We are very bad at estimating correlation coefficients directly

Risk Factors Model How Correlation Occurs Coefficients are Calculated (2)

Risk Probability = .25,
Range .8, .95, 1.05

Risk Probability = .5,
Range .95, 1.05, 1.15

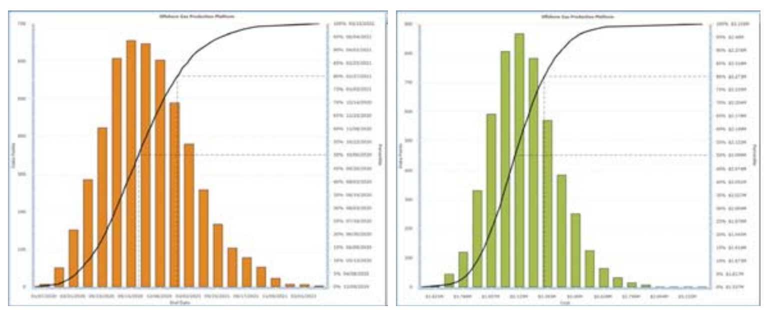
Risk Probability = .45,
Range 1.0, 1.10, 1.20

Activity 1 | Activity 2

Correlation = 37%

- Correlation is modeled as it is caused in the project
- Correlation coefficients are generated, not guessed
- Correlation drives the results correctly
- By modeling correlation we never get an inconsistent correlation coefficient matrix

What End Date and Cost should be put forward?

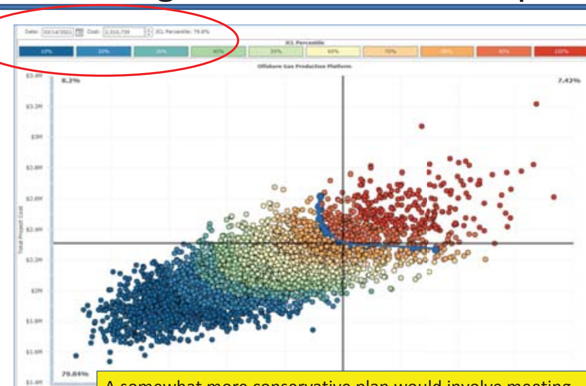


P-80 finish date is 1/27/21, adding another 5 months to the project
P-80 cost is $2.27 billion, adding another $150 million to the project from uncertainty
Is this enough?

Use the Time – Cost Scatterplot to Estimate Targets to meet BOTH Objectives

- The histograms / cumulative distribution functions estimate finish date and cost to meet each target individually
- To meet BOTH targets, use the scatterplot
- Meeting both targets requires a more conservative (later date, more cost) estimate
- How much more time and cost depends on their correlation

Plan to Meet BOTH Finish Date and Cost Targets from JCL Scatterplot

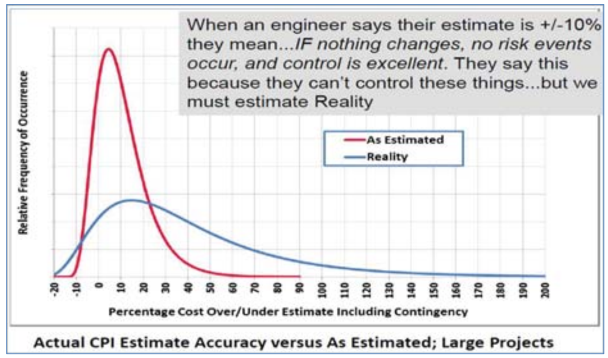


A somewhat more conservative plan would involve meeting BOTH time and cost targets, from the JCL Scatterplot

JCL-80 compared with P-80 Results

Histogram/Cumulative Distributions (P-80) and Joint Confidence Level (JCL-80) Results with Project-Specific Risks and Uncertainty		
	Baseline	
Finish Date	4/4/2020	
Budgeted Cost	$1.70	Billions
	Risk Analysis Results	
Schedule	Date	Months added
P-80	1/27/2021	9.8
JCL-80	3/14/2021	11.3
Difference	46	1.5
Cost	Billions	Dollars Added (billions)
P-80	2.27	$0.58
JCL-80	2.31	$0.61
Difference	0.04	

Compare what Risk Analysis Typically Predicts vs. What Actually Happens



Source: John K. Hollmann, PE, "Reliable Risk Quantification for Project Cost and Schedule", AACE International webinar December 15, 2015

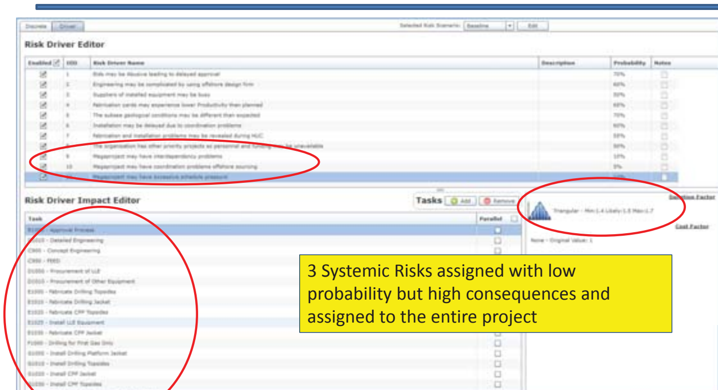
Incorporate Systemic Risks into the Monte Carlo Simulation (MCS)

- Systemic Risks that include:
  - Technical complexity, new technology challenging
  - Scope not fully known
  - Process definition not complete
  - Megaproject complexity, size / duration, participants
  - Project organization, e.g., joint venture, multiple EPCs
  - Project management, scheduling and estimating process, bias
- These factors can be measured and their impact on project success estimated using parametric techniques

Inserting 3 Systemic Risks

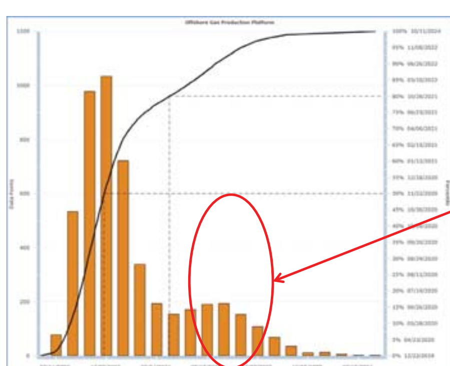
- Identifying the systemic risks and inserting them with appropriately-large impacts allows us to:
  - Specify the probability of occurrence
  - Identify the risks for risk mitigation
- In this case study, these megaproject risks:
  - May have interdependency issues between project elements
  - May have complex offshoring of supply chain and even EPC contractors
  - May have excessive schedule pressure "I want it sooner"

Adding Systemic Risks



3 Systemic Risks assigned with low probability but high consequences and assigned to the entire project

Complexity and Pressure Combined



Many projects are within tolerances (+ - 20%) but some have serious problems, with overruns nearer to 70%.

Hollmann, John, "Risk Analysis on the Edge of Chaos," Cost Engineering (© AACE International), January/February 2015

In our case: P-80 → 10/28/21 or about 19 months total
P-80 cost → 2.49 or about $793 million (47%) over baseline (without contingency)

Scatterplot with Systemic Risks Added

The 80th percentile is approaching the second mode in the histogram

JCL-80 finish date ➔ 2/7/22 or about 22.2 months beyond scheduled finish date

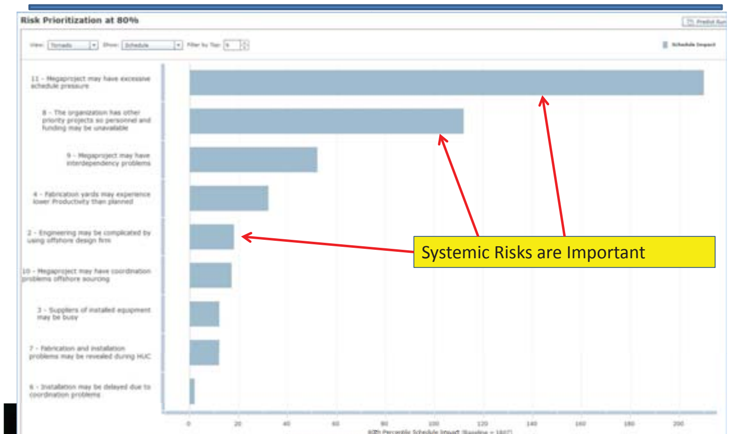
JCL-80 cost ➔ $2.57 billion or about +$873 million (+ 51%) from baseline

Picture of Prioritized Risks Selected by their Days Saved at P-80

Iterative Approach to Prioritizing Risks (Based on Days Saved at P-80)

Risk #	1	2	3	4	5	6	7	8
Priority Level (Iteration #)	Abusive Bids	Offshore design firm	Suppliers Busy	Fab productivity	Geology unknown	Coordination during Installation	Problems at HUC	Resources may go to other projects
1	X	X	X	X	X	X	X	1
2	X	X	X	2	X	X	X	
3	X	3	X		X	X	X	
4	X		X		X	X	4	
5	X		5		X	X		
6	X				X	6		
7	7				X			
8					8			

Risks Prioritized at the P-80 Confidence Level measured in "Days Saved"



Risks Prioritized to P-80 and Days Saved, plus Effect of Uncertainty

Risks Prioritized to P-80

Name	Days Saved
Megaproject may have excessive schedule pressure	210
The organization has other priority projects so personnel and funding may be unavailable	112
Megaproject may have interdependency problems	52
Fabrication yards may experience lower Productivity than planned	32
Engineering may be complicated by using offshore design firm	18
Megaproject may have coordination problems offshore sourcing	17
Suppliers of installed equipment may be busy	12
Fabrication and installation problems may be revealed during HUC	12
Installation may be delayed due to coordination problems	2
Bids may be Abusive leading to delayed approval	0
The subsea geological conditions may be different than expected	0
Contingency due to Project-Specific and Systemic Risks	467
Contingency due to Uncertainty	150
Total Contingency	617

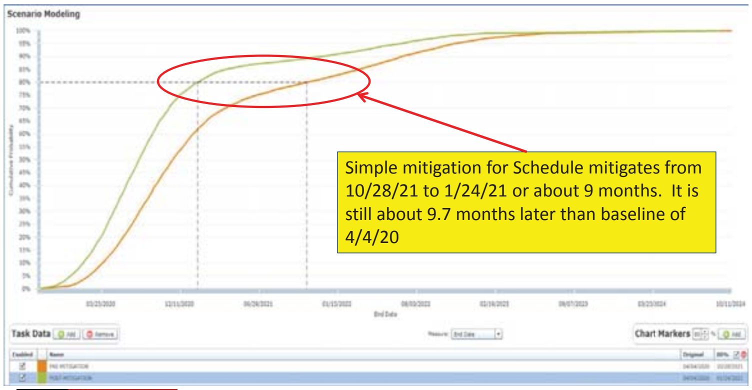
Risk Mitigation

- Risks can be mitigated but usually not completely
- Mitigation actions are:
  - New, not known to the interviewees, different from yesterday
  - Committed to by management so funded, staffed, monitored and reported on
- Once agreed to, estimate the owner, cost and timing of the mitigation
- Estimate the improvement to risk parameters

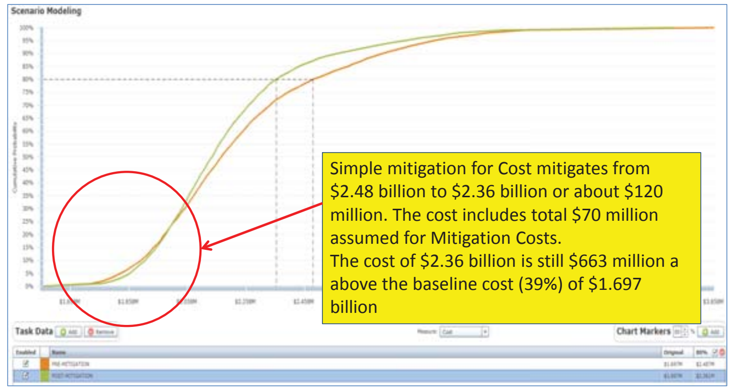
Mitigation Strategy and Simple Scenario

- Prioritize the risks according to days saved
- Recognize that as schedule risk is addressed, the indirect effect on cost risk will be good
- Each risk mitigation has a cost and that cost will be added, so cost risk will represent two conflicting forces
- Simple scenario,
  - Cut probability in half
  - Add $5 million to project specific risk cost and $10 million to systemic risk for cost of risk mitigation

Compare
Pre- and Post-Mitigation Schedule



Compare
Pre- and Post-Mitigation Cost



Summary

- Get a good schedule per GAO Best Practices
- Add costs as time-dependent and time-independent resources
- Interview for good Risk Data
- Model uncertainty
- Model project-specific and systemic risks using Risk Drivers
- Use JCL-80 as promise dates and costs
- Prioritize the risks @ P-80 and days saved
- Mitigate risks partially, recording mitigation costs
- Commit to the risk mitigations

Quantitative Cost-Schedule Risk Analysis in the 2015 LFM

2016 National Science Foundation Large Facilities Workshop May 25, 2016

David T. Hulett, Ph.D., FAACE
Hulett & Associates, LLC
Los Angeles, CA

CTSC
CENTER FOR TRUSTWORTHY SCIENTIFIC CYBERINFRASTRUCTURE
The NSF Cybersecurity Center of Excellence

The NSF Cybersecurity Center of Excellence and Large Facility Cybersecurity

James A. Marsteller
NSF Large Facilities Workshop
25 May 2016

trustedci.org

Center for Trustworthy Cyberinfrastructure
The NSF Cybersecurity Center of Excellence

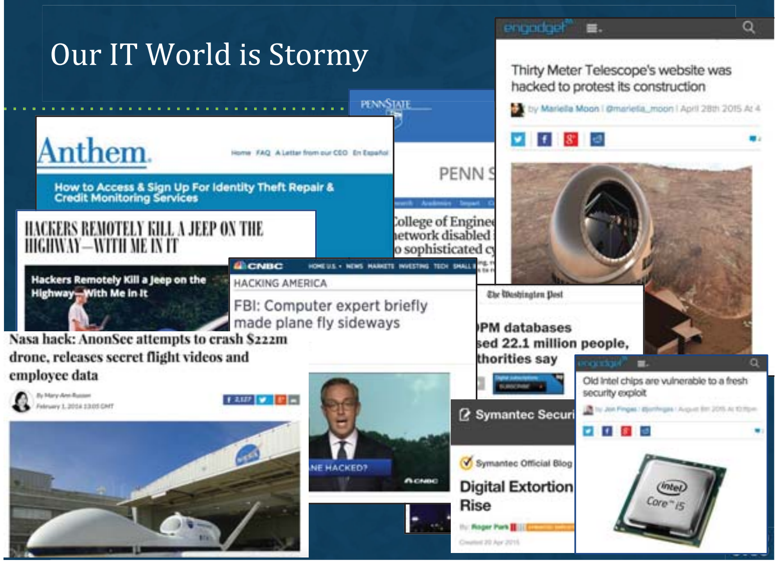
The mission of CTSC is to provide the NSF community with a coherent understanding of cybersecurity, its importance to computational science, and what is needed to achieve and maintain an appropriate cybersecurity program.

CENTER FOR APPLIED CYBERSECURITY RESEARCH
INDIANA UNIVERSITY
NCSA
PITTSBURGH SUPERCOMPUTING CENTER
THE UNIVERSITY OF WISCONSIN MADISON
NSF

The Cybersecurity Challenge to NSF Science

Science Must be Trusted and Reproducible

Our IT World is Stormy



Science Happens on a Complicated Ecosystem

Science!

Distributed Scientific Community

NSF Cyberinfrastructure (IT++)

Multiple Universities and/or Research Orgs (IT and policies)	CI, R&E, and Commercial Services	CI and Open Source Software	R&E Networks	…

Requirements, Risks

Services, Risks, Policies

Cybersecurity + Science Workforce?


Forbes / Tech

Top 20 Stocks for 2016

JAN 2, 2016 @ 09:06 AM 81,800 VIEWS

One Million Cybersecurity Job Openings In 2016

Steve Morgan, CONTRIBUTOR

I write about the business of cybersecurity.

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FULL BIO

http://www.forbes.com/sites/stevemorgan/2016/01/02/one-million-cybersecurity-job-openings-in-2016/

How does computational science navigate all of this?

Cybersecurity Programmatic Goal

<u>Minimize:</u>

Cost of breaches/incidents

+

Cost of cybersecurity program

+

Negative impact on science productivity

Test paraphrased from: "The Defender's Dilemma. Charting a Course Toward Cybersecurity" http://www.rand.org/pubs/research_reports/RR1024.html

Images from NIST's "Framework for Improving Critical Infrastructure Cybersecurity"

Caution: "Our data is public" doesn't save the day

Reputation, trust, and other "intangibles" matter.

Integrity and availability of data

Illicit use of systems

Availability of instruments

Hacktivism

Etc.

Understand where to focus

Know key liabilities and assets critical to science mission and can put focus there.

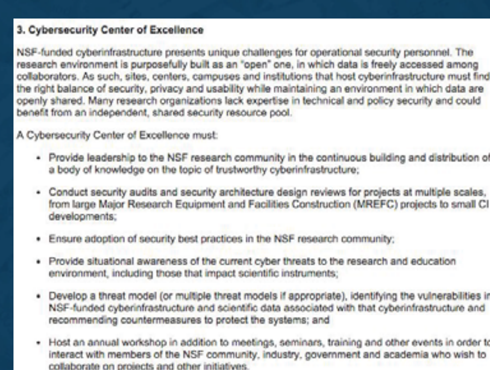
Critical assets. Deep thinking here.

Non-critical assets. Apply baseline controls and practices

NSF Cybersecurity Center of Excellence (CCoE)

NSF 2015 Cybersecurity Innovation for Cyberinfrastructure (CICI) solicitation created the NSF CCoE.

CTSC submitted a proposal and was awarded this honor.


3. Cybersecurity Center of Excellence

NSF-funded cyberinfrastructure presents unique challenges for operational security personnel. The research environment is purposefully built as an "open" one, in which data is freely accessed among collaborators. As such, sites, centers, campuses and institutions that host cyberinfrastructure must find the right balance of security, privacy and usability while maintaining an environment in which data are openly shared. Many research organizations lack expertise in technical and policy security and could benefit from an independent, shared security resource pool.

A Cybersecurity Center of Excellence must:

- Provide leadership to the NSF research community in the continuous building and distribution of a body of knowledge on the topic of trustworthy cyberinfrastructure;
- Conduct security audits and security architecture design reviews for projects at multiple scales, from large Major Research Equipment and Facilities Construction (MREFC) projects to small CI developments;
- Ensure adoption of security best practices in the NSF research community;
- Provide situational awareness of the current cyber threats to the research and education environment, including those that impact scientific instruments;
- Develop a threat model (or multiple threat models if appropriate), identifying the vulnerabilities in NSF-funded cyberinfrastructure and scientific data associated with that cyberinfrastructure and recommending countermeasures to protect the systems; and
- Host an annual workshop in addition to meetings, seminars, training and other events in order to interact with members of the NSF community, industry, government and academia who wish to collaborate on projects and other initiatives.

http://www.nsf.gov/pubs/2015/nsf15549/nsf15549.htm

CTSC Activities

Engagements (LF)
LIGO, SciGAP, IceCube, Pegasus, CC-NIE peer review, DKIST, LTERNO, DataONE, SEAD, CyberGIS, HUBzero, Globus, LSST, NEON, U. Utah, PSU, OOI, U. Oklahoma, Gemini….

Education, Outreach and Training
Guide to Developing Cybersecurity Programs for NSF Science and Engineering Projects, Securing Commodity IT in Scientific CI Projects Baseline Controls and Best Practices, Training for CI professionals.

Leadership
Organized 2013, 2014 & 2015 Cybersecurity Summits for Large Facilities and CI, Incident response, Identity Management.

New CTSC Activities as CCoE

Expanded situational awareness service
http://trustedci.org/situational-awareness/
(Large Facility participation requested - more on this later!)

Annual community benchmarking survey

Software assurance
http://trustedci.org/software-assurance/

Threat model for open science
http://trustedci.github.io/OSCTP/

Tailoring resources for smaller / newer projects

Identity and access management (IAM)
http://trustedci.org/iam/

CTSC Goals as a CCoE

1. For the NSF science community to understand fully the role of cybersecurity in producing trustworthy science.
2. For all NSF projects and facilities to have the information and resources they need to build and maintain effective cybersecurity programs appropriate for their science missions, and responsive to evolving risks and requirements.
3. For all Large Facilities to have highly effective cybersecurity programs.

CTSC & Large Facilities

Our Strategic 3-Year Goal for LFs

For all Large Facilities to have highly effective cybersecurity programs

Let's unpack this.

For all Large Facilities to have highly effective cybersecurity programs.

- As of May 2016, there are 28 LFs listed on the LFO's site. https://nsf.gov/bfa/lfo/
- We've had contact (engagements, summit) with 21 of the LFs.
- That leaves 7 LFs with whom we have not had an opportunity to engage or interact, or we remain unsure of how/whether to reach out….

For all Large Facilities to have highly effective cybersecurity programs.

We've not yet developed a relationship with:

1. Arecibo Observatory (AO)
2. Academic Research Fleet (ARF)
3. Alaska Region Research Vessel (ARRV)
4. Regional Class Research Vessel (RCRV)
5. Geodesy Advancing Geosciences and EarthScope (GAGE)
6. National Nanotechnology Coordinated Infrastructure (NNCI)
7. Seismological Facilities for the Advancement of Geosciences and EarthScope (SAGE)

For all Large Facilities to have highly effective cybersecurity programs.

Bottom line:

We think we can and should be interacting with all the LFs.

For all Large Facilities to have highly effective cybersecurity programs.

The Information Security article of the Cooperative Agreement Supplemental Financial & Administrative Terms and Conditions (CA-FATC) calls for a written summary describing a program.

In our own practice and in working with LF's, the "program" concept has been critically helpful in structuring ongoing security activities and projects.

Security for all information technology (IT) systems employed in the performance of this award, including equipment and information, is the awardee's responsibility. Within a time mutually agreed upon by the awardee and the cognizant NSF Program Officer, the awardee shall provide a written Summary of the policies, procedures, and practices employed by the awardee's organization as part of the organization's IT security program, in place or planned, to protect research and education activities in support of the award.

The Summary shall describe the information security program appropriate for the project including, but not limited to: roles and responsibilities, risk assessment, technical safeguards, administrative safeguards, physical safeguards, policies and procedures, awareness and training, and notification procedures in the event of a cyber-security breach. The Summary shall include the institution's evaluation criteria that will measure the successful implementation of the IT Security Program. In addition, the Summary shall address appropriate security measures required of all subawardees, subcontractors, researchers and others who will have access to the systems employed in support of this award.

The Summary will be the basis of a dialogue which NSF will have with the awardee, directly or through community meetings. Discussions will address a number of topics, such as, but not limited to, evolving security concerns and concomitant cyber-security policy and procedures within the government and at awardees' institutions, available education and training activities in cyber-security, and coordination activities among NSF awardees.

How do facilities go from having a program to have highly effective cybersecurity program?

For all Large Facilities to have highly effective cybersecurity programs.

Large Facilities Manual: NSF 15-089 (June 2015)

5.3 Guidelines for Cyber-Security of NSF's Large Facilities

"NSF has responsibility for oversight of facilities it constructs and operates, including associated IT Infrastructure. This section, to be written, will describe what NSF considers to be a fundamental set of IT security requirements that facilities should consider in developing and deploying their IT plans, policies and procedures. These minimal requirements and their associated evaluation criteria, as provided by the facility and agreed to by NSF, are used as part of NSF's facility oversight and review process. This module will document NSF's expectation for the recipient and PO oversight for the implementation and monitoring of cyber-security best practices. These expectations extend over the full life cycle of an award, and are appropriately modified as the award passes through various stages of its life cycle."

CTSC submitted a proposed version of the section to the Large Facilities Office.

For all Large Facilities to have highly effective cybersecurity programs.

In our experience, as both security practitioners and NSF community members, these are some of the features of security programs that inspire confidence.

1. A budget for both personnel and tools
2. Defined governance and risk acceptance processes
3. A CISO or similar role with defined authority
4. An adopted framework (e.g., CTSC's Guide, SANS Top 20, NIST Framework, NIST RMF, ISO)
5. Coordination of identity and access management (IAM).

New CCoE Activity: Providing Situational Awareness

Advise NSF LFs about relevant software vulnerabilities and provide guidance on mitigation.

Leverage NIST, US-CERT, XSEDE, REN-ISAC, and other sources of vulnerability information.

Please subscribe to the email list(s) to receive situational awareness notifications of relevance to you.

Goal: 90% participation from LFs

http://trustedci.org/situational-awareness/

IAM challenge for LFs: Enabling multi-organization, multi-national collaborations

CTSC IAM activities include:

- Engagements
- Sharing best practices and lessons learned
  - Blog posts, training, webinars
- Coordination with:
  - InCommon/Internet2
  - GÉANT/TERENA/REFEDS/AARC (EU Collaboration)
- Gathering community input (Summit, email lists)

trustedci.org/iam

InCommon went international in February!

CTSC & LIGO engagement launched InCommon's interfederation working group in 2013.

blog.trustedci.org/2013/01/interfed.html

incommon.org/edugain/

How will CTSC help Large Facilities?

We know we're moving forward on these:

1. One on one engagements
2. Facilitating a community of practice around infosec
3. Organizing community activities and events (the Summit)
4. Training (like we've done with the Guide)
5. Better integrating IAM into our programmatic training
6. Developing a community survey
7. LF Manual Subsection
8. *Building on our reputation as a trusted partner and resource*

For all Large Facilities to have highly effective cybersecurity programs.

What would be helpful to CTSC's effort?

1. Contacts and connections with the facilities that are not engaged in events like the summit.
2. Support for Large Facility Community of Practice around information security.
3. Benchmarking data on cybersecurity (e.g., personnel budgets).
4. Feedback on Large Facilities challenges regarding information security.
5. Other suggestions, feedback, and comments are welcomed..

NSF Cybersecurity Summit

- Inaugural summit in 2004 in response to cyber attack affecting many NSF funded projects
- CTSC Relaunched Summit in 2013 after 4 year hiatus
- Opportunity for CI, MREFCs to collaborate: solve common challenges, develop best practices, share experiences/knowledge, training sessions
- Help to address the changing threat landscape for NSF CI

2015 Summit Highlights

"Understanding the Information Assets that Enable Science"

- 90 Participants
- Significant growth in Call For Participation (17 submissions) had more proposals than available time
- Attendee evaluations and feedback were overwhelmingly positive - 95% rating summit as "good" or "excellent"
- Expanded training program to full day

2016 Summit Call For Participation (CFP)

Now accepting community proposals:

- Plenary Presentations
- Training Sessions
- Table Talk Sessions
- Student Program
- CFP Deadline June 3rd

Seeking CFPs addressing:

- Budgeting for Cybersecurity
- Cybersecurity Metrics
- Risk Acceptance Practices
- Software Assurance

Email CFPs (1-5 pages) to CFP@trustedci.org
More information: http://trustedci.org/2016-nsf-cfp/

2016 NSF Cybersecurity Summit:

August 16-18, 2016 - Arlington, Virginia

http://trustedci.org/summit

CTSC
CENTER FOR TRUSTWORTHY SCIENTIFIC CYBERINFRASTRUCTURE
The NSF Cybersecurity Center of Excellence

Thank You

trustedci.org
@TrustedCI

We thank the National Science Foundation (grant 1547272) for supporting our work.

U.S. DEPARTMENT OF ENERGY

Project Management Career Development Program (PMCDP)

http://www.energy.gov/projectmanagement/project-management-career-development-program

Linda Ott
Linda.ott@hq.doe.gov 202-287-5310
Professional Development Division,
Office of Project Management
Oversight and Assessments

May 2016

Agenda

Project Management Career Development Program (PMCDP)

- PMCDP Background and Principles
- Competency Based: Training and Experience Requirements
- Value Proposition
- Certification Review Board (CRB)
- Performance Metrics and Statistics
- Challenges and Issues

PMCDP Background

- GAO High-Risk List for "Contract (Project) Management" since 1990
- National Research Council (1999) recommended establishment of Department-wide training program
- Deputy Secretary (September 2003) directed development and implementation of PMCDP
- Congress funded PMCDP (2001, CRPT 106-907) and recommended central funding of PMCDP (2005, CRPT 108-212)
- Secretary (2005) directed Programs to determine current number and assess future needs

PMCDP Guiding Principles

- Promote project management excellence
- Develop gold-star project management personnel development standard
- Tough, flexible, and fair – best program in government
- Instill continuous improvement and learning – it is a development program
- FPD advancement is more than just taking classes; it is demonstrated experience, performance, leadership and communication skills

Importance of Effective, Formal Project Management: Why We Care

- DOE manages some of the largest, most complex, and technically challenging projects in public or private sector
  - 35 projects over $100M
  - DOE has been on GAO's High-Risk list for project management since 1990
    - We have shown some improvement
      - For example, SC removed from high-risk list in 2009
    - Remaining projects of high concern to GAO are EM and NNSA projects $750M or greater

Project Management Has the Secretary's attention

- Secretary Moniz established a special working group in 2013 which culminated in the Improving Project Management report
- Recommendations
  - Institutionalize Secretarial memoranda on improving Project Management for the DOE enterprise

New Push to Further Improve Project Management (cont.)

- Additional recommendations from Improving Project Management
  - Improve the lines of responsibility and the peer review process
    - Designating a clear project owner and clear lines of functional authority
    - Establishing a project assessment office that does not have line responsibility for project execution, but will conduct programmatic peer reviews

PMCDP Competency Based Program (Training or Experience)

- FPD must demonstrate familiarity-, working-, or expert-level knowledge of listed competencies: (Total of 62 competencies)
  - General Project (8) Management
  - Leadership/Team Building (5)
  - Scope Management (4)
  - Communication (3) Management
  - Quality/Safety (3) Management
  - Cost Management (4)
  - Time (Schedule) (3) Management
  - Risk Management (3)
  - Contract Management (6)
  - Integration Management (5)
  - Related Course Electives (13)
  - Behavioral (5)
  - Work and Developmental Requirements

PMCDP Coursework
Level of Effort

Years (Project Mgmt Experience)	FPD Level	Classroom (Hours)	Desktop Adobe Connect (Hours)	On-line 24x7 (Hours)	TOTAL (Hours/Days) (Includes Electives)
	Level IV	--	--	--	--
8	Level III	212	48	0	260/32
4	Level II	208	50	24	282/35
2	Level I	156	88	106	350/43
1	TOTAL	576	186	130	892/110

Note: All classroom competencies can be satisfied via experience, as documented. Some waived by other credentials (i.e., PE, PMP, etc.). At each level, requirements move from prescribed training to execution and demonstrated performance.

PMCDP Program Directives and Guidance – A Mature Framework

- DOE Order 361.1C Acquisition Career Management Program
- Certification and Equivalency Guidelines
- Acquisition Certifications Program Handbook
- PMCDP Training Curriculum Map
- PMCDP Website: http://www.energy.gov/projectmanagement/project-management-career-development-program

Certification Review Board

- Grants federal project director certifications and develops PMCDP policies, training and certification requirements
- Co-chaired by PM and NNSA; total (7) members with Reps from EM, SC, and NNSA
- Meets monthly and also convenes "virtual" certification approval sessions (Level I/II only)
- Conduct interviews and requests reference checks for Level III/IV candidates

Challenges & Issues

- Getting level III & IV FPDs on the right project at the right time
- Ease of application – documenting competencies and experience
- How to enculturate a mature project manager from another agency or from industry to the DOE FPD environment?

Questions?

Visit our website
http://www.energy.gov/projectmanagement/project-management-career-development-program

2016 NSF Large Facilities Workshop

New Initiatives

Business Roundtable II-III

May 25-26, 2016

Jeff Lupis, Division Director, *Division of Acquisition and Cooperative Support*

jlupis@nsf.gov (703) 292-7944

Purpose of Briefing:

- Discuss background and context of the current environment of strengthened cost oversight of NSF large facility awards
- Discuss four specific areas of strengthened cost oversight
- Solicit awardee insights and concerns with the award oversight process
- Look to improve the business oversight process going forward

Background/Context

- In 2004, responsibility for large facility cooperative agreements was moved to the "Division of Contracts and Complex Agreements"
- In FY 2010, NSF's Financial Statement Audit cited a large facility cooperative agreement where $88M in questioned contingency costs were reported
- Beginning in FY 2011, NSF's Financial Statement Audit has included a Significant Deficiency titled "Monitoring of Construction Type Cooperative Agreements," expanding findings from the 2010 audit
- NSF's efforts to ensure the proper level of cost oversight, as well as outside concerns raised by NSF Stakeholders, has driven a close examination and strengthening of business procedures for managing these awards

Background/Context (Cont.)

- OIG Alert Memo "NSF's Management of Cooperative Agreements," (Sept. 2012) highlighted concerns with both pre-award and post-award monitoring processes. Recommendations for awards over $50M included:
  - ✓Obtaining proposal and accounting systems audits for all planned large facility cooperative agreements
  - ✓Requiring annual incurred cost submissions and audits
  - ✓Requiring awardees to properly account for and separately track budgeted versus actual contingency use
- The OIG has issued additional alert memos and audit reports highlighting concerns under specific NSF large facility awards

Four Areas of Strengthened Procedures:

- Proposal and Accounting System Reviews/Audits
- Incurred Cost Audits
- Contingency Management
- Risk-Based End-to-End Cost Surveillance Policies

Proposal and Acct. System Reviews/Audits

Strengthened Procedure:

More detailed pre-award evaluation of proposal cost estimates and review (or audit) of awardee cost accounting systems/practices prior to awarding CAs

Implementation:

- NSF Standard Operating Guidance (SOG) requires the completion of a Cost Proposal Review Document (CPRD) for all awards over $100M, documenting cost analysis and review of awardee's accounting system
- Thorough review of the budget estimate will be completed on a cost element basis (FDR stage)
- Guidance updated in 2015 to include reviews at CDR and PDR phases

Proposal and Acct. System Reviews/Audits (Cont.)

- Additional guidance included in Large Facilities Manual on format and detail required for construction and operations proposals
- Supportability of proposal is key
- Proposal audits are to be obtained when determined necessary
- NSF will execute independent cost assessments for construction awards > $100M
- The CPRD will document review of awardee accounting system

  Note: NSF will obtain audits of awardees' accounting systems/practices prior to entering into construction CA's totaling $100M or more, where NSF is the cognizant agency and such an audit has not been performed within the past two years.

Proposal and Acct. System Reviews/Audits (Cont.)

Note: 2 CFR 200 requires that agencies awarding cooperative agreements must have in place a framework for evaluating the risks posed by applicants before they receive Federal awards. Examples of areas to be reviewed include:

- Financial stability
- History of performance
- Reports and findings from audits performed under the Uniform Guidance Audit Requirements and findings from any other available audits

Incurred Cost Audits

<u>Strengthened Procedure</u>:
Requirements for incurred cost audits

<u>Implementation</u>:

- NSF will require, at a minimum, a final review of incurred costs at project completion for large facility projects totaling $100M or more
- NSF will use risk analysis on a project-by-project basis to determine whether additional incurred cost audits are needed during a project
- NSF committed to explore best practices and to complete an analysis and recommendation for awardee cost submissions (now completed)

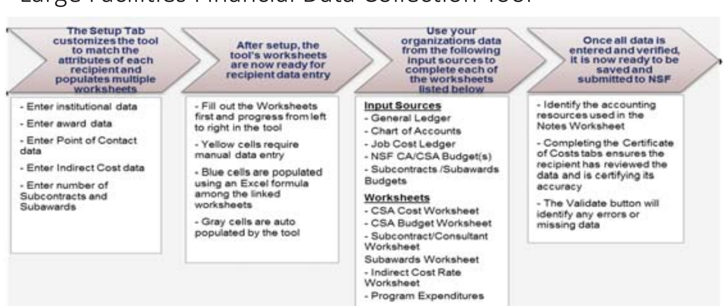
Incurred Cost Audits (Cont.)

- Pre-award, the CPRD requires an initial determination of the need for an incurred cost audit
- Post-award, a separate SOG has institutionalized NSF's project-by-project annual review of the need for incurred cost audits during performance
- With transition of audit process to NSF's cognizance (and unavailability of DCAA to complete audits), NSF is working to obtain audit support services
- Recipients should be prepared for such an audit at any time based on requirements set forth in 2 CFR 200
- NSF completed a review of best practices for incurred cost submissions and determined a perspective award provision and cost data collection tool

Incurred Cost Audits (Cont.):

- In preparation for a cost incurred audit, recipients will be required to submit financial expenditures (incurred cost) data to NSF
- The Financial Data Collection Tool was created by NSF to assist recipients in preparing and recording financial expenditure information
- This tool will be required for submission of the financial expenditures data
- The Financial Data Collection Tool is a macro-enabled Excel workbook that provides recipients a single, standardized method for submitting cost data

Incurred Cost Audits (Cont.):
Large Facilities Financial Data Collection Tool



Large Facility Financial Data Collection Tool

Yellow Cells:	Manual fill by user
Blue Cells:	Linked from other report tabs
Gray Cells:	Auto-calculated

Recipient Name (pull from set up)

Name of Facility (pull from set up)

Report Period Start:
Report Period End:

Cooperative Support Agreement (CSA) Cost Schedule

Select CSA Type

Enter CSA #

Claimed Direct Costs
by Budget Category

	Reconciliation of Claimed Expenditures to Job Cost Ledger				
	General Ledger	Job Cost Ledger	Adjustment	Current Claimed	Comment
Senior Personnel	$ -	$ -	$ -	$ -	
Other Personnel	$ -	$ -	$ -	$ -	
Total Salaries and Wages	$ -	$ -	$ -	$ -	
Fringe Benefits	$ -	$ -	$ -	$ -	
Total Salaries/Wages/Benefits	$ -	$ -	$ -	$ -	
Equipment	$ -	$ -	$ -	$ -	
Travel	$ -	$ -	$ -	$ -	
Participant Support	$ -	$ -	$ -	$ -	
Other Direct Costs: Materials and Supplies	$ -	$ -	$ -	$ -	
Other Direct Costs: Publication/Documentation/Dissemination	$ -	$ -	$ -	$ -	
Other Direct Costs: Consultant Services	$ -	$ -	$ -	$ -	
Other Direct Costs: Computer Services	$ -	$ -	$ -	$ -	
Other Direct Costs: Subawards	$ -	$ -	$ -	$ -	
Other Direct Costs: Other	$ -	$ -	$ -	$ -	
Total Other Direct Costs	$ -	$ -	$ -	$ -	
Total Direct Costs	$ -	$ -	$ -	$ -	
Indirect Costs: F&A	$ -	$ -	$ -	$ -	
Indirect Costs: G&A	$ -	$ -	$ -	$ -	
Indirect Costs: Name	$ -	$ -	$ -	$ -	
Total Indirect Costs:	$ -	$ -	$ -	$ -	
Total Direct and Indirect Costs:	$ -	$ -	$ -	$ -	

Recipient Preparation Notes

Please enter any notes or comments regarding your calculations or the data submitted for this worksheet.

Incurred Cost Audits (Cont.):

Large Facilities Financial Data Collection Tool

The Large Facilities Manual and the Large Facilities Financial Data Collection Tool can be viewed on the public NSF webpage at:

https://www.nsf.gov/bfa/lfo/lfo_documents.jsp

To provide comments on the Large Facilities Manual and the Large Facilities Financial Data Collection Tool, please go to the Federal Register at:

https://www.gpo.gov/fdsys/pkg/FR-2016-05-09/pdf/2016-10793.pdf

Contingency

Strengthened Procedure:

Contingency management

Implementation:

- Standardized guidance for contingency estimating in the Large Facilities Manual
- Supportability of the estimate is key
- NSF Completed a review of the controls and thresholds for the Change Control Board (CCB) process

Contingency (Cont.)

- Standardized reporting of contingency in monthly project reports and the bi-monthly large facilities status report
- New standardized award provision to clearly identify the NSF approved contingency budget and incremental allocations to the Recipient
- New SOG to incorporate the NAPA recommendation that NSF retain control of a portion of contingency (up to 100%) based on the circumstances of the award

End-to-End Cost Surveillance Policies

Strengthened Procedure:

Development of a risk-based approach for end-to-end cost surveillance

Implementation:

- NSF chose the threshold of $100M to focus on the highest risk awards
- NSF committed to expand the scope of strengthened procedures to large facility operations by September 15, 2015 (completed)
- After implementation, NSF will invite a qualified third-party organization to evaluate the results

End-to-End Cost Surveillance Policies

- BFA continues to strengthen cost estimating and cost monitoring oversight procedures through issuance and update of numerous SOGs, e.g.,:
  - ✓SOG 15-1 Negotiation, Award and Payment of Management Fee
  - ✓SOG 15-6 Guidance on Pre and Post-Award Cost Monitoring Procedures
  - ✓SOG 16-2 Budget Contingency Obligation and Allocation
  - ✓SOG 16-4 DACS CSB Standardized Cost Analysis Guidance
- NSF is further evaluating cost oversight procedures considering subsequent internal evaluation and Stakeholder input

Additional Issues Identified

Additional issues identified through:

- Internally determined areas for improvements
- Ongoing interactions with Stakeholders
- National Academy of Public Administration (NAPA) Report "Use of Cooperative Agreements to Support Large Scale Investment in Research"

Additional issues include but are not limited to:

- Proper use of management fee
- Conducting awardee estimating system reviews

Questions?

Concerns?

Other Issues?

Appendix D: Presentations

## D.3	Thursday May 26, 2016

NASA Johnson Space Center – Exploration Mission Planning Office
Stephen J. Hoffman, Ph.D. | Science Applications International Corporation | NASA's Johnson Space Center
Larry Toups | NASA Johnson Space Center

Agenda

- Introduction
- How Do We Plan to Explore Mars
- Mars Environment
- Mission Planning Basics
- NASA's Evolvable Mars Campaign

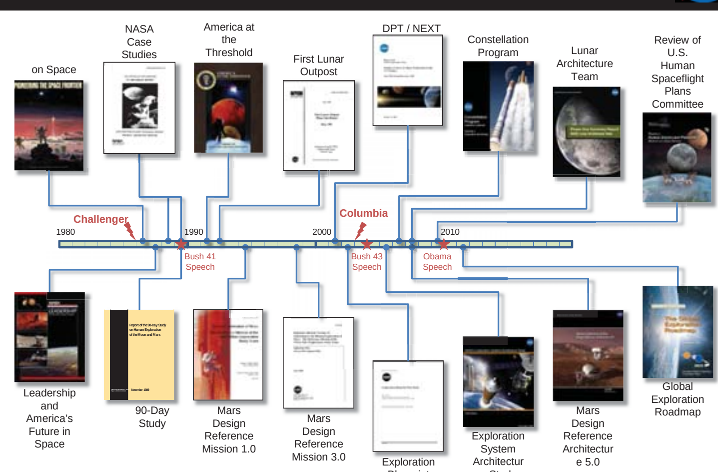
Evolvable Mars Campaign Development

INTRODUCTION

Why Do We Want To Explore Mars?

- **Long-standing curiosity, particularly since it appears that humans could one day visit there**
- **Current scientific goals (developed by MEPAG, a NASA chartered group):**
  - Determine if life ever arose on Mars
    - Characterize past habitability and search for evidence of ancient life
    - Characterize present habitability and search for evidence of extant life
    - Determine how the long-term evolution of Mars affected the physical and chemical environment critical to habitability and the possible emergence of life
  - Understand the processes and history of climate on Mars
    - Characterize Mars' atmosphere, present climate, and climate processes under current orbital configuration
    - Characterize Mars' recent climate and climate processes under different orbital configurations
    - Characterize Mars' ancient climate and climate processes
  - Determine the evolution of the surface and interior of Mars
    - Determine the nature and evolution of the geologic processes that have created and modified the Martian crust
    - Characterize the structure, composition, dynamics, and evolution of Mars' interior
    - Understand the origin, evolution, composition and structure of Phobos and Deimos.
- **Prepare for human exploration**
  - Obtain knowledge of Mars sufficient to design and implement a human mission with acceptable cost, risk and performance

A Brief History of Human Exploration Beyond LEO



Evolvable Mars Campaign – Study Activity

Body of Previous Architectures, Design Reference Missions, Emerging Studies and New Discoveries

- Internal NASA and other Government
- International Partners
- Commercial and Industrial
- Academic
- Technology developments
- Science discoveries

2010 Authorization Act, National Space Policy, NASA Strategic Plan

- Establish capacity for people to live and work in space indefinitely
- Expand human presence into the solar system and to the surface of Mars

Evolvable Mars Campaign

- An ongoing series of architectural trade analyses, guided by Strategic Principles, to define the capabilities and elements needed for a sustainable human presence on Mars
- Builds off of previous studies and ongoing assessments
- Provides clear linkage of current investments (SLS, Orion, etc.) to future capability needs

NASA's "Journey to Mars"

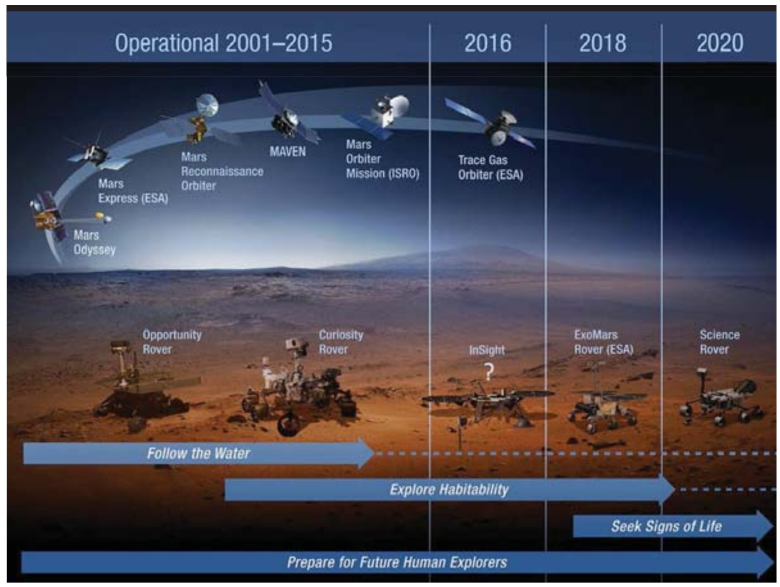
- **Currently the "Journey to Mars" is a long range vision to guide near term activities and investments – there is no line item in the NASA budget for a "Journey to Mars" program**
- **Studies supporting the Evolvable Mars Campaign are an ongoing series of architectural trade analyses, guided by Strategic Principles, to define the capabilities and elements needed for a sustainable human presence on Mars**
- **The infrastructure and operations on the surface of Mars will undoubtedly qualify as a "large scientific research facility" but specific facility management approaches and operations for this facility are still part of ongoing trades studies**
  - We are here to listen and learn about best practices and discuss options
- **Despite an "evolvable" approach, there are known physical and operational challenges that will constrain the Mars surface infrastructure**
  - This presentation will describe some of those challenges and some of the currently favored approaches being used

High Level Ground Rules and Assumptions for the EMC

- **First crew mission to Mars vicinity in 2030s - mission lays the foundation for later crew Mars surface missions**
  - Accommodate Mars Mission opportunities throughout the 2030s
  - All missions/crews return to the same location on the surface
- **Crew of 4 for Mars missions**
- **ARM / ARV SEP derived vehicle used for missions to Mars vicinity**
  - ACRM mission occurs in 2025
- **Use Lunar DRO as aggregation point for missions to Mars vicinity and Mars surface**
  - Use of Proving Ground foundational capabilities for Mars vehicle build-up and checkout
  - Use Lunar DRO for potential refurbishment and resupply location
- **Use test and validation missions as pre-deployment missions**
  - Emphasis on reducing the number of unique system developments
  - Maintain cadence of at least one crewed mission per year
  - Utilize SLS Block 1B co-manifested cargo capability to the greatest extent possible
  - 1 SLS crew flight per year in the Proving Ground
  - SLS Block 2B for Mars era missions
- **Utilize ISS to greatest extent possible for capability development**

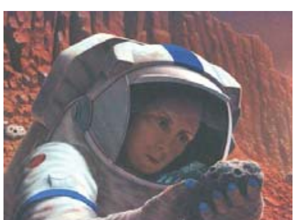
Evolvable Mars Campaign Development

HOW DO WE PLAN TO EXPLORE MARS



How to Capitalize on the Unique Attributes of Human Explorers

- **Human explorers bring unique abilities to exploration:**
  - Cognition
    - Rapidly recognize and respond to unexpected findings; sophisticated, rapid pattern recognition (structural/morphological biosignatures).
  - Dexterity
    - Humans are capable of lifting rocks, hammering outcrops, selecting samples, etc..
  - Adaptability
    - Humans are able to react in real time to new and unexpected situations, problems, hazards and risks.
  - Efficiency
    - Sample and equipment manipulation and problem solving.



What "Unknowns" need to be addressed?

<u>Known unknowns</u> (to achieve Earth independence) – examples include:

- Human physiology in the Mars environment
  - Gravity
  - Radiation
  - Dust (e.g., perchlorates)
- Plant/animal physiology in the Mars environment
  - Gravity
  - Radiation
  - Light
- Source of usable water
  - If in the form of H2O then where is it and how can it be collected
  - If in the form of hydrated minerals then where is it, how is the raw material collected, and what is the "best" process (given local environmental conditions and available infrastructure) to extract the water
- Martian civil engineering "best practices"
  - Surface preparation/stabilization
- Martian chemical engineering "best practices"
- TBD others

<u>Unknown unknowns</u>

- By definition unknown, but not unanticipated
- Surface infrastructure should be implemented in such a way that it is adaptable and has built-in margin to accommodate different (than originally planned) activities without requiring a complete redesign and redeployment

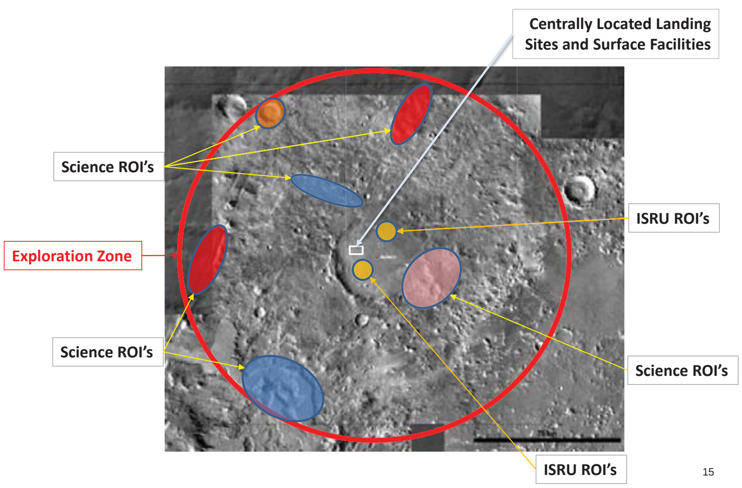
Exploration Zones, Regions of Interest, and Limits

- **Exploration Zone**
  - A collection of Regions of Interest (ROIs) that are located within approximately 100 kilometers of a centralized landing site
- **Region of Interest**
  - Areas that are relevant for scientific investigation and/or development/maturation of capabilities and resources necessary for a sustainable human presence
- **Latitude and Elevation limits**
  - Landing and ascent technology options place boundaries on surface locations leading to a preference for mid- to low- latitudes and mid- to low- elevations
  - Accessing water ice for science and ISRU purposes is attractive, leading to a preference for higher latitudes
  - Preliminary latitude boundaries set at +/- 50 degrees
  - Preliminary elevation boundary set at no higher than +2 km (MOLA reference)

Small Pressurized Rover

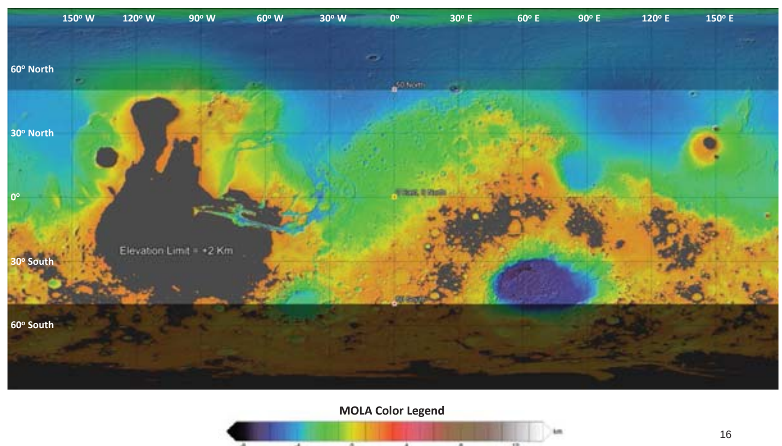
- Two crew
  - capable of carrying four crew in a contingency
- Two week duration without resupply
- ~400 km "odometer" range
  - 200 km out, 200 km back
  - Factor of 2 for actual distance over straight line distance
  - ***Results in ~100 km straight line range from starting point***

Example Mars Exploration Zone Containing Several Regions of Interest (ROI's)

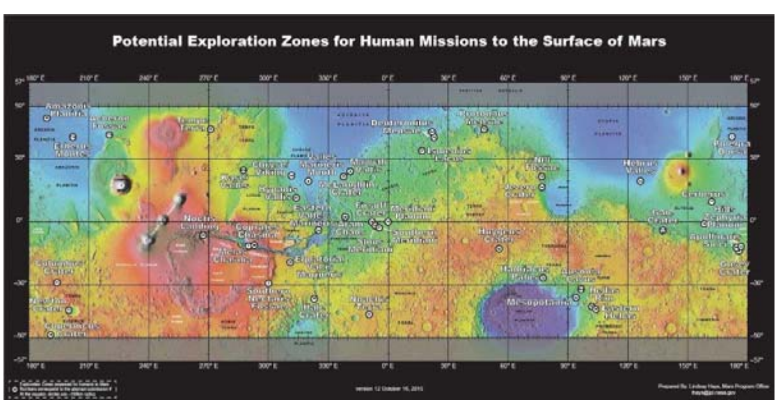


Preliminary Mars Surface Location Constraints for EZs

Elevation Limit = +2 km   Latitude Limits = +/- 50º

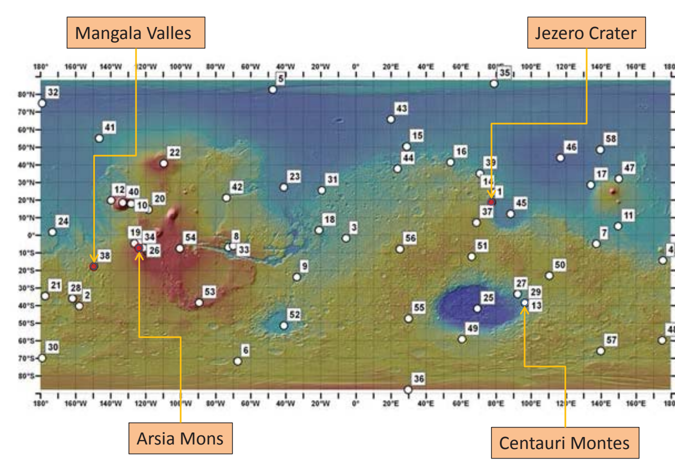


Exploration Zones Proposed at First EZ Workshop



This map is posted at http://www.nasa.gov/sites/default/files/atoms/files/exploration-zone-map-v10.pdf

HEM-SAG (Human Exploration of Mars – Science Analysis Group) candidate Mars landing sites



Bridging the Gap: A Mars Surface Field Station

- **Once the primary Emplacement objective – enabling crews to remain on the surface of Mars for 12 – 18 months – is achieved, this infrastructure and experience base will be used as the foundation for building capabilities needed for the Mars Surface Proving Ground phase**
- **These capabilities should give priority to investigating the known unknowns with flexibility to investigate unknown unknowns as they emerge.**
- **One well-established concept that is used to handle "unknowns" is the *field station* or *experiment station***
  - Field Stations bring the basic tools of research—from electricity to communication to community—to the places where research needs to be done
    - They provide access to the environment.
    - They provide logistical support for a wide range of activities including individual research projects; networking of research on larger scales; science, technology, engineering, and mathematics (STEM) training; and public outreach.
    - Through time they become environmental and operational models in which the steady accumulation of knowledge becomes a platform for future research.
  - *Field Stations* create a bridge between natural environments and [Earth-based] research laboratories. *Research laboratories* offer considerable power to conduct analyses in a predictable environment and to infer cause and effect from manipulative experiments, but they may miss factors that turn out to be critical in a natural environment. Field studies can encompass the full range of relevant interactions and scales, but they are not as tightly controlled. By offering access to both laboratories and field environments, Field Stations combine the best of both worlds.

Note: Adapted from Billick, I., et.al. 2013. Field Stations and Marine Laboratories of the Future: A Strategic Vision. National Association of Marine Laboratories and Organization of Biological Field Stations.

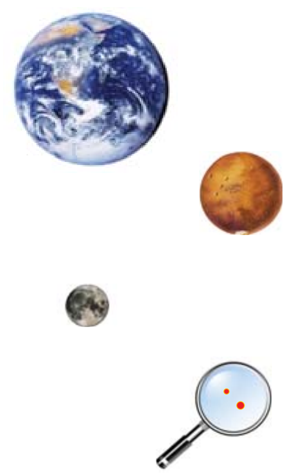
Mars Surface Field Station Capabilities "Scorecard"

- **EMC Assumptions**
  - Operational in the 2030s and beyond
  - Crew of four
  - Multiple visits to the same site
- **Research Support**
  - Physical sciences
  - Biological sciences
  - Atmospheric sciences
  - Human physiology
  - ISRU and civil engineering applied technology
- **Exploration Zone**
  - 100 km radius activity zone
  - +/- 50 deg. latitude
  - Less than 2 km elevation

Evolvable Mars Campaign Development

MARS ENVIRONMENT

Sizing Things Up



Earth
Diameter = 12800 km
Rotation period = 23.9 hrs
Axis Tilt = 23.5 deg

Mars
Diameter = 6800 km
Rotation period = 24.6 hrs
Axis Tilt = 25.2 deg

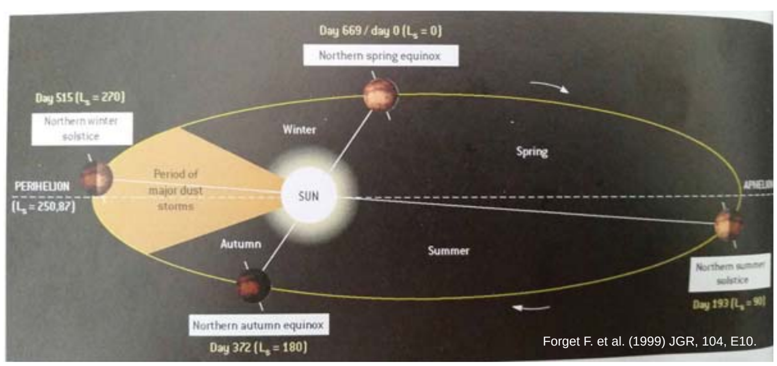
Moon
Diameter = 3500 km
Rotation period = synchronous

Phobos and Deimos
Diameter = ~25 km and ~15 km
Rotation period = synchronous

Some Atmosphere Charateristics

- **Pressure**
  - Averages 7.5 millibars. (1000 millibars at sea level on Earth) It can vary by 50% depending on the location on Mars and time of year.
- **Temperature**
  - Average temperature on Mars: −55 ° C (218 K; −67 ° F)
  - Nights are much colder than days
  - High: > 20 ° C (293 K; 68 ° F) (noontime at the equator)
  - Low: < −153 ° C (120 K; −243 ° F) (during the polar night)
  - Midlatitudes: - 20 ° C with a nighttime minimum of - 60 ° C
- **Humidity**
  - 100% during the night, when it is very cold, and varies during the day.
- **Wind**
  - Maximums measured by the Viking Landers was 30 m/s (60 mph), average of 10 m/s (20 mph). However, the wind is not strong.

Seasons on Mars



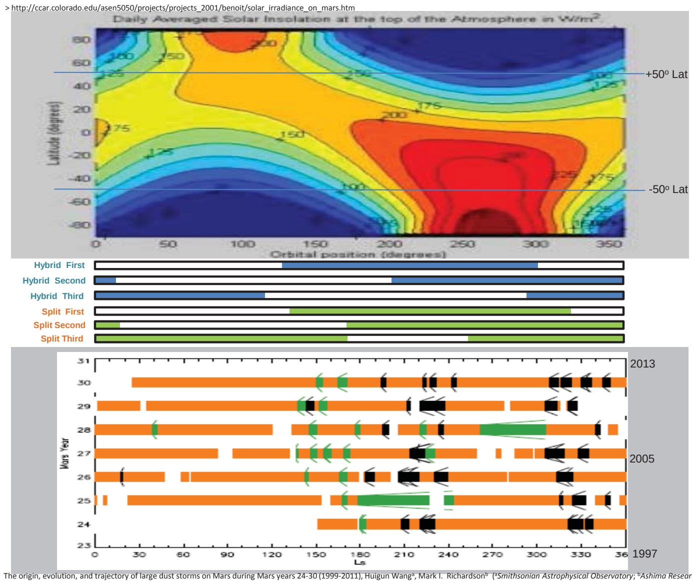
Forget F. et al. (1999) JGR, 104, E10.

The surface receives 40% more sunlight during perihelion than during aphelion.

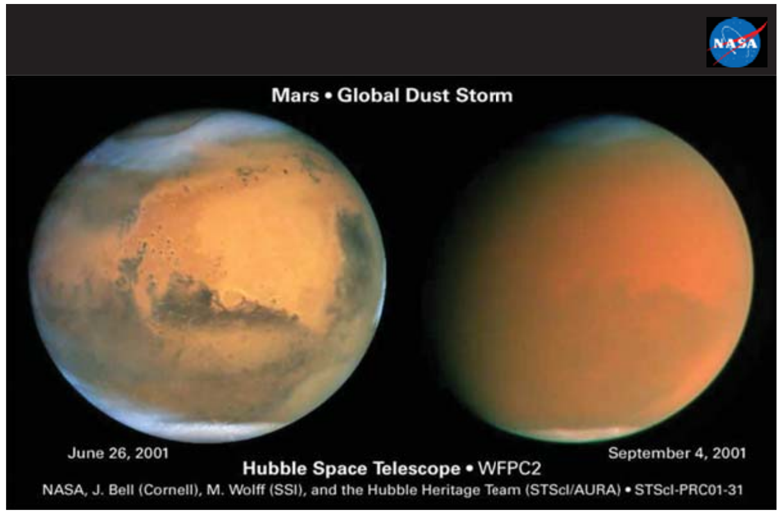
Perihelion: Dust storms

Aphelion: Cloud belts

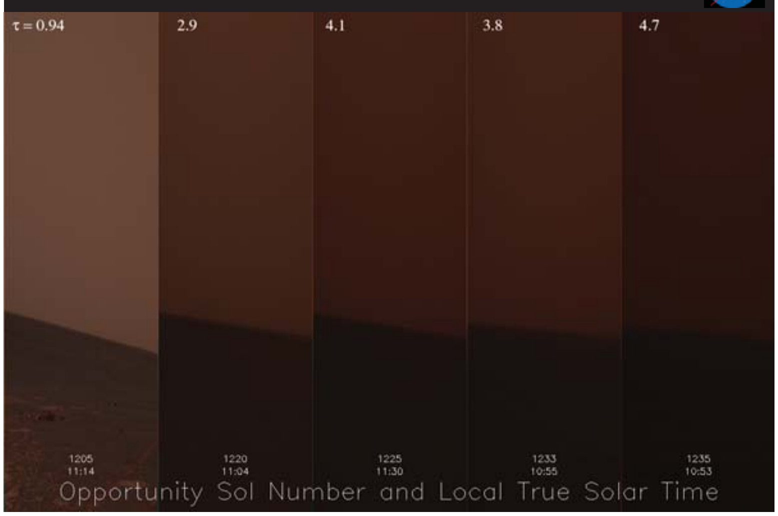
> http://ccar.colorado.edu/asen5050/projects/projects_2001/benoit/solar_irradiance_on_mars.htm



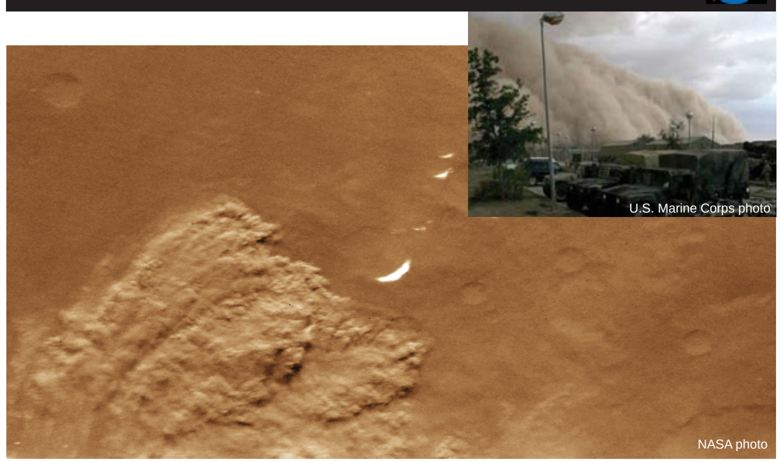
The origin, evolution, and trajectory of large dust storms on Mars during Mars years 24-30 (1999-2011), Huiqun Wang[a], Mark I. Richardson[b] ([a]*Smithsonian Astrophysical Observatory*, [b]*Ashima Research*)



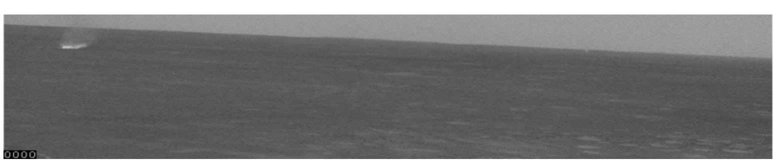
Global Dust Storm - as seen from the surface



Regional Dust Storm – as seen from orbit



Dust Devils – as seen from the surface



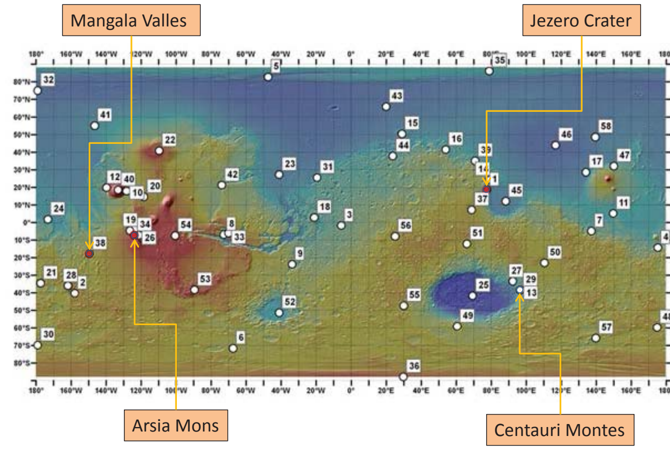
Dust Devils – as seen from orbit

"Feels Like" Wind Speed

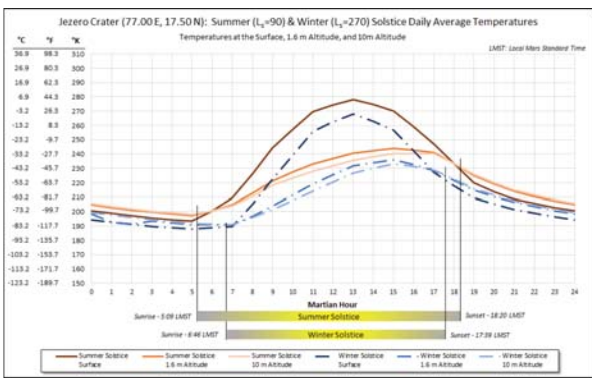
Wind speed on Mars			"Feels like" wind speed on Earth (at STP)	
mph	m/s	dynamic pressure	m/s	mph
10	4.5	0.2367	0.6	1.4
50	22.4	5.9169	3.0	6.8
67	30.0*	10.6587	4.1	9.1
100	44.7	23.6677	6.1	13.5
150	67.1	53.2523	9.1	20.3

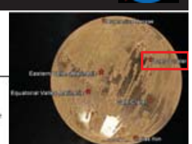
* Highest measured wind speed on the surface of Mars: Viking 2 Lander site – Utopia Planitia

HEM-SAG candidate Mars landing sites



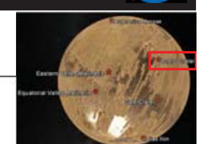
Jezero Crater





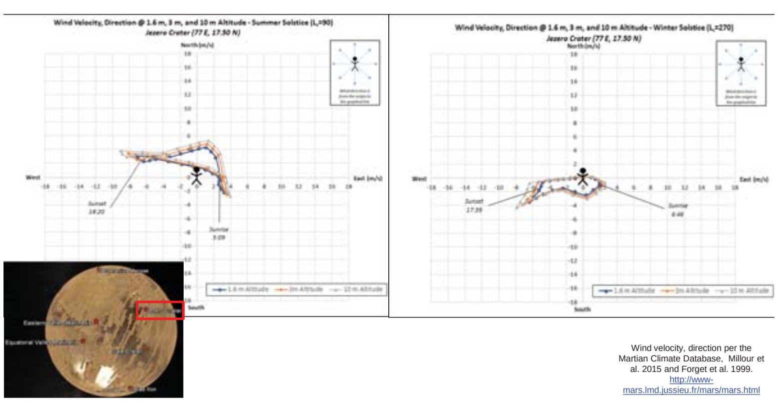
Temperatures per the Martian Climate Database, Millour et al. 2015 and Forget et al. 1999. http://www-mars.lmd.jussieu.fr/mars/mars.html

Jezero Crater



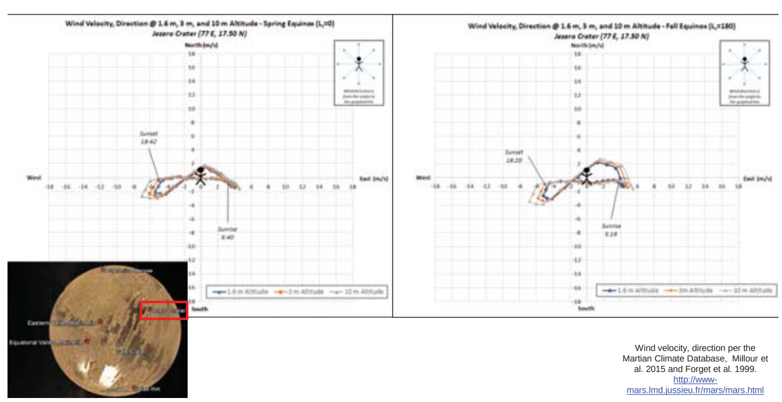
Temperatures per the Martian Climate Database, Millour et al. 2015 and Forget et al. 1999. http://www-mars.lmd.jussieu.fr/mars/mars.html

Jezero Crater



Wind velocity, direction per the Martian Climate Database, Millour et al. 2015 and Forget et al. 1999. http://www-mars.lmd.jussieu.fr/mars/mars.html

Jezero Crater



Wind velocity, direction per the Martian Climate Database, Millour et al. 2015 and Forget et al. 1999. http://www-mars.lmd.jussieu.fr/mars/mars.html

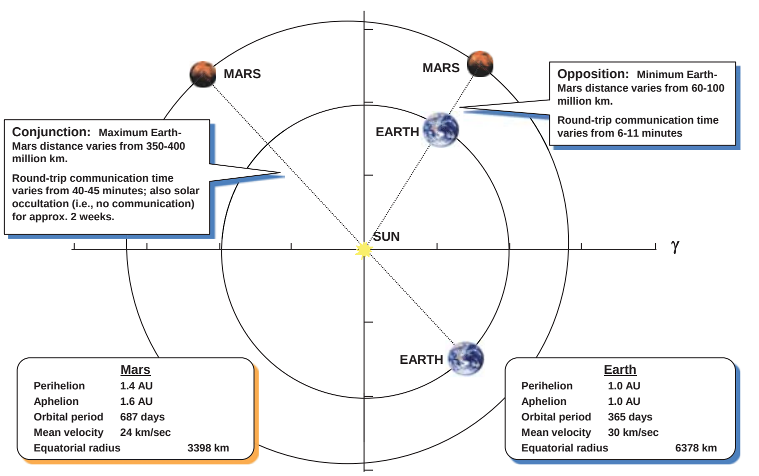
Mars Surface Field Station Capabilities “Scorecard”

- EMC Assumptions
  - Operational in the 2030s and beyond
  - Crew of four
  - Multiple visits to the same site
- Research Support
  - Physical sciences
  - Biological sciences
  - Atmospheric sciences
  - Human physiology
  - ISRU and civil engineering applied technology
- Exploration Zone
  - 100 km radius activity zone
  - +/- 50 deg. latitude
  - Less than 2 km elevation
- **Mars Environment**
  - Seasonal changes
  - Periodic dust storms
- **Mars Environment (cont.)**
  - Daylight (at 50 deg lat):
    - ~15 hrs (summer solstice)
    - ~9 hrs (winter solstice)
  - Temperature range (extremes):
    - Highs > ~20 deg C
    - Lows < ~ -110 deg C
  - Winds: typically < 20 m/s with low dynamic pressure

Evolvable Mars Campaign Development

MISSION PLANNING BASICS

Earth-Mars Orbital Characteristics

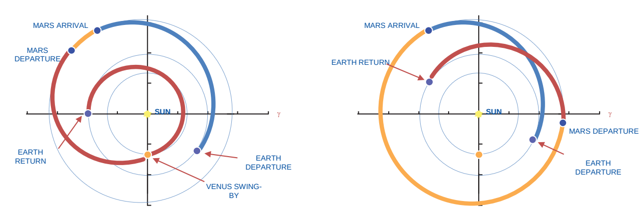


BGD-LS-98-002

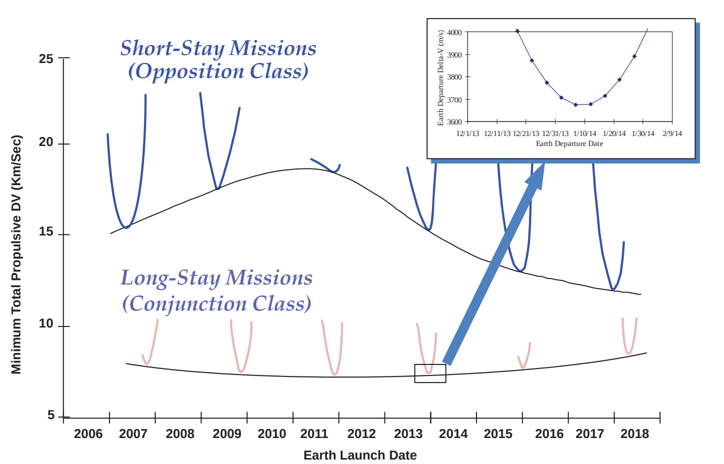
Mars Mission Modes

- **Round-trip human missions to Mars are double rendezvous problems**
  - Relative phasing of Earth-Mars (outbound leg) must be considered along with the relative phasing Mars-Earth (return leg)
- **This leads to two distinct mission classes**

Short-Stay (Opposition Class)	Long-Stay (Conjunction Class)
• Variations of missions with short Mars surface stays and may include Venus swing-by • Often referred to as Opposition Class missions	• Variations about the minimum energy mission • Often referred to as Conjunction Class missions

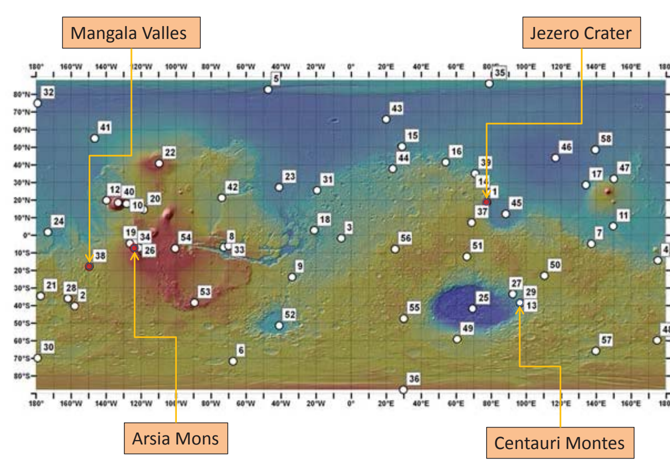


Delta-V Variations

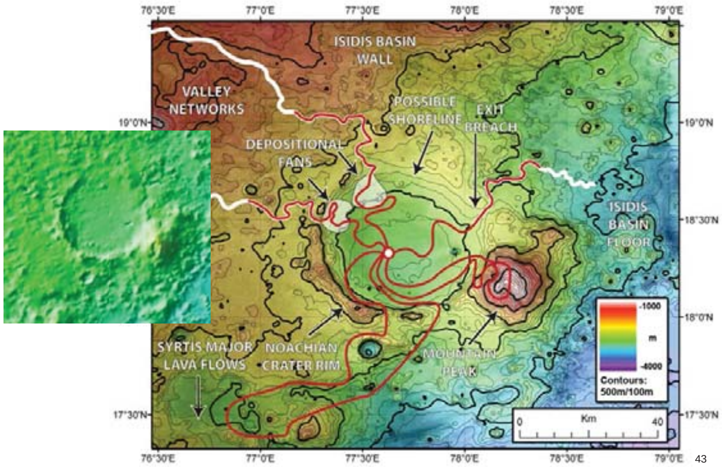


BGD-LS-98-005

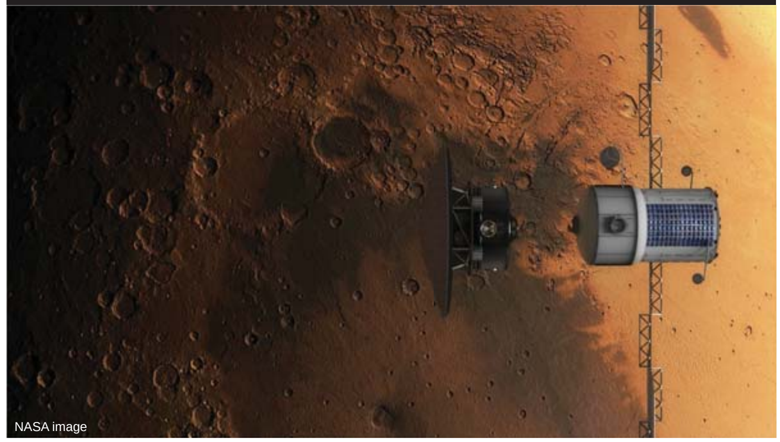
HEM-SAG candidate Mars landing sites



HEM-SAG Exploration Map for Jezero Crater



Mars Lander with Crew Departing From Orbit

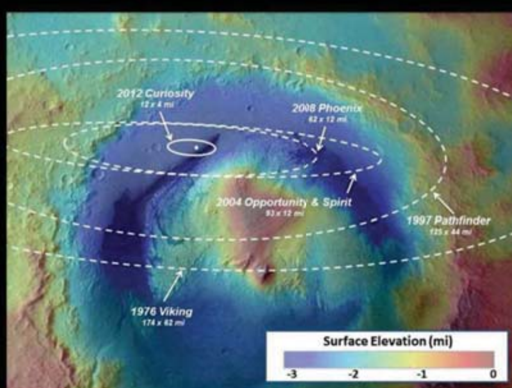


NASA image

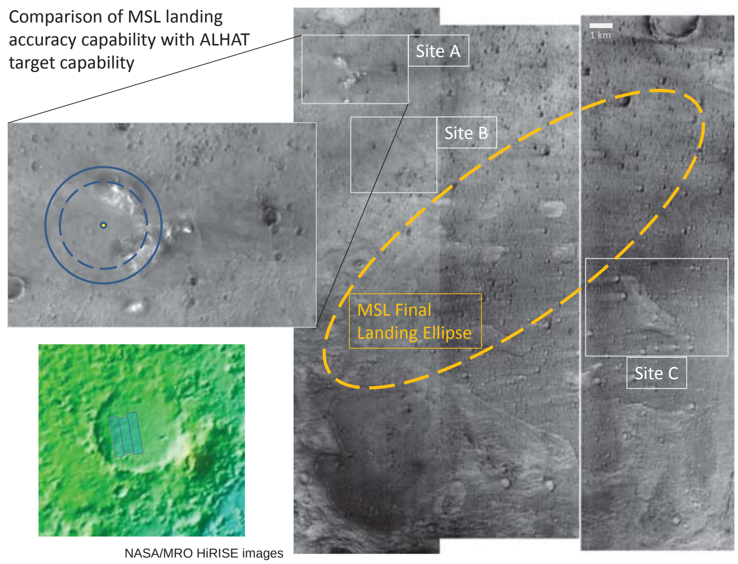
Challenges of Landing on Mars

Landing Supplies for a Human Mission Requires Greater Landing Accuracy

Because multiple landings will be required to deliver all the equipment and supplies needed, Human missions may require accuracy within 100 meters



Comparison of MSL landing accuracy capability with ALHAT target capability



NASA/MRO HiRISE images

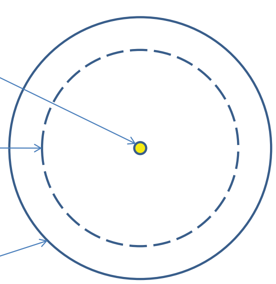
Landing Site Symbology

On the following pages this symbology will be used to indicate landing site factors discussed on the previous pages

100 meter diameter circle inside of which the ALHAT system is targeting for delivery of a lander

700 meter diameter circle that analysis indicates will be the maximum range of debris lofted by a large terminal descent thruster

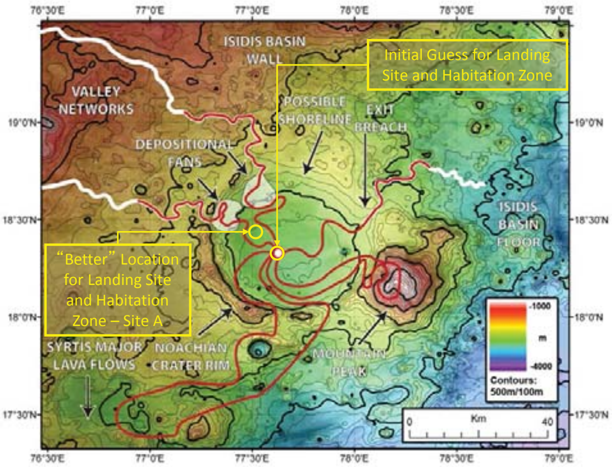
1000 meter diameter circle outside of which an element of surface infrastructure should be safe from terminal descent thruster debris



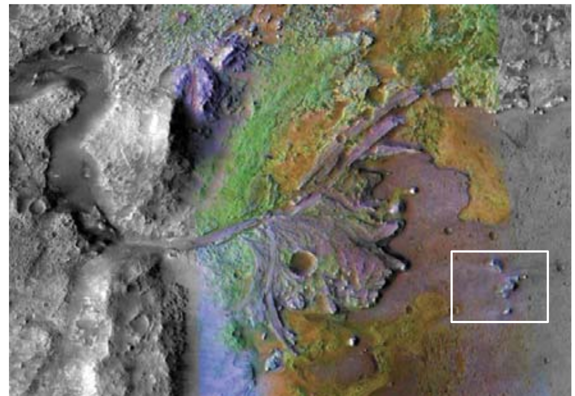
Common Lander with representative payload

NASA image

HEM-SAG Exploration Map for Jezero Crater



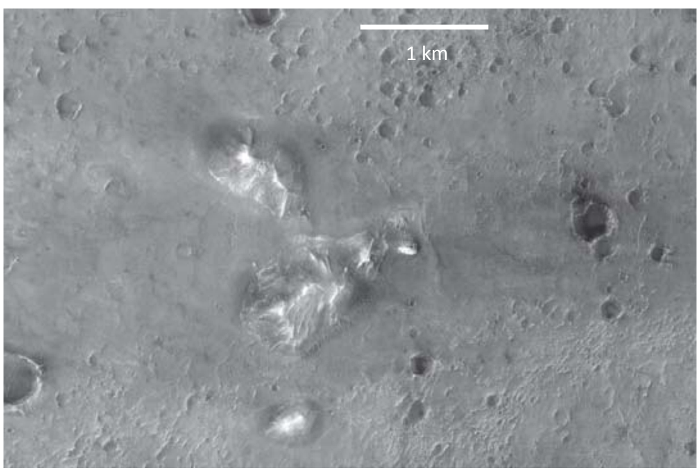
Landing Site 'A' Within Jezero Crater



Jezero contains Fe-Mg smectite clay indicative of multiple episodes of fluvial/aqueous activity on ancient Mars, elevating the potential for preservation of organic material.
(Green = phyllosilicates, orange = olivine, purple = neutral/weak bands.)

Image credit: NASA/JPL/JHUAPL/MSSS/Brown University (Ehlmann et al. 2008)

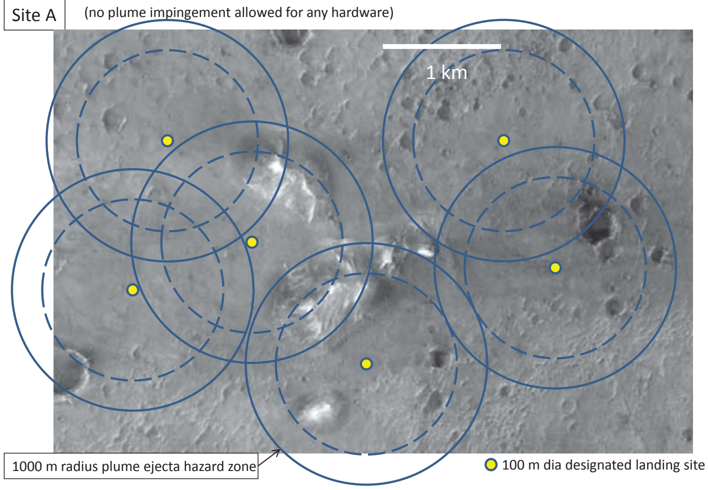
Site A



Site A

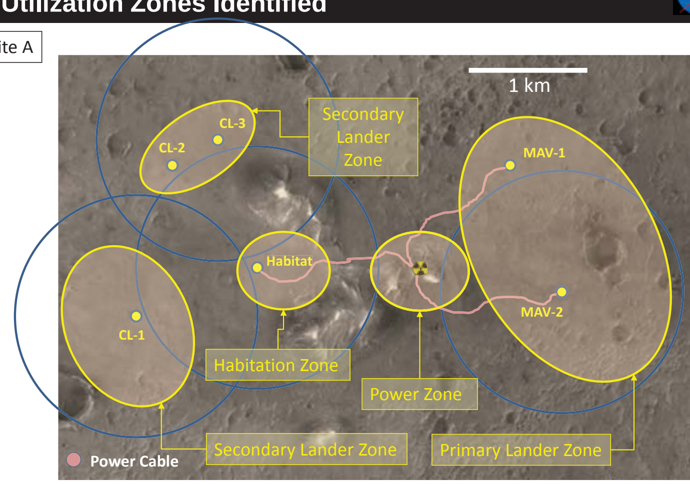
Non-Interfering Landing Zones at Site A

Site A (no plume impingement allowed for any hardware)



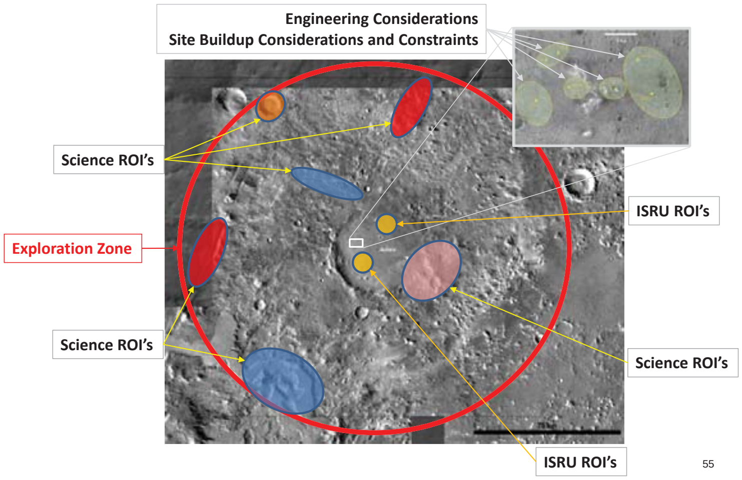
Example of Field Station Layout with Specific Utilization Zones Identified

Site A



(plume impingement *allowed* for any "dead" hardware)

Example Mars Surface Field Station and Surrounding Regions of Interest (ROI's)



Mars Surface Field Station Capabilities "Scorecard"

- EMC Assumptions
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  - Biological sciences
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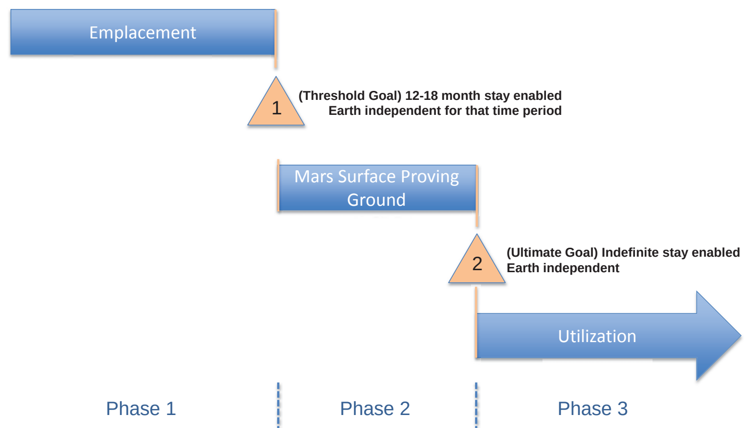
- Mars Environment (cont.)
  - Daylight (at 50 deg lat):
    - ~15 hrs (summer solstice)
    - ~9 hrs (winter solstice)
  - Temperature range (extremes):
    - Highs > ~20 deg C
    - Lows < ~ -110 deg C
  - Winds: typically < 20 m/s with low dynamic pressure
- **Crew/Mission Planning**
  - Occupied up to ~500 days followed by TBD days of dormancy
  - Approximately 25 sq km area for Field Station infrastructure

Evolvable Mars Campaign Development

THE EVOLVABLE MARS CAMPAIGN

Mars Surface Field Station Evolutionary Phases



Capabilities Needed to Achieve Primary Objectives and Defining Characteristics

- **Utilization**
  - Indefinite stay time on the surface will be enabled by:
    - Reliable source of power
    - Reliable source of breathable air and potable water
    - Ability to produce food, consistent with a basic but balanced diet and sufficient to support a crew of four (TBR)
    - Protection from / mitigation of (harmful) environmental effects
    - Ability to maintain and repair emplaced infrastructure using local resources and supplies (i.e., existing infrastructure can be maintained but not necessarily expanded)
- **Emplacement**
  - Interplanetary transportation system for crew and cargo
  - EDL at a scale sufficient to support human mission payload needs and landing accuracy
  - Basic habitation
  - Support infrastructure (i.e., power, communications, etc.)
- **Mars Surface Proving Ground**
  - Capabilities and knowledge / experience sufficient to ***bridge the gap*** between Emplacement and Utilization
    - This includes addressing the known unknowns and any unknown unknowns revealed to be an impediment to achieving Utilization objectives

Field Station Analog – McMurdo Station Antarctica

Emplacement

British National Antarctic Expedition 1902
R.F. Scott's "winter quarters hut." Used for both local scientific research and as a logistical base for traverses inland.

Photo by Tas50 - Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=5736171

Permanent occupation - 1955
Naval Air Facility McMurdo part of "Operation Deep Freeze" to support the International Geophysical Year. A collection of semi-permanent structures (e.g., tents, Jamesway huts)

Mars Surface Proving Ground

Photo courtesy of USAP

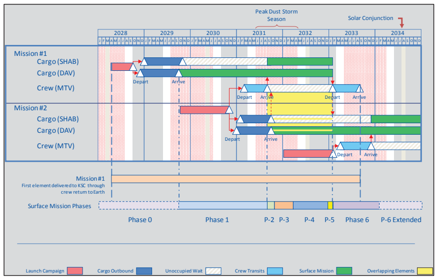
McMurdo Station Today
Antarctica's largest community and a functional, modern-day science station, including a harbour, three airfields (two seasonal), a heliport, and more than 100 permanent buildings

Utilization

Photo by USAP/Andrew Klein

Representative Mission Phases

- **Phase 0 – Prior to Cargo Landing**
  - Observations and investigations of the landing site by previously deployed orbital and surface assets
  - Characterize habitability, including potential special regions
- **Phase 1 – Post Cargo Landing (~2.25 Years)**
  - Cargo Landing
  - FSPS and ISRU deployment
  - Exploration by robotic assets, micro-climate monitoring
  - Final crewed landing site selection
- **Phase 2 – Crew Landing & Acclimation (~30 Sols)**
  - Crew Landing and acclimation to Mars gravity environment
  - Additional deployment of assets and local science investigations as time and capabilities permit
- **Phase 3 – Local Exploration (~30 Sols)**
  - EVAs within local area (~10 km) to set up central stations and complete initial science objectives
  - Deployment of Deep drill system
- **Phase 4 – Regional Exploration (~410 Sols)**
  - Up to 19 separate 15-sol traverses with 2 SPRs
  - Mobility extends up to ~200 km from landing site
  - Sample analysis and follow-on local investigations continue
- **Phase 5 – Preparation for Ascent (~30 Sols)**
  - Final curation of samples and preparation of MAV
  - Crewed Launch with contingency window
- **Phase 6 – Post Crew Departure**
  - Robotic assets continue exploration



The figure above illustrates the relative sequence of each phase with trajectory data for a Mars surface mission set to occur in the early 2030 time frame.

Each mission will:

- Prepare a surface mission plan based on the objectives set for the EZ
- Customize the mission plan based on discoveries made and lessons learned by previous crews
- Develop a science payload (1000 kg allocated) based on the customized mission plan

Surface System Elements Needed for the Emplacement Phase

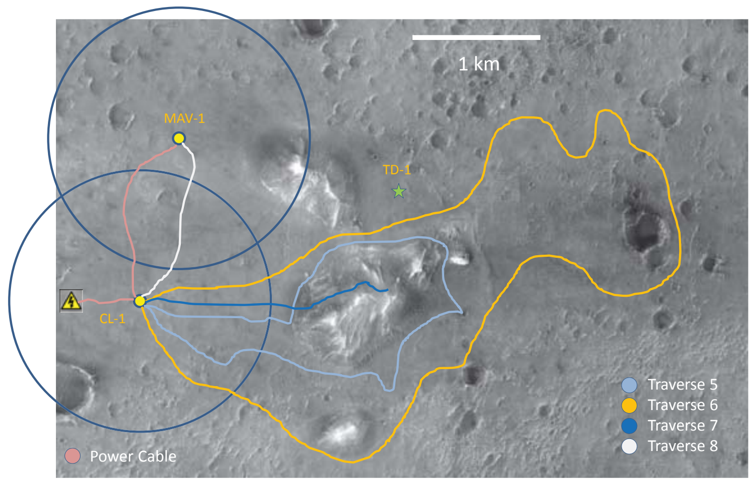
- **Mars Ascent Vehicle (MAV)**
- **Crew Descent Module**
- **Atmospheric ISRU**
- **Power (4 x 10 kW units)**
- **Robotic Rovers**
  - Special regions
  - Crew support
- **Cargo Off-loading**
- **Habitation**
- **Tunnel**
- **Science payloads**
- **Logistics modules**
- **Logistics**
  - Crew consumables
  - Fixed system spares
  - Mobile system spares
  - EVA spares
- **Mobility platform to reposition payloads**
- **Small unpressurized rover (crew)**
- **Small pressurized rover (crew)**

Surface Habitat Concept

NASA image

Site A

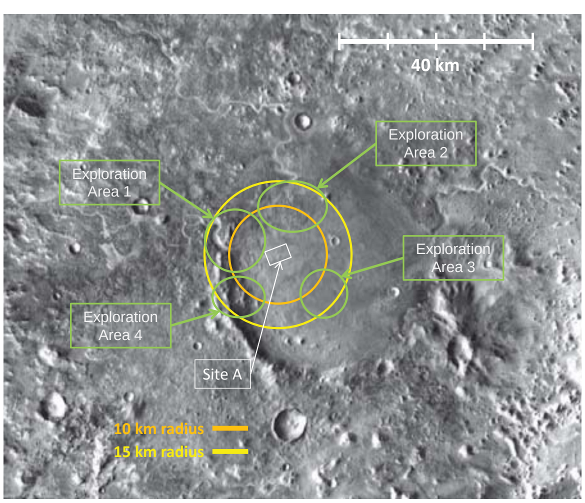
Mission 4: Short (Surface) Stay Mission (Part 2)



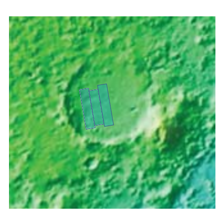
(plume impingement *allowed* for any "dead" hardware)

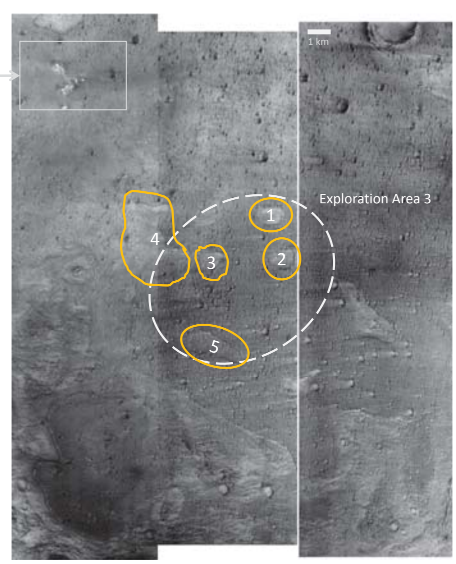
Site A

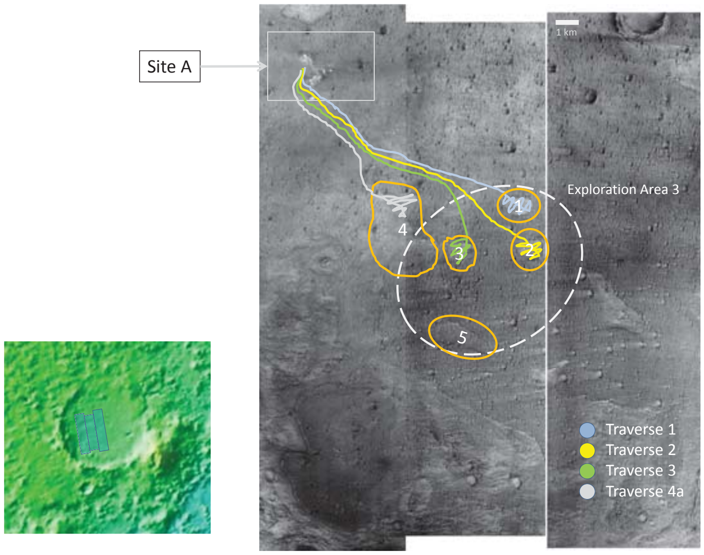
Mission 6: Full-scale Surface Habitat with Intermediate Stay Crew



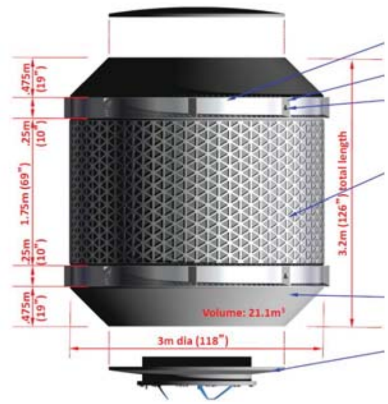
Site A



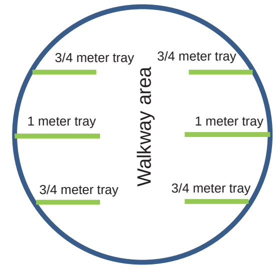




Converting Logistics Modules for Food Growth



Could we realistically squeeze any more tray area in a cylinder like this?



Total tray area = 1.75 x 2 x 2.5 = 8.75 m2 per module

For 320 m2 -> ~37 modules for 8 crew 80% food
For 160 m2 -> ~18 modules for 4 crew 80% food
For 100 m2 -> ~11 modules for 4 crew 50% food

Conceptual Plant Growth Chamber

NASA image

Mars Surface Field Station Capabilities "Scorecard"

- EMC Assumptions
  - Operational in the 2030s and beyond
  - Crew of four
  - Multiple visits to the same site
- Research Support
  - Physical sciences
  - Biological sciences
  - Atmospheric sciences
  - Human physiology
  - ISRU and civil engineering applied technology
- Exploration Zone
  - 100 km radius activity zone
  - +/- 50 deg. latitude
  - Less than 2 km elevation
- Mars Environment
  - Seasonal changes
  - Periodic dust storms
- Mars Environment (cont.)
  - Daylight (at 50 deg lat):
    - ~15 hrs (summer solstice)
    - ~9 hrs (winter solstice)
  - Temperature range (extremes):
    - Highs > ~20 deg C
    - Lows < ~ -110 deg C
  - Winds: typically < 20 m/s with low dynamic pressure
- Crew/Mission Planning
  - Occupied up to ~500 days followed by TBD days of dormancy
  - Approximately 25 sq km area for Field Station infrastructure
- **Field Station Capabilities**
  - Habitation (4 people x 500 days)
  - "Dedicated" research support volume
  - Communication (locally out to 100 km and high volume with Earth)
  - Power (current estimate 40 kW)
  - Surface transportation (EVA and SPR)
  - Maintenance/repair for all of the above

http://www.nasa.gov/feature/where-on-mars-might-humans-first-land

.mov

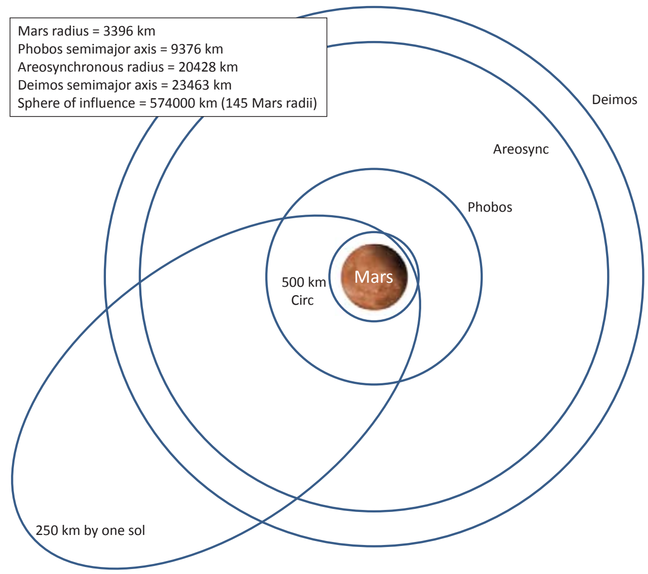
.wmv

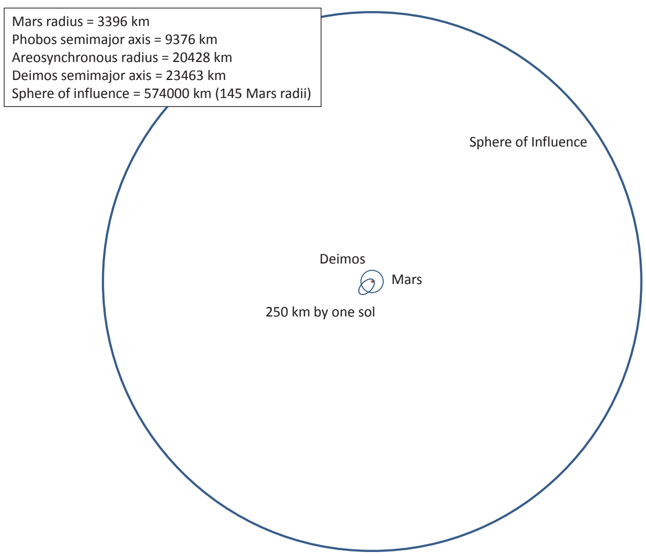
Evolvable Mars Campaign Development

BACKUP

Strategic Principles for Sustainable Exploration

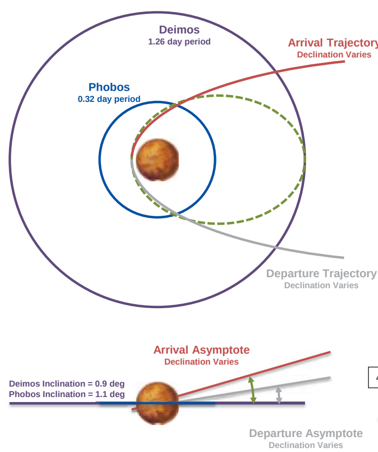
- Implementable in the ***near-term with the buying power of current budgets*** and in the longer term with budgets commensurate with economic growth*;*
- ***Exploration enables science*** **and** ***science enables exploration****, leveraging robotic expertise for human exploration of the solar system*
- Application of ***high Technology Readiness Level*** (TRL) technologies for near term missions, while focusing sustained investments on ***technologies and capabilities*** to address challenges of future missions;
- ***Near-term mission opportunities*** with a defined cadence of compelling and integrated human and robotic missions providing for an incremental buildup of capabilities for more complex missions over time;
- Opportunities for ***U.S. commercial business*** to further enhance the experience and business base;
- ***Resilient architecture featuring multi-use, evolvable space infrastructure*****,** minimizing unique major developments, with each mission leaving something behind to support subsequent missions; and
- Substantial ***new international and commercial partnerships***, leveraging the current International Space Station partnership while building new cooperative ventures.

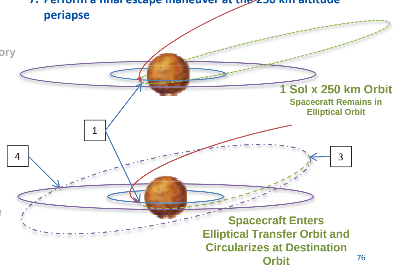




Assumed Mars In-Space Orbit Strategy (for this example)

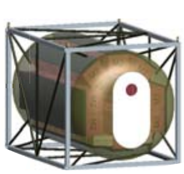
1. **Capture into an elliptical orbit at Mars with a periapse at 250 km altitude**
2. **If the 250 km by one sol destination orbit is used, then no further maneuvers until time for departure (step 7 below)**
3. **If a circular destination orbit is used, then perform a circularization maneuver making the transfer orbit the same size as the destination orbit**
4. **Perform a plane change maneuver (to enter Mars' equatorial plane) at the first equator crossing**
5. **For departure (and return to Earth) reverse the sequence of propulsive maneuvers. First perform a plane change maneuver to place the transfer orbit in the same plane as dictated by the departure trajectory**
6. **Perform a maneuver to enter an elliptical transfer orbit with a periapse of 250 km altitude**
7. **Perform a final escape maneuver at the 250 km altitude periapse**





10t Mars Surface Logistics Module

06-30-2015



Design Constraints/Parameters

- Destination: Mars Surface
- Module Length: 5.5 m
- Module Diameter: 4.5 m
- Pressurized Vol.: 69 m3
- Maximum Number of CTBEs: 472
- Maximum Loaded Mass: 5,770 kg

Category	Mass (kg)
Structure	1,725
Protection	0
Propulsion	0
Power	220
Control	0
Avionics	55
Thermal	170
ECLSS	260
Crew Systems	15
Growth	290
Dry Mass Total	**2,735**
External Frame	110
Project Manager's Reserve	285
TOTAL	**3,130**

Description: The 10t Mars Surface Logistics Module provides pressurized delivery of logistics payloads to Mars surface. The logistics module is packaged within the lander shroud during transit to Mars. There is no specific allocation for MMOD protection. The module supports and secures pressurized cargo throughout all launch, transit, and Mars descent loads. The internal structure includes frames to secure multi-row packing of CTBEs. The module will maintain conditioning of payload for extended durations on lander (~3-4 years) prior to crew arrival on surface and transfer to habitat. The ECLSS contains atmospheric monitoring, air recharge, and passive and active thermal control systems. The module provides structural capabilities (external frame) to enable securing of log module to lander and transfer of carrier off of raised (>3m) lander deck to habitat. The module can survive transfer window from lander to habitat without external power source. The module may remain mated to habitat for extended duration without posing safety hazard to crew.

Mars Surface Exploration Vehicle

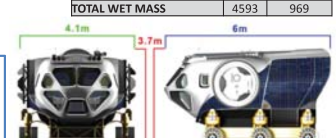
April 2014

Design Constraints/Parameters

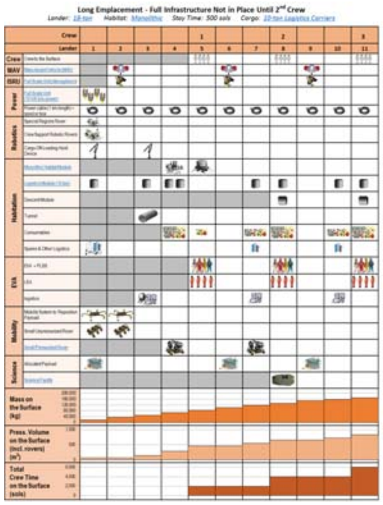
Pressurized Vol.	12.0 m³
Habitable Vol.	10.8 m3
Max Crew Capacity	4
Max Crew-Day Capacity*	14 crew-days
*Core vehicle capacity	
Est. power, uncrewed	1.5 kW
Est. power, crewed	2 kW
Solar power generation	3 kW
Total Batter Energy Storage	100 kW-h
Depth of Discharge	80%
ECLSS System	Open-loop
Max Speed	20 km/hr
Range	100s of km
Max. Length	6 m
Max. Width	4.1 m
Max Height	3.7 m

	Mass (kg)	
Category	**Cabin**	**Chassis**
Structure	1456	334
Protection	40	0
Propulsion (Wheeled)	0	237
Power	535	104
Control	30	39
Avionics	145	14
Environ./Active Therm	415	17
Other	120	0
Growth	823	224
DRY MASS SUBTOTAL	3564	969
Non-cargo	10	0
Cargo	579	0
INERT MASS SUBTOTAL	4153	969
Non-propellant	440	0
Propellant	0	0
TOTAL WET MASS	4593	969

The MSEV is configured as a destination servicing/exploration system for short term mission durations with the capability to support EVAs from the two suitports. The system consists of a core cabin and a destination-appropriate mobility chassis, plus a grappling/docking system. Augmentation modules e.g. a Portable Utility Pallet (PUP) can extend operational durations and ranges.

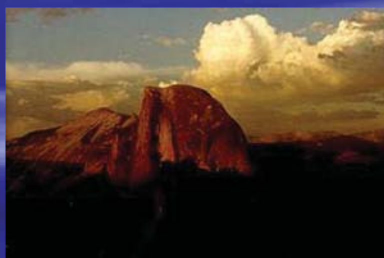


Example: Mission Manifests



Large Facilities Office Workshop
May 26, 2016

Environmental Compliance and Permitting for NSF Funded Projects



Environmental Compliance and Permitting

Environmental Compliance

- NSF's legal responsibility
- Occurs before a funding decision is made

Permitting

- Typically, it is the Awardee's responsibility
- Permits are obtained after a funding decision is made

What Is Environmental Compliance?

- Federal agencies must consider the impacts of their proposed activities on the environment as part of their decision-making processes.
- Major federal statutes requiring environmental compliance include:
  - National Environmental Policy Act ("NEPA")
  - National Historic Preservation Act ("NHPA")
  - Endangered Species Act ("ESA")

Threshold Issues

- ***What are examples of triggers for federal agencies' environmental compliance obligations?***
  - An activity, the issuance of a license or permit, or the issuance of federal funds
  - At NSF, compliance is triggered by the issuance of federal funds
- ***When does compliance begin and end?***
  - Compliance should begin at the *earliest* possible point in the process, but **only after a proposal is deemed viable for funding**
  - Compliance should end when the steps have been completed and documented, but **before a decision is reached**

Roles of Program Officer, PI, and OGC

- **Program Officers**: Responsible for identifying *viable* proposals and determining whether significant environmental impacts are anticipated
- **PI's**: Responsible for providing program officers sufficient information to determine whether significant environmental impacts may result
- **OGC**: Responsible for providing support (i.e., training, tools, advice and assistance) to program officers so that NSF's environmental compliance obligations can be met

Environmental Compliance at NSF

1. Program Officer identifies viable proposals
2. Program Officer notifies PI and requests that the *Organization Environmental Impacts Checklist* be completed
3. Upon receipt of the completed *Checklist,* Program Officer determines (with the help of EC Team, if requested) whether compliance can be completed in-house or with the assistance of a contractor
4. If negligible or no impacts are anticipated, Program Officer completes *NSF Record of Environmental Compliance*

Environmental Compliance at NSF - continued

1. If impacts are anticipated, Program Officer may use NSF's Blanket Purchase Agreement to complete compliance work
2. Environmental impacts are factored into NSF's decision-making process
3. Completion of environmental compliance can take from a couple of minutes to over a year, depending upon the level of impacts associated with the proposed project

Major Environmental Compliance Statutes Implicated by NSF's Funding Decisions

- **National Environmental Policy Act**: Requires federal agencies to consider impacts on the human environment before decisions are made
- **National Historic Preservation Act**: Requires federal agencies to consider impacts on significant historic, cultural, and archeological resources before decisions are made
- **Endangered Species Act**: Requires federal agencies to consider impacts on endangered and threatened species and their habitats

NEPA Compliance: Three Levels of Review

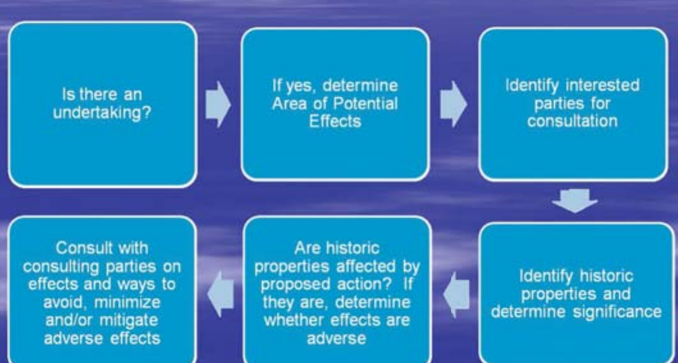
- **Categorical Exclusions**: Pursuant to NSF regulations, no significant impacts are anticipated to result (most NSF proposals fall under this category)
- **Environmental Assessments**: Activities that are not categorically excluded, but are not anticipated to result in significant impacts (some NSF proposals)
- **Environmental Impact Statement**: Activities that are anticipated to result in significant impacts (few NSF proposals fall under this category)

Note: OGC can assist in determining appropriate level of environmental review

Examples of Activities Requiring Limited Environmental Review

- Interior alterations/renovations
- Theoretical and/or laboratory research
- Data analysis/Modeling
- Planning/conducting scientific workshops/conferences
- Conducting day-to-day management activities of FFRDCs
- Educational development grants
- Scholarships/Fellowships
- Purchasing Equipment
- Field work not affecting the environment
- Activities having minor disturbance to the local environment
- Drilling/excavation of the earth with no significant impacts

National Historic Preservation Act: the Section 106 Process



Endangered Species Act

- Requires NSF to determine whether endangered/threatened species and/or their habitat are present in the area of the proposed project
- Requires determination of anticipated effects to such species/habitat
- Preparation of Biological Assessment if formal consultation with USFWS or NMFS is required
- Incidental Take Permit might also be required

Streamlining Environmental Compliance

- Overlap exists in requirements of planning statutes such as NEPA, the NHPA, and the ESA
- NEPA document can be used as an umbrella document to demonstrate compliance with other statutes such as the NHPA, and ESA

Permitting

- Awardees typically are the entities responsible for obtaining required permits to carry out the proposed activities.
- Permitting does *not* include environmental compliance responsibilities – permitting occurs *after* NSF has issued a decision to fund the proposed activities.

Examples of Permits

- Construction Permit
- Research Permit
- Special-Use Permits (SUP)
  - Note that when a SUP is issued by a federal agency (i.e., the National Park Service or the National Forest Service), that agency will have to complete its environmental compliance processes before issuing the SUP.

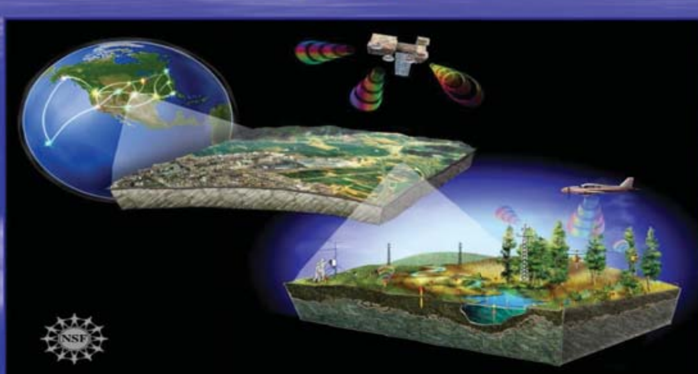
NCAR Wyoming Supercomputer Center

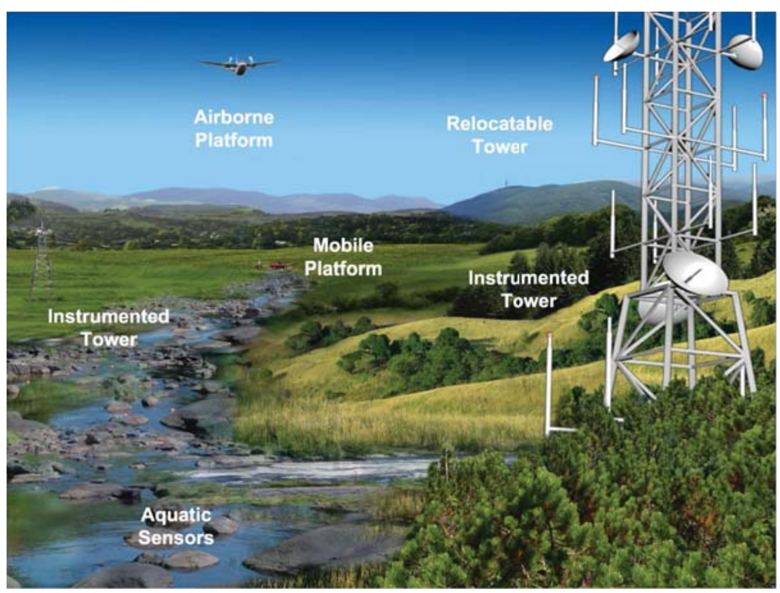
Compliance:

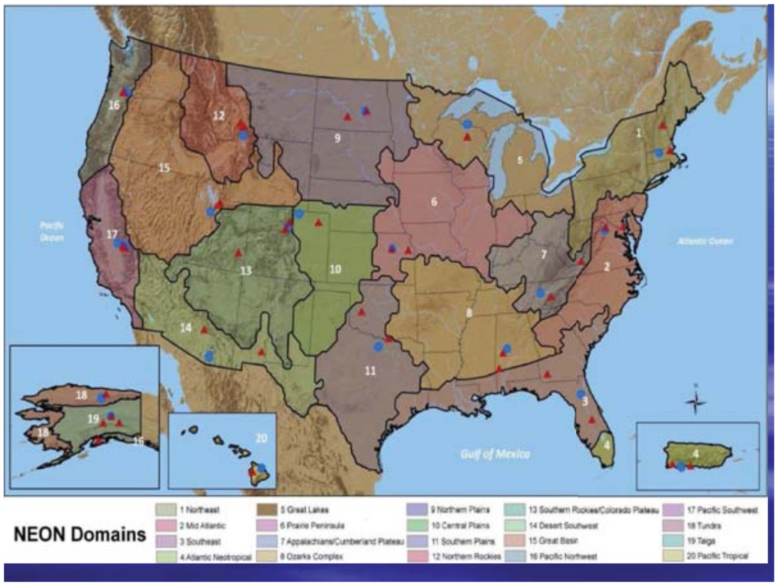
1. Few, if any, impacts were anticipated

2. EA/FONSI

National Ecological Observatory Network





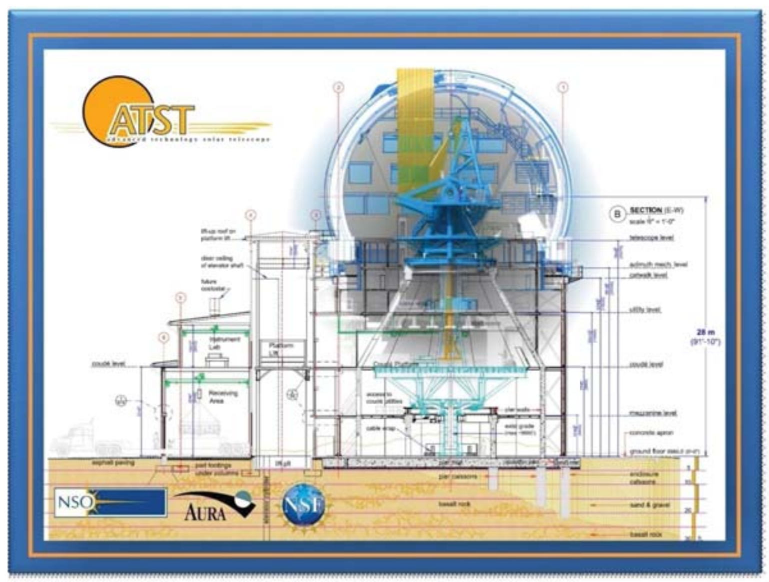


NEON:
Lessons Learned

Environmental Compliance

v.

Permitting



The u'au -- Hawaiian Petrel

ATST Environmental Compliance

Dr. Bement signing the ROD

EIS:
- 3116 pages, ~$3.5M.
- Preceded by a DEIS and a SDEIS
- ROD: Signed in December 2009

NHPA Programmatic Agreement:
- SHPO
- ACHP
- Native Hawaiian Stakeholders

ESA:
- USFWS – Biological Opinion
- State – Habitat Conservation Plan

DKIST: Lessons Learned

Understand the local culture

And

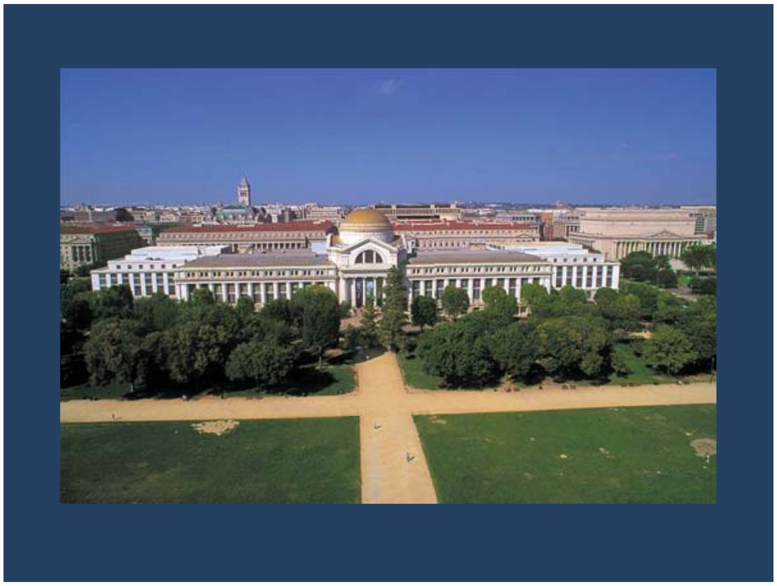
Begin permit process early

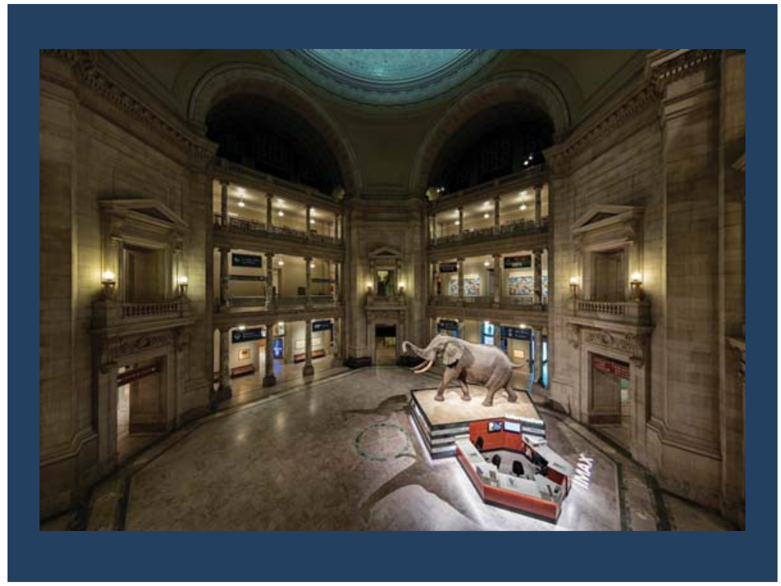
Additional Thoughts

- Do not imply that the decision is a done deal; refer to the project as the "proposed project"
- All memoranda, correspondence (including letters and e-mails), technical studies, records of public participation, public comments, notes, etc. become part of the administrative record
- Try to develop more than one action alternative if possible; if not possible, explain why other alternatives were not selected
- Begin environmental compliance **early on** in the decision-making process

Resources

- NSF: Caroline M. Blanco, Assistant General Counsel, cblanco@nsf.gov, (703) 292-4592
- ECOs: Kristen Hamilton and Holly Smith
- Legal Analyst: Dana Thibodeau
- NEPA: Council on Environmental Quality (www.NEPA.gov)
- NHPA: Advisory Council on Historic Preservation (www.achp.gov)



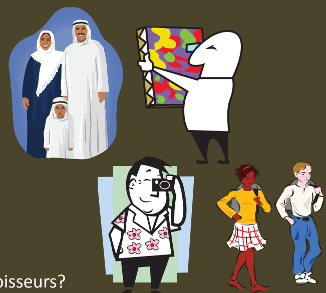


Classifying the Exhibit
From "Exhibitions and their Audiences: Actual and Potential",
SI Office of Policy and Analysis, September 2002
Exhibition as Artifact Display
Exhibition as Visitor Activity
Exhibition as Communicator of Ideas
THE MOVEMENT
Exhibition as Environment
Smithsonian Institution
National Museum of Natural History

Classifying the Exhibit
Chronological
Hybrid
Thematic
MEXICO EXPORTA
1700
CORREOS
40
MEXICO
Smithsonian Institution
National Museum of Natural History

•Accommodating visitor needs and wants
•Fostering shared experiences
SORTIDA
SALIDA
SORTIE
EXIT
WC
MUSEU
Learning from Architecture and Urbanism
Smithsonian Institution
National Museum of Natural History

Determining Target Audiences



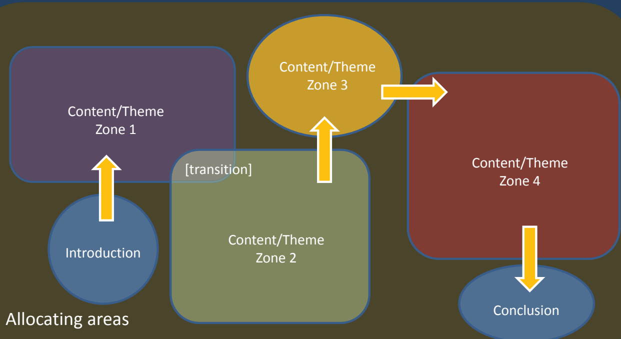
Families, teens, tourists, connoisseurs?
What are their needs, wants, interests?

Appropriate Design

Thought-Provoking
PATRIOTIC
elegant
authoritative
Historically Correct
Inviting
Dynamic
Kid-friendly
Definitive
Exotic
Sociable

Associative words & images

Developing Thematic Zones



Allocating areas

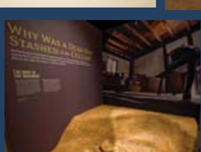
Design & Display Issues

Designer in conversation with curator & developer/project manager to determine:

- Key artifacts (landmarks) with strongest stories
- Variety
- Environmental concerns: case interiors, lighting, need for rotation
- Budget impact

Design Input into the Artifact Selection Process

Design & Display Issues



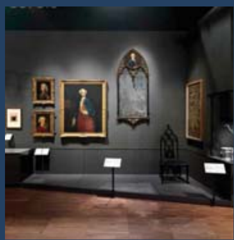
Act as visitor advocate:

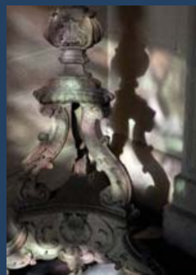
- Can I locate myself in the stories? (*audience relevance*)
- How much is enough, and too much?
- How am I made to feel in relation to the objects? (*point of view, voice*)
- Am I inspired, moved, informed?

The Importance of Visitor Perceptions

Accessible 3D and 2D Design

Lighting





Accessible 3D and 2D Design

Smithsonian Institution
National Museum of Natural History

1. CONTRAST 5.
2. CONTRAST 6.
3. CONTRAST 7.
4. CONTRAST 8.

1. Legibility
2. LEGIBILITY
3. Legibility
4. Legibility
5. Legibility
6. Legibility
7. Legibility
8. Legibility

Accessible 3D and 2D Design

Smithsonian Institution
National Museum of Natural History

Readability

Confederate Pistol with Brass Frame
ca. 1860
Griswold & Gunnison, Macon, GA

Unlike in the North, where ample resources and established arms factories (such as the Whitney Armory in Connecticut) produced a steady stream of high-quality arms during the War, Confederate arms were less numerous and more difficult to produce; this pistol, for example, made in Georgia before the conflict began, has a brass frame – later brass frames may have come from melted church bells.

Accessible 3D and 2D Design

Smithsonian Institution
National Museum of Natural History

Readability

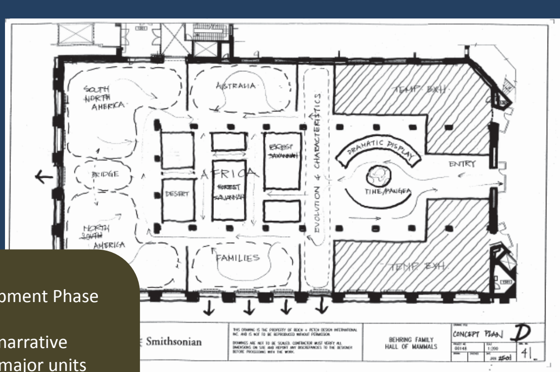
Confederate Pistol with Brass Frame
ca. 1860
Griswold & Gunnison, Macon, GA

This pistol with brass frame was made in Georgia before war. During the conflict brass frames may have come from melted church bells.

It was difficult for the Confederate armories to produce weapons due to the lack of resources and established factories.

Accessible 3D and 2D Design

Smithsonian Institution
National Museum of Natural History



Concept Development Phase

Script gives narrative description of major units

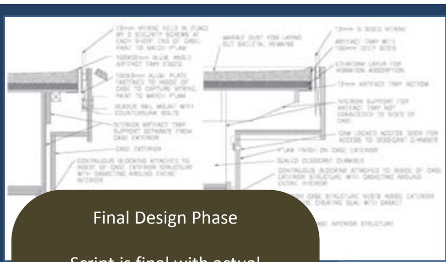
Bubble Diagram gives impression of look and feel of the exhibit

Draft Design Phase

Script is an attempt at actual words intended for the wall

Object and graphic inventory approximately 75% complete

Design of the exhibit is 65% complete, connected to the script with typical case designs and specimen layouts



Final Design Phase

Script is final with actual words for the wall, captions and photo credits

Object and graphic inventory approximately 100% complete

Design of the exhibit is 95-100% complete, documents can be bid on and used as a base for production drawings

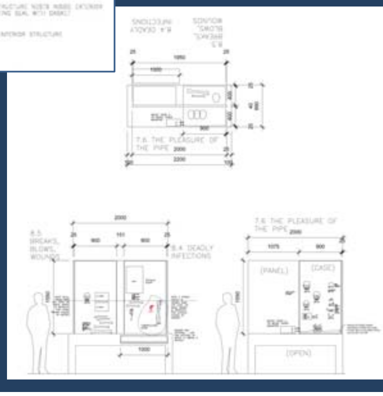
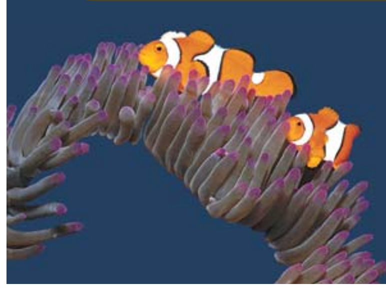


Exhibit Supplements

Using on-line and other technologies to make education engaging and interactive



- On-line exhibits
- Educational Resources
- Research and Collections
- Field Guides
- Q?rius Programming

WRITTEN IN BONE

STORIES OF LIFE AND DEATH IN THE COLONIAL CHESAPEAKE

National Museum of Natural History
Smithsonian Institution, Washington, DC

CONCEPT DESIGN: 26 JUNE 2006

mfmdesign

Goals of the Exhibit:

- To develop a sense of wonder at the quantity and kinds of information that can be obtained from skeletal remains
- To introduce the work of physical anthropologists, both as contemporary forensic detectives and as bioarchaeologists
- To explain how forensic anthropology has enlarged our view of early colonization in the Chesapeake, the century that made Americans physically and culturally *American*
- To convey the vital importance of scientifically studying human skeletal remains, because they can contain information unavailable from any other source or by any other means

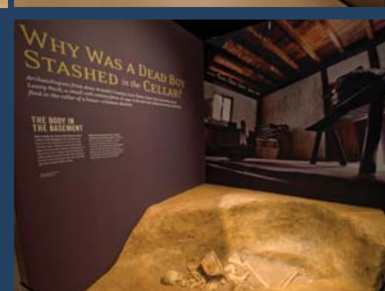
Exhibit Goals:

WRITTEN IN BONE STORIES OF LIFE AND DEATH IN THE COLONIAL CHESAPEAKE

mfmdesign

A temporary exhibit, but built with "permanent" durability:

- Museum receives 7 million visitors annually
- Fragile items require solid substrates
- Lighting and environmental concerns same as with permanent exhibit.
- Opened early 2008, now extended to 2014



• Painted sculpture and scenic units have been treated respectfully
• "Shock absorber" cases for remains sustained no earthquake damage

• Frequent monitoring of case seals, interior conditions (temperature and Rh)

"The skeleton is a personal legacy. It is an individual's life story – a gift to the present."
-Douglas Owsley, curator

Written in Bone:
Forensic Files of the 17th Century Chesapeake

National Museum of Natural History
Smithsonian Institution
Washington, DC

Displaying Human Remains in a Museum Setting

•Skeletons represent the most direct evidence of the biology of past populations: health, lifestyle, diet, trauma, disease, etc.

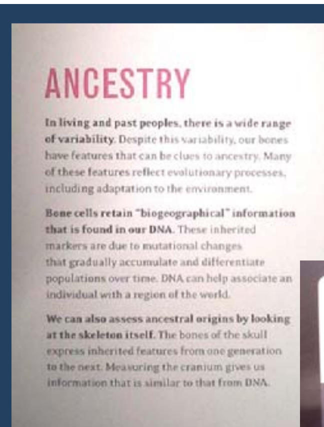
•Most retrieved from unmarked graves, discovered by accident – professionals treat them with care and respect

•Donated remains intended for teaching

•When possible, identified remains returned to families if so desired

Full-term fetus (neonate), approximately 40 weeks

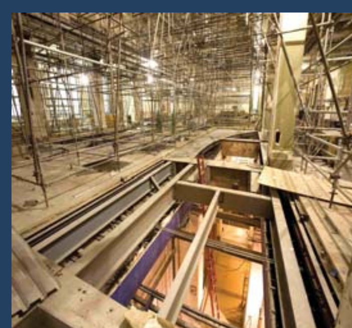
Fetus second trimester, approximately 22 weeks

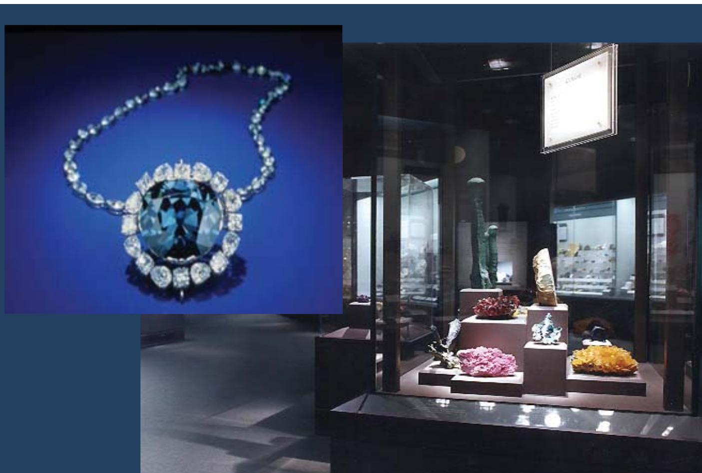


- Few fragile items requiring trade-outs; removal of unique 17th c. surgeon's chest required exhibit unit redesign

Written in Bone: Forensic Files of the 17th Century Chesapeake

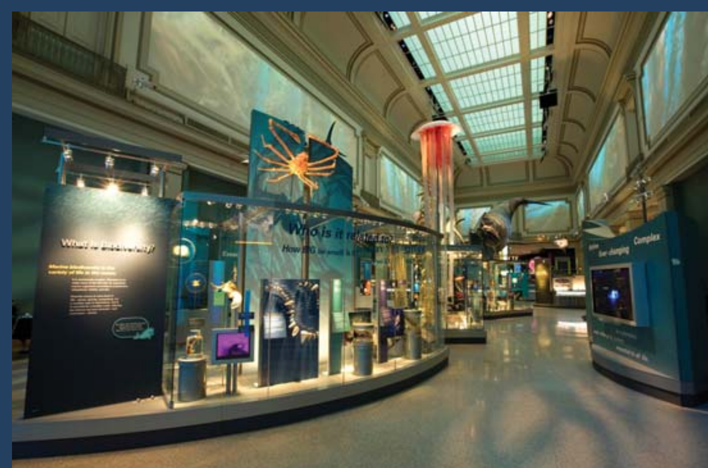
Construction and Installation





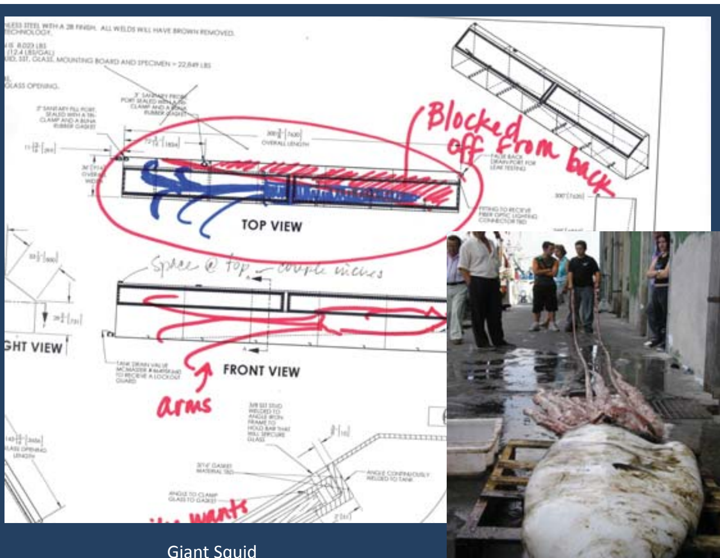
Janet Annenberg Hooker
Hall of Geology Gems and Minerals, 1997

Kenneth E. Behring Family Hall of Mammals, 2003



Sant Ocean Hall, 2008

Phoenix the North Atlantic Right Whale



Giant Squid

Raven Canoe

Development of the NSF Process for Validation and Acceptance of Facility Project EVMS

Large Facilities Workshop 2016

Earned Value Management –
Certification or Verification?
Breakout Session

Purpose and Goals

NSF is establishing guidelines and requirements for Earned Value Management Systems (EVMS) for evaluating construction project status and management. Other federal agencies have established EVMS requirements, with varying ranges of rigor, depth of inspection, and involvement by external EVM professionals, that are based upon the 32 EIA Standard 748 guidelines.

Please provide thoughts and experiences on the impacts and benefits of EVMS evaluation to inform development of NSF EVM guidance and requirements for the 2017 revision to the LFM.

IG Recommendations for EVMS Validation and Certification:

"Obtain certification of AURA's EVM system for LSST and validate EVM data for LSST" OIG Alert Memo #15-3-001

"Validat(e) AURA's EVM data for DKIST, and certify AURA's EVM system." " OIG Alert Memo #16-3- 004

"In light of the critical insights robust EVM data can provide those managing and overseeing projects, NSF should …. take decisive action to ensure the quality of EVM data on all its large construction projects." IG to US house of Representatives Subcommittee on Research and Technology, Feb 4, 2016

IG Comments on EVMS Validation and Certification: OIG Alert Memos #15-3-001 and 16-3-004

"Certification of an EVM system is needed to ensure that an awardee maintains an acceptable EVM system, which includes data to support scheduling of work and interim progress measures, among other things. Our examination of thresholds other federal agencies use when determining whether an awardee's EVM system should be certified found thresholds of \$10 million and \$50 million…."

"Certification of an EVM system, including supporting data, is conducted by the Defense Contract Management Agency to ensure that an awardee maintains an acceptable EVM system.."

Terms

Validation: review and acceptance for compliance with EIA-748

Certification: typically refers to the DOD one-time issuance of a letter of acceptance by DCMA after validation. (once certified, EVMS can be used for multiple projects.)

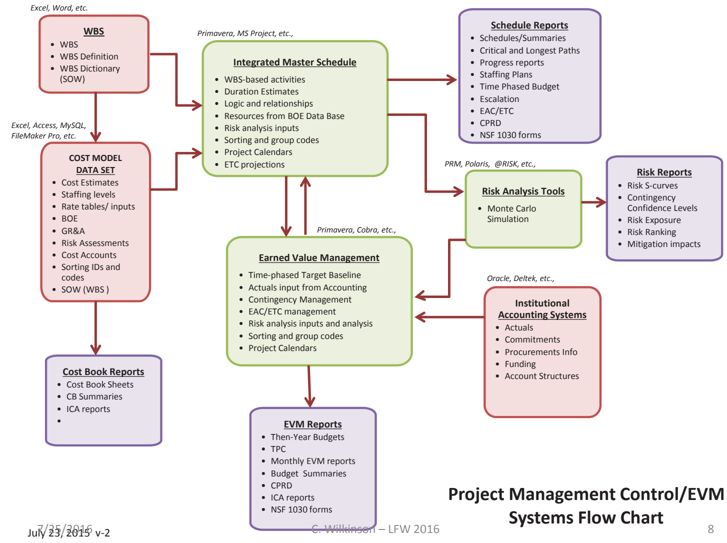
Surveillance: periodic reviews to verify proper implementation after initial validation and acceptance

Federal Agency Practices

- DOD, NASA use DMCA validation/certification requirements and DCMA professionals
- Many Non-DOD agencies use self-validation, peer validation, or other third-party validation according to various thresholds.
  - Third-party validation by EVM professionals most desirable for 'large capital acquisitions'
  - Acceptance/approval methods vary
- Validations can take months and \$\$\$ - normally consist of initial visits, progress assistance visits for project corrections, and actual validation reviews (names vary by performing agency).

NSF Response to IG

- NSF is evaluating the benefits of EVM system validation/certification as a requirement for facilities projects.
- LFO performed a pilot validation of EVM data for LSST as part of the 2016 annual review process.
- LFO is drafting a Standard Operating Guide (SOG) for EVMS Validation
- Seeking community input on the impacts and benefits of EVMS validation implementation



Project Management Control/EVM Systems Flow Chart

July 23, 2015 v-2

NSF Pilot EVMS Evaluation of LSST

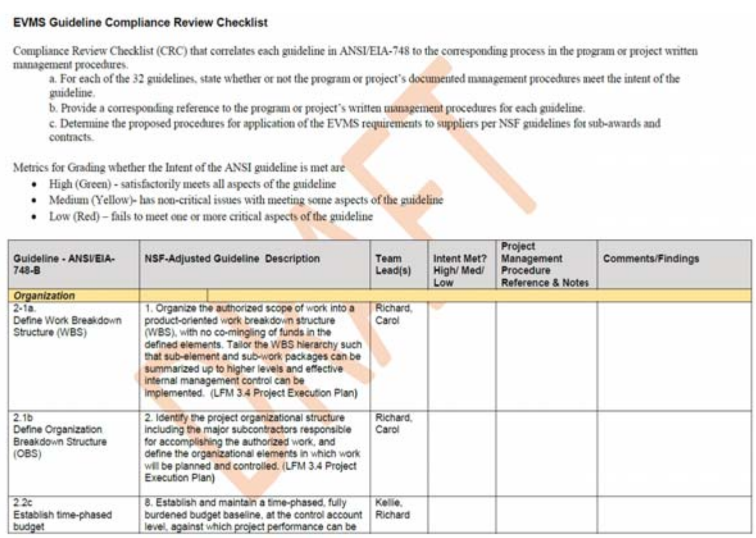
- Conducted in tandem but separate from annual review
- 3 Reviewers: certified EVM professional contractor, LFO staffer, and SME for telescope projects
  - Did not use DCMA reviewers
- 3 weeks of EVMS document reviews
- 2 days of on site interviews – AURA and LSST staff
- Issued report stating ‘In compliance with areas for improvement’ (not exactly acceptance/certification)
- Project response by next annual review (late 2016)
- Repeat surveillance by reviewing implementation at time of 2017 annual review
- Duration ~ 5 weeks with Cost to program ~$10K

Pilot Review Process

- Review documents for compliance with the 32 EIA-478 standards
- Interview project accounting, project controls, and project team members for knowledge and proper implementation against documentation and EIA-478 standards
- Use interview templates for consistency
- Fill out EIA-478 checklist and report findings

Steps to SOG

- Decide whether NSF uses DCMA certification or it’s own version of written “acceptance/approval”
- Settle on thresholds and processes for review -> correct -> final review and acceptance/approval, including designating approvers
- Agree on qualifications and number of reviewers (3rd party EVMP versus DCMA)
- Improve interview templates and EIA-checklist as needed; create standard report and “acceptance” letter templates
- Determine timing and requirements for initial and follow-up surveillance reviews.
- Determine who pays for validation and surveillance reviews
- Differentiate deeper dive for initial review (pre-FDR) from surveillance reviews=> larger initial burden (time and money)
- Likely to require project implementation of EVM tools and processes during Final Design phase in order to be able to pass initial EVM validation as part of FDR.
- Determine process for dealing with chronic non-compliance



EVMS Guideline Compliance Review Checklist

Compliance Review Checklist (CRC) that correlates each guideline in ANSI/EIA-748 to the corresponding process in the program or project written management procedures.

a. For each of the 32 guidelines, state whether or not the program or project’s documented management procedures meet the intent of the guideline.

b. Provide a corresponding reference to the program or project’s written management procedures for each guideline.

c. Determine the proposed procedures for application of the EVMS requirements to suppliers per NSF guidelines for sub-awards and contracts.

Metrics for Grading whether the Intent of the ANSI guideline is met are

- High (Green) - satisfactorily meets all aspects of the guideline
- Medium (Yellow)- has non-critical issues with meeting some aspects of the guideline
- Low (Red) – fails to meet one or more critical aspects of the guideline

Guideline - ANSI/EIA-748-B	NSF-Adjusted Guideline Description	Team Lead(s)	Intent Met? High/ Med/ Low	Project Management Procedure Reference & Notes	Comments/Findings
Organization					
2-1a. Define Work Breakdown Structure (WBS)	1. Organize the authorized scope of work into a product-oriented work breakdown structure (WBS), with no co-mingling of funds in the defined elements. Tailor the WBS hierarchy such that sub-element and sub-work packages can be summarized up to higher levels and effective internal management control can be implemented. (LFM 3.4 Project Execution Plan)	Richard, Carol			
2.1b Define Organization Breakdown Structure (OBS)	2. Identify the project organizational structure including the major subcontractors responsible for accomplishing the authorized work, and define the organizational elements in which work will be planned and controlled. (LFM 3.4 Project Execution Plan)	Richard, Carol			
2.2c Establish time-phased budget	8. Establish and maintain a time-phased, fully burdened budget baseline, at the control account level, against which project performance can be	Kellie, Richard			

Guideline - ANSI/EIA-748-B	NSF-Adjusted Guideline Description	Team Lead(s)	Intent Met? High/ Med/ Low	Project Management Procedure Reference & Notes	Comments/Findings
	measured. Initial budgets established for performance measurement will be based on either internal management goals or the external customer negotiated target cost including estimates for authorized but undefinitized work. Budget for far-term efforts may be held in higher level accounts until an appropriate time for allocation at the control account level. If an over target baseline is used for performance measurement reporting purposes, prior notification must be provided to the customer.				
2.2d Assign cost element categories to budgets for authorized work	9. Establish burdened budgets for authorized work with identification of NSF cost elements (labor, material, etc.) as needed for internal management and for control of contractors. (http://www.nsf.gov/pubs/policydocs/pappguide/nsf16001/gpg_2.jsp#IIC2g)	Kellie, Richard			
2.2e Identify discrete work packages	10. To the extent it is practical to identify the authorized work in discrete work packages, establish budgets for this work in terms of dollars, hours, or other measurable units. Where the entire control account is not subdivided into work packages, identify the far term effort in larger planning packages for budget and scheduling purposes.	Richard, Kellie			
2.2f All work package budgets and planning packages sum to control account	11. Provide that the sum of all work package budgets plus planning package budgets within a control account equals the control account budget.	Kellie, Richard			
2.2g Identify and control LOE budgets	12. Identify and control level of effort activity by time-phased budgets established for this purpose. Only that effort which is not measurable or for which measurement is impractical may be classified as level of effort.	Kellie, Richard			

Guideline - ANSI/EIA-748-B	NSF-Adjusted Guideline Description	Team Lead(s)	Intent Met? High/ Med/ Low	Project Management Procedure Reference & Notes	Comments/Findings
2.2h Establish overhead budgets by organization element	13. Establish overhead budgets for each significant organizational component for expenses which will become indirect costs. Reflect in the program budgets, at the appropriate level, the amounts of overhead that are planned as indirect costs.	Kellie, Richard			
2.1c Earned Value Management Systems (EVMS) integrated with WBS and OBS	3. Provide an earned value management system (EVMS), as part of the project management controls plan, for the integration of the planning, budgeting, work authorization and cost accumulation processes with each other, and as appropriate, the project work breakdown structure and the program organizational structure. (LFM 3.4 Project Execution Plan)	Carol, Kellie			
2.1d Identify Organization/Function for overhead	4. Identify the organization or function responsible for controlling overhead (indirect costs).	Kellie			
2.1e Create control accounts integrated with WBS and OBS for EVMS	5. Provide for integration of the project work breakdown structure and the project organizational structure in a manner that permits cost and schedule performance measurement by elements of either or both structures as needed. (LFM 3.4 Project Execution Plan)	Kellie			
Planning, Scheduling and Budgeting					
2-2a Create Integrated Master Schedule (IMS)	6. Schedule the authorized work in a manner which describes the sequence of work and identifies significant task interdependencies required to meet the requirements of the project. (LFM 3.4 Project Execution Plan)	Carol, Richard			
2.2b Identify interim measures for progress	7. Identify physical products, milestones, technical performance goals, or other indicators that will be used to measure progress.	Carol, Richard			

Guideline - ANSI/EIA-748-B	NSF-Adjusted Guideline Description	Team Lead(s)	Intent Met? High/ Med/ Low	Project Management Procedure Reference & Notes	Comments/Findings
2.2i Identify contingency budget	14. Identify cost and schedule contingency budget per LFM Sections 4.2 and 5.2.	Carol, Richard			
2.2j Reconcile the sum of all budgets with the Total Project Cost (TPC)	15. Provide that the program target cost goal is reconciled with the sum of all internal program budgets and contingency amounts.	Richard, Carol			
	Accounting Considerations				
2.3a Record direct costs from accounting system	16. Record direct costs in a manner consistent with the budgets in a formal system controlled by the general books of account.	Kellie			
2.3b Summarize direct costs into WBS without multiple allocation	17. Summarize direct costs from control accounts into the work breakdown structure without allocation of a single control account to two or more work breakdown structure elements.	Kellie			
2.3c Summarize direct costs into OBS without multiple allocation	18. Summarize direct costs from the control accounts into the organizational elements without allocation of a single control account to two or more organizational elements.	Kellie			
2.3d Record indirect costs	19. Record all indirect costs which will be allocated to the program consistent with the overhead budgets.	Kellie			
2.3 e Identify unit or lot costs	20. Identify unit costs, equivalent unit costs, or lot costs when needed.	Kellie			
2.3f Accurate material cost accumulation; simultaneous EVM measurement; full accountability of material	21. For EVMS, the material accounting system will provide for: (1) Accurate cost accumulation and assignment of costs to control accounts in a manner consistent with the budgets using recognized, acceptable, costing techniques. (2) Cost recorded for accomplishing work performed in the same period that earned value is measured and at the point in time most suitable for the category of material involved, but no earlier than the time of actual receipt of material. (3) Full accountability of all material purchased for the program including the residual inventory.	Kellie, Richard			

Guideline - ANSI/EIA-748-B	NSF-Adjusted Guideline Description	Team Lead(s)	Intent Met? High/ Med/ Low	Project Management Procedure Reference & Notes	Comments/Findings
	Analysis and Management Reports				
2.4a Monthly control account summary and EVM metrics	22. On a monthly basis, generate EVM reports including the following information at the control account and other levels as necessary for management control using actual cost data from, or reconcilable with, the accounting system: (1) Comparison of the amount of planned budget and the amount of budget earned for work accomplished. This comparison provides the schedule variance. (2) Comparison of the amount of the budget earned and the actual (applied where appropriate) direct costs for the same work. This comparison provides the cost variance.	Richard, Carol			
2.4b Explain significant variances	23. Identify, on a monthly basis, the significant differences between both planned and actual schedule performance and planned and actual cost performance, and provide the reasons for the variances in the detail needed by program management. Provide plans for remediation.	Richard, Carol			
2.4c Identify and explain indirect cost variances	24. Identify budgeted and applied (or actual) indirect costs at the level and frequency needed by management for effective control, along with the reasons for any significant variances.	Kellie			
2.4d Summarize data elements and variances for management reports	25. Summarize the data elements and associated variances through the program organization and/or work breakdown structure to support management needs and any customer reporting specified in the contract.	Carol, Richard			
2.4e Implement management actions as a result of EVM analysis	26. Implement managerial actions taken as the result of earned value information. Negative cost and schedule variances greater than -10% require submission to NSF of a recovery plan with timeline for accomplishment.	Carol, Richard			
2.4f Revise cost and Schedule EAC and VAC on a periodic basis	27. Periodically develop revised estimates of EAC and end date forecast based on performance to date, commitment values for material, and estimates of future conditions.	Carol, Richard			

Evaluating Facilities-based Education and Public Outreach Activities

John Taber & Michael Hubenthal
Incorporated Research Institutions for Seismology
Hilarie Davis
Technology for Learning

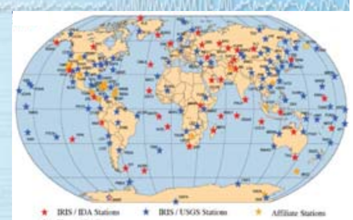
5/26/16 – Large Facilities Workshop

Overview

- Why Education and Public Outreach (EPO) in a research facility?
- EPO evaluation needs
- One collaborative approach: Impact Analysis Method
- Potential outcomes
- Critical success factors for implementation

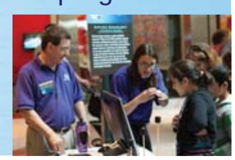
Incorporated Research Institutions for Seismology

- Formed in 1984
  - Global Seismic Network (with USGS)
  - Portable seismographs (PASSCAL)
  - Data management center
- Now includes
  - Education and Public Outreach
  - EarthScope Transportable Array
  - Ocean Bottom Seismograph Instrument Pool
  - Other instrumentation
- Over 120 member organizations and over 100 educational and foreign affiliates



Why EPO in a research facility?

- Strong NSF encouragement to add EPO
  - Initiation of NSF Broader Impacts criteria (1997)
  - First staff member in 1998
- Value of a facility EPO program
  - National consortium with local university connections
  - Strong community involvement
  - Unique data and scientific resources
  - Stable consortium structure for long-term programs
  - Professional staff
  - Considerable emphasis on outreach



Positioning facility EPO programs

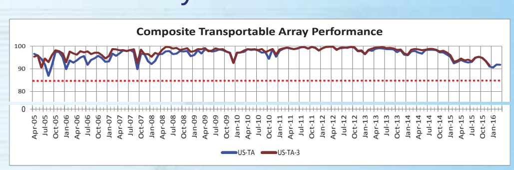
Education and outreach spectrum

Education research
Detailed external evaluation

Single PI outreach
Self reporting, counts

Reporting metrics to NSF

- Instrumentation and data
  - Number of portable instruments available for the research community
  - % data availability of each seismic network

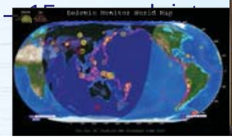


  - % uptime for the Data Management Center
- EPO
  - Number of products and services provided

Prior IRIS EPO evaluation approach

- Internal assessment during development and implementation
- Occasional external assessment at conclusion of projects
- Regular oversight by community steering committee

- Difficult to decide on appropriate level of evaluation for a very wide range of products and services
  - Millions of website visitors for a minute



Need of IRIS EPO

We evaluate the products and programs in our portfolio….

but could benefit from increased consistency and rigor.

Need to assess both quality and impact

Desired Outcome:

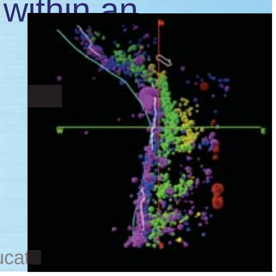
Make evaluation an integral part of IRIS EPO staff's work so

- we can state why we do the activities we do (needs assessment),
- enhance the impact, and
- make evidence-based claims about our work.

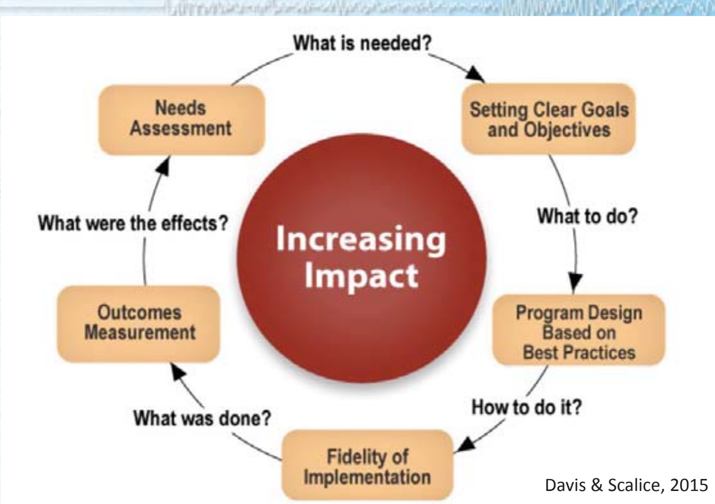
Impact -The intended and unintended effects on the Behavior, Attitudes, Skills, Interest, Knowledge, (BASIK) of the participants (Friedman, 2008)

Evaluation choice

- Adopted the Collaborative Impact Analysis Method of Davis and Scalice, 2015
- Used by a number of NASA EPO programs
- Designed to be implemented within an existing EPO program
  - Focus on incremental improvements



Evaluation Approach



Davis & Scalice, 2015

Process

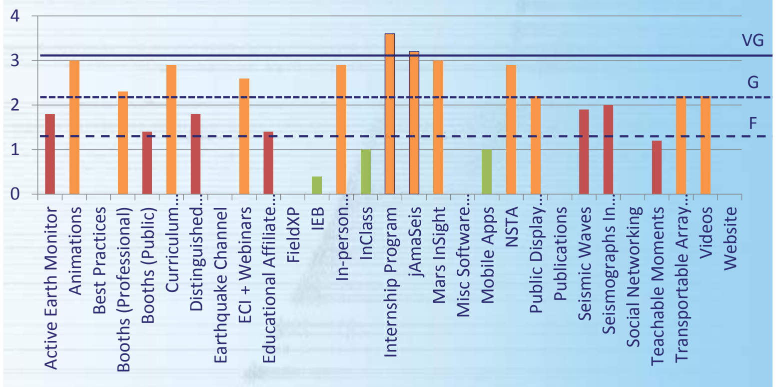
- Consultations with external evaluator - Assess current evaluation for each project
- Internal staff development – Consultations with external evaluator, presentation, reading
- Action plans - Develop internal structures and reporting mechanisms to support evaluation
- Implementation - Make incremental changes to our projects to improve rubric scores

Quantitative Collaborative Impact Analysis Method

Project Phase	Fair (1)	Good (2)	Very Good (3)	Excellent (4)
Needs Assessment What is the evidence of need?	Prior experience; "Seems like a good idea"	Research on what works; Literature review on similar programs/ products/ populations/ goals	Conversation with and/or direction from stakeholders (Focus Group); Experts review the ideas/plan	Survey of or pilot with potential audience/ users about the draft program
Goals and Objectives How measurable are the goals and objectives?	General direction; Understood by team; Agenda substituting for objectives	Explicit, written; For a target audience	Objectives are SMART: Specific, Measurable, Action-oriented, Realistic, Time-bound	Logic model of inputs, outputs, and outcomes in place
Design of Project How evidence- or research-based is the design?	Series of activities; Uses what has worked before	Based on objectives; Connects to standards; Includes contingency plans for emerging needs	Thematic; Has continuity; Participatory, personalized, responsive; Uses advanced organizers	Developmental; Embeds evaluation/ reflection
Implementation How true to the design is the implementation? (fidelity)	Facilitators prepare to implement the design	Collect and use feedback during implementation	High fidelity to design OR implements contingency plans to meet objectives if needed	Participants able to monitor their own progress against objectives
Outcomes Assessment/ Methods What is the evidence of impact on BASIK?	Post only survey or reflection; Follow up survey or interview; Web stats; Anecdotes; Facilitator reports	External evaluator observes, or does case studies; Pre/post self-report survey, reflections; Post only measure (test, retrospective survey, task)	Pre/post measures (tests, performance tasks, observation); Pre/post follow-up	Comparison group studies (quasi-experimental); Experimental study (random assignment)

Davis and Scalice, 2015

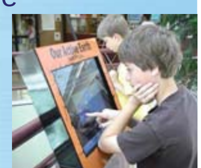
Collaborative Impact Analysis Scores



Min = 0, Max = 3.6, Median 1.9

Post-consultation

- What we expect
  - Incremental improvement everywhere
- What we don't expect
  - Achieve a 4 everywhere, *unless*
    - Core to the mission
    - Additional funding for enhancement/expansion
    - A gap in the literature we can uniquely fill

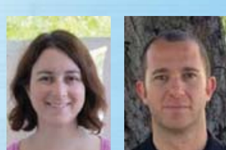


Action Plan - Examples

- Write SMART Objectives
- Conduct survey of existing users
- Review and update design criteria/critical features
- Request pre/post survey data from collaborative workshops
- Create a logic model for project
- Conduct needs assessment of Educational Affiliate members of IRIS

IRIS/SSA Distinguished Lectureship - Example

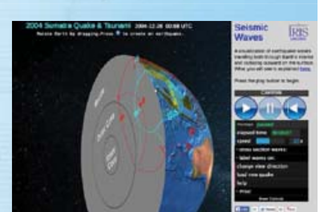
- Initial Score <u>1.8</u>
  - <u>N</u>eeds Assessment - 4
  - <u>G</u>oals and Objectives - 2
  - <u>D</u>esign - 2
  - <u>I</u>mplementation - 1
  - <u>O</u>utcome Assessment - 0
- Action Plan
  - Rewrite goals as SMART Objectives
  - Post lecture surveys
    - Speakers
    - Venue
  - Obtain feedback from SSA (partner organization)
- Projected Score <u>2.6</u>



2016 Distinguished Lecturers

Seismic Waves web application - Example

- Current Score <u>2.8</u>
- Actions
  - Needs assessment & competitive analysis - 4
  - SMART objectives - 3
  - Critical feature list (design)
  - Beta/Usability testing (implementation) - 3
  - Revision based on testing (design) - 4
  - Promotion (built from the above)
  - Measuring effects of use (outcomes) - 1



Positive Effects on IRIS EPO

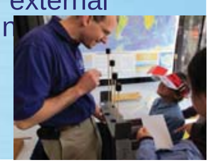
- Each project is explored in consultation with the evaluator, which provides
  - expert outside feedback
  - a benchmark score
  - possible pathways to improve the evaluation
- Promotes improvement, no matter the initial state

Positive Effects on IRIS EPO

- Change in staff knowledge, attitude and behavior
  - Development of staff knowledge and skills regarding evaluation
  - Common language among staff
  - Increased enthusiasm to collect and share data
  - Desire for consultations to get evaluation ideas
  - Inclusion of evaluative approaches up front for discussion of new activities
- Improved impact of products and

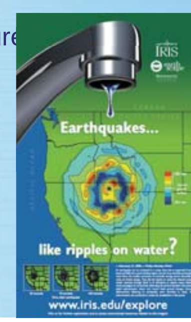
Evaluation cycle

- Combines internal and external assessment
- Annually
  - Build internal capacity through consultations with external evaluator
  - Develop action plans to increase level of evaluation
  - Collect data and prepare annual report which is reviewed by external evaluator
- Every 2-3 years
  - Conduct total portfolio evaluation with external evaluator, followed by strategic plannin



Potential items to report

- Lists of products/activities
- Accomplishments by project
- Audiences
- Types of impact (BASIK),
  - Counts of participants
  - Deeper intervention –evidence and nature of of impact
  - How measured
  - Generalizability
- Annually – impact analysis scores by project, mean, median



Evaluation process

- How does this process differ from typical, single project evaluations?
  - Lower cost for external evaluator
    - Instead of commonly used 10% of budget
    - Depending on staff time instead
  - Greater staff involvement and ownership
- Still challenging to include in flat budget environment

Potential facility model for evaluation

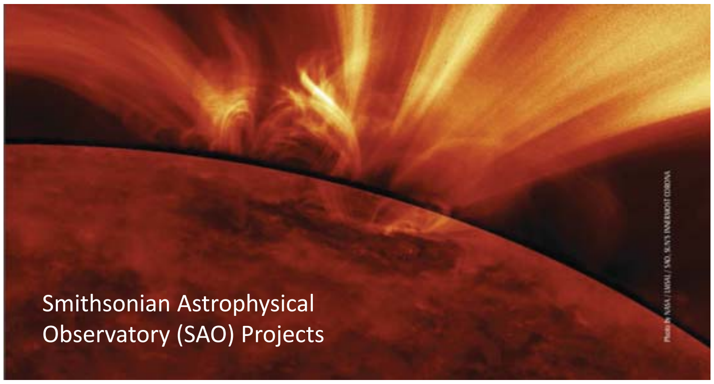
- Planning discussion with leadership
- Evaluator consultations with individual staff
- Staff develop/implement action plans
- Expert review and support with evaluation tools and analysis
- Discuss and report results

Critical Success Factors

- Some existing internal evaluation expertise
- Clear leadership commitment and involvement
- Intentional cultural change
- Ongoing support from external evaluator
- Use of evaluation results for improvement and reporting

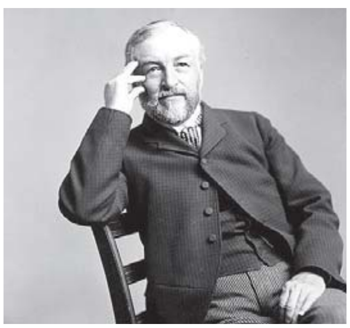
Summary

- Collaborative evaluation method
  - Capacity building of implementers
- Can be initiated at any stage of the project
- Evaluation integrated throughout the project life cycle
  - Ongoing use of data
- More focused implementation
  - More efficient use of resources
- Richer reporting to NSF
- Greater impact



Common Challenges

- Extreme Climactic Conditions
- Facility Complexity
- Leased Properties and Sites
- Native American Lands
- Respect for Natural Habitat
- 24/7/365 Operations
- Aging Infrastructure
- Fiscal Planning Cycles
- Funding Constraints
- Competitive Science
- Tight Deadlines
- Maintenance
- Decommissioning



Samuel Pierpont Langley, 3rd Secretary of the Smithsonian
Founder of Smithsonian Astrophysical Observatory 1887

Fred Lawrence Whipple, Director Smithsonian
Astrophysical Observatory 1955-1973

CfA Harvard-Smithsonian Center for Astrophysics

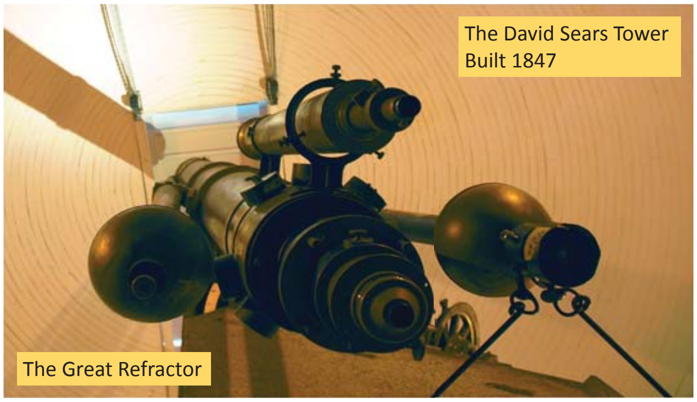
July 1, 1973: Smithsonian Institution and Harvard University formalize their collaboration as the Harvard-Smithsonian Center for Astrophysics (CfA)

Coordinated strengths and combined staffs in six research divisions:

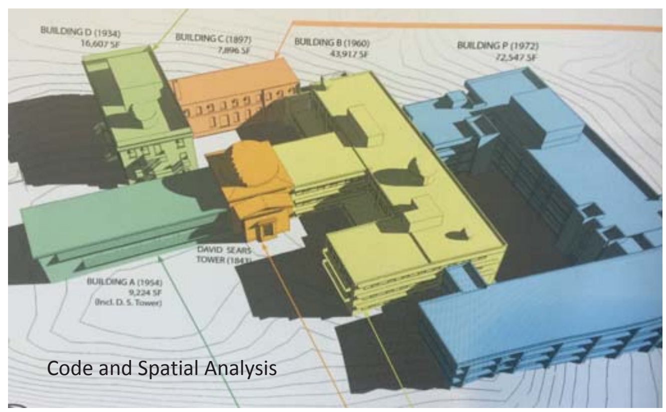
Atomic and Molecular Physics;
High Energy Astrophysics;
Optical and Infrared Astronomy;
Radio and Geoastronomy;
Solar, Stellar, and Planetary Sciences; and
Theoretical Astrophysics.

SAO
HCO
CfA

Cambridge Locations

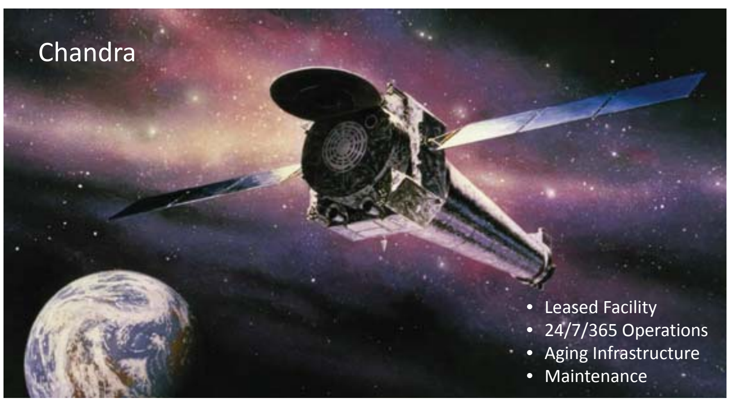


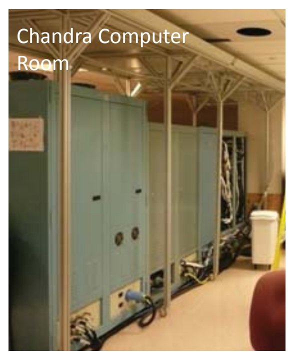
2013-
2014

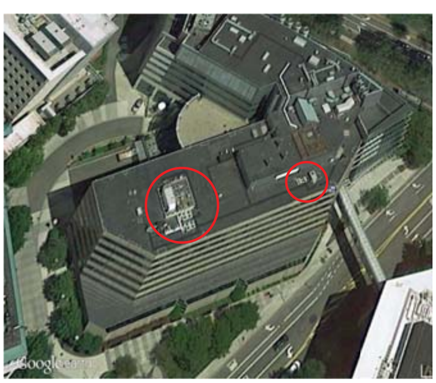


Code and Spatial Analysis

Egress and Accessibility Analysis

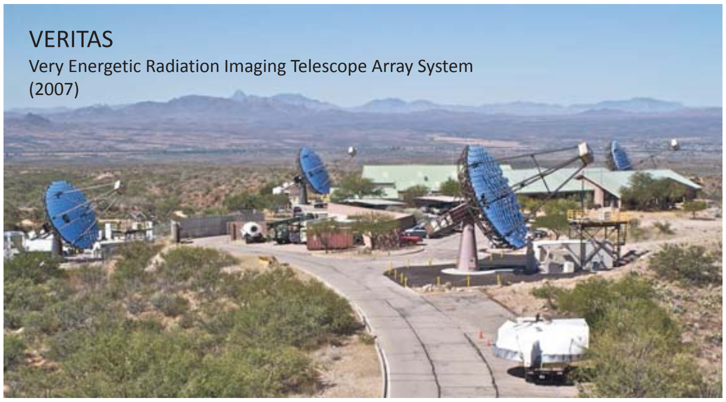


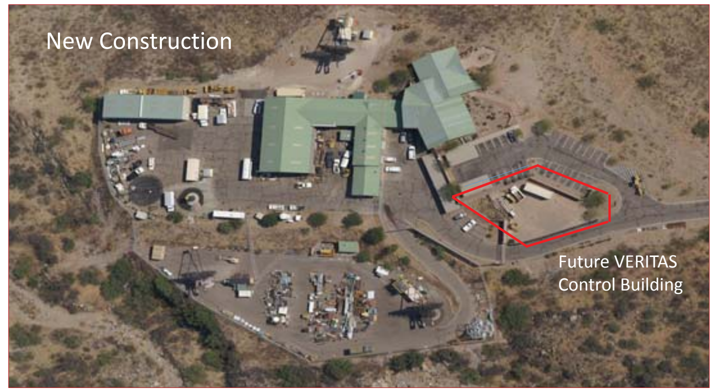




Replace failing HVAC equipment and increase cooling capacity

Challenge - Replace HVAC systems while maintaining operations


VERITAS
Very Energetic Radiation Imaging Telescope Array System
(2007)

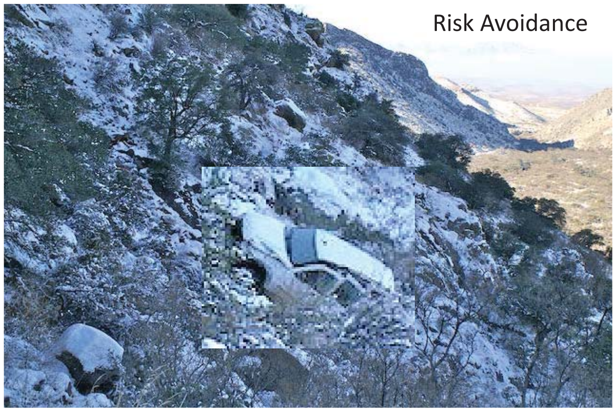

New Construction
Future VERITAS
Control Building


VERITAS Control Building

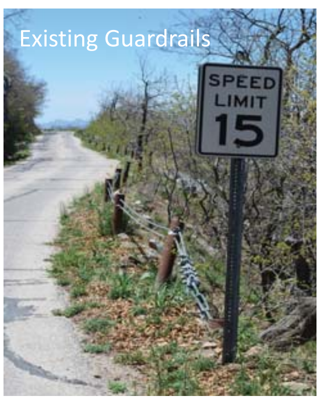

VERITAS Control Building
Entrance


MMT
Ridge
Mt Hopkins Road
20 Km to Summit
Base Camp

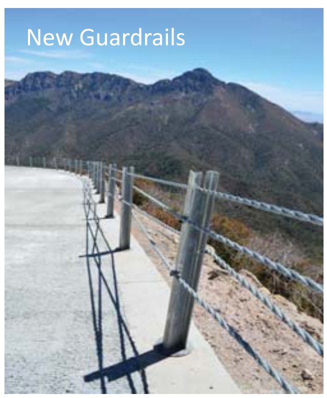

FLWO Road Traffic


Risk Avoidance


Existing Guardrails



Existing Guardrails

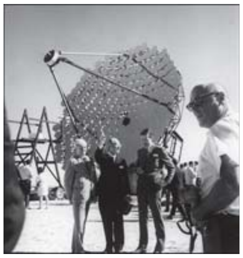

New Guardrails


Understanding Existing Conditions

Road Stabilization

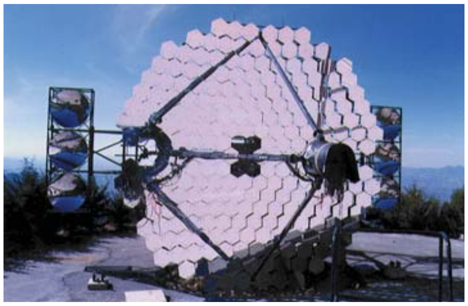
Culvert Replacement

Ridge Facilities



Dedication

Repurposing Site for New Science:
10 Meter Gamma Ray Telescope 1968-2011



Repurposing Site for New Science:
Minerva Telescope Array 2016

Mountain Power

- Facility Complexity
- 24/7/365 Operations
- Aging Infrastructure
- Maintenance

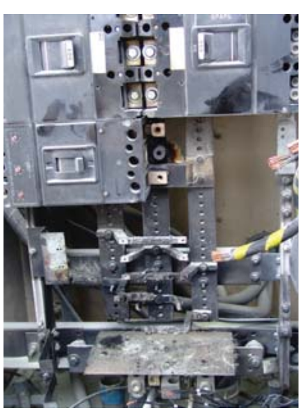
Existing Unisource Power 13800v Substation

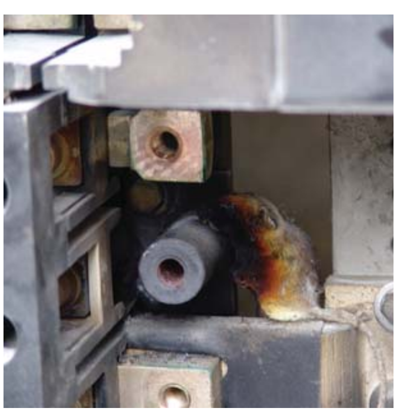
Existing SAO 4160v Distribution System

Existing SAO Generator

Challenging Neighbors

Spotted Owl Mating Season March 1st to September 1st





Creative Problem Solving


Road Reconstruction
• 24% Slope to Summit
Existing Asphalt Pavement

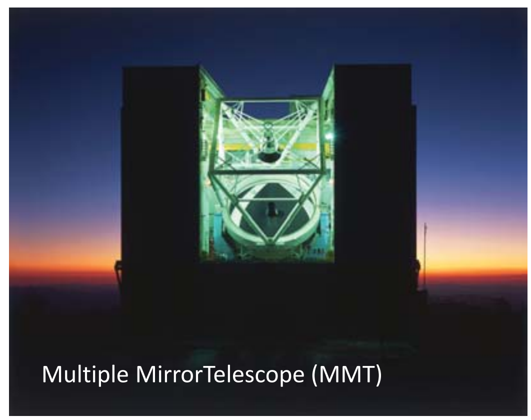

New Concrete Pavement and Guardrail design to Summit

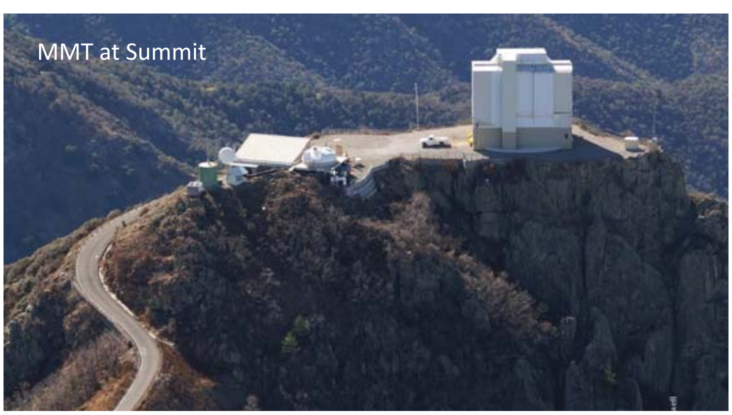

New Guardrail design

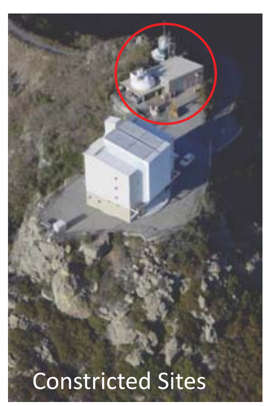

New Concrete Pavement


New Concrete Pavement and Guardrail design

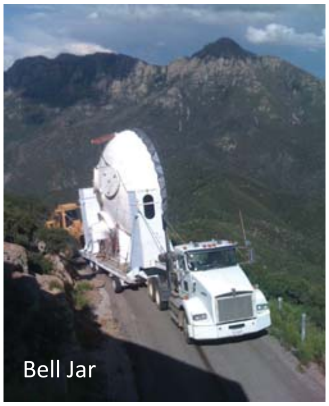

MMT
Mount Hopkins
• Elevation 8,500 ft


Multiple MirrorTelescope (MMT)

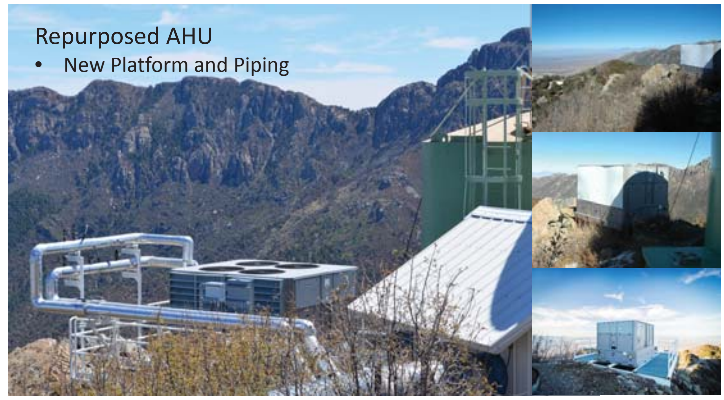

MMT at Summit


Constricted Sites

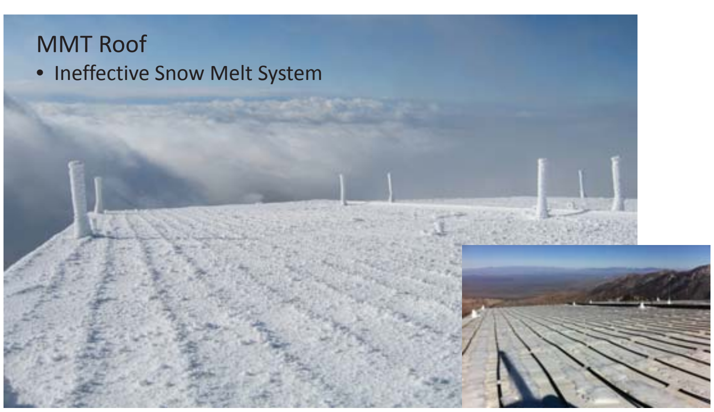

New Construction Instrument Repair Facility


Bell Jar


Operations:
Bell Jar Placement for MMT Aluminizing


Repurposed AHU
• New Platform and Piping

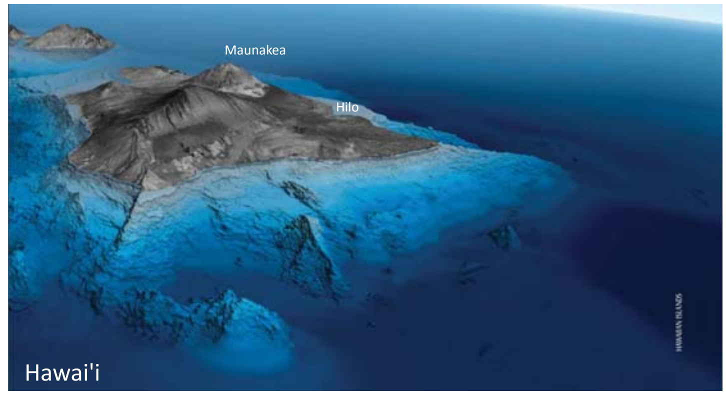

Extreme Climatic Conditions


MMT Roof
• Ineffective Snow Melt System


MMT Roof Testing Snow Melt System

2005: New 300,000 Gallon Water Tank

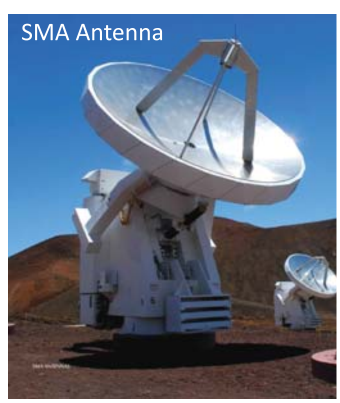
Strategically Placed Additional Tanks

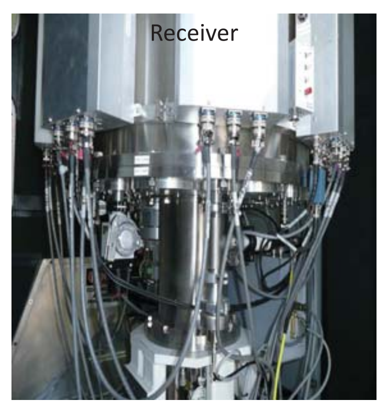

Maunakea
Hilo
Hawai'i

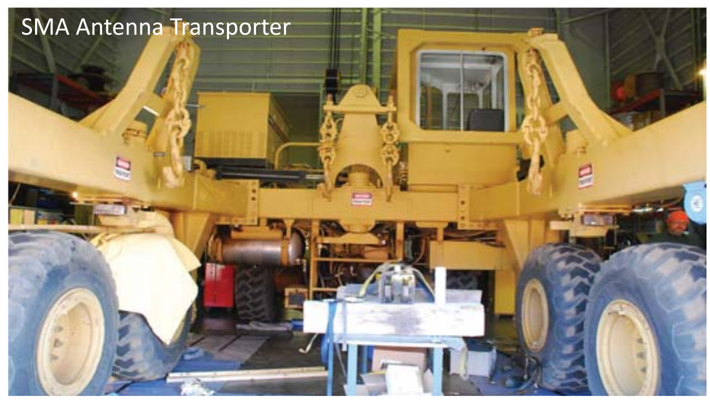

Maunakea


Challenges:
• Native Lands
• Extreme Climactic Conditions
• Acclimate at 9,500 before proceeding to Summit
• 13,796 Summit
• No Expansion Permitted
• Decommission site at end of lease


SMA Support Facility
SMA Antenna Array
Sub Millimeter Array


SMA Antenna


Receiver

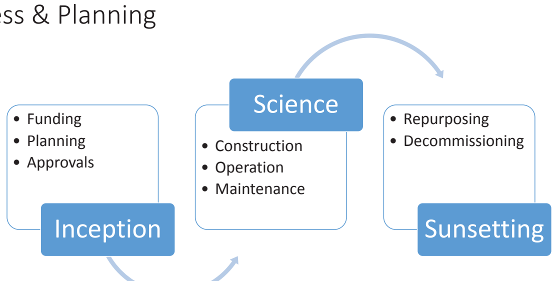


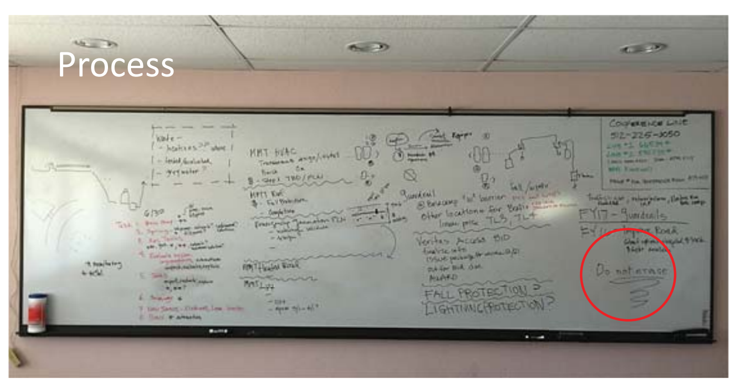
Computer Room

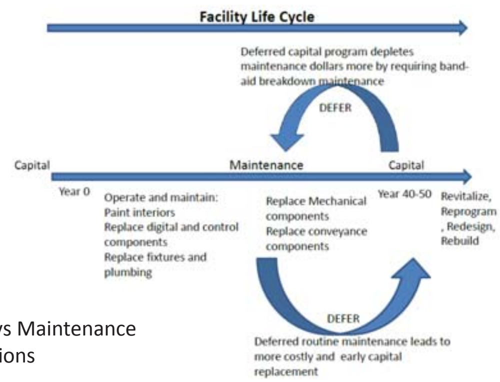
Emergency Generator

Hawaiian Shaved Ice

Process & Planning







Capital vs Maintenance Implications

Communities of Practice

& LESSONS LEARNED

Budget, Finance, and Award Management
Large Facilities Office
May 2016

Large Facilities Workshop 2016
S. Dillon Ripley Center
Washington, D.C.

NATIONAL ACADEMY OF PUBLIC ADMINISTRATION

Use of Cooperative Agreements to Support Large Scale Investment in Research
December 17, 2015

RECOMMENDATION 6.9

Recommendation 6.9

"To facilitate project management knowledge sharing across the agency and with award recipients . . . ."

"NSF should formally establish communities of practice to share best practices and implement a "lessons learned" requirement for all MREFC projects."

KNOWLEDGE SHARING

"The NSF Academy should promote the formation of **communities of practices** and encourage staff participation." — INTERNAL

"The LFO should develop a **lessons learned** process and template to capture instructive experiences from projects and to inform policies and practices to strengthen the management of future projects." — EXTERNAL

Focus Today

NAPA Likes & Dislikes & NSF PLANS

Likes -	Dislikes -	NSF Plans to -
LFM tasks LFO with sharing Lessons Learned (LL).[1]	No collection or distribution guidance provided	• Introduce a means to collect and distribute LL.
DOE and NASA have LL policy and databases.		• Review DOE and NASA systems.
DOE and NASA collect both positive and negative lessons.		• Collect both positive and negative lessons • Inform agency policy with LLs

1. LFM NSF 15-89, Sec. 2.1.6

Questions

1. What kinds of lessons learned would assist a project at each of its various stages?
2. What elements should a lessons learned template include?
3. How might NSF motivate projects to share both positive and negative lessons learned?
4. Who should input lessons learned and how often?
5. Who should have access to the lessons learned and under what circumstances would these groups have access?

Who in Government has Lessons Learned Systems?

Smithsonian Institution

NASA

CDC

Advice on Lessons Learned

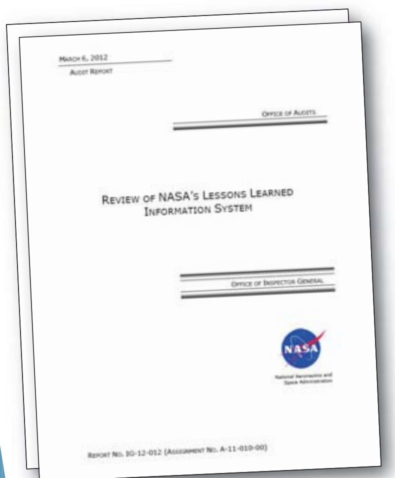
- "Structure by lifecycle stage or role, not by project."
- "Collect lessons in a form."
- "Input lessons throughout the project."
- "Review lessons before posting."
- "Associate an action with each lesson."
  - *Repeatable or adaptable*
  - *Preventative measure or response*
- "Turn lessons into policy."
- "Open access as widely as possible."
- "Enable filter and free text searching."
- "Prompt for inputs and notify following posts."
- "Track usage metrics."
- "Archive closed or obsolete lessons."

What else?

Elements for a Template

Category or Categories	Lifecycle stage or role
Name	Title representative of the problem or success
Description	Explanation of the problem or success in two to three sentences
Root Cause(s)	Brief summary of what created the issue or opportunity
Impact(s)	Costs the problem or benefits the success introduced
Action(s)	What a project or the sponsor could do to prevent the problem or claim the success

What else?


March 6, 2012
Audit Report
Office of Audits
Review of NASA's Lessons Learned Information System
Office of Inspector General
Report No. IG-12-012 (Assignment No. A-11-010-00)

Findings
- Infrequent entries
- Low usage
- Policies not encouraging entries or usage
- Minimal monitoring

Action
- Broadened policy on lessons learned to create a "Chief Knowledge Officer" and assign other responsibilities

Barriers to Recording Lessons Learned

Costs (time) to . . .
- Initiate and maintain the system
- Prompt recipients for submissions
- Prepare, edit, and approve entries
- Review and archive past submissions

Fear of . . .
- Embarrassment
- Harm to reputation
- Reduced responsibilities or funding

Administrative
- Culture
- Trust
- Policy changes

What else?

Institutionalizing Lessons Learned

- **Reduce the stigma** -
  - *Minimize who at NSF knows what each project has submitted.*
  - *Anonymize listings of lessons learned.*
- **Broaden submissions** – accept from:
  - *Project and facility personnel*
  - *NSF program officers, grants and agreement officers, etc.*
  - *Reviewers and other stakeholders*
- **Require submissions** in conjunction with reviews
- **Report annually** including
  - *Submission and access counts*
  - *Lessons that changed policies or procedures*

What else?

Selecting a Medium

	Spreadsheet	Database
Pros	• Quick implementation • Low maintenance • Low first cost	• Accommodates multiple roles • User-friendly searches and outputs
Cons	• Time consuming compiling • Querying not user friendly • Low security • Usage metrics not available	• High initial investment • Learning curve • Routine maintenance

What else?

Access to the Lessons Learned

- Who?
  - National Science Foundation
    - Program officers and Grants and agreements officers?
    - Large Facilities Office?
    - Office of the Director?
    - Office of Legislative and Public Affairs?
    - Office of General Counsel?
    - Office of the Inspector General?
  - Projects
    - . . . in development or design?
    - . . . in construction?
    - . . . in operations or divestment?
  - Office of Management and Budget?
  - Public?
- How much access?
  - Read some?
  - Read all?
  - Comment?
  - Write?
  - Edit others?

Next steps

- Slides posted on the workshop Web page
- Notes from the session included in the workshop proceedings
- Large Facilities Office (LFO) will pilot test a collection tool in fiscal year 2017
- The **Large Facilities Manual** (18-XX) will identify recipient requirements with options and approaches –
  - NSF will publish a public comment draft in April 2017 with comments accepted for three months
  - NSF will publish the final Large Facilities Manual in October 2017 to take effect in January 2018.
- LFO will issue its first report on its lessons learned system in March 2018.

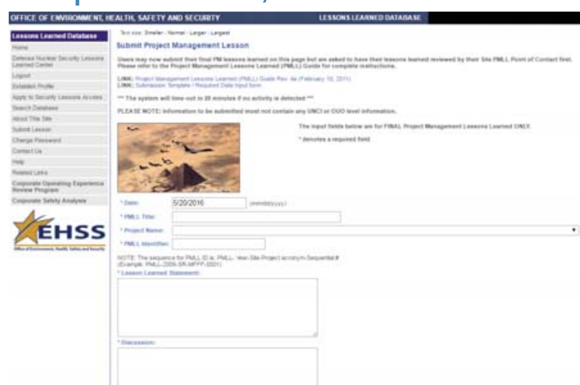
For more information:

Ivan Graff
Large Facilities Advisor
(703) 292-4416
igraff@nsf.gov

Backup

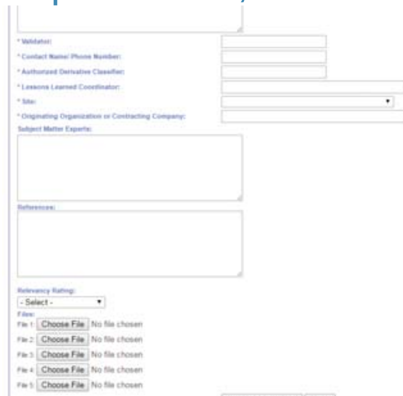
U. S. Department of Energy
Lessons Learned System
Screen Shots

Input Screen, 1 of 3

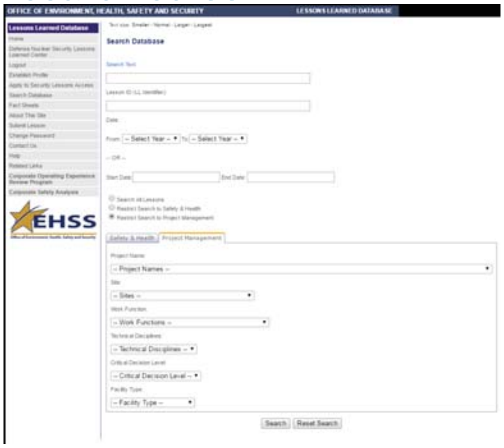


Input Screen, 2 of 3

Input Screen, 3 of 3



Search Screen



National Science Foundation
OFFICE OF BUDGET FINANCE & AWARD MANAGEMENT

Large Facilities Manual
New Guidance on Cost Estimating and Analysis

2016 NSF Large Facilities Workshop

Kevin Porter
Large Facilities Advisor, LFO, NSF
kporter@nsf.gov
703-292-7484

Purpose of Workshop Session

- Get the Word Out
- We Want Your Input
- Purpose of Guidance
- Key Content & Concepts

We Want Your Input

- Public Comment on LFM Revisions
  - May 9: Draft For Public Comment
    - Federal Register
    - LFO Website
  - July 8: End of Public Comment Period
    - < July 8 – assured of consideration
    - > July 8 – considered to the extent practicable

Purpose of Guidance

- Improve Cost Estimates – Construction & Operations
- Clarify NSF Expectations
- More Effective and Efficient NSF Cost Analysis
- Better Align w/ Best Practices
- Implement NAPA Recommendation

Key Content & Concepts

- Follow GAO Cost Estimating and Assessment Guide
- NAPA Panel Recommendation: "To further strengthen NSF's policy on cost estimating and ensure rigor in the process: 4.2 NSF should change current language in the Large Facilities Manual so that it is clear that award recipients are expected to follow the guidance in the Government Accountability Office's Cost Estimating and Assessment Guide and Schedule Assessment Guide when developing cost and schedule estimates"

Key Content & Concepts

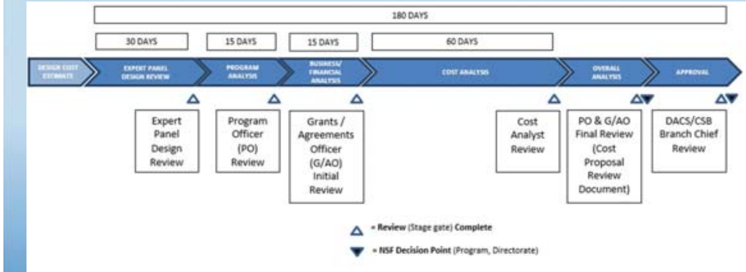
- **"Cost Analyst** – NSF staff from the Cost Analysis and Audit Resolution (CAAR) Branch of the Division of Institution and Award Support (DIAS), which perform cost assurance reviews of proposals and monitor awardee financial practices."

Key Content & Concepts

- Cost Analysis Process and Timeline
  - At CDR, PDR, FDR
  - New Awards above threshold
  - Risk based determination
    - Changes in scope, cost, schedule
    - New risks, complexity
    - Past performance
  - Plan for 90-180 days

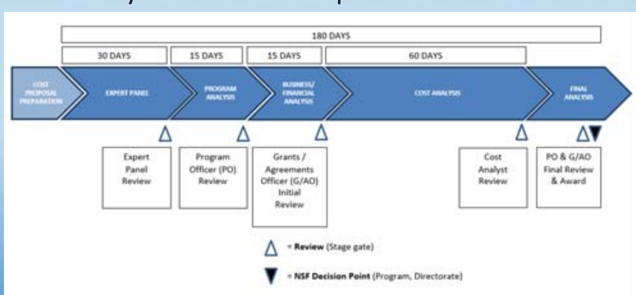
Key Content & Concepts

- Design Phases for Construction Awards



Key Content & Concepts

- Cost Analysis Process for Operations Awards



Key Content & Concepts

- Cost Estimating Plan
  - How implement LFM & GAO cost estimating guidance
  - How cost estimate will evolve over time
  - How the "Cost Model Data Set" will meet the various needs of the project.
  - Ground rules and assumptions, practices, systems, and calculations used to develop the cost estimate

Key Content & Concepts

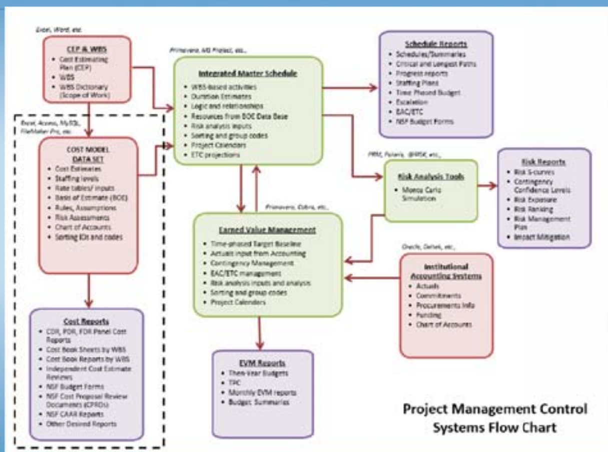
- Submit Estimate in 2 Formats:
  - Deliverable-based Work Breakdown Structure
  - Standard NSF Budget Format

Key Content & Concepts

- **"Cost Model Data Set**. The cost data used as input to software tools and/or project reports to organize, correlate, and calculate different project management information."

Office of Budget Finance & Award Management

Stewardship Enabling Science



Office of Budget Finance & Award Management

Stewardship Enabling Science

Key Content & Concepts

- NSF Budget Categories
  - Expand upon PAPPG and GPG
  - Explain acceptable justification
  - Put Contingency in “G.6 Other”

Office of Budget Finance & Award Management

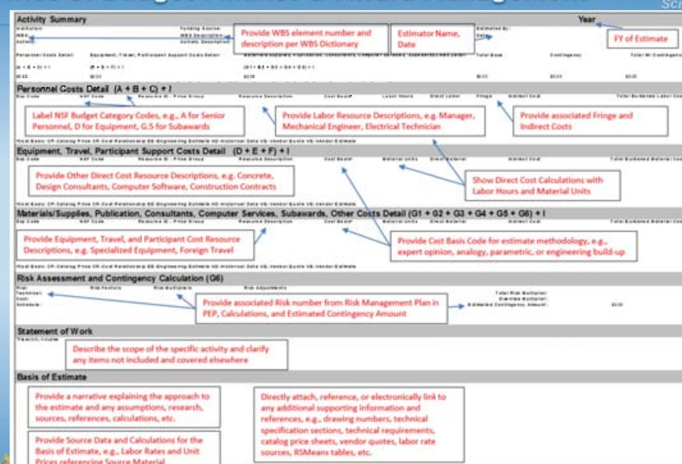
Stewardship Enabling Science

Construction Estimates

- Content & Format (WBS!)
- How GAO Guides & Best Practices Integrate w/ LFM & MREFC Process
- Basis of Estimate
  - Level of detail, justification, traceability
- Definitions
  - Cost Book Sheets → Cost Book Report

Office of Budget Finance & Award Management

Stewardship Enabling Science



Office of Budget Finance & Award Management

Stewardship Enabling Science

Operations & Management Awards

- Content & Format (WBS: functional activity and/or deliverable based)
- GAO Best Practices
- Basis of Estimate
- Delineate costs for maintenance, infrastructure changes, utilities, general support services

National Science Foundation
OFFICE OF BUDGET FINANCE & AWARD MANAGEMENT

QUESTIONS?!?

Introducing

the **National User Facility Organization**

Susan White-DePace
NUFO Executive Administrator

NSF Large Facilities Workshop
May 24-26, 2016
Washington, DC

Overview

- Introduction to NUFO
- What is NUFO's role?
- What does NUFO do?
- How is NUFO changing?
- What's in it for you?

Introduction to NUFO

- 1997 first formal meeting of user administrators to share best practices
- 2003 user representatives were included in meeting
- 2006 formally became NUFO
- Currently has 47 member facilities (materials science, astrophysics, computing, high-energy, nuclear energy, neutron, etc.)
- Two-branch organization: user administrators and user representatives
- Primary mission is to provide a unified message at a national level on issues for science done at federally-funded user facilities
- Current NSF-funded facilities are: NSCL, NOAO, NRAO, Maglab, & CHESS
  - Love to have broader NSF membership and participation

NUFO's Unique Role

- Only professional association dedicated to the user science community
- Provides a forum for multiple communities of practice
- Only unified voice for the user science community in Washington, DC
- BUT: NUFO is not a lobbying organization

NUFO Activities

- Annual Membership Meetings
- Science Expositions on Capital Hill
- Congressional Testimony
- Expert input to federal agencies (e.g., DOE Order on Foreign Visits, Immigration)
- Public outreach (e.g. Science & Engineering Expo)
- Share Benchmarking

NUFO on Capital Hill

Providing a *unified message* at the national level…

- Congress invites NUFO to hold yearly Exhibitions on Capital Hill about User Facility science

NUFO Testifies to Congress

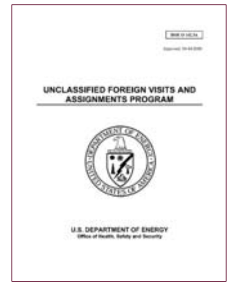
Providing a *unified message* at the national level…

- **As a direct result of the 2012 User Science Exhibition, NUFO was invited to testify to Congress about User Facility science**
- The U.S House of Representatives Science Space & Technology Committee, Subcommittee on Energy & Environment hearing on Utilizing the Tools of Science to Drive Innovation through Fundamental Research" was held on June 21, 2012, discussing:
  - The role that the Department of Energy's (DOE) national scientific user facilities play in enabling basic research that drives innovation and economic growth.
  - Challenges and opportunities associated with user facility planning and management.
- Dr. Tony Lanzirotti (U. of Chicago) testified as Chair of NUFO. Also on the panel were
  - Dr. Stephen Wasserman from Eli Lilly
  - Dr. Persis Drell (director of SLAC),
  - Dr. Suzy Tichenor (ORNL), and
  - Dr. Ernest Hall (GE Global).

NUFO Support the DOE

Providing a *unified message* at the national level…

- NUFO involvement led to modification of DOE Order 142.3: Foreign Visits and Assignments – facilitating access for non-US citizen users
  - Enhances accountability within the security function
  - Removed requirements that did not advance national interest or laboratory security
  - Improved efficiency in administering processing
  - Minimized administrative barriers to scientific research



NUFO

Promoting science to the public…

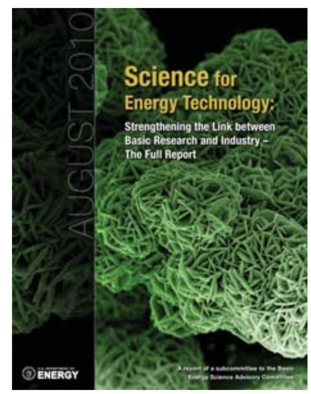
- USA Science & Engineering Festival in Washington, DC
  - NUFO conducted hands-on demonstrations to stimulate interest in science.
  - children, parents, high school students, and teachers participated in activities at the NUFO booth

NUFO Supports Industry

Providing a *unified message* on industrial user access….

NUFO advances and promotes industry access to User Facilities

- NUFO 2009 workshop focused on industrial use of national user facilities
- NUFO Report led to a BESAC study
- **BESAC report recommended changes that directly tracked NUFO recommendations**
- This has the direct potential to increase "industrial friendliness" of the facilities



Enhancing Immigration Procedures for International Users

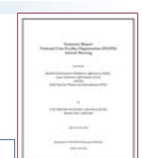
Supporting a *unified message* on international collaborations…

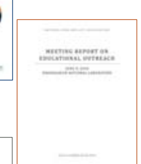
- Discussions with the Democratic Counsel on the Judiciary Committee and private law firms
- NUFO conducted two surveys on the immigration experiences of international users
- Based on the survey results, NUFO sent formal communications to Dept. of State, Dept. of Homeland Security, and Bureau of Immigration and Customs Enforcement, seeking to improve access to U.S. user facilities to better meet the needs of international scientists.

NUFO Benchmarking

Communities support communities

- NUFO conducts benchmarking studies to enable facilities to adopt best practices
  - DOE User Agreements
  - Calls for Proposals
  - Shipping Policies and Procedures
  - Multilingual Websites
  - Housing for Users
  - Multi-facility proposals – APS/ATR, APS/CNM
  - Complementary research by users at two different facilities with different capabilities
- Planned benchmarking
  - Federated Systems
  - Training Programs





NUFO's Future

- NUFO will soon become the Society for Science at User Research Facilities (SSURF)
- SSURF will be a 501c3 non-profit corporation
- SSURF will be a member-oriented, professional society dedicated to all aspects of user facility research
- More inclusive membership categories with membership benefits
- Incorporation will allow growth, programmatic expansion, fundraising opportunities, employees

SSURF's Mission

Advance the science performed at user research facilities by (1) supporting their professional communities and research networks through the sharing of best practices and facilitation of professional development, and (2) promoting public awareness about the benefits and significance of the facilities and their research

Building a Larger Community of Practice

In December 2015, the National Academy of Public Administration recommended:

"NSF formally establish communities of practice to share best practices and implement a "lessons learned" requirement for all MREFC projects."

NUFO can help you;

please join us in our mission.

What's in it for you?

SSURF plans to:

- Host annual meetings on topics of importance to it membership
  - "Power in Numbers: Building Partnerships and Common Standards across User Facilities" will challenge attendees to develop shared practices for improving users' experience, and create community performance standards to facilitate easier multi-facility use and collaboration.
  - Examples of previous meeting themes: Industrial Usage, Educational Outreach, Bridging Science Across User Facilities, Big Data
  - Community-determined parallel workshops and breakout sessions are always welcome

What's in it for you?

- Continue the Annual Science Exhibitions on Capital Hill
- Coordinate Congressional staff visits to facilities
- Organize Congressional home district office visits
- Facility adoption of unique identifiers for all users to enable data sharing
- Training reciprocity
- Other plans as staff and resources allow (e.g., speaker series, or professional societies forums)

What would you need, what do you want, what can we help you with?

Questions and Comments

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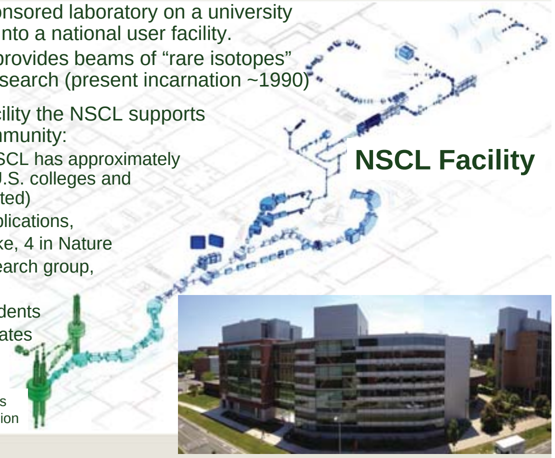
National Superconducting Cyclotron Laboratory – Interactions with Users

David J. Morrissey

NSCL Associate Director for Operations

The NSCL is Operated to Facilitate Nuclear Science

- Originally an NSF sponsored laboratory on a university campus that evolved into a national user facility.
- NSCL produces and provides beams of "rare isotopes" for nuclear science research (present incarnation ~1990)
- As a national user facility the NSCL supports a broad scientific community:
  - The user group of NSCL has approximately 1350 members (98 U.S. colleges and universities represented)
  - Past 4 years 359 publications,
    - 79 were letter-like, 4 in Nature
  - Including a local research group,
    - 41 faculty
    - 73 graduate students
    - 100 undergraduates



Operation of NSCL user facility is supported by NSF Physics Division

External Program Advisory Committee Statistics (April 2016)

- Written Proposals Submitted to PAC40 (no oral presentations)
  - 44 Proposals, for a total of 7515 hrs
    - 33 proposals led by an Outside Spokesperson
    - 365 Proposers from 75 institutions in 17 countries
    - 118 Students
- Proposals Approved at PAC40
  - 19 Proposals (43%), for a total of 2744 hrs (37%) [468 hrs on reserve]
    - 8 GRETINA, 2 ReA3, 3 Low Energy Area, 6 Other
    - 16 proposals led by an Outside Spokesperson
    - 233 Experimenters from 52 institutions in 14 countries
    - 70 Students

PAC41 is expected to take place in Spring, 2017

Communication with Users is Critical

Web Presence and Single Point of Contact at Lab

nscl.msu.edu

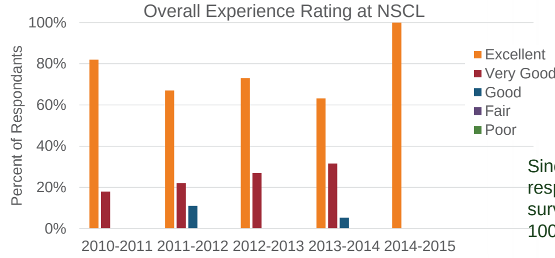
Dr. Jill Berryman, Manager for User Relations reports directly to NSCL Director handles all user interactions, coordinates experiment schedule, collects statistics

External User Organization

- Jill Berryman (Manager for User Relations) is the point of contact with NSCL users
- FRIB (nee NSCL) Users Organization (FRIBUO) www.fribusers.org
  - 1354 members from 98 US Universities/Colleges, 12 National Labs, in 50 countries
  - Quarterly newsletters "FRIB Laboratory Update for Users"
  - Announcements of important conferences, workshops, Call for Proposals
- Executive Committee of the FRIBUO contains an Operations Subcommittee, with three members focused on operations at NSCL
  - NSCL Laboratory Management has quarterly conference calls with Operations Subcommittee and chair of Executive Committee
  - One member of the Operations subcommittee attends the PAC meeting and records his/her observations. http://www.nscl.msu.edu/users/PAC39-Crawford-Signed2.pdf
- Annual Low Energy Community Meeting
  - Opportunity for users to come together annually, next at Notre Dame, Aug 11-13, 2016 http://2016.lecmeeting.org/
  - NSCL receives and acts on "Consensus Statements" on scientific thrusts and equipment or facility development plans created at these meetings
- User survey for feedback at the completion of each experiment

Experiment Feedback

- As part of the dedication to delivering world-class beams of rare isotopes to enable our users to achieve their scientific objectives the NSCL has a quality management system that was registered as compliant with the ISO 9001 standard and continues with external audits. Part of that quality management system is getting feedback from our users.
- Experiment Feedback survey is on-line the NSCL website (here).



Since 2012, the response rate to survey has been 100%

Summary

- The NSCL is a national user facility that provides RIB's for nuclear science experiments proposed by users.
- PAC-approved beam time is scheduled and run by the NSCL in close coordination with the experiment spokesperson. ~Twenty experiments per year with several hundred (unique) experimenters.
- Large user community with various forms of engagement:
  - User Manager (scientist)
  - Large web utilization
  - User oversight of PAC and Operations
  - Annual meeting
  - Feedback on completed experiments

PROJECT MANAGEMENT PERSONNEL CERTIFICATION

Budget, Finance, and Award Management
Large Facilities Office
May, 26 2016

Large Facilities Workshop 2016
S. Dillon Ripley Center
Washington, D.C.

NATIONAL ACADEMY OF PUBLIC ADMINISTRATION

2

USE OF COOPERATIVE AGREEMENTS TO SUPPORT LARGE SCALE INVESTMENT IN RESEARCH
DECEMBER 17, 2015

RECOMMENDATION 6.8

Recommendation 6.8

"To ensure that award recipients have the requisite project management experience and knowledge to successfully lead a MREFC project . . . ."

"NSF should require award recipient project managers to be certified in project management. NSF should also specify minimum project management experience thresholds for project positions."

KEY PERSONNEL

"NSF POs and G/AOs should work together to include **project management certification** and requisite **experience** requirements in cooperative agreements for MREFC projects."

NAPA LIKES AND DISLIKES AND NSF PLANS

Likes -	Dislikes -	NSF Plans -
	Agreements do not include certification requirements	Include qualifications requirements in agreements
PO and G/AO review key personnel		NSF would confirm qualifications

QUESTIONS

- How do training (i.e., certificates) and certification differ in terms of costs and benefits?
- Which roles on a project should demonstrate adequate qualifications?
  - Project manager only?
  - Others?
- When would NSF require experience above and beyond that required by certifications?
- What approach should NSF take to establishing equivalence?

CERTIFICATES VS. CERTIFICATION

- Certificates
  - Documentation of completion of a short course in a particular subject
  - Number of classes prescribed
    - Core &
    - Elective
  - Offered through universities
  - Online or in person
  - High first costs but no ongoing costs
- Certification
  - Designation earned by an individual demonstrating attainment of a standard level of **expertise, experience, and skills** within the subject field.
  - Applicants must have certain experience or other qualifications.
  - Typically require passing an **examination**.
  - Variable first and ongoing costs
    - Prep class?
    - Continuing professional development?

CERTIFICATES VS. CERTIFICATION

	Certificates	Certification
Pros	• University-based • Customizable • Online or in person	• Uniform requirements • Recognizable • 2 – 4 months
Cons	• No experience needed • Not standardized • Not recognizable • 6 months – 2 years	• General experience accepted • Passing a standardized test • Test preparation

What else?

Note: The Uniform Guidance (2 CFR § 200.472 Training and education costs) states:

"The cost of training and education provided for employee development is allowable."

CERTIFICATES

- **What must coursework include?**
  - Fundamentals
    - Scoping
    - Scheduling
    - Budgeting
  - Accounting
  - Law
  - Managing teams
  - Cost control
  - Risk
  - Performance measurement

NOTE

NSF will **not** endorse specific providers

What else?

CERTIFICATION

- **What should NSF consider in setting minimum standards?**
  - Knowledge Base
  - Experience (quantity not quality)
  - Cost (to obtain and maintain)
  - Time (to obtain and maintain)
  - Reputation and Notoriety

What else?

NOTE NSF will **not** endorse specific providers

CERTIFICATION

Prioritization Exercise

	Knowledge Base	Experience	Cost	Time to obtain	Reputation		
Knowledge Base	--	9 : 16	23: 0	23:1	16:7	:	:
Experience	:	--	22:0	20:4	16:10	:	:
Cost	:	:	--	3:20	0:22	:	:
Time to obtain	:	:	:	--	0:23	:	:
Reputation	:	:	:	:	--	:	:
	:	:	:	:	:	--	:
	:	:	:	:	:	:	--

WHO? PROJECT MANAGERS & OTHERS?

- OR -

Project manager only

1. Project manager
2. Schedulers
3. Cost estimators
4. Systems engineers
5. Project controllers
6. Quality managers
7. Risk managers

Others?

EXPERIENCE AND CERTIFICATION

- Rest assured . . . projects will remain responsible for personnel actions -
  - Selections
  - Releases
- For this slide's discussion, assume that NSF sets a certification requirement without a certificate option.
- Would an **analogous experience** requirement *over and above* the experience required by a certification help projects?

EQUIVALENCE

Certifications	No equivalence issue. Certification requirements meet NSF requirements or not.
Certificates	No equivalence issue. Classes taken meet NSF requirements or not.
Experience	Equivalence issue. How will NSF establish equivalence?

Professional judgement by -

By whom?	By when?
Program Officer?	Stage gate reviews?
NSF Internal Panel?	Routine reviews?
External Panel?	As needed?

NEXT STEPS

- Slides posted on the workshop Web page
- Notes from the session included in the workshop proceedings
- NSF will hold internal discussions and may follow up with the community
- The **Large Facilities Manual** (18-XX) will identify options and criteria –
  - NSF will publish a public comment draft in April 2017 with comments accepted for three months
  - NSF will publish the final Large Facilities Manual in October 2017 to take effect in January 2018.

For more information:

Ivan Graff
Large Facilities Advisor
(703) 292-4416
igraff@nsf.gov

15 BACKUP

- Certification Providers

PROJECT MANAGEMENT CERTIFICATIONS

- PMI (Project Management Institute): Project Management Professional
- GAQM (Global Association for Quality Management)
- IPMA (international project management association): Certified Project Manager
- PPM: Professional in Project Management
- AAPM (The American Academy of Project Management): Master Project Manager
- CMAA (Advancing Professional Construction and Program Management Worldwide): Certified Construction Manager
- IAPPM (International Association of Project and Program Management): Certified Project Manager

COST ESTIMATING AND ENGINEERING

- ICEAA: Certified Cost Estimator/ Analyst
- aace International (The Authority for Total Cost Management): Certified Estimating Professional; Certified Cost Professional
- American Society of Professional Estimators: Certified Professional Estimator

PROJECT CONTROLS (SCHEDULING & EV)

- PMI (Project Management Institute): Scheduling Professional
- aace International (The Authority for Total Cost Management): Project Scheduling Professional; Earned Value Professional
- EVMi (Earned Value Management Institute): Certified Project Control Officer; Earned Value Management Professional

SYSTEM ENGINEERING CERTIFICATION

INCOSE International Council on Systems Engineering

Certified System Engineering Professional

QUALITY ASSURANCE AND CONTROL

GAQM Global Association for Quality Management

ISO 9001 Certified Internal Auditor

ASQ

Certified Manager of Quality

Certified Quality Engineer

RISK MANAGEMENT CERTIFICATIONS

PMI Project Management Institute

Risk Management Professional

GAQM Global Association for Quality Management

Certified Risk and Crisis Manager

2016 NSF Large Facilities Workshop

New Initiatives

Business Roundtable II-III

May 25-26, 2016

Jeff Lupis, Division Director, *Division of Acquisition and Cooperative Support*

jlupis@nsf.gov (703) 292-7944

Progress on NAPA Recommendations

- Business Practices
  - Cost analysis – supported by NAPA; exceptions documented
  - Contingency – guidance issued
  - **Management fee – analysis in progress**
  - Government Accountability Office (GAO) Guide mandatory
  - Oversight and Planning
  - Roles and responsibilities – Business & Operations Advisory Committee
- Experience, certification, competencies
  - NSF program directors with facility oversight responsibilities
  - Facility project managers

NAPA Recommendation on Mgt. Fee

NAPA Full Report (Note: Mgt. Fee Issue covered on pp. 41 – 47):

http://napawash.org/images/reports/2015/NSF_Phase_2_Comprehensive_Report.pdf

NAPA Report Recommendation 4.3 (pg. 47):

Objective: To eliminate the additional management burdens and potential for funding inappropriate expenses posed by management fee.

- Recommendation: NSF should eliminate the practice of including management fee in cooperative agreements in future projects.
- Implementation Steps: The appropriate BFA office should develop NSF policy clarifying that management fee will no longer be included in federal awards.

Management Fee - NSF Analysis to Date:

- Considered the impact on NSF's ability to continue to partner with academic consortia and other non-profit awardees.
- Took into account OMB citing NSF's management fee policy as a federal best practice.
- Evaluated alternative approaches to cover awardee expenses.
- Sought to incentivize participation in large facility competitions.

Management Fee - Findings:

- Implementation of NSF's new management fee policy in 2015 clarified the appropriate uses of management fee.
- A follow-up review in Spring 2016 confirms that many appropriate uses of management fee are not otherwise reimbursable under the cost principles.
- Allowing organizations to request and receive a fee helps ensure competition among qualified organizations for large facility construction and operations.
- Eliminating management fee would deny awardees the ability to recover ordinary and necessary expenses not otherwise reimbursable.
- NSF will continue to use management fee and complete the analysis of the policy's impacts.

Background – NSF's Current Mgt. Fee Policy

Context – Development of Current Policy

- Previous to December 2014 – NSF did not have a formal written policy on payment of management fee.
- Fees were understood to be paid for the purpose of awardees covering necessary costs, including "ordinary and necessary" expenses not otherwise covered by the federal cost principles.
- At NSF, management fees were limited to a small group of awardees (approximately seven) involved in construction and operations of large facilities under cooperative agreements.
- Previous NSF practice was to determine the fee amount based on a proposal by the awardee specifying planned uses of fee (e.g., educational outreach, business meals).

Background – NSF's Current Mgt. Fee Policy

Context – Development of Current Policy

- Agreement on planned use of fee by the awardee was not subsequently verified/enforced – fee was considered as awardee funds above costs and therefore not subject to audit.
- In 2014 – OIG Report raised issue that DCAA review of a NSF awardee's management fee included such items as alcohol, entertainment, and lobbying.
- NSF accelerated efforts to publish and implement a management fee policy addressing appropriate uses of fee, prohibited uses, and requirements for awardees to verify actual uses during performance.
- A new policy became effective immediately with publication in the Federal Register in December 2014. However, policy was still subject to final revisions based on NSF review of public comments.

Background – NSF's Current Mgt. Fee Policy

Context – Development of Current Policy

- House Science Committee Hearing in February 2015 was critical of management fee expenses incurred by NSF awardee.
- NSF addressed public comments and issued final policy in June 2015.
- Upon finalization of new policy, provision added to the Terms & Conditions of impacted awards to ensure compliance.
- Awardees receiving management fee were immediately required to comply with requirement to justify <u>planned</u> uses of fee, and to provide available documentation on <u>previous</u> uses of fee.
- Time and resource intensive review completed (July – Sept 2015) to confirm or re-determine fee amounts for current awards.

Background – NSF's Current Mgt. Fee Policy

Context – Impact on Awardees

- As part of NSF's evaluation of alternatives, in March 2016 impacted awardees were asked to provide feedback on NSF's new management fee policy.
- Questionnaire solicited feedback on perceived advantages, disadvantages, administrative burden of the management fee policy, and alternatives or improvements to the policy.
- Questionnaire was forwarded to organizations that currently receive fee under NSF awards.
- Some, but not all of these organizations provided responses to the management fee questionnaire.

Background – NSF's Current Mgt. Fee Policy

Context – Impact on Awardees

Results from the questionnaire are still being analyzed. Comments include:

✓ Importance of fee to organizations in order to efficiently manage awards.
✓ Increasing administrative burden and delays in timely determination of fee amounts.
✓ Continued ambiguity and risk to organizations in interpreting appropriate fee expenses.
✓ Review of individual expenses by NSF results in unreasonable standards for acceptability of management fee expenses.
✓ Negative impact on morale by reducing funding of legitimate low-cost but morale-boosting expenses.
✓ Disadvantages awardees compared to other organizations receiving substantially higher fees for managing large facility awards under contracts.

Background – Alternate Means of Addressing Expenses

Analyzing Expenses Historically Paid through Fee

- The NSF Divisions of Acquisition and Cooperative Support (DACS) and Institution and Award Support (DIAS) formed a task team to evaluate reasonableness of approach to eliminate management fee by finding other alternatives to address necessary expenses not covered under the cost principles.
- To complete this action, DACS and DIAS reviewed historical use of management fee at NSF using historical actual use information submitted by awardees during the 2015 review conducted as part of the initial implementation of NSF's new management fee policy.
- Since organizations had not been required to keep historical information on use of management fee prior to implementation of NSF's new policy in 2015, available information was in many cases incomplete and did not provide substantive detail on actual use of fee.
- Notwithstanding the ambiguity of available historical information on fee use, some conclusions can be drawn from analyzing historic management fee uses.

Background – Alternate Means of Addressing Expenses

Results and Conclusions based on Analyzing Expenses Historically Paid through Fee

- Data on historic use of management fee was not detailed enough to determine whether expenses could have been instead submitted as appropriate costs under the award.
- Some <u>historic</u> uses of management fee were clearly in violation of NSF's <u>new</u> management fee policy.
- Some historic uses of management fee were clearly in compliance with NSF's new management fee policy (support of educational and public outreach activities, lease cancellation costs, and improvements to child care facilities).
- Some historic uses of management did not contain sufficient detail to determine whether the uses were consistent with NSF's new management fee policy (e.g., travel fees and related costs, employee recruitment and relocation expenses, tuition assistance).