

- AIMS Draft LFM 5\_4\_16 Questions\_Comments LFO Responses 08-17-16
- AURA comments on draft LFM2016
- Coles Comments on LFM 2016 Draft 160701
- Falkner-LargeFacilitiesManual2016Draft\_5 4 2016
- Graff LFM Errata\_ Commissioning Plan and \_IMP\_
- Graff LFM, minor addition\_ Section 3.4.1-10.2
- Graff NSF LFO Improvement Suggestions 2016-06-23
- Hawkins-Wilkinson Re\_ Contingency for MREFC Fixed Price Contracts
- McGovern Comments on Large Facilities Manual May 2016
- OIA \_'No comment' on draft Large Facilities Manual
- OIG Audit Comments on NSF's Large Facilities Financial Data Collection Tool
- OIG Comments on Draft Large Facility Manual
- Porter LFM PEP Guidance & Draft Comments\_
- Santoro 2.2.2
- Sholhead comment\_ LFM draft
- Whitehurst\_ LFM GAO-CO
- Whitehurst RE\_ LFM 'termination'
- Wilkinson Page from Large Facilities Manual (LFM) - Draft May 2016

LM AIMS team questions on Draft LFM 5\_4\_2016

General Statement: A majority of the LFM appears to be geared toward cooperative agreements and not for our situation.

1. Pg 2.1.3-1. Points at which there may be departure from the MREFC process outlined here should be identified early in the project development and documented as part of the NSF Internal Management Plan (IMP) Individuals should discuss any proposed departures with the cognizant Program Officer.
  - a. Question: Will there be any documentation that the Operations and Divestment stage are not part of this project? The document says any departure from these stages would be identified in the NSF IMP but I wasn't sure if that information was reflected.
  
2. Pg 2.1.3-3. Preliminary Design Phase Definition: Further advances the project baseline definition and the Project Execution Plan. It produces a bottom-up scope, cost, schedule, and risk analysis of sufficient maturity to allow determination of the Project Total Cost and overall duration for a given Fiscal Year start and to establish the MREFC budget request to congress.
  - a. Question: It is understood we provide a funding profile and spend plan for PDR. We also understand we baseline at PDR per the LFM for scope, cost and schedule. Does the LFO allow for changes in the funding and spend plan profiles at the end of FDR to allow for any updates we may need to make based on the awarded subcontract?

3. Pg 2.1.6-5. Table –

Program Officer (PO)	Grants/Agreements (G/AO) or Contracts Officer (CO)	LFO Liaison
<b>Preliminary Design Phase</b>		
<ul style="list-style-type: none"> <li>• Works with the research community to develop a proposal that includes a preliminary Project Execution Plan (PEP)</li> <li>• Arranges external peer review of the proposal</li> <li>• Presents the proposed project to the MREFC Panel</li> <li>• Updates the IMP</li> <li>• Continues to meet with the IPT</li> <li>• Reports monthly to HLFO on project's technical and financial status</li> </ul>	<ul style="list-style-type: none"> <li>• Creates solicitations for enabling research, workshops, summer studies, and other activities of the research community that will result in a proposal (shared responsibility with PO)</li> <li>• Responsible for the business aspects of the proposal review and cost analysis and in surveillance or mentoring of the proposing institutions</li> <li>• Participates in preparation of materials for the MREFC Panel and Director's Review Board (DRB)</li> </ul>	<ul style="list-style-type: none"> <li>• Advises PO</li> <li>• In collaboration with PO, plans Preliminary Design Review (PDR)</li> <li>• Independently assesses outcome of PDR for the LFO</li> <li>• Receives monthly reports on project development from PO, and provides independent assessment to the Head, LFO</li> </ul>

- a. Who is the PO – Scott or Ben? It was confirmed at our meeting on 8/5/16 that Ben is the Program Officer in our case. What do they mean by the CO “creates solicitations for enabling research, workshops, summer studies.... (the first

bullet). 8/5/16 Scot confirmed the first bullet was more for cooperative agreements and not required for us.

Program Officer (PO)	Grants/Agreements (G/AO) or Contracts Officer (CO)	LFO Liaison
<b>Construction/Implementation Stage</b>		
<ul style="list-style-type: none"> <li>Develops a Cooperative Agreement (CA)</li> <li>Approves the establishment of a project baseline scope, cost, and schedule and other updates to the PEP</li> <li>Approves significant changes to the project baseline</li> <li>Receives monthly financial and technical status reports, quarterly and annual progress reports</li> <li>Reports monthly to HLFO on project's technical and financial status</li> <li>Conducts periodic reviews of project progress using an external ad hoc panel</li> <li>Arranges internal review of Memorandums of Understanding (MOUs)</li> <li>Regularly visits the project</li> <li>Updates the IMP</li> <li>Ensures compliance with Government Performance and Results Act (GPRA)</li> </ul>	<ul style="list-style-type: none"> <li>Approves submittals from recipient</li> <li>Reviews the scope of activities associated with each award to ensure that the financial and administrative framework aligns with NSF's expectations for stewardship and reporting.</li> <li>Receives and provides approval to the recipient</li> <li>Participates in baseline review and subsequent periodic reviews as necessary to assure the NSF that the recipient follows agency financial policies</li> <li>Serves on the IPT to expedite financial and administrative actions and decisions concerning the project</li> </ul>	<ul style="list-style-type: none"> <li>Advises PO</li> <li>In collaboration with PO, plans construction reviews and independently assesses outcome</li> <li>Receives monthly project status reports from the PO</li> <li>Visits the project site periodically in coordination with PO</li> </ul>

b. For those items highlighted yellow:

- i. Does the PO have authority to approve significant change to the project baseline? 8/5/16: Response was in our case the PO does not authority to approve baseline changes.
- ii. Who are the external ad hoc panel members? 8/5/16: Requires further review.
- iii. Need to understand the “periodic reviews” of project progress – monthly, quarterly, annually so we can determine frequency and requirements for these reviews? 8/5/16: This has not been determined.
- iv. Is the GPRA where the requirement for an annual performance plan comes from? 8/5/16: Requires further review and verification by NSF.

4. Pg 2.1.6-13. The G/AO is responsible for oversight of the financial and administrative terms and conditions of the assistance agreement,<sup>1</sup> just as the PO is responsible for scientific and technical oversight. Unlike the PO, he/she holds the warrant to obligate government funds. The G/AO and the PO jointly share the principal technical and financial responsibilities for the oversight and assurance of a large facility project. In this capacity, the G/AO is jointly responsible with the PO for the success of a project.

a. What is the difference between the G/AO and the CO?

5. Pg 2.1.6-14. The CO holds the warrant and is the only individual authorized to obligate or de-obligate government funds. The CO, through their warrant, has the sole authority to

award and administer the construction contract(s) used in support of Large Facility projects.

- a. This statement says the “CO has the sole authority to award and administration the construction contract (s) used in support of Large Facility projects. This does not make sense for our situation – can NSF clarify the CO’s role in our case.

6. Pg 2.1.6-14. Cost Analyst. The G/AO or CO requests assistance from a NSF Cost Analyst from the Cost Analysis and Audit Resolution (CAAR) Branch of the Division of Institution and Award Support (DIAS), located within BFA (CAAR) when cumulative or individual awards exceed certain thresholds or for Recipients with previously identified risks. The PO, G/AO or CO, and Cost Analyst all review proposed budgets to help determine if they are allowable, allocable, reasonable, and realistic for the scope of work. However, the primary purpose of the NSF Cost Analyst’s budgetary review is to support the G/AO or CO to ensure that the Recipient has properly estimated and calculated costs and that they are supported and documented with sufficient rigor. The Cost Analyst provides a written recommendation to the G/AO stating whether costs are supported or unsupported. The recommendation may include advice on award terms and conditions or limitations or other concerns identified.

The Cost Analyst may also help determine if the Recipient has adequate business and accounting systems in place, assess a Recipient’s financial capability and viability, validate indirect cost rates, or assist in other areas of concern as identified by the requesting G/AO.

- a. Who is this on NSF side? 8/5/16. Need to confirm with Kevin that this is not a cost item that NSF must bear and verify if this person is in place right now.

7. Pg 2.1.6-14 (Footnote).

<sup>1</sup> Refer to *the Business Systems Review (BSR) Guide* described in Section 4.5.3.3 for discussion on this point. When NSF is not the cognizant audit agency for the recipient institution, its oversight of recipient business practices is narrowly defined.

- a. Will there be another BSR on ASC as there was already one conducted when the current contract was awarded? We need to understand timing as well for when this will take place.

8. Page 2.3.3-1 4<sup>th</sup> bullet and 2.3.3-2 footnote comment: A fully implemented PMCS, including a final version of the resource-loaded schedule and mechanisms for the project to generate reports – using the Earned Value Management System (EVMS)<sup>1</sup> – on a monthly basis and use them as a management tool. Path dependencies, schedule float, and critical path are defined; and footnote <sup>1</sup> During construction, progress should be tracked and measured using the Earned Value method (this method is required by OMB in *Planning, Budgeting, Acquisition, and Management of Capital Assets, OMB Circular No. A-11 (2014)*. A discussion of Earned Value is included section of Section 8, Guidelines for Earned Value Management.

- a. Will this be a requirement for LM which we will then flow down to our subcontractors? This is a requirement for the prime contractor (or the award

recipient for cooperative agreements). Subcontractors must be able to provide the appropriate cost and schedule inputs to put into the prime's EVMS. So this would apply to LM, but not necessarily subcontractors. (Please note, this requirement is not new to the 2016 draft, it has been in the LFM in similar form since at least 2009. Additional guidance for how projects are expected to meet this requirement is the part currently being developed.) 8/5/16 - Need definition between certification and validation from the power point presentation we were shown and which is required and by whom (government audit agency or third party). Also need to understand how the FAR 34.2 and DFARS 234.2 words compliant and non-compliant differ from certification and validation. NSF guidance is being developed to require validation of EVMS to the intent of the EIA-748 standard. This guidance will explain how the EVMS is validated for NSF MREFC projects. NSF will not require that EMVS be certified by DCMA. An expert third party will validate the EVMS meets the intent of EIA-748. The EVMS section of the LFM will be comprehensively updated during the 2017 review cycle. However, in the interim, NSF standard operating guidance will be provided to projects. LFO will also consider adding some clarifying words to this draft of this 2016 LFM to (1) require validation of the project's EVMS to the intent of the EIA-748 standard and (2) allow projects to request minor deviations with supporting justification. What are the ongoing monthly ASC (and subcontractor flow-downs) EVMS requirements/deliverables/expectations? (ie. Will the government auditing agency or 3<sup>rd</sup> party agency continue to audit the project monthly, meaning we deliver all month end business files (including subcontractor?), respond to findings, work corrective actions, etc. together with NSF EVMS person and EVMS auditing agency or will the EVMS system be "validated" 1x for the project and monthly EVMS reporting will continue as per our current rhythm/deliverables on the ASC contract? The LFM requires LM to provide monthly EVM reports for construction. Subcontractors must be able to provide the appropriate cost and schedule inputs to LM for incorporation in LM's EVMS. An initial validation will be done in conjunction with FDR to allow resolution of any findings prior to the start of construction. The validation will include a "desk review" of plans and procedures followed by a visit to the project to interview project controls personnel and review the system. Future periodic surveillance by a third party is expected to be done annually, unless findings require more immediate or routine follow-up until resolution. If the agency/3<sup>rd</sup> party EV company is on contract for the duration of the project, who is the EVMS NSF contact that ASC would deliver monthly deliverables to and ensure compliance/work off findings? Expert third party will be contracted by NSF. No expectation for monthly deliverables except the EVM report per the LFM. LM should have the appropriate PMO to maintain the PMCS, including EVMS, and

issue monthly reports. When does the EVMS system need to be “validated”? Is it a constraint to exiting PDR/baselining, or required prior to FDR (we will already be baselined)? In conjunction with FDR, to allow resolution of any findings prior to the start of construction. Having the EVMS up earlier is prudent to ensure it is working properly. If EVMS findings are required post initial baseline, will we have an opportunity to clean up and re-baseline? If findings are significant and meet criteria in LFM section 4.5.5, yes possibly. But it is not obvious why a future surveillance of the EVMS might prompt a re-baselining. Note: It is the ASC recommendation that EVM compliance/validation not be a mandatory subcontract flowdown. Rather ASC will define requirements for subcontractor submittals and enter the data into the ASC EVM complaint system. Agree, this has been done successfully for other projects. This requires clear requirements in subcontracts (e.g., for timely, discrete cost and schedule inputs that can be physically verified). **A RESPONSE TO THIS IS CRITICAL TO ENSURE WE CAN MEET PDR SCHEDULE AND INCORPORATE ANY ADDITIONAL COSTS REQUIRED DURING CONSTRUCTION DEPENDING ON EVMS DETERMINATION.** Ben emailed Kevin to set up a meeting for this specific topic.

- b. The bullet would indicate that we are to provide a “final version of the resource loaded schedule” during FDR. Does this mean we are allowed to update the “project baseline that is set following PDR (pg 4.2.5-3)? We understand our Total Project Cost would not change but are we allowed to re-baseline our entire IMS schedule once we receive a refined schedule from our awarded subcontractor? Is the intent that the Project (from total project cost and high level scope/schedule – buildings in/buildings out) is “baselined/locked down” at PDR, but the actual IMS (detailed tasks, resources, cost spreads/allocations) is not baselined? If so, is that PDR baseline to remain intact per the “NSF No Cost Overrun” direction for the entirety of the project? If, at FDR, we learn the General Contractor bids/schedules are significantly different (more than 10% cost or schedule) than what we planned and baselined at PDR, are we able to re-baseline to the GC plan, or are we held to the plan we established at PDR? If/when re-baselining is necessary, what is the process/timeline to work with the NSB to re-baseline (approvals, any change boards mtgs/formal change presentations, paperwork) in order to not compromise delay in funding or in construction on the ice? If we have to exercise risk contingency, can NSF approve or does the NSB also need to approve? Can the project continue working when a risk event is realized exercising risk contingency or is the program on a stop work pending NSF/NSB approval/exercise of risk item?
- c. Are we allowed to carry an amount of “schedule contingency” (ie. time in the form of an actual “schedule contingency” task) in the IMS? Are we allowed to carry those schedule contingency tasks throughout the IMS (completion of each

building) or a total amount attached to the end of the project? Which date do we report as our estimated complete date? Or both dates?

9. Pg 3.4.2-1

- a. Can we get the additional details NSF PO expects to see in the PEP?

10. Pg 4.2.1-2, NSF requires 90-180 days to do a cost analysis before we progress to the next design phase, yet the figures 4.2.1-1 reflects this analysis is done post FDR but prior to construction award. 1 – It sounds like NSF intends to perform this prior to FDR, is this accurate and if yes why the deviation from the LFM. 2. Does NSF expect to do a cost analysis of our subcontractor proposals (IAW 4.2.1) prior to award of construction? **THIS IS ANOTHER CRITICAL ITEM AND REQUIRES IMMEDIATE DISCUSSION AND RESOLUTION.** (LM to provide graphic)

PJJ Comment: It is my assumption that in order to complete a cost analysis post FDR but prior to award of construction (CLIN 005) we will need to have our subcontractor proposals received, down select, site visits, final proposals, orals, negotiations and LMs analysis. After all of that, then NSF will start their analysis of the LM submittal which will take up to 180 days. It will take LM 30 days to finalize our review and analysis, NSF 180 days to do the same. Then at least 30 more days for the NSF to issue the modification to our prime contract and 20 days for LM to process the award once funding has been received – this is 260 days or 8.6 months. This is an extraordinary amount of time for construction proposal validity period. Three months is often at the high end of a validity period range. However, extending this period will cause subcontractors to price in additional risk due to cost of materials, resource availability, etc.

11. Pg 4.2.2-7 Section 4.2.2.4, G.5 –

- a. 8/5/16: Clarification on the reference to uniform guidance, 2 CFR section #200.331 is incorrect so needs to be fixed. GPO.gov says parts 305-399 are reserved. Would like clarification on intent of this reference or an alternate source document for its availability. <https://www.gpo.gov/fdsys/search/pagedetails.action?collectionCode=CFR&searchPath=Title+1%2FChapter+III%2FPart+304&granuleId=CFR-2014-title2-vol1-sec200-331&packageId=CFR-2014-title2-vol1&oldPath=Title+1%2FChapter+III&fromPageDetails=true&collapse=true&yCORD=479>.

12. Pg 4.2.2-8 Management Fees

- a. 8/5/16 - This needs to be clarified for situations involving contracts. This addresses cooperative agreements. Contracts need to be addressed differently or its specific exclusion noted in the IMP to avoid confusion (see question 1 and Pg 2.1.3-1).

13. Pg 4.2.3-3 and Figure 4.2.3-2.

- a. 8/5/16 - Are we required to provide the cross-walk to the NSF budget format/category code?

14. Pg 4.2.3-5 Construction Cost Book Detail and Supplementary Guidance

- a. Is this how they want to see our subs proposals? Do subs need to submit BOEs for each labor category? Do they need to use NSF budget category codes? If yes, do we want to have the GC use A-I or just G-5 for all BOEs (this section refers back to section 4.2.2.4)? While I am not used to doing this for construction it is not impossible. It should be noted that in addition to BOEs there will be need a detailed cost estimate by WBS in excel to match up with each BOE.
  - i. 8/5/16 - Requiring a General Contractor to provide this level of detail for each labor category seems unnecessary. This may be more appropriate for contracts that are not fixed price.

15. Pg. 4.2.5-1 – Discussion on Budget Contingency Planning for the Construction Stage.

- a. This section states, “In support of NSF’s “No-Cost Over-run” policy, confidence levels (does “confidence level” mean high level total project cost and high level scope (buildings in/buildings out), or detailed IMS level tasks, resources, cost spreads?) must be in the 70-90% range when the project baseline is set following PDR depending on the nature of the project; including the ability to de-scope.
  - i. Subcontract awards for the construction will not be finalized by PDR so requiring a 70-90% confidence in our baseline at this time may be challenging. Is it up to the PO to either de-scope or use any budget contingency if subcontractor pricing comes in above the estimate.

16. Pg 4.5.3-2– What BSRs is NSF planning to do and when?

17. Pg 4.5.3-3 – This is a general question but is NSF considering all three buildings one award or each building individually? Does the NSF plan to perform an incurred cost audit on any subcontractor award that exceeds \$100M?



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University of Wisconsin 1957  
Vanderbilt University 2010  
Yale University 1958

July 8, 2016

National Science Foundation  
4201 Wilson Blvd.  
Room 1265  
Arlington, VA 22230

Attention: Suzanne Plimpton – Reports Clearance Officer

Subject: Draft 2016 Large Facilities Manual

Dear Ms. Plimpton:

In accordance with the May 9, 2016 Federal Register Comment Request, AURA is providing the attached comments regarding the subject Large Facilities Manual draft. We hope you will take the attached remarks into consideration when finalizing this document. Please do not hesitate to contact me with regards to any questions you may have on our feedback.

Sincerely,

A handwritten signature in blue ink that reads "Val Schnader". The signature is fluid and cursive, with the first letters of the first and last names being capitalized and prominent.

Val Schnader  
Vice President for Operations  
Phone: 202 204 1373  
Email: vschnader@aura-astronomy.org

## **AURA comments on draft LFM 2016**

### **Table 3.4.1-1, List of the Essential Components of a Project Execution Plan**

Section 4.4 of the components table “Scope Management Plan and Scope Contingency” includes “up-scoping opportunities” remarks. The intent of this phrase should be clarified, as it is unclear if this relates to the recovery of prior de-scopes or allows true scope increases.

### **Figure 4.2.2-1 Sample Project Management Control System Flow Chart**

Regarding Risk Analysis Tools, the flow chart only shows only one approach; Monte Carlo Simulations. We recommend that other approaches be documented (e.g. bottoms up methodology using Cost, Schedule and Technical risk factors)

### **Section 4.2.2.4 Supplementary Guidance for Construction and Operations Awards.**

To preclude confusion and to ensure consistency with Section 2.3.3.3 language, the word “sub-awards” should be replaced with “sub-awards and subcontracts” in both sub-sections G.5 and G.6 of Section 4.2.2.4. Given that the OMB Guidance addresses the terms “sub-awards” and “subcontracts” separately, and noting that Section 2.3.3.3 of the Manual also addresses the terms separately, we suggest that Section 4.2.2.4 should read in the same manner.

Provision 5 on Section 4.2.5.1 states “NSF will hold budget contingency through project completion, in an amount up to 100% of the total NSF-approved contingency budget, until it can be justified for obligation.”

It should be noted that the NSF has already approved the contingency budget through the rigorous exercise noted in Section 4.2.5, so clearly the contingency amount (in aggregate) has been justified. In addition, as per ‘standard’ Cooperative Support Agreements, the NSF requires “All proposed changes or proposed use of contingency will be made known to NSF (posted via a change control database or similar) prior to authorization.” It would thus appear that justification before approval is already established. It is not clear what additional justification is required by this provision.

Also, it is unclear from this language as to whether the contingency funds will be provided as part of the annual funding action consistent with the funding profiles already established as part of the NSF process. If it is not, then there would potentially be delays in timely receipt of funds for contingency events; this could increase project costs. This change could restrict the ability of the projects to proactively manage risk (since funds may not be available as planned when needed – this again would drive project costs).

With regards to determining the amount to withhold, the burden to predict usage and the amount of contingency to allocate is a new administrative task that has the potential to drive

new tools or new features to existing tools. The new NSF expectation for risk levels and project health to be verified through Monte Carlo analysis of integrated cost, schedule and risk plans is not immediately suited to a time phased assessment. If historical performance and algorithmic models can be used this burden will be minimized but this policy is a noticeable increment in periodic administrative effort

### **Section 4.5.3 Recipient Performance Reviews and Audits**

The review processes documented in Sections 4.5.3.2 through 4.5.3.4 are in essence “open ended” in number of reviews that may take place. It would be beneficial for the Foundation to establish some estimate of expected effort required by the awardee to support these activities. For programs already in place wherein project costing did not assume such required support, consideration should be provided for additional funding to address this additional scope.

In addition, the BSR explanation notes that the BSR “...determines if these policies and procedures conform to OMB requirements, NSF expectations, and other applicable federal regulations.” While the OMB requirements and federal regulations are explicit documents, it is not clear where “NSF expectations” are defined. This lack of clarity extends to the BSR Guide, and needs to be addressed more specifically.

### **The following are additional comments regarding the Large Facility Financial Data Collection Tool:**

The instructions on the form are unclear as to whether a form for each CSA under a CA is to be submitted or if one form for all CSAs under a CA is required.

Additionally, the guidance does not provide specific deadlines requirements. Currently, it references to the award terms and conditions. However, the award terms and conditions do not address this compliance requirement.

It is not yet clear when the requirement for submitting the ‘first’ report is, if for FY16 data that could create issues. NSF is asking for public comment that will certainly lead to some changes in the data collection tool and will take time for NSF to revise. Given that we are already into the FY 4th quarter, there likely will not be sufficient lead time to properly prepare once the revised tool is released.

#### *Tab: Instructions*

Cell 10 – Instruction do not clearly define if awardees are expected to insert summarized expense total in the cells Users are to complete, or if detail (raw data) behind the summarized expense totals is to be provided. The draft spreadsheet allows for new tabs to be added which could facilitate the importing of detail, but it is unclear if the draft spreadsheet works in the same manner the final version will.

Cell 12 - This cell implies that multiple CSAs should be reported in the spreadsheet tool and the data will be consolidated on this worksheet. Conversations with NSF personnel at the Large Facility Workshop indicate that a separate spreadsheet tool should be submitted for each separate CSA. Clarification is required on this matter. Please note that AURA has separate CSAs under the same NSO CA that are funded from NSF funds and MREFC funds and we suspect these should not be reported as a combined total.

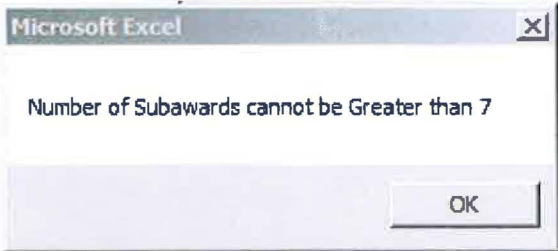
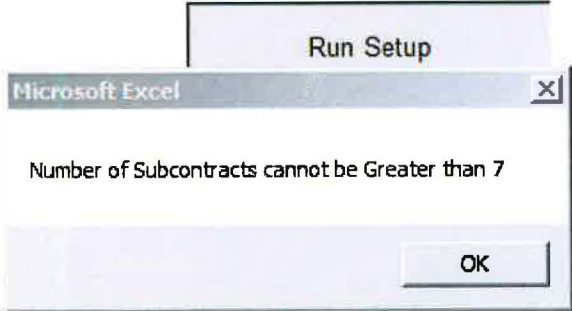
*Subcontract & Consultants Worksheet (comments apply to Sub-awards worksheet as well)–*

- Data as outlined on contracts is not required from the vendors in this format, so now requiring this data would result in additional cost for both the awardee and the vendor.
- Having this kind of detail in the proposal\budget stage is not part of current process.
- Having to gather data for each contract paid during the reporting period could result in an unmanageable amount of data.
- Not all contracts provide this information, requiring it could cause additional expense raising prices of services or goods.
- Many contractors that we work with are for profit companies so their costs may not reflect the price we pay for services; how do we report profit?
- Verification that the data is accurate will be difficult or costly.
- Time involved in gathering, storing and organizing this data would require additional effort by the awardee.

**Setup tab** – The cell in which the Users is to fill in the number of Subcontracts or Subawards being reported will not take a number greater than 7.

If Other, list name below:	
Name 1:	
Name 2:	
Name 3:	
Name 4:	
Name 5:	
Name 6:	

CSA	# of Subcontracts	# of Subawards
CSA 1	10	10



There will likely be situations where there are more than 7 contracts totaling a minimum of \$150,000. Either remove the limit and allow input for all contracts above 150k or explicitly state if contracts should be chosen by highest BAC, highest BCWS, highest Actuals, etc. for the 7 being chosen.

For grand totals to tie out for the total project all subcontract values should be used. Only selecting contracts totaling a minimum of \$150,000 could leave a substantial gap in reporting the total BAC of the project and may cause confusion validating data. Perhaps a solution is one line for all other contracts less than \$150,000.

The input sheets need to be clearer if budgets being entered are cumulative to date or BAC. Reducing the ambiguity of the budget data being requested would be helpful (specifically call out if this is a FY request, cumulative to date, or BAC). It may be useful to populate the tool with a sample (test) data for examples of how the budget and actual totals trace across the worksheets.

There are some cases where cells should be merged on the Subcontract/Sub award sheets (i.e. D:E, F:G, etc. for general look and feel). It also seems like rows 31 and 32 on those sheets should be formulas from the data entered above (Gray). Just a note, there could be a disconnect with this tool and EVMS data as EVMS data also includes estimated actuals based on delayed accounting processing of invoices.

#### *Cooperative Support Agreement (CSA) Budget Worksheet –*

Guidance needed for the level of supporting documentation detail required to provide for “total expenditures to date” on existing CSAs. Is the first report submitted supposed to report inception to date expenses as the current year expenses?

On the CSA Budget worksheet, it is unclear if this should only include the 7 Subawards listed from previous sheets or if this is a grand total. This is the problem with only entering a subset of data for the Subcontract/Subawards as there will be a delta between total budget numbers for the CSA and the numbers displayed in other sheets.

#### *General questions on data to be provided:*

Are totals in this report intended to tie to any other report submitted to NSF?

- Program reports include data on commitments which are not reported here.
- ACM\$ reports only show cash drawn, some expenses reported here may not have been paid in cash yet.
- Audited financial statements
- How is program income reported?

## Comments on LFM 2016 Draft

1. I did not find this: Changed issuance of the HLFO MREFC facility status report from “monthly” to “periodic” on page 2.1.6-13. Whether or not HLFO issues status reports, the spending rate for MREFC projects motivates NSF Program Officers and other staff receiving technical and financial status reports on a monthly basis during construction.
2. Table 2.1.6-1 says the PO is “Experienced or trained in management of large projects.” It also says the LFO Liaison “Advises POs on project management issues during project development and oversight” yet there is no requirement that the LFO have similar experience or training.
3. Change 5 refers to a third bullet on page 2.2.2-9, yet there is no page 2.2.2-9. (The manual goes from 2.2.2-1 to 2.3.1-1)
4. Section 4.2.2.2 “Relevant Guidance” needs editing. It says: “Proposed budgets must comply with the applicable federal regulations, as implemented by NSF in the Proposal and Award Policies and Procedures Guide (PAPPG), including Grant Proposal Guide (GPG) and Award and Administration Guide (AAG). Recipients are required to follow the best practices within the GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs (GAO-09-3SP March 2009, or subsequent revision) and GAO Schedule Assessment Guide: Best Practices for Project Schedules (GAO-16-89G December 2015, or subsequent revision), taking into consideration NSF policy and practice as provided in this manual. Recipients must note any departures from these GAO guides and explain their rationale.” The first part doesn’t need saying – as NSF never tells proposers that they do need to comply with federal regulations. As the title is “Guidance”, instituting the requirement to follow best practices restricts flexibility that can be potentially beneficial in a scientific research environment. The logic of the paragraph is further tangled when it concludes that the recipients apparently are not required to adhere to best practices but can instead explain their rationale for deviating. (I support that flexibility – but the logic of the paragraph is a muddle and needs to be rewritten coherently.)
5. 4.2.5.1 – NSF Policy position is inconsistent in stating that NSF has a “No Cost Overrun” policy and that that Directorates are responsible for the first 10% of the cost overrun. Item 5 says “NSF will hold budget contingency through project completion, in an amount up to 100% of the total NSF-approved contingency budget, until it can be justified for obligation.” This provision may skew the budget profile requested by a project towards higher award amounts in early years, since the year-by-year funding must exceed the sum of expenditures, obligations, and risks in a given year. A Project Manager, in dealing with the uncertainty in the level of availability of budget contingency, may overestimate its potential need in early years. How will NSF protect against this?
6. Section 4.5.3.2 External Reviews makes no distinction between operations and construction reviews. It says: “The PO will typically use a standard review ‘template.’ These well-defined review formats provide a broad outline against which the project can be compared and checklists that can be used to assess the status of the project.” A footnote regarding the template says: “Please contact the cognizant NSF PO for details and a description of best practices and/or preferred templates.” To be effective, the Program Officer should have in-depth professional knowledge of the scientific operation of the facility, and should develop a review charge written to elicit advice matched to the specific needs and challenges of the

facility. The review should not be based on a check-the-box template. The PO should consult with the DD, G/AO, DD, and LFO (where appropriate) to develop the charge.

7. 4.2.2-9 Prohibited use of management fees. The NSF large facilities manual seems like a very odd place to look for this information. Obviously NSF needs to make these policies clear to awardees, but it might be better to direct the reader of the LFM, via a hyperlink or reference, to a more general source for information on this topic such as the CFR. That way the LFM will be current if the CFR is updated.
8. 4.5.3.1 misuses a lot of terms and creates confusion. It refers in a single sentence to conducting reviews and internal audits in conformance with generally accepted accounting, project management, and operations management standards and practices. Further in, it talks about safety reviews, as well as many technically oriented reviews. Financial reviews of awardees, and the internal audit and processes of the awardee, is a huge subject that should not be addressed here. This guidance is useless and amateurish. Safety reviews of the awardee organization are similarly the subject of state regulation, OSHA, and other standards. Often, awardees are state universities subject to regulation and oversight. It seems absurd to include this in the PEP.
9. 4.5.3.2 – LFO seems to have invited themselves to all operations reviews and assumed the right to concur on all operational review charges. It claims the PO will use a standard review template. It claims that exceptional circumstances may require the PO to consult with LFO Liaison to constitute a review charge and format to meet the specific requirements of the review. This is absurd – the NSF’s PO - scientific expert that follows the facility closely needs to consult the LFO Liaison, who apparently has the time to participate in more than 20 reviews per year, to develop specific requirements!
10. 4.5.5 Rebaselining. Every re-allocation of budget or schedule contingency changes the baseline, as does the use of scope contingency! Usually rebaselining occurs when the underlying planning assumptions are so different from project reality that the major replanning is needed. What criteria trigger the re-baselining definition? What should be done as a result? This section has little information content, and needs to be rewritten to provide substantive definition.
11. 4.2.5.8 – monthly reporting is a tricky issue – it should be done monthly but the paper work reduction act says we cannot compel an awardee to do so. This section entirely omits reporting technical status! It’s only financial status! It is very important that the technical status be reported, accompanied by a narrative of progress relative to the plan and the factors that contribute to cost and schedule variances. The liens should be listed by date for a decision on whether to initiate a CCB action. A time-phased risk profile is helpful.
12. Heading 5.6 has a typo.
13. 4.2.6 “Budget Contingency Planning during the Operations Stage” needs a better title to avoid the implication that it is about including budget contingency in operation. It includes a paragraph about divestment that would benefit from its own heading.
14. There is no discussion of performance incentives in the discussion of management fee. This has been used by NSF at times.



National Science Foundation  
WHERE DISCOVERIES BEGIN

## **LARGE FACILITIES MANUAL**

**Prepared by the Large Facilities Office in the Budget,  
Finance, and Award Management Office (BFA-LFO)**

**Draft for Public Comment**

**NSF 16-XXX**

**May 2016**





## SUMMARY OF SIGNIFICANT CHANGES

This document has been cleared for publication under OMB approval number 1315-0239, which expires 6/30/2018. The purpose of this revision is to update the material and to improve the clarity and legibility of the manual for the targeted audience of users both inside and outside NSF. A summary of the changes for this revision is given below. Footers within each section of this document indicate the last revision date of the content in that section, while all page headers in the document include the date and NSF number of the current version of the Large Facility Manual.

1. Replaced the title of the “Deputy Director for Large Facility Projects, (DDLFP)” with the new title” Head, Large Facilities Office (HLFO)” throughout the document. Created new heading in Section 2.1.6, with the roles and responsibilities of the DDLFP listed as “Reserved”. Changed issuance of the HLFO MREFC facility status report from “monthly” to “periodic” on page 2.1.6-13.
2. Revised Section 2.1.6 to clarify the roles of the Grants and Awards Officer and Contracting Officer and to include the roles and responsibilities of the NSF Cost Analyst. Four figures were added to illustrating the relationships and position within the NSF organization of entities with roles and responsibilities for oversight and management of large facilities.
3. Removed references to “contingency reserves” throughout the document in order to avoid confusion/conflict of the NSF definition of allowable “contingency” with the definition of the term “reserves” contained in 200.433(c) of the Uniform Guidance, the Project Management Book of Knowledge (PMBOK), GAO Cost Estimating and Assessment Guide, or other publications.
4. Renamed the last stage in the project lifecycle from “Termination Stage” to “Divestment Stage” throughout the document.
5. Language in Section 4.2.2.2 first paragraph was changed to clarify an illustrative example of a circumstance appropriate for use of management fee. Also changed wording in the third bullet under “Prior Approval of Management Fees” section on page 2.2.2-9, to remove undue emphasis on the term “necessary” in discussions of “ordinary and necessary” expenses.
6. The NSF policy on withholding allocations of budget contingency for construction projects until justified was added to sub-Section 4.2.5.1, NSF Policy Positions.
7. Removed the bullet on page 4.2.5-4 referencing use of budget request form NSF 424C in lieu of SF 1030, as this form is not used for large facility awards and the guidance is overtaken by strategies in revised Sections 4.2.1 – 4.2.4.



8. Section 4.5.3 was reorganized into sub-sections to clearly separate the types of performance reviews. Existing text on recipient Internal Reviews (4.5.3.1), External Reviews (4.5.3.2), and Business Systems Reviews (4.5.3.3) were revised for clarity.
9. New material was introduced in a new sub-section, 4.5.3.4, Cost Incurred Audits, including NSF requirements for recipients of award amounts >\$100M to submit incurred cost data on at least an annual basis using a mandatory Excel data tool created by NSF for the purpose.
10. Section 4.5.3.5, Earned Value Management Validation, was created and reserved for future content on the NSF requirements and process for validating construction project EVM systems.
11. Language in Section 4.5.4, NSF's Performance Measurement Metric, was re-written to clarify that the metric is applied to total project variance against the performance baseline.
12. Section 4.2.5.8, Reporting Requirements, was edited to clarify requirements for reporting contingency status, and Section 4.5.2 Frequency and Content of Reports was edited to include all reporting requirements. Redundancies were removed and references inserted to improve clarity.
13. Section 5.5, Environmental Considerations for Large Facilities, was edited for clarity regarding the Program Officers responsibilities and to include references to publically available regulations. A NEPA acronym, "CATEX," was added to the Section 7, Acronym List.
14. Replaced the term "awardee" with the term 'recipient' throughout the manual to allow generic use on all award instruments (cooperative agreements, contracts, etc.).
15. Deleted text referencing the Major Overhaul Stabilization Account (MOSA) as an example for operating budget development in Section 4.2.6.
16. Table 3.4.1-1, List of the Essential Components of a Project Execution Plan, was edited to update language regarding cost, schedule, and scope estimating and management plans definitions and terminology to be consistent with revisions and clarifications in Section 4.2, Cost Estimating and Analysis.
17. In Section 4.2, Cost Estimating and Analysis, major revisions were made to sub-Sections 2.4.1, 4.2.2, 4.2.3, and 4.2.4 to consolidate and clarify NSF guidance and requirements and to ensure alignment with GAO guidelines. The material on Management Fees was moved from the previous Section 4.2.2.2 to the new Section 4.2.2.5. The section on Education and Outreach Budgeting during Operations (Section 4.2.4), was eliminated and the material was incorporated into the new Section 4.2.4, Cost Estimating and Analysis for Operations Awards.



18. The material in Section 5.6, Guidelines for Reporting Requirements, was eliminated since the material is now covered in Section 4.5, Requirements for Performance Oversight, Reviews, Audits, and Reporting. Section 5.6 is now a place holder for future content on Property Management.
19. References to a Financial Management Module in Section 5.7 and elsewhere in the manual were eliminated as the document in question is unpublished and out of date. Section 5.7 has been retained as a place holder for potential future content on Financial Management.
20. Section 5.8, Guidelines for Conducting Business Systems Reviews of NSF Large Facilities, was eliminated since the material was redundant with Section 4.5.3.3.
21. Section 5.9, OMB Inflatars, was eliminated as the material was incorporated into the new cost estimating Section 4.2.2.6.
22. New cost related acronyms (3) and terms (5) introduced in Section 4.2 revisions were added to Section 7, List of Acronyms, and Section 8, Lexicon, respectively. The Acronym List was also updated to include additional acronyms for roles within the NSF Office of Budget, Finances, and Awards.
23. Corrections were made to various minor typographical errors and formatting errors. Document references were updated to latest versions where applicable.



## TABLE OF CONTENTS

### 1 INTRODUCTION

- 1.1 Purpose and Scope
- 1.2 Precedence
- 1.3 Document Structure

### 2 LARGE FACILITY LIFE CYCLE AND THE MREFC PROCESS

- 2.1 MREFC Process Introduction
  - 2.1.1 Definition of the MREFC Account
  - 2.1.2 Eligibility for MREFC Funding
  - 2.1.3 Facility Life Cycle
  - 2.1.4 Summary of the MREFC Process
  - 2.1.5 Timeline and Flowcharts for the MREFC Approval Process
  - 2.1.6 Roles and Responsibilities for NSF Staff for Management and Oversight of Large Facilities
    - 2.1.6.1 Overview
    - 2.1.6.2 Main Participants
    - 2.1.6.3 Coordinating and Advisory Bodies
    - 2.1.6.4 Governing Bodies
- 2.2 Development Stage
  - 2.2.1 Initiation of a Potential MREFC Project
  - 2.2.2 Exit from Development to Design Stage
- 2.3 Design Stage – Conceptual, Preliminary, and Final Design Phases
  - 2.3.1 Conceptual Design Phase
    - 2.3.1.1 Introduction – Conceptual Design Phase
    - 2.3.1.2 Conceptual Design Phase Activities
    - 2.3.1.3 Conceptual Design Review (CDR)
    - 2.3.1.4 Exit from the Conceptual Design Phase
  - 2.3.2 Preliminary Design Phase
    - 2.3.2.1 Introduction – Preliminary Design Phase
    - 2.3.2.2 Preliminary Design Phase Activities
    - 2.3.2.3 Preliminary Design Review (PDR)
    - 2.3.2.4 Exit from Preliminary Design Phase
    - 2.3.2.5 NSF Director’s Recommendation for Advancement to Final Design
    - 2.3.2.6 National Science Board Approval
    - 2.3.2.7 Inclusion in an NSF Budget Request
  - 2.3.3 Final Design Phase
    - 2.3.3.1 Introduction – Final Design Phase
    - 2.3.3.2 Final Design Review (FDR)
    - 2.3.3.3 Exit from the Final Design Phase
- 2.4 Construction Stage
  - 2.4.1 Construction Award Management and Oversight



- 2.4.2 Commissioning Plan
- 2.4.3 Construction Award Close-out
  - 2.4.3.1 Project Close-out Process
  - 2.4.3.2 Request for No-Cost Extension
- 2.5 Operations Stage
  - 2.5.1 Operations Management and Oversight
  - 2.5.2 Renewal/Recompetition
- 2.6 Divestment Stage
- 2.7 Application of MREFC Process to Non-MREFC Funded Projects
  - 2.7.1 Flexible Requirements for Non-MREFC Facility Projects
  - 2.7.2 Pre-construction Planning and Development of Non-MREFC Projects
- 3 LIFE CYCLE MANAGEMENT PLANS FOR LARGE FACILITIES**
  - 3.1 Introduction to Management Plans
  - 3.2 NSF Facility Plan
  - 3.3 Internal Management Plans for the Large Facility Life cycle
  - 3.4 Project Execution Plan
    - 3.4.1 Components of a Construction-ready Project Execution Plan
    - 3.4.2 Detailed Guidelines for Project Execution Plans
  - 3.5 Operations Plan
    - 3.5.1 Preparation of Proposals for Operations and Maintenance
    - 3.5.2 Procedures for Renewal or Recompensation of an Operating Large Facility
    - 3.5.3 Detailed Guidelines for Oversight of Operations
  - 3.6 Facility Divestment Plan
- 4 KEY MANAGEMENT PRINCIPLES AND REQUIREMENTS FOR LARGE FACILITIES**
  - 4.1 Introduction
  - 4.2 Cost Estimating and Analysis
    - 4.2.1 Cost Estimating and Analysis Overview
    - 4.2.2 Cost Estimating and Analysis Process
      - 4.2.2.1 Cost Estimating Plan
      - 4.2.2.2 Relevant Guidance and Reporting Formats
      - 4.2.2.3 Funding Sources and Award Instruments
      - 4.2.2.4 Supplementary Guidance for Construction and Operations Awards
      - 4.2.2.5 Management Fees
      - 4.2.2.6 OMB Inflatons
    - 4.2.3 Cost Estimating and Analysis for Construction Awards
      - 4.2.3.1 Purpose and Process
      - 4.2.3.2 Construction Cost Reports Overview
      - 4.2.3.3 Construction Cost Book Report Format and Work Breakdown Structure
      - 4.2.3.4 Construction Cost Book Detail and Supplementary Guidance
    - 4.2.4 Cost Estimating and Analysis for Operations Awards
      - 4.2.4.1 Purpose
      - 4.2.4.2 Operations Awards Proposals Overview



- 4.2.4.3 Operations Awards Proposals Format
- 4.2.4.4 Operations Awards Proposals Supplementary Guidance
- 4.2.5 Budget Contingency Planning for the Construction Stage
  - 4.2.5.1 NSF Policy Positions
  - 4.2.5.2 Introduction
  - 4.2.5.3 Contingency Planning and Assessment during Conceptual Design
  - 4.2.5.4 Contingency Planning and Assessment during Preliminary Design
  - 4.2.5.5 Development of the Contingency Use Process
  - 4.2.5.6 Contingency Planning and Assessment during Final Design
  - 4.2.5.7 Contingency Use and NSF Oversight during Construction
  - 4.2.5.8 Reporting Requirements
  - 4.2.5.9 Partnership Considerations
- 4.2.6 Budget Contingency Planning during the Operations Stage
- 4.3 System Integration, Commissioning, Testing and Acceptance
- 4.4 Documentation Requirements
- 4.5 Requirements for NSF Performance Oversight, Reviews, Audits, and Reporting
  - 4.5.1 Introduction to Oversight, Reviews, Audits and Reporting
  - 4.5.2 Recipient Performance Reports
  - 4.5.3 Recipient Performance Reviews and Audits
    - 4.5.3.1 Recipient Internal Reviews
    - 4.5.3.2 NSF External Reviews
    - 4.5.3.3 Business Systems Reviews (BSR)
    - 4.5.3.4 Cost Incurred Audits
    - 4.5.3.5 Earned Value Management Validation
  - 4.5.4 NSF Performance Metric for Construction
  - 4.5.5 Re-Baselining
- 4.6 Partnerships
  - 4.6.1 Partnerships Overview
  - 4.6.2 Partnership Funding
  - 4.6.3 Memorandum of Understanding (MOU)
- 5 SPECIAL TOPICS AND SUPPLEMENTARY MATERIALS**
  - 5.1 Introduction
  - 5.2 Risk Management Guidelines
    - 5.2.1 Introduction
    - 5.2.2 Definition of Project Risk and Risk Exposure
    - 5.2.3 Definition of Allowable Contingencies
      - 5.2.3.1 Allowable Contingency
      - 5.2.3.2 Contingency Definitions
    - 5.2.4 Risk Management Steps and Methodology
    - 5.2.5 Risk Management Planning
      - 5.2.5.1 Risk Management Plan (RMP)
      - 5.2.5.2 Roles and Responsibilities



- 5.2.6 Risk Identification
  - 5.2.6.1 Risk Identification Process
  - 5.2.6.2 Risk Identification and the Risk Register
  - 5.2.6.3 Risk Description
  - 5.2.6.4 Risk Identification Concerns
- 5.2.7 Qualitative Risk Analysis – Risk Register Ranking
  - 5.2.7.1 Purpose of Qualitative Risk Analysis
  - 5.2.7.2 Considerations When Performing Qualitative Risk Analysis
  - 5.2.7.3 Limitations of Qualitative Analysis
  - 5.2.7.4 Qualitative Risk Analysis – Probability and Impact Assessment
  - 5.2.7.5 Alternative Approach to Qualitative Risk Impact Analysis – Maxwell
  - 5.2.7.6 Qualitative Risk Analysis – Risk Level Matrix
  - 5.2.7.7 Risk Level Input to the Risk Register
  - 5.2.7.8 Other Qualitative Risk Analysis Methods
- 5.2.8 Quantitative Risk Analysis – Estimating Contingency
  - 5.2.8.1 The Purpose of Quantitative Risk Analysis
  - 5.2.8.2 Key Elements in Quantitative Risk Analysis
  - 5.2.8.3 Platforms for a Project Quantitative Risk Analysis
  - 5.2.8.4 Case Study: Quantitative Risk Analysis Exercise
  - 5.2.8.5 Schedule Risk Analysis – Uncertainty
  - 5.2.8.6 Schedule Risk Analysis – Discrete Risks Added as Drivers
  - 5.2.8.7 Cost Risk Analysis – Uncertainty and Discrete Risk Drivers
  - 5.2.8.8 Handling Inflation
  - 5.2.8.9 Prioritizing the Discrete Risks – Risk Mitigation Workshop
- 5.2.9 Risk Response Planning
- 5.2.10 Risk Monitoring and Control
- 5.2.11 Contingency Management for Risk Mitigation
  - 5.2.11.1 Contingency Budget Timeline
  - 5.2.11.2 Change Control for Contingency Adjustments
  - 5.2.11.3 Liens List: Forecasting and Opportunity Management
  - 5.2.11.4 Updates of the Estimate at Complete and Risk Exposure
  - 5.2.11.5 Contingency Use and NSF Oversight during Construction
  - 5.2.11.6 Documentation and Reporting of Contingency Use
- 5.2.12 Partnership Considerations for Contingency Management
- 5.3 Guidelines for Cyber-Security of NSF’s Large Facilities
- 5.4 Guidelines for Planning and Executing External Reviews of NSF's Large Facilities
- 5.5 Environmental Considerations in Large Facility Planning
- 5.6 Guidelines for Property Management
- 5.7 Guidelines for Financial Management
- 5.8 Guidelines for Earned Value Management Systems



---

**6 REFERENCES**

**7 LIST OF ACRONYMS**

**8 LEXICON**

8.1 Lexicon Preface

8.2 Terms and Definitions

**9 APPENDICES**

Appendix A. Ranking Criteria for Prioritizing MREFC Projects

Appendix B. Memoranda Requesting NSB Approval of MREFC Project





## LIST OF FIGURES

- Figure 2.1.3-1 Progressive Steps in the MREFC Life Cycle, Showing Review and Decision Points for Exit and Entry into Each Stage. The Design Stage is highlighted to indicate that it is further broken down into phases
- Figure 2.1.3-2 Progressive Phases in the Life Cycle Design Stage, showing review and decision points for advancement to the next phase and NSB approvals for budgeting and award.
- Figure 2.1.4-1 Summary Timeline for MREFC Projects
- Figure 2.1.6-1 NSF organization chart highlighting staff who have primary oversight and management roles and responsibilities for large facilities.
- Figure 2.1.6-2 NSF organization chart showing coordinating and advisory bodies for large facilities.
- Figure 2.1.6-3 NSF organization chart showing planning, policy, and advisory bodies for large facilities.
- Figure 2.1.6-4 An Integrated Project Team (IPT), chaired by the Program Officer, is composed of three subgroups, with appointed Award Management Group members from BFA, Science and Technology Group members from the originating program offices, and Strategic Group members from the Office of the Director.
- Figure 4.2.1-1 Cost Analysis Process During Design Phases for Construction Awards (Post – CDR, PDR, FDR to Support MREFC Stage-Gate Review Process)
- Figure 4.2.1-2 Cost Analysis Process for Operations Awards
- Figure 4.2.2-1 Sample Project Management Control Systems Flow Chart
- Figure 4.2.2-2 NSF Budget Categories Sample Format
- Figure 4.2.3-1 Construction WBS and Cost Book Report Sample Format
- Figure 4.2.3-2 Construction Cost Book Sheet Sample Format
- Figure 4.2.4-1 Operations WBS and Budget Sample Format (For Each Physical Site Location or Decentralized Overall Research Activity)
- Figure 4.2.5-1 Sample of a Change Control Request Form, with instructions for filling out the various sections
- Figure 4.5.3-1 Large Facility Financial Data Collection Tool Process Flow Diagram, identifying the core data sources recipients should utilize to complete the worksheets to accurately capture the data. Progressing through the tool's worksheets from left to right will streamline the data capture and submission process.
- Figure 5.2.4-1 Picture of Six Risk Management Processes (According to PMI)
- Figure 5.2.6-1 Risk Identification Process
- Figure 5.2.6-2 Typical Risk Breakdown Structure (RBS)
- Figure 5.2.6-3 OMB Risk Categories: to be used as a starting point for projects to select their own categories
- Figure 5.2.7-1 Qualitative Risk Analysis Process



- Figure 5.2.7-2 Overlap in Risk Probability of Occurring When Descriptors Are Used
- Figure 5.2.7-3 Symmetrical Risk Level Matrix
- Figure 5.2.7-4 Asymmetrical Risk Level Matrix
- Figure 5.2.7-5 Probability and Impact Matrix including Threats and Opportunities
- Figure 5.2.7-6 Sample Risk Register with Risk ID Number, Associated WBS Identification, Qualitative Probability and Impact for Initial and Post-mitigation States, and Mitigation Actions
- Figure 5.2.7-7 Sample Top Risk Matrix and Status Report, showing list of project risks selected as most significant to monitor on a frequent basis, with ranking and trend data
- Figure 5.2.8-1 Quantitative Risk Analysis Process
- Figure 5.2.8-2 Typical Result of a Quantitative Schedule Risk Analysis
- Figure 5.2.8-3 Time-Cost Scatter Diagram: Each data point represents one realization of the simulation
- Figure 5.2.8-4 Resource Loaded Schedule Used for a Simple Case Study of an Integrated Cost-Schedule Risk Analysis for Design, Fabrication, Testing, and Delivery of a Space Vehicle
- Figure 5.2.8-5 End Date Results for Schedule Duration Uncertainties
- Figure 5.2.8-6 Cost Result for Schedule Duration Uncertainties
- Figure 5.2.8-7 Total Cost and End Date Scatterplot for Schedule Uncertainties
- Figure 5.2.8-8 Schedule Risk Drivers – Organizational Risk
- Figure 5.2.8-9 Total Cost and End Date Scatterplot Showing Greater Correlation of Time and Cost Risk
- Figure 5.2.8-10 Uncertainty in the Burn Rate and Total Cost
- Figure 5.2.8-11 Screenshot of Risk Driver Editor
- Figure 5.2.8-12 Scatterplot Showing Less Connection between Time and Cost
- Figure 5.2.8-13 Scatterplot with Addition of Cost Inflation Factor
- Figure 5.2.9-1 Risk Response Planning Process
- Figure 5.2.10-1 Risk Monitoring and Control Process



## LIST OF TABLES


Table 2.1.6-1	Summary of Principal Roles and Responsibilities of the core members of the IPT (PO, G/AO or CO, and LFO) Liaison by Facility Life Cycle Stage
Table 2.4.3-1	Sample of a No-Cost Extension Tasks Table
Table 3.4.1-1	List of the Essential Components of a Project Execution Plan, with Sub-Topics and Descriptions
Table 5.2.5-1	Sample Format for a Risk Management Plan
Table 5.2.5-2	Example of a Risk Management Roles and Responsibilities Table
Table 5.2.7-1	Sample Risk Probabilities Table
Table 5.2.7-2	Sample Risk Consequences Table
Table 5.2.7-3	Maxwell Risk Driver Assessment Framework
Table 5.2.8-1	Resources for Quantitative Risk Analysis Example
Table 5.2.8-2	Schedule Duration Risk Reference Ranges
Table 5.2.8-3	Results with Schedule Uncertainties Assigned
Table 5.2.8-4	Results with Schedule Uncertainties and Discrete Risks Assigned
Table 5.2.8-5	Results with Uncertainties and Cost Risks Assigned
Table 5.2.8-6	Savings and Days Saved
Table 5.2.9-1	Impact of Risk Handling on Project Cost




## 1 INTRODUCTION



### 1.1 PURPOSE AND SCOPE

A major responsibility of the National Science Foundation (NSF) is the support of scientific facilities as an essential part of science and engineering enterprise. NSF makes awards to external Recipient entities – primarily universities, consortia of universities or non-profit organizations – to undertake construction, management,  operation of facilities. Such awards frequently take the form of cooperative agreements.<sup>1</sup> Generally speaking, NSF does not directly construct or operate the facilities it supports. However, NSF retains responsibility for overseeing the Recipient's development and management of the facility as well as assuring the successful performance of the funded activities.

Facilities are defined as shared-use infrastructure, instrumentation and equipment that are accessible to a broad community of researchers and/or educators. Facilities supported by NSF may be centralized or may consist of distributed-but-integrated installations. They may incorporate large-scale networking or computational infrastructure, multi-user instruments or networks of such instruments, or other infrastructure, instrumentation, and equipment having a major impact on a broad segment of a scientific or engineering discipline. Historically, awards have been made for such diverse projects as  accelerators, telescopes, research vessels, aircraft, and geographically distributed but networked observatory systems.

The *Large Facilities Manual* contains NSF policy on the planning and management of large facilities. The purpose of the Manual is to provide guidance for NSF staff and recipients to:

- Carry out effective project planning, management, assistance, assurance, and oversight of large facilities,
- Clearly state the policies, requirements, and recommended procedures pertinent at each stage of a facility's life cycle, and
- Document best practices that ensure accountability and effectiveness of the program.

The policies in the *Large Facilities Manual* apply to all large facility projects funded by NSF, including:

- Large facilities that have been or will be constructed or acquired with funds from the Major Research Equipment and Facility Construction (MREFC) Account;
- Facilities or infrastructure projects that have been or will be constructed or acquired with funds provided through the Research and Related Activities (R&RA) and/or leveraged with Education and Human Resources (EHR) Accounts and that require National Science Board (NSB) approval; and

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<sup>1</sup> See *NSF Proposal and Award Policies and Procedures Guide* for detailed information on awards. NSF staff should also be consulted for material contained in the internal NSF document, *Proposal and Award Manual*.



- Existing facilities for which operation and replacement cost would be similar in size to MREFC-funded and MREFC-eligible projects.

NSF typically supports facility construction from two appropriations accounts: the MREFC Account and the R&RA Account. The MREFC Account was created in 1995 to fund the acquisition, construction, commissioning, and upgrading of major science and engineering infrastructure projects that could not be otherwise supported by Directorate level budgets without a severe negative impact on funded science. MREFC projects generally range in cost from one hundred to several hundred million dollars expended over a multi-year period. The R&RA account can be used to support other activities involving an MREFC-funded facility that the MREFC Account cannot support, including planning, conceptual design, development, operations and maintenance, and scientific research. Construction and acquisition projects at a smaller scale, usually of a scale ranging from millions to tens of millions of dollars, are also normally supported from the R&RA Account. The provisions and principles in the *Large Facilities Manual* also apply to these smaller-scale facilities funded through the R&RA Account, but procedures should be modified appropriately to fit the needs of each facility.



## 1.2 PRECEDENCE

The *Large Facilities Manual* comprises Chapter XIII of the *Proposal and Award Manual* (PAM), but is published under separate title. It replaces the *Large Facilities Manual*, NSF 13-38, published in 2013, and incorporates changes in organization and content intended to clarify the policies and procedures by which MREFC candidate projects are identified, developed, prioritized and selected.<sup>1</sup>

The *Large Facilities Manual* is a public document owned and managed by the Office of Budget, Finance and Award Management's (BFA) Large Facilities Office (LFO). It is available on the LFO public website (<https://www.nsf.gov/bfa/lfo/index.jsp>) as well as through the internal LFO website.

The Manual does not replace existing formal procedures required for all NSF awards, which are described in the publically available *Proposal and Award Policies and Procedures Guide* and in the NSF internal *Proposal and Award Manual*. Instead, it draws upon and supplements them for the purpose of providing detailed guidance regarding NSF management and oversight of facilities projects. All facilities projects require merit review, programmatic/technical review, and a substantial approval process. This level of review and approval differs substantially from standard grants, as does the level of oversight needed to ensure appropriate and proper accountability for federal funds. The policies, requirements, recommended procedures, and best practices presented herein apply to any facility large enough to require interaction with the NSB or any facility so designated by the Director, the Deputy Director, or the Assistant Director/Office Head of the Originating Organization(s).<sup>2</sup> For all other facilities, NSF staff members should use their judgment in proportionately scaling the requirements and recommended procedures for specific projects.

This Manual will be updated periodically to reflect changes in requirements and/or policies. Program Officers (PO) are encouraged and expected to continue to identify and adopt best practices aimed at improving NSF oversight and Recipient management of large facilities projects and at enabling the most efficient and cost-effective delivery of tools to the research and education communities.

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<sup>1</sup> See the Joint National Science Board —National Science Foundation Management Report: *Setting Priorities for Large Facility Projects Supported by the National Science Foundation* (NSB-05-77); September 2005

<sup>2</sup> See Section 2.1.6 for definition of this and other key terms. It also describes the NSF organizations and officers that are involved throughout the initiation, development, approval and implementation of an MREFC project. Readers not familiar with NSF and its processes should review this material before proceeding.



### 1.3 DOCUMENT STRUCTURE

The Manual is organized as follows:

- Section 1 introduces the purpose, scope, and historical perspective of this document.
- Section 2 describes the life cycle stages and the process and principles NSF uses to plan, construct and operate large facilities. The steps for approval and execution of projects funded using the MREFC Account and the roles and responsibilities of NSF staff are detailed.
- Section 3 describes the requirements for preparing and following the various detailed management plans required during the life cycle of a large facility.
- Section 4 is an expanded compendium of several NSF key requirements and principles listed in Sections 2 and 3. It includes detailed descriptions of processes used to plan, acquire, and manage large facilities.
- Section 5 contains extensive supplementary information on specific topics concerning NSF's role in the planning, oversight, and assurance of large facility projects. It consists of sections containing important explanatory and procedural information and pointers to separate documents (or modules) with similar information. The information in the documents is presented in a tutorial format that should be of particular benefit to individuals who are newly involved with large facility projects.<sup>1</sup>
- The appendices contain other information relevant to MREFC projects and large facilities.

This Manual is intended for use by NSF staff and by external proponents of large facility projects for use in planning. However, there are occasional references to materials, such as the *NSF Proposal and Award Manual*<sup>2</sup> (PAM), which are available only internally to NSF staff and refer to details of NSF administrative practices and procedures that are not relevant to external project proponents. Wherever these internal references are included, they are clearly noted as such.

Owing to the rigor of merit and programmatic review, constraints on funding, changing priorities and competing interests of NSF and the research community, only a limited number of projects will proceed successfully through all stages described herein. To improve the possibility of success, facility advocates should be thoroughly familiar with the entire contents of this manual even if the proposed project is in the earliest stages of formulation. Anticipating downstream requirements will dramatically improve the efficiency of the process.

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<sup>1</sup> Section 5 will be further updated to include additional information, with the intent to provide to NSF and the research communities a single reference location for all relevant policies and procedures.

<sup>2</sup> The *NSF Proposal and Award Manual* is a compendium of internal policies and procedures.



## 2 LARGE FACILITY LIFE CYCLE AND THE MREFC PROCESS

### 2.1 MREFC PROCESS INTRODUCTION

National Science Foundation (NSF) investments through the Major Research Equipment and Facility Construction (MREFC) Account provide state-of-the-art infrastructure for research and education, such as laboratory and field instrumentation and equipment, multi-user research facilities, distributed instrumentation networks and arrays, and mobile research platforms. In addition, investment is increasing in highly sophisticated information technology (IT)-based infrastructure, including distributed sensor networks, extensive data-storage and transmission capabilities, advanced computing resources, and Internet-based distributed user facilities.<sup>1</sup>

This section describes the overall MREFC process as well as the roles and responsibilities of the various participants. It provides guidelines for planning and managing facilities supported through the MREFC Account. Because each facility has unique aspects, each project necessarily requires adaptation of general principles. NSF promotes flexibility in the application of these guidelines, but requires justification and substantiation for the specific approach taken in each case. That is accomplished through the processes of formal planning, documentation, and review.

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<sup>1</sup> These resources, many of which are now in development, are collectively known as “cyber infrastructure.”



**2.1.1 Definition of the MREFC Account**

*Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)*

**2.1.1 Definition of the MREFC Account**

The MREFC Account is an agency-wide account, created in 1995 with Congressional approval, which provides funding to establish major science and engineering infrastructure projects that exceed 10% of the Directorate's annual budget, or roughly one hundred million dollars or greater. Specifically, the MREFC Account is intended to:

- Provide a special account to fund acquisition, construction and commissioning of major facilities and other infrastructure projects;<sup>1</sup>
- Prevent large periodic obligations from distorting the budgets of NSF Directorates and program offices; and
- Ensure availability of resources to complete large projects that are funded over several years.<sup>2</sup>

The MREFC Account funding is specifically for construction related activities; it cannot be used to support other activities involving an MREFC-funded facility, such as planning, conceptual design, development, operations and maintenance, or scientific research.

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<sup>1</sup> In some cases, MREFC funds may be used to support development after construction of a facility begins.

<sup>2</sup> Reliable long-term funding commitments are essential to maintaining partnerships and for preventing cost overruns due to schedule delays.



### 2.1.2 Eligibility for MREFC Funding

To be eligible for consideration for MREFC funding, each candidate project should represent an outstanding opportunity to enable research and innovation, as well as education and broader societal impacts. Each project should offer the possibility of transformative knowledge and the potential to shift existing paradigms in scientific understanding, engineering processes and/or infrastructure technology. Moreover, each should serve an urgent contemporary research and education need that will persist for years beyond the often lengthy process of planning and development.

In addition, a candidate project should:

- Be consistent with the goals, strategies and priorities of the NSF Strategic Plan;<sup>1</sup>
- Establish a long-term tools capability accessible to an appropriately broad community of users on the basis of merit;
- Require large investments for construction/ acquisition, over a limited period of time, such that the project cannot be supported within one or more NSF Directorate(s)/ Office(s) without severe financial disruption of their portfolios of activities;
- Have received strong endorsement of the appropriate science and engineering communities, based upon a thorough external review, including an assessment of (1) scientific and engineering research merit, (2) broader societal impacts, (3) importance and priority within the relevant Science and Engineering communities, (4) technical and engineering feasibility, and (5) management, cost, and schedule issues;
- Be of sufficient importance that the Originating NSF Organization<sup>2</sup> is prepared to fully fund the costs of pre-construction planning, design and development, operation and maintenance, and associated programmatic activities (with full awareness that, for a long-lived facility, operations costs may ultimately amount to many times the construction costs); and
- Have been coordinated with other organizations, agencies and countries to ensure complementarity and integration of objectives and potential opportunities for collaboration and sharing of costs.

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<sup>1</sup> *Empowering the Nation Through Discovery and Innovation: NSF Strategic Plan for Fiscal Years (FY) 2011-2016.*

<sup>2</sup> See Section 2.1.6 for definition of this and other key terms. It describes the NSF organizations and officers that are involved throughout the conception, development, approval and implementation of an MREFC project.

### 2.1.3 Facility Life Cycle

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)

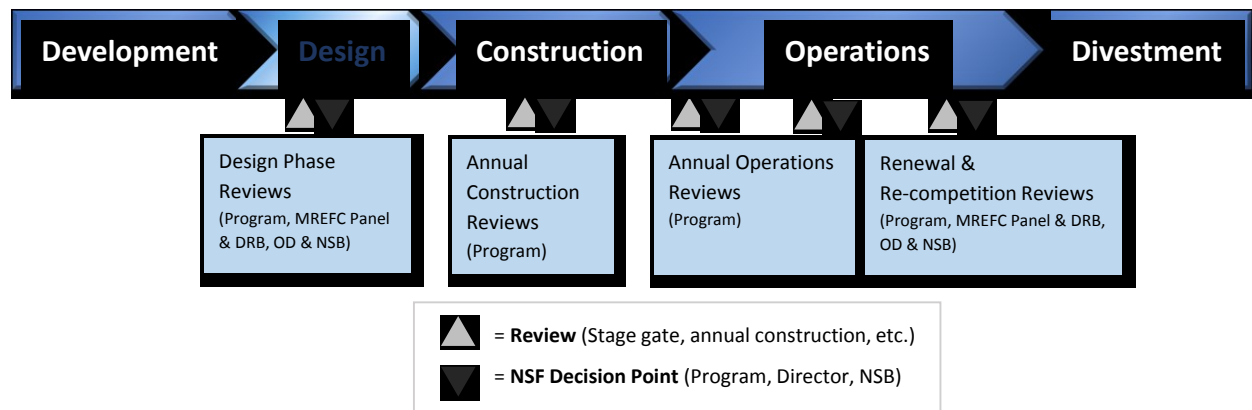
### 2.1.3 Facility Life Cycle

A facility's lifetime is characterized by the following life cycle stages:

1. Development<sup>1</sup>
2. Design
3. Construction
4. Operation
5. Divestment.

Each life cycle stage entails different actions appropriate to the advancement of the project, the review and approval needed to obtain NSF funding, and the creation of NSF budgets to support these activities. Entry and exit from each life cycle stage are clearly defined including required documents and deliverables. A high-level graphic of the progression through the stages is given below in Figure 2.1.3-1.

Figure 2.1.3-1 Progressive Steps in the MREFC Life Cycle, Showing Review and Decision Points for Exit and Entry into Each Stage. The Design Stage is highlighted to indicate that it is further broken down into phases



Points at which there may be departure from the MREFC process outlined here should be identified early in the project development and documented as part of the NSF Internal Management Plan (IMP) Individuals should discuss any proposed departures with the cognizant Program Officer.

The Design Stage is further divided into three phases, each with defined entry and exit points, as shown in Figure 2.1.3-2 below:

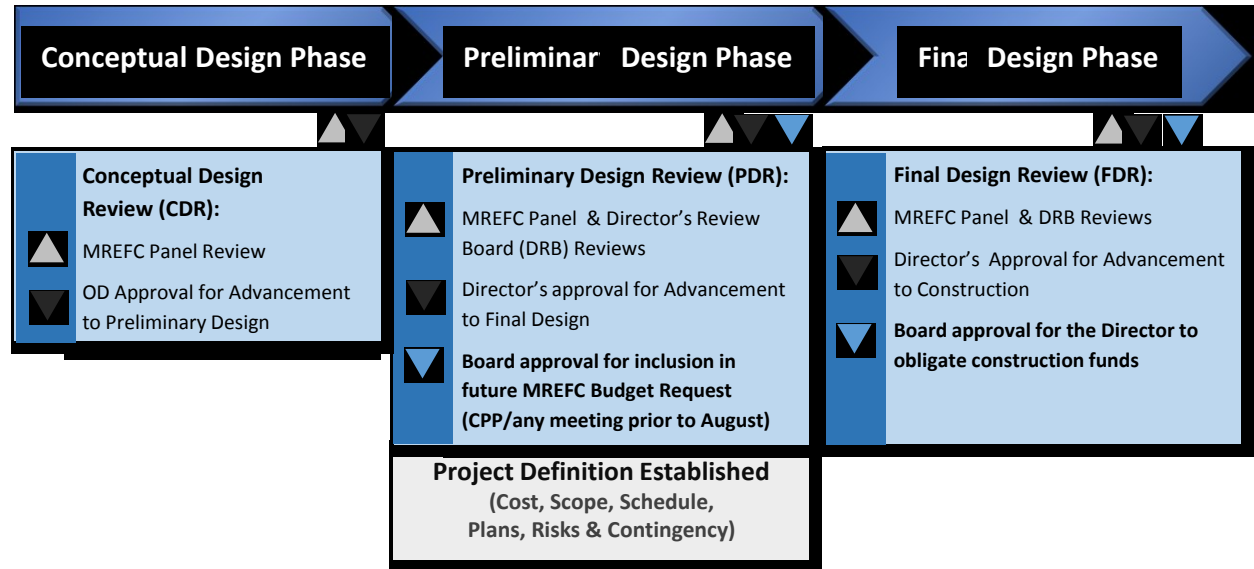
1. Conceptual Design
2. Preliminary Design
3. Final Design

<sup>1</sup> A project in the Development Stage may be referred to as a "Horizon" or a Conceptual Development project in earlier NSF documents and references.

2.1.3 Facility Life Cycle

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)

Figure 2.1.3-2 Progressive Phases in the Life Cycle Design Stage, showing review and decision points for advancement to the next phase and NSB approvals for budgeting and award.



Summary definitions of each stage and phase are given below. See sub-sections 2.2 to 2.6 for detailed discussions of the various procedures and deliverables for each step in the facility life cycle.

Development Stage

The life cycle stage in which initial ideas emerge and a broad consensus built for the potential long-term needs, priorities, and general requirements for Research Infrastructure (RI) of interest to NSF. Investments in development by NSF, other government agencies, or private interests can be focused or sporadic but are generally smaller annual investments than in the Design Stage. The effort is focused on the high-level ideas and building community consensus on requirements and setting priorities across a broad landscape of potential needs. This stage can last 10 years or more. The cumulative investment over this period can be quite substantial. Next to the Divestment Stage, the Development Stage is often the most challenging to navigate depending upon how federal agencies and science communities are organized. The exit process from this stage begins, once the issues have coalesced, with a proposal from a Division (via its Directorate) to the NSF Director that a project is ready to begin the Conceptual Design Phase. At that point a formal senior-level agency internal review takes place and the NSF Director may approve this transition to the first phase in the Design Stage, with the provision that no commitment to advance the project beyond the approved design phase is implied.

Design Stage

This is the life cycle stage for detailed planning of RI which is formally approved by the NSF Director and funded by the sponsoring Directorate or Division as a candidate MREFC (or other)

### 2.1.3 Facility Life Cycle

*Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)*

project. It is divided into the Conceptual, Preliminary, and Final Design Phases; with a formal and rigorous review gate at the end of each phase to show readiness for advancement to a higher level of design readiness. Entrance into this stage occurs when the NSF Director approves the proposed Research Infrastructure as a national priority and the Directorate obligates funding to detailed cost, scope and schedule development for possible construction. This stage includes a series of readiness reviews to assure proper design progress and advancement through the defined phases. This Stage generally lasts 3-5 years and costs 10% or more of the estimated construction cost depending on the nature of the infrastructure. It is also the stage where construction funds are identified and (ideally) were partnerships are formalized.

Conceptual Design Phase: Advances the definition of the scope and requirements, determines feasibility, and produces updated drafts of most elements of the Project Execution Plan, including parametric cost and schedule range estimates and a preliminary risk analysis.

Preliminary Design Phase: Further advances the project baseline definition and the Project Execution Plan. It produces a bottom-up scope, cost, schedule, and risk analysis of sufficient maturity to allow determination of the Project Total Cost and overall duration for a given Fiscal Year start and to establish the MREFC budget request to congress.

Final Design Phase: Further refines the project baseline definition and the Project Execution Plan and demonstrates that project planning and management meet requirements for readiness to receive funding. The Final Design phase ends after review and NSF recommendation to approve the obligation of construction funds.

#### Construction Stage

This stage begins when MREFC funds are obligated for acquisition and/or construction of RI that fulfills the terms and conditions set forth in an award instrument between NSF and the recipient(s). Depending on the nature and scale of the facility, construction typically lasts 2-6 years and costs between \$100M and \$800M. This stage has the most stringent requirements for managing the scope, cost, schedule, and performance; for reporting progress; and for formality of oversight and assurance by NSF. Progress is reported against the approved Project Execution Plan and project status is reviewed periodically to ensure that the project is capable of finishing within budget and schedule. The Construction Stage normally includes activities to transition to operations. It ends after final delivery and acceptance of the defined scope of work and facility performance per the terms of the award agreement.

#### Operations Stage

This life cycle stage includes the day-to-day work to operate and maintain the RI and to perform research. During this stage, the facility is actively collecting and distributing data for use by the

science community. Operations may include activities to transition from construction to operations, refurbishment or upgrade activities, and activities that support planning for and transition to the Divestment Stage. This stage typically lasts 20-40 years, the total cost of which often greatly exceeds the cost of construction. It normally includes a series of periodic status reviews but may also include reviews and decisions on further investment, capability up-grades, and refurbishments and eventually the final decision on divestment. Annual operating costs and Concept of Operations Plans (including operational agreements between parties for funding, data sharing, etc.) should already be well established before entering this stage. The decision to divest is generally made when NSF and/or the scientific community determine that the facility is no longer considered an operational priority with regard to advancing science. This final decision is often the most challenging.

#### Divestment Stage

Entrance into this stage occurs when the first financial investment is made to divest or decommission the RI. The decision to divest happens at the end of the Operations Stage. Divestment could include transfer to another entity's operational and financial control or decommissioning, including complete de-construction and removal of the infrastructure. Cost of decommissioning can be substantial and must be thoroughly considered in terms of process and costs as part of divestment planning.



## 2.1.4 Summary of the MREFC Process

MREFC projects cover a wide range of disciplines and activities in science and engineering, and they can require rather different approaches to the development and ultimate acquisition of facilities, equipment, and/or infrastructure. The approach described in this Manual is derived largely from experience with construction projects defined by the following characteristics:

- They serve a relatively large community or a large collaboration, whose members have organized and agree on the basic parameters of the project; and
- They result from proposals to NSF, either unsolicited or through a targeted NSF solicitation, proposing to construct the particular equipment or infrastructure; and
- Operation of the equipment or infrastructure is carried out by the entity or community that proposes construction (or by some other entity in cases where the operations expertise may not necessarily reside with the construction team).

As the diagram in Figure 2.1.4-1 indicates, pre-construction planning and development for MREFC candidate projects progress through a sequence of stages of increasing investment, planning, assessment, oversight, and assurance. Among other uses, these stages ensure that the technical evolution of a candidate project is coordinated with NSF requirements, thus increasing the likelihood that it will be able to qualify for funding for further planning and eventual construction.

However, because NSF supports investigation at the frontiers of understanding, where specific research targets and methodology often are not firmly established, some candidate projects may need to progress in ways that are not as neatly well-defined as the prototypical cases described above. The guidelines in this Manual allow for such cases. For example:

- Because NSF is responsible for nurturing the various science and engineering disciplines that it supports, it may provide researchers access to funding sufficient to develop compelling research agendas, to refine and prioritize their facility requirements, and to complete research and development on facility designs and needed technologies, without assuming a direct role in overseeing either construction or operation. Such projects should nevertheless be sanctioned by, and ultimately driven by, the community through merit review that establishes that candidate new facilities represent a high priority of the researchers in that discipline.
- Following successful concept development, the entire project may be best developed and implemented by an award directly to industry – for example, in the case of cyber-infrastructure. In such cases, provision should nevertheless be made for proper pre-construction planning, with thorough community input and merit review, followed by proper oversight throughout the implementation stage of the project.

In all cases, NSF is committed to the principle that flexibility does not preclude rigor. Every MREFC candidate project – including those that call for novel treatment – is subject to the highest standards of merit review and technical evaluation.

2.1.4 Summary of the MREFC Process

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)



Figure 2.1.4-1 Summary Timeline for MREFC Projects

		<b>FIGURE 1 Conceptual Design Phase</b>	<b>Preliminary Design (Readiness) Phase</b>	<b>Final Design (Board Approved) Phase</b>	<b>Construction</b>	<b>Operations</b>
		<b>Preconstruction Planning Funded via R&amp;RA and EHR funds</b>			<b>MREFC funds</b> →	<b>R&amp;RA, EHR funds</b>
<b>Budget evolution</b>		Develop construction budget based on conceptual design Develop budget requirements for advanced planning Estimate ops \$	Expend ~5-25% of construction cost on planning & design activities Construction estimate based on prelim design Update ops \$ estimate		Expend budget & contingency per baseline Refine ops budget	Yearly budgets with out-year projects
			Final design over ~ 2 years Construction-ready budget & contingency estimates Update ops \$ estimate			
<b>Project evolution</b>		Proponents development strategy defined in Project Development Plan			Construction per baseline and PEP	Annual Work Plans with goal setting Annual Reports that track progress relative to goals
		Formulate science goals; define requirements, prioritize, review Develop conceptual design; identify critical technologies, high risk items Formulate initial risk assessment Develop top-down parametric cost and contingency estimates Initial proposal submission to NSF Initial Project Execution Plan (PEP)	Develop site-specific preliminary design, environmental impacts Develop enabling technologies Bottom-up cost and contingency estimates, updated risk analysis Develop Project Management Control System Develop preliminary operations cost estimate Update PEP	Develop final construction-ready design & PEP Industrialize key technologies Refine bottom-up cost and contingency estimates Finalize Risk Assessment & Mitigation, Management Plans Complete key staff recruitment		
NSF oversight defined in Internal Management Plan, updated by development phase						
<b>Program &amp; Oversight evolution</b>		Merit review, apply 1 <sup>st</sup> and 2 <sup>nd</sup> ranking criteria MREFC Panel recommendation → Director approval for CD start Develop Internal Management Plan (IMP), est. PD costs, timeline Establish interim review plan and competition milestones Forecast international and interagency participation, issues Initial analysis of NSF opportunities, risks <b>Conceptual Design Review (CDR)</b>	<b>NSF Director approves PD phase</b> NSF Director approves PD start, Internal Mgmt Plan (IMP) Approve Project Development Plan (PDP) & budget Evaluate design costs, schedules; and ops costs est. Forecast external partner decision milestones <b>Preliminary Design Review (PDR)</b> & integrated baseline review, cap total project budget NSF Director requests NSB approval for MREFC request NSB prioritization	<b>NSF approves submission to NSB</b> OMB/Congress negotiations on proposed project and budget profile Semi-annual assessment of baseline and projected ops budget for projects not in construction Finalization of interagency and international requirements, agreements <b>Final Design Review (FDR)</b> , fix baseline	<b>Congress appropriates funds</b> Congress appropriates MREFC funds & NSB approves obligation Periodic external review during construction Review of project reporting Site visit and assessment	Annual or regular reviews of operations Preparation for facility re-competition, renewal or disposal/divestment





### **2.1.5 Timeline and Flowcharts for the MREFC Approval Process**

This section, to be written, will illustrate when various preconstruction planning activities should be completed in order to commence construction in a particular future fiscal year. Although the majority of those activities proceed at a pace specific to the needs of an individual project, late-stage planning activities following completion of a project's Preliminary Design are paced by the process for developing NSF's annual Budget Request to Congress. This section will also explain key features of that process that are of particular interest to those involved with MREFC projects.

## 2.1.6 Roles and Responsibilities for NSF Staff for Management and Oversight of Large Facilities

### 2.1.6.1 Overview

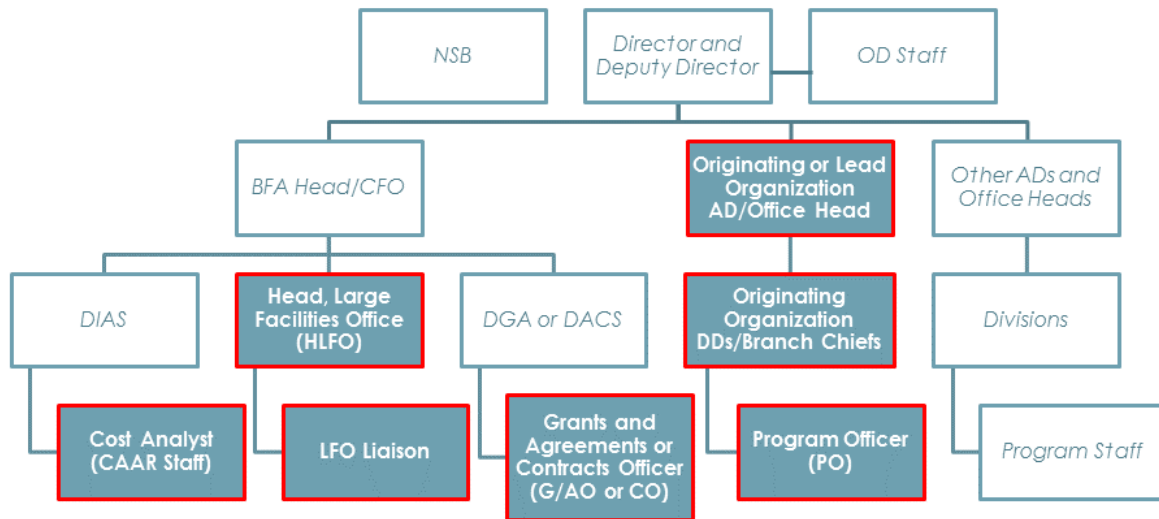
The Large Facilities Manual (LFM) describes the actions NSF takes to carry out its oversight and assurance responsibilities for large facility projects. One key element is the definition of the roles and responsibilities of the NSF participants who carry out those actions. The participants with primary oversight and management roles and responsibilities are listed below and highlighted in the NSF organizational chart in Figure 2.1.6-1:

- **Program Officer (PO)** – A scientist or engineer having primary oversight responsibility within NSF for all aspects of the project.<sup>1</sup>
- **Originating Organization** – The NSF Division, Directorate, or Office which proposes projects for funding through the MREFC Account or other funding source and is committed to pre-construction planning activities and eventual facility operation and use.
- **Senior Management of the Originating Organization** – The leadership individuals who utilize community inputs, discipline-specific studies, advisory committee recommendations and internal NSF considerations to prioritize the opportunities represented by the candidate project relative to competing opportunities and demands for available resources.
- **Grants and Agreements Officer or Contracting Officer (G/AO)** – NSF grants management officer who has legal responsibility and authority for the business and financial management of grants and cooperative agreements.
- **Contracting Officer (CO)** - NSF contracts management staff which have legal responsibility and authority for the business and financial management of award contracts.
- **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.
- **Deputy Director for Large Facility Projects, (DDLFP)** – [Reserved]
- **Head, Large Facilities Office (HLFO)**, – The individual who heads the Large Facilities Office (LFO). The LFO provides an NSF-wide resource for assistance with project oversight and assurance. The LFO is administratively located in BFA.
- **Large Facilities Office Liaison** – The designated project management advisor from the LFO, who is assigned as project liaison by the **HLFO**. This individual is the PO's primary resource for assistance with all policy, process, and procedural issues related to the development, implementation, and oversight of MREFC projects.

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<sup>1</sup> The PO may have a title such as Program Manager or Program Director. The PO is administratively part of a Directorate or Office, comprised of Divisions, which serves a range of research disciplines. These are referred to as the “originating Division, Directorate or Office” in this document.

Figure 2.1.6-1 NSF organization chart highlighting staff who have primary oversight and management roles and responsibilities for large facilities.



As shown in Figure 2.1.6-2, various bodies within NSF provide coordination, assistance, assurance, and advice to the main participants and to the agency as a whole:

- Integrated Project Team (IPT)<sup>1</sup>** – Comprised of NSF personnel with knowledge and expertise in areas related to the scientific and technical, award management, and strategic aspects of a particular MREFC project. The IPT is a coordinating body that provides internal agency assurance and guidance to the PO in the planning, review, and oversight of that project. The members of the IPT are selected by the management of the cognizant directorates and offices, in consultation with the PO, at the beginning of the Conceptual Design Phase. The IPT is chaired by the PO.
- Large Facilities Working Group (LFWG)<sup>2</sup>** – An advisory group composed of internal NSF staff and administrators that reviews and provides feedback to the LFO on draft policies, processes and procedures related to NSF Large Facilities (including but not limited to the Large Facilities Manual); raises and provides inputs on issues related to NSF Large Facilities; and reviews and comments on IMPs prior to the Conceptual Design Review (CDR).

<sup>1</sup> The IPT replaces the Program Advisory Team (PAT) and the Business Oversight Team (BOT).

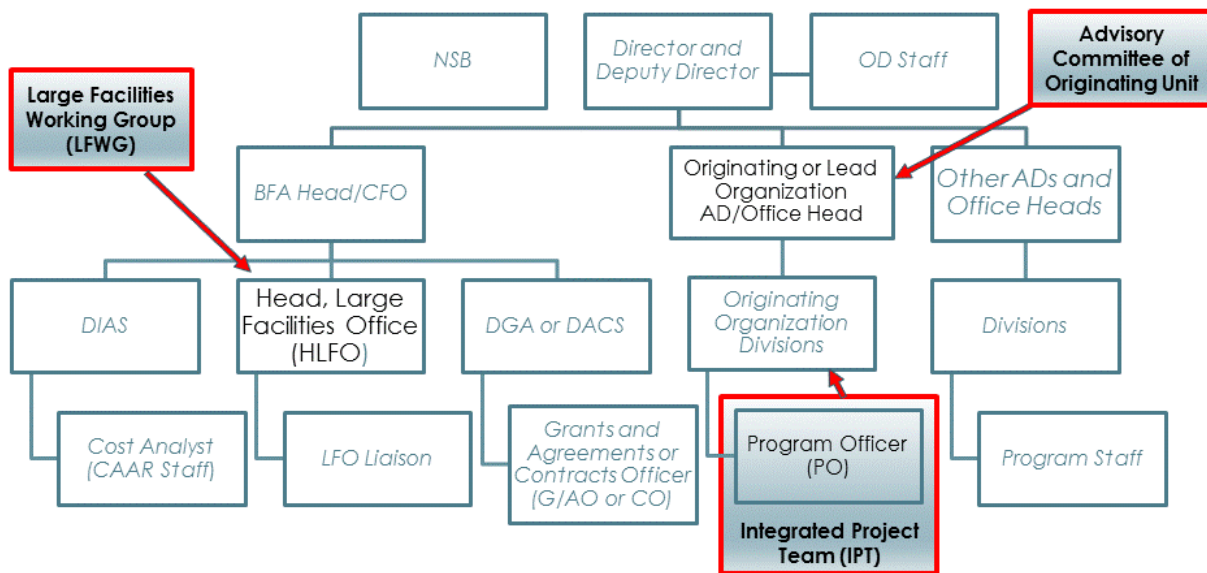
<sup>2</sup> The LFWG replaces the Facilities Panel.

2.1.6 Roles and Responsibilities for NSF Staff for Management and Oversight of Large Facilities

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)

- **Advisory Committee of the Originating Directorate or Office** – Comprised of researchers from the community (external to NSF), it advises the originating Directorate or Office in a wide variety of programmatic areas, including large facilities.

Figure 2.1.6-2 NSF organization chart showing coordinating and advisory bodies for large facilities.



There are also planning and assurance bodies, shown in Figure 2.1.6-3, that review and make recommendations on the suitability and readiness as well as on the allocation of resources for the development, funding, and operation of large facility projects, according to the NSF strategic objectives:

- **MREFC Panel** – Comprised of Senior Management representatives from the Directorates and Offices of NSF, it reviews and recommends projects for advancement through the MREFC process, as presented by the Originating Organization(s), and makes recommendations to the NSF Director on priorities and use of NSF resources.
- **Director's Review Board** – Comprised of Senior Management Representatives from the Directorates and Offices of NSF, it reviews and approves the package of materials associated with all topics to be submitted to the National Science Board (NSB) for information or action, including MREFC projects.

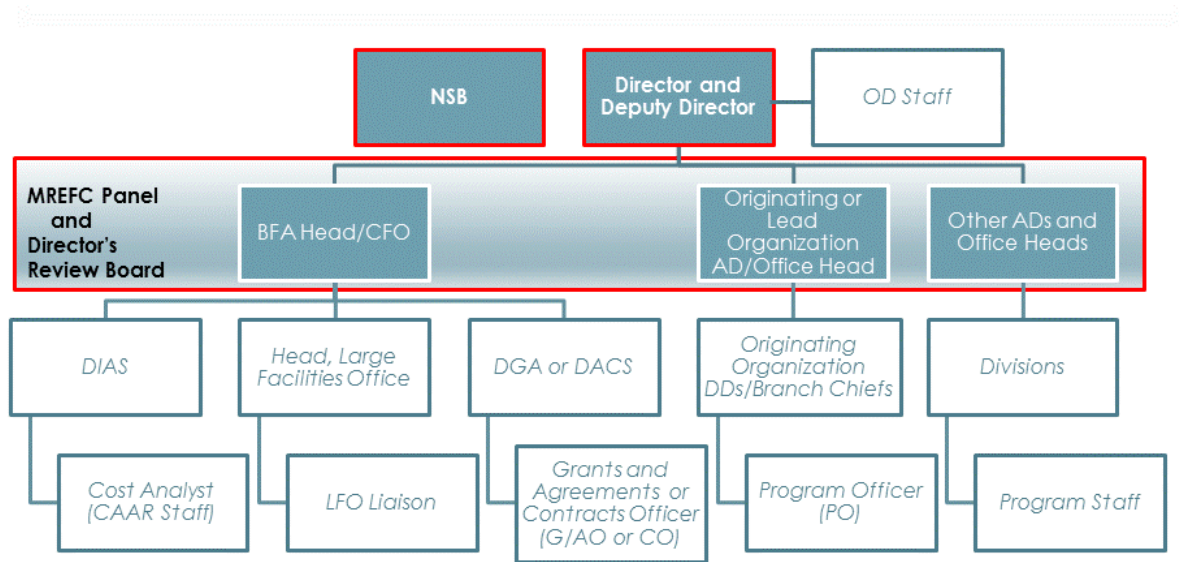
2.1.6 Roles and Responsibilities for NSF Staff for Management and Oversight of Large Facilities

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)

Finally, there are entities also shown in Figure 2.1.6-3 that set NSF policy and that approve the advancement, funding requests, and obligation of funds for the development, construction, and operation of large facility projects:

- **NSF Director** – Has ultimate responsibility for the approval of the obligation of funds from the MREFC Account and for proposing new MREFC projects to the NSB, the Office of Management and Budget (OMB), and Congress.
- **NSB** – Establishes policy, reviews and approves MREFC Account budgets, and reviews and approves specific MREFC projects for funding.

Figure 2.1.6-3 NSF organization chart showing planning, policy, and advisory bodies for large facilities.



The PO, G/AO, and LFO staff members are the individuals that interact most frequently to carry out NSF’s oversight and assurance role for large facility projects. Their roles and responsibilities are summarized, by life cycle stage, in Table 2.1.6-1. Fuller descriptions of their roles (and those of senior management in the originating Directorate or Office, and the support, advisory, policy making, and approving entities) are provided in individual sections of this document following Table 2.1.6-1.

**2.1.6 Roles and Responsibilities for NSF Staff for Management and Oversight of Large Facilities**

*Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)*

**Table 2.1.6-1 Summary of Principal Roles and Responsibilities of the core members of the IPT (PO, G/AO or CO, and LFO) Liaison by Facility Life Cycle Stage**

Program Officer (PO)	Grants/Agreements (G/AO) or Contracts Officer (CO)	LFO Liaison
<b>Summary</b>		
<ul style="list-style-type: none"> <li>• Primary responsibility for all oversight aspects of a MREFC project</li> <li>• Experienced or trained in management of large projects.</li> <li>• Appointed by the Division Director (DD)</li> <li>• Must not be a temporary employee of the NSF</li> </ul>	<ul style="list-style-type: none"> <li>• Primary representative of the NSF in all business dealings with the recipient</li> <li>• Assigned to a project on a long-term basis</li> <li>• Experienced with Federal regulations and unique NSF requirements needed for adequate NSF oversight of large facility projects</li> </ul>	<ul style="list-style-type: none"> <li>• Program’s primary resource for all policy or process issues related to the development, implementation, and oversight of MREFC projects</li> <li>• Advises POs on project management issues during project development and oversight</li> </ul>
<b>Conceptual Design Phase</b>		
<ul style="list-style-type: none"> <li>• Determines the importance and research priority to the affected research community of the science objectives motivating consideration of a future large facility</li> <li>• Works with the research community to develop an overall scope for a large facility project.</li> <li>• Develops the IMP</li> <li>• Organizes and chairs the IPT</li> <li>• Formulates a plan for eventual divestment of the facility</li> <li>• Devises and carries out a renewal or termination strategy that implements recompetition of the operating award wherever feasible</li> </ul>	<ul style="list-style-type: none"> <li>• Becomes acquainted with the anticipated scope of the proposed project</li> <li>• Participates in planning meetings to work out details of partnerships, international or multi-agency agreements, property issues, etc.</li> <li>• Participates in the development of the IMP</li> <li>• Serves on the IPT throughout the project</li> </ul>	<ul style="list-style-type: none"> <li>• In collaboration with PO, plans CDR</li> <li>• Independently assesses the CDR outcome for the LFO</li> <li>• Serves on the IPT throughout the project</li> </ul>

**2.1.6 Roles and Responsibilities for NSF Staff for Management and Oversight of Large Facilities**

*Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)*

Program Officer (PO)	Grants/Agreements (G/AO) or Contracts Officer (CO)	LFO Liaison
<b>Preliminary Design Phase</b>		
<ul style="list-style-type: none"> <li>• Works with the research community to develop a proposal that includes a preliminary Project Execution Plan (PEP)</li> <li>• Arranges external peer review of the proposal</li> <li>• Presents the proposed project to the MREFC Panel</li> <li>• Updates the IMP</li> <li>• Continues to meet with the IPT</li> <li>• Reports monthly to HLFO on project's technical and financial status</li> </ul>	<ul style="list-style-type: none"> <li>• Creates solicitations for enabling research, workshops, summer studies, and other activities of the research community that will result in a proposal (shared responsibility with PO)</li> <li>• Responsible for the business aspects of the proposal review and cost analysis and in surveillance or mentoring of the proposing institutions</li> <li>• Participates in preparation of materials for the MREFC Panel and Director's Review Board (DRB)</li> </ul>	<ul style="list-style-type: none"> <li>• Advises PO</li> <li>• In collaboration with PO, plans Preliminary Design Review (PDR)</li> <li>• Independently assesses outcome of PDR for the LFO</li> <li>• Receives monthly reports on project development from PO, and provides independent assessment to the Head, LFO</li> </ul>
<b>Final Design Phase</b>		
<ul style="list-style-type: none"> <li>• Continues to monitor project in accordance with the IMP</li> <li>• Provides monthly project status updates to the HLFO</li> <li>• Organizes periodic cost update reviews</li> <li>• Organizes the Final Design Review (FDR)</li> </ul>	<ul style="list-style-type: none"> <li>• Instigates as required review, cost analysis, or mentoring necessary to ensure that the recipient follows NSF business and budgeting policies and requirements</li> <li>• Participates in periodic cost update reviews.</li> <li>• Participates in preparation of materials for the MREFC Panel and DRB</li> </ul>	<ul style="list-style-type: none"> <li>• Continues to monitor project</li> <li>• Receives monthly project status updates from the PO, adds comments and evaluation</li> <li>• Aids the PO with the organization of the periodic cost update reviews in interval between PDR and FDR.</li> <li>• In collaboration with PO, plans FDR and independently assesses outcome</li> </ul>

**2.1.6 Roles and Responsibilities for NSF Staff for Management and Oversight of Large Facilities**

*Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)*

Program Officer (PO)	Grants/Agreements (G/AO) or Contracts Officer (CO)	LFO Liaison
<b>Construction/Implementation Stage</b>		
<ul style="list-style-type: none"> <li>• Develops a Cooperative Agreement (CA)</li> <li>• Approves the establishment of a project baseline scope, cost, and schedule and other updates to the PEP</li> <li>• Approves significant changes to the project baseline</li> <li>• Receives monthly financial and technical status reports, quarterly and annual progress reports</li> <li>• Reports monthly to HLFO on project's technical and financial status</li> <li>• Conducts periodic reviews of project progress using an external ad hoc panel</li> <li>• Arranges internal review of Memorandums of Understanding (MOUs)</li> <li>• Regularly visits the project</li> <li>• Updates the IMP</li> <li>• Ensures compliance with Government Performance and Results Act (GPRA)</li> </ul>	<ul style="list-style-type: none"> <li>• Approves submittals from recipient</li> <li>• Reviews the scope of activities associated with each award to ensure that the financial and administrative framework aligns with NSF's expectations for stewardship and reporting.</li> <li>• Receives and provides approval to the recipient</li> <li>• Participates in baseline review and subsequent periodic reviews as necessary to assure the NSF that the recipient follows agency financial policies</li> <li>• Serves on the IPT to expedite financial and administrative actions and decisions concerning the project</li> </ul>	<ul style="list-style-type: none"> <li>• Advises PO</li> <li>• In collaboration with PO, plans construction reviews and independently assesses outcome</li> <li>• Receives monthly project status reports from the PO</li> <li>• Visits the project site periodically in coordination with PO</li> </ul>



2.1.6 Roles and Responsibilities for NSF Staff for Management and Oversight of Large Facilities

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)

Program Officer (PO)	Grants/Agreements (G/AO) or Contracts Officer (CO)	LFO Liaison
<b>Operations Stage</b>		
<ul style="list-style-type: none"> <li>• Prepares and participates in solicitation of award for Operations and Maintenance (O&amp;M) CA</li> <li>• Ensures compliance with GPRA</li> <li>• Approves the Annual Work Plan (which includes high level performance goals) developed by the recipient</li> <li>• Reviews and approves the Annual Report</li> <li>• Develops budgets that operate and maintain facilities</li> <li>• Obtains Condition Assessment reports</li> <li>• Monitors planning for IT and property security, and validates through periodic review</li> <li>• Organizes and participates in periodic reviews of the facility including annual operations reviews</li> <li>• Formulates a plan for eventual divestment of the facility</li> <li>• Devises and carries out a renewal or termination strategy that implements recompetition of the operating award wherever feasible</li> </ul>	<ul style="list-style-type: none"> <li>• Prepares solicitation for O&amp;M award (shared responsibility with PO)</li> <li>• Creates special terms and conditions in the CA to capture requirements for annual performance goals (shared responsibility with the PO)</li> <li>• Defines business practices for renewal, recompetition, or termination of Award</li> <li>• Attends periodic reviews including operations and business systems reviews (BSRs) as appropriate</li> <li>• Assists in developing financial strategy, as appropriate, to budget for facility maintenance and replacement or refurbishment of long-lived capital-assets (shared responsibility with PO)</li> <li>• Prepares Cost Proposal Review Document (CPRD) and performs independent cost analyses as required</li> </ul>	<ul style="list-style-type: none"> <li>• Advises PO and G/AO on effective operational oversight strategies, renewal and recompetition strategies, and termination</li> <li>• Periodically visits operating facilities in coordination with PO</li> <li>• In collaboration with PO and G/AO, insures implementation of performance measures within the CA for operation</li> <li>• Assists with organizing and evaluating the results of operational reviews of large facilities</li> <li>• Advises PO and G/AO on project management issues related to recompetition of award for facility operation</li> </ul>

2.1.6.2 Main Participants

Program Officer (PO)

The PO is the research community’s primary interface to the NSF. The PO’s responsibilities are substantial, and crucial to NSF’s success. Examples of these responsibilities are listed below:<sup>1</sup>

- They are typically the main contact a principal investigator (PI) has with NSF.
- They are the link between what is happening in the research community and the appropriately responsive program solicitation from NSF.
- They are the catalysts for the increasing amount of research that crosses traditional single-discipline boundaries.

<sup>1</sup> Paraphrased from *National Science Foundation: Governance and Management for the Future*, a report by a panel of the National Academy of Public Administration, April 2004. pp. 10-11.

- They are the coaches and encouragers for proposals from less experienced researchers – particularly ones with innovative ideas – as well as those from underrepresented segments of the research community.
- They are the recruiters and managers of a peer review process that involves numerous experts from the research community to assess the intellectual merit and broader impacts of proposals from the community for new research.
- They are the post-award managers and monitors for awarded research.

NSF's Authorization Act of 2002, 42 U.S.C.1862n-4l, signed into law on December 19, 2002, restricts the choice of POs (also referred to within the NSF as Program Directors or Program Managers) to be regular employees of the NSF. The statutory language of the Act states:

*“PROJECT MANAGEMENT. No national research facility project funded under the major research equipment and facilities construction account shall be managed by an individual whose appointment to NSF is temporary.”*

Administratively, the PO is part of a Directorate or Office that provides supervisory oversight and the budgetary authority to fund PO actions. Depending on the administrative structure of the originating Directorate or Office, a Section Head, Division Director, Assistant Director (AD), or Office Head may assign a PO (or POs)<sup>1</sup> to oversee a particular facility-related initiative and will directly or indirectly oversee and guide the activities of the PO. Actions of the PO described here implicitly recognize the authority of the individuals within this supervisory structure to appropriately guide, direct, and approve the actions of the PO.

The PO exercises primary responsibility within NSF for all aspects of a large facility project, including:

- Project planning, both internally and in coordination with the relevant research community;
- Serving as the NSF interface with the research community to nurture concepts for development and utilization by the community of a facility;
- Formulating an IMP that defines NSF strategy for conducting project oversight, managing NSF risk, and providing project funding;
- Coordinating contact between the project proponents and other NSF staff members that may need to have direct contact with the project or that the project may wish to contact;
- Chairing the IPT;

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<sup>1</sup> In some cases, more than one individual will be designated as a PO for a facility related initiative. Wherever the PO is referenced in this manual, it should be understood that the reference is to all the relevant assigned POs.


- Conducting merit and programmatic/technical reviews of proposals for development, implementation, operation, and utilization of a facility (CDR, Preliminary Design Review, Final Design Review (FDR), construction and operational reviews);
- Preparing all required documentation for internal project review and approval within the NSF;
- Participating in developing the estimated costs of planning, construction, operations, maintenance and related programmatic activities, and, under management direction of the originating Division, Directorate, or Office, assigns budgets to these tasks; and
- Overseeing implementation, operation, and eventual divestment and termination of NSF support for the project.

#### Senior Management of the Originating Division, Directorate, or Office Assistant Director or Office Head

Assistant Directors (ADs) and Office Heads lead Directorates or Offices, and by extension their Divisions or Sections, which propose projects for funding through the MREFC Account or other funding source.

The AD (or Office Head) of the Originating Organization utilizes community inputs, discipline-specific studies, advisory committee recommendations and internal NSF considerations to prioritize the opportunities represented by the candidate project relative to competing opportunities and demands for NSF resources. The AD determines that the scientific merit and relative importance of the proposed facility are sufficiently strong to justify advancement of the project to Readiness Stage (i.e., ready to begin Preliminary Design activities), and authorizes the PO to proceed with organizing the development and external review of a Project Execution Plan and with updating the IMP to explain how NSF will oversee and fund further development. The AD reviews and approves the IMP prior to its submission to the LFWG for review and comment. The AD determines whether to propose a project to the MREFC Panel as a candidate for future construction funding, based on the project's relative scientific importance and on the Originating Organization's commitment to pre-construction planning activities and eventual facility operation and use. The AD is regularly updated by the PO on the status of the project throughout the remainder of its life cycle phases, and brings critical issues to the attention of the NSF Office of the Director (OD) and NSB as appropriate.


The AD has overall responsibility for advancing prospective projects for consideration of construction funding. In this capacity, the AD formulates strategic planning and budget development within the originating Directorate or Office. This strategic planning includes prioritizing across the research objectives of the range of disciplines served by the Directorate or Office. The AD oversees and monitors development of NSF's project planning, with the assistance of supporting staff, advisory committees, and direct interactions with the broader community affected by the facility.

 The AD oversees development of MOUs with other agencies, international partners, private foundations, and other entities and, with the approval of the NSF OD, enters into negotiations with those parties and signs these agreements on behalf of NSF when authority to do so is delegated by NSF OD.


Throughout a project's life, the AD has a primary responsibility to keep all major stakeholders in the project informed. Interested parties include policy stakeholders (the NSF, OD); funding stakeholders (OMB, Congress); and community stakeholders (scientific organizations and the relevant research community).

At each stage of project development, the AD has the responsibility for making key decisions within the originating Directorate or Office that advance a project or remove it from consideration for further development.

Specific responsibilities include, but are not limited to:

- Approving the IMP at the Directorate level;
- Ensuring that the performance plans of the relevant Division Directors reflect the requirements and expectations of the LFM and other NSF policy statements, and the necessity to provide an environment of open communication and transparency in the management of MREFC projects;
- Assuring the evaluation and endorsement of a candidate MREFC project by the Directorate or Office advisory committee prior to submission of the project to the MREFC Panel for entry into the Readiness Stage;
- Overseeing the organization of all design reviews including appointment of review panels, charges to the panels, and Directorate responses to review panel recommendations ;
- Reviewing and approving all Director's Review Board packages and organizing representation of the project before NSF internal approval bodies, i.e., DRB, MREFC Panel, and the NSB;
- Representing the originating Directorate or Office in decisions to recompetete management of an operating facility, terminate support, admit new partners, and other major decisions affecting the facility;
- Assigning members of Directorate Office staff to serve as representatives on an IPT; and
- Establishing appropriate Delegation of Authority for awards following NSB action.

### Division Director

The Division Director (DD), assisted by Divisional Staff, has primary responsibility for  overseeing planning, review, oversight and funding of Large Facilities. This responsibility includes coordination of planning; serving as the interface with relevant scientific and engineering communities; preparing all required documentation for project consideration and approval;

conducting merit review of proposals; fully funding costs of operations, maintenance and relevant programmatic activities; and overseeing the project.

Administratively, a large facility in planning, construction, or operation, is under the purview of an Originating<sup>1</sup> Organization, a Directorate, Division, or Office. The Originating Organization provides supervisory oversight and budgetary authority. Depending on the administrative structure of the Originating Organization, the cognizant PO is usually selected by the Divisional management (e.g., Section Head and DD collaborate in the selection) with concurrence of the AD. The PO's superiors directly or indirectly oversee and guide the activities of the PO.

The DD has overall responsibility for the conduct of programs in a related range of disciplines within NSF, and for the NSF interfaces between these programs and the scientific communities in these disciplines. For large facility projects, the DD:

- Evaluates and maintains, through appropriate mechanisms, the proper balance between the totality of life cycle costs for MREFC facilities and the rest of the division's activity;
- Establishes and continually examines, through appropriate mechanisms and forums, the priorities among MREFC candidate projects within the discipline (those in development, under construction, and in operation);
- Appoints a cognizant PO for each project;
- Ensures that the program officer has the requisite experience and/or training to respond to the responsibilities of the position;
- Ensures that the cognizant PO follows appropriate best practices;
- Ensures that the PO is responding appropriately to the requirements of the Large Facilities Manual and other NSF policies and practices;
- Ensures that the PO is managing interfaces with other NSF units effectively and productively;
- Ensures that the performance plan of the program officer reflects the requirements and expectations of the LFM and other NSF policy statements; and
- Facilitates the flow of information at an appropriate level of detail and timescale to keep all NSF stakeholders appropriately informed of project progress, status, and problems.



#### Grants and Agreements Officer

The Grants and Agreements Officer or Contracting Officer (G/AO) has authority, subject to statutory limitations, to award and administer CAs. The G/AO is appointed by, and is administratively part of the DGA or DACS within the BFA. The timing of this assignment is at the discretion of the DGA or DACS DD in response to a request from the PO, but should be early enough in the planning stage of a large project to allow the participation of the G/AO in the strategic planning and development of the IMP for a large project (i.e., during the Conceptual

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<sup>1</sup> This is the "lead organization" in the case where more than one Division participates in originating a project.

Design Stage when NSF begins to consider strategies for the business aspects of managing oversight of the proposed project).

As a member of the IPT, this NSF officer participates in management reviews, risk assessment and issues management. The G/AO plans and coordinates development of award instruments from early planning stages through award administration and closeout. The G/AO negotiates terms and conditions, interprets Federal and NSF policy, and reviews business proposals and budgets, significant sub-awards, MOUs, and partnership agreements. The G/AO also monitors awards for compliance with the most current NSF financial and administrative policies and procedures.

The G/AO is the primary point of contact at the NSF with the recipient institution for all business and financial matters. The G/AO represents the NSF in conducting all of the financial and administrative business related oversight of the recipient, including:

- Providing approval or authorization for all financial transactions,
- Ensuring compliance with financial and administrative award terms and conditions,
- Accepting submittals or reports from the recipient, and
- Negotiating any specific terms and conditions which define the conduct and execution of a project, such as CAs and subsequent amendments, MOUs, property leases, etc.

The G/AO is responsible for oversight of the financial and administrative terms and conditions of the assistance agreement,<sup>1</sup> just as the PO is responsible for scientific and technical oversight. Unlike the PO, he/she holds the warrant to obligate government funds. The G/AO and the PO jointly share the principal technical and financial responsibilities for the oversight and assurance of a large facility project. In this capacity, the G/AO is jointly responsible with the PO for the success of a project.

The G/AO is an integral member of the IPT for a facility project in order to expedite NSF action on business and administrative issues related to the project.

The G/AO confers with the PO and other relevant offices to ensure that the NSF's technical and administrative oversight activities are well coordinated. The G/AO and the PO collaborate on the preparation of solicitations and the proposal and award process. The G/AO has individual responsibility for developing and overseeing the implementation of financial and administrative aspects of the award process, and joint responsibility with the PO for recompetition planning and execution, and award termination and closeout.

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<sup>1</sup> An assistance agreement is a grant or cooperative agreement (CA) to an institution with fiduciary responsibility for the project or facility.

The G/AO develops the CAs that establish a business relationship between the NSF and the recipient. Consequently, the G/AO has an oversight responsibility that extends to the business practices of that recipient, in addition to the specific business operations and oversight practices of the particular project that may be based with that recipient.<sup>1</sup>

The G/AO, with the assistance of BFA resources, establishes that the financial stewardship and reporting practices of the recipient institution, as they pertain to NSF instruments, are consistent with NSF requirements, OMB circulars, or Federal Acquisition Rules.<sup>2</sup>

### Contracting Officer

The Contracting Officer (CO) has authority, subject to statutory limitations, to award and administer contracts for the construction and operations of facilities that are managed through contract rather than Cooperative Agreements (CAs). The CO is appointed by the agency Senior Procurement Executive, and is administratively part of the Division of Acquisition and Cooperative Support within BFA. The CO is solely responsible for oversight of the terms and conditions of the contractual agreement.

The CO holds the warrant and is the only individual authorized to obligate or de-obligate government funds. The CO, through their warrant, has the sole authority to award and administer the construction contract(s) used in support of Large Facility projects.

### Cost Analyst

The G/AO or CO requests assistance from a NSF Cost Analyst from the Cost Analysis and Audit Resolution (CAAR) Branch of the Division of Institution and Award Support (DIAS), located within BFA (CAAR) when cumulative or individual awards exceed certain thresholds or for Recipients with previously identified risks. The PO, G/AO or CO, and Cost Analyst all review proposed budgets to help determine if they are allowable, allocable, reasonable, and realistic for the scope of work. However, the primary purpose of the NSF Cost Analyst's budgetary review is to support the G/AO or CO to ensure that the Recipient has properly estimated and calculated costs and that they are supported and documented with sufficient rigor. The Cost Analyst provides a written recommendation to the G/AO stating whether costs are supported or unsupported. The recommendation may include advice on award terms and conditions or limitations or other concerns identified.

The Cost Analyst may also help determine if the Recipient has adequate business and accounting systems in place, assess a Recipient's financial capability and viability, validate indirect cost rates, or assist in other areas of concern as identified by the requesting G/AO.

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<sup>1</sup> Refer to *the Business Systems Review (BSR) Guide* described in Section 4.5.3.3 for discussion on this point. When NSF is not the cognizant audit agency for the recipient institution, its oversight of recipient business practices is narrowly defined.

<sup>2</sup> Refer to the *NSF -Award Monitoring and Business Assistance Program [AMBAP]* and *Business Systems Review [BSR] Guides* for more details on the criteria and processes for this assessment.

While the G/AO is the primary point of contact with the Recipient for all award and cost analysis issues, this should not inhibit direct communications between the Cost Analyst and Recipient when necessary. Cost analysis communications with the Recipient should include the Cost Analyst, G/AO, and PO to help ensure efficient resolution, close collaboration, and clear and consistent direction.

Deputy Director for Large Facility Projects, (DDLFP) – [Reserved]

Head, Large Facilities Office and BFA's Large Facilities Office

The NSF's Head, Large Facilities Office (HLFO), and the LFO supporting staff are the NSF's primary resource for all policies or processes related to the development, implementation, and oversight of MREFC projects. They are the NSF-wide resource on project management. The HLFO has the institutional authority and resources to effectively develop mandatory policies, which are approved by Senior Management, for all project stages. The HLFO works closely with the BFA and NSF Senior Management Officers, providing expert opinion on non-scientific and non-technical aspects of project planning, budgeting, implementation, and assurance to further strengthen the oversight capabilities of NSF. The HLFO also facilitates coordination and collaboration throughout NSF fosters the sharing of lessons learned and the use of best practices from prior projects.

The HLFO develops and implements processes for insuring that all facility award instruments include, at a minimum, four performance evaluation and measurement components:

1. Clear and agreed-upon goals and objectives;
2. Performance measures and, where appropriate, performance targets;
3. Periodic reporting; and
4. Evaluation and feedback to assess progress.

Prior to NSF requesting NSB approval to include a proposed project in a future budget request, the HLFO contributes to agency assurance that the project plans are construction ready, and that the construction and operations budgets are satisfactorily justified.<sup>1</sup> This assurance comes through assignment of the LFO Liaison to the IPT and membership (as assigned) on various governance bodies such as the Director's Review Board and MREFC Panel.

The HLFO prepares a periodic status report for NSF Leadership on all ongoing MREFC projects, candidate MREFC projects in planning, and other large facility projects designated by the originating Directorate or Office. Inputs to the monthly report are provided by each cognizant PO and their associated Directorate/Division. The PO provides a monthly report that

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<sup>1</sup> See "Priority Setting for Large Facility Projects" (NSB-04-96), National Science Board White Paper, May 2004, Attachment 5 to NSB Meeting Report, [https://www.nsf.gov/nsb/meetings/2004/may\\_srprt.doc](https://www.nsf.gov/nsb/meetings/2004/may_srprt.doc).



summarizes the technical and financial status of the project, pending near-term milestones, and any other issues that should be brought to the attention of the LFO. The HLFO combines all of these inputs into a single report, summarizes the key technical and financial status information, and provides an independent commentary on project management issues as necessary.

Under the direction of the NSF Senior Management, the HLFO prepares an annual *National Science Foundation Facility Plan* and presents it to the National Science Board (NSB), usually at the NSB's February meeting. The Facility Plan describes the status and plans for the portfolio of major multi-user facility projects that are either receiving or are candidates for receiving MREFC funds. The Facility Plan supplements information contained in the NSF's annual Budget Request to Congress.

#### LFO Liaison

For each large facility project, the HLFO designates an LFO Liaison to work closely with the PO and the G/AO or CO, providing expert assistance on non-scientific and non-technical aspects of project planning, budgeting, implementation, and management to further strengthen the oversight capabilities of NSF. The LFO Liaison participates in each project IPT and also advises the cognizant PO of mitigating steps when project management challenges arise. The LFO Liaison works with the PO and the G/AO, not directly with the recipient or their project staff.

The LFO Liaison also collaborates with the PO and G/AO to plan and carry out key project reviews including CDR, PDR, FDR, Operations Reviews, and other *ad hoc* project reviews in all life cycle stages as appropriate. While the PO is responsible for planning, carrying out, and assessing the full range of topics addressed in the review, LFO Liaison focuses on project management, business, and administrative issues, and assists the PO and G/AO in these areas. The LFO Liaison independently assesses and reports to the HLFO on the outcome of these reviews with respect to project management issues.

The LFO Liaison participates in site visits in coordination with the PO and originating organization, to strengthen project management and affirm aspects of NSF's oversight and assurance role. During these interactions, the PO is the single point of contact with the project for all programmatic issues, and the G/AO is the point of contact with the recipient institution for administrative issues. Any project-specific communications between the LFO Liaison and the project is coordinated through the respective PO and/or G/AO, and generally as part of the IPT process.

LFO also carries out BSRs of recipient business systems for large facilities in design, construction or operation based on a regular review cycle and other potential risks, such as building institutional capacity in advance of an MREFC award. BSRs may also be conducted at smaller scale facilities at the request of NSF Leadership or the originating organization. BSR objectives and processes are described in detail in NSF's *Business Systems Review (BSR) Guide*, described in Section 4.5.3.3.

### 2.1.6.3 Coordinating and Advisory Bodies

#### The Integrated Project Team

The Integrated Project Team (IPT) replaces the Project Advisory Team (PAT) and the BOT. The PAT and BOT were advisory in nature, whereas the IPT serves as a formal coordinating body for Large Facilities throughout the Design and Construction Stages. The IPT consists of three primary sub-groups:

1. Science and Technical Group led by Program and primary responsible for oversight. May include other Staff from the Division and/or Directorate as deemed appropriate by Program (budget, science program, etc.).
2. Award Management Group comprised of various Offices and Divisions within the BFA. This group is primary responsible for assurance. The linkage with the Science and Technical Group is with the review and monitoring of cost, scope and schedule as well as the Project Execution Plan. The linkage with the Strategic Group is with internal NSF processes and procedures related to Large Facilities.
3. Strategic Group comprised of various offices within the OD. This group's role is primarily with assurance. The linkage with the Science and Technical Group is with communication with external stakeholders.




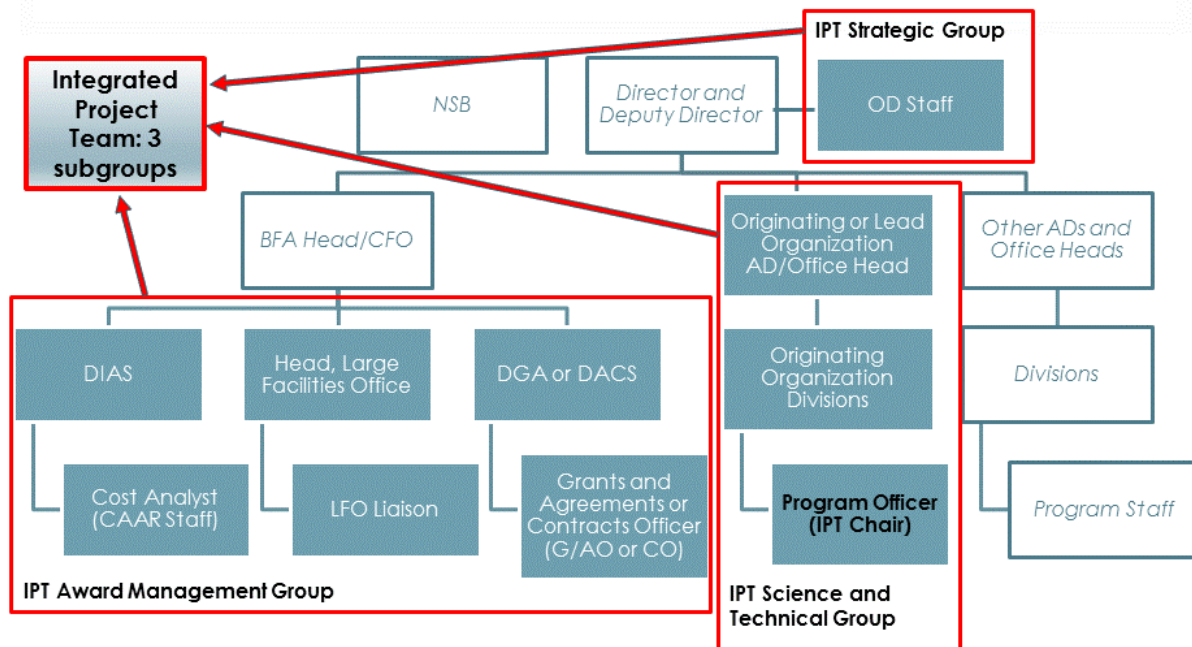
The IPT is chaired by the PO. See  Figure 2.1.6-4. Members are appointed by the ADs or Office Heads, in consultation with the PO.  Appointments shall be for the duration of the project or until new appointments are made by the  Office Heads. The PO will convene the IPT at least quarterly to discuss any project-related issues.

Figure 2.1.6-4 An Integrated Project Team (IPT), chaired by the Program Officer, is composed of three subgroups, with appointed Award Management Group members from BFA, Science and Technology Group members from the originating program offices, and Strategic Group members from the Office of the Director.



### Large Facilities Working Group

The Large Facilities Working Group (LFWG), previously known as the Large Facilities Panel, serves in an advisory capacity to the LFO and is charged with:

1. Reviewing and providing comment on draft policies, processes and procedures related to NSF Large Facilities including, but not limited to, the LFM
2. Raising, discussing and providing inputs on issues related to NSF Large Facilities
3. Review and comment on IMPS prior to the CDR

The Working Group is chaired by the Head, Large Facilities Office (HLFO). Members are appointed by the ADs, in consultation with the DDLPF, to ensure that the overall make-up provides a diverse range of perspectives from programmatic and project management to Directorate-level interests. Appointments shall be for a term of one (1) year.

A member of the LFO staff will serve as the Group's executive secretary. Ex-officio members include representatives from the OD, the Cooperative Support Branch (CSB) of the Division of Acquisition and Cooperative Support (DACs), and the Office of the General Counsel (OGC).

The HLFO will convene the Group at least quarterly to discuss issues raised by the Group or the agency, and set priorities related to review of documentation related to Large Facilities.

#### Advisory Committee of the Originating Directorate or Office

The Advisory Committee of the Originating Organization provides input to the NSF AD, or Office Head of the Originating Organization concerning priorities among and between projects and other activities sponsored by the Directorate. The NSF Director requires the endorsement of the Advisory Committee of the Originating Organization prior to requesting NSB action approving a project's inclusion (at the Director's discretion) in a future NSF budget request to Congress.

#### **2.1.6.4 Governing Bodies**

##### MREFC Panel

The MREFC Panel ensures that the overall MREFC process is followed. It reviews specific cases as presented by the Originating Organization(s) and makes recommendations to the Director. The Panel consists of the NSF Deputy Director (Chair), the Ad Program Office Heads, the Chief Financial Officer, the other Senior Management of NSF, and (in non-voting capacity) the HLFO.

The MREFC Panel assesses and prioritizes major research infrastructure projects funded through the MREFC account.<sup>1</sup> The Panel reviews specific on-going and candidate projects as presented by the Originating Organization and makes recommendations to the NSF Director. In particular, because the Panel is composed of administrators with responsibility for every area of science and engineering supported by NSF, it applies the third ranking criteria<sup>2</sup> for prioritizing MREFC projects, which pertain to overall NSF priorities:

- Which projects are in new and emerging fields that have the most potential to be transformative? Which projects have the most potential to change how research is conducted or to expand fundamental science and engineering frontiers?
- Which projects have the greatest potential for maintaining U.S. leadership in key science and engineering fields?
- Which projects produce the greatest benefits in numbers of researchers, educators and students enabled?
- Which projects most need to be undertaken in the near term? Which ones have the most current windows of opportunity, pressing needs and international or interagency commitments that should be met?
- Which projects have the greatest degree of community support?

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<sup>1</sup> For example, the MREFC Panel reviews the Large Facilities Manual and supporting information, such as this document. The Large Facilities Manual and its supporting materials are "living materials" that are periodically updated to reflect additional requirements and/or policy changes as they are reviewed by the MREFC Panel, NSF Director and the National Science Board.

<sup>2</sup> See Appendix A of the Large Facilities Manual – Ranking Criteria for Prioritizing MREFC Projects.

- Which projects will have the greatest impact on scientific advances across fields taking into account the importance of balance among fields for NSF's portfolio management in the nation's interest?

Under the guidance of the NSF Director and Deputy Director, the MREFC Panel reviews the current status, planning and implementation, challenges and concerns, and any policy issues concerning MREFC projects throughout the year. The MREFC Panel recommends advancement of projects into successive stages of development, and may provide other review and assessment as directed by the Deputy Director.

### Director's Review Board

The purpose of the Director's Review Board (DRB) is to assure the Director that all recommendations and proposed action items have undergone thorough review, assessment and discussion. The DRB reviews proposed actions for adequacy of review and documentation and for consonance with Foundation policies, procedures and strategies. The DRB also brings to the Director's attention any policy issues that have been identified.

The DRB is the Director's forum for reviewing timely recommendations to the NSB on a variety of critical NSF awards, actions, and information items, including those related to large facilities. The DRB reviews for responsiveness to questions that may be raised by the NSB.

Members of the DRB may include:

- Chairperson (NSF Deputy Director or other);
- Three ADs, serving on a rotating basis;
- Chief Financial Officer;
- Staff Advisor, OD;
- Executive Secretary, DRB; and
- Such other persons as the Director may designate (i.e., OGCs, Legislative and Public Affairs, etc.).

Joint meetings between the DRB and MREFC Panel may be scheduled as the particular situation warrants, but keeping in mind their distinct roles and responsibilities.

### NSF Director

The NSF Director has ultimate responsibility for the approval of the obligation of funds from the MREFC Account and for proposing new MREFC projects to the NSB, OMB and Congress. The Director approves all materials submitted to the NSB, OMB or Congress.

## National Science Board

The National Science Board (NSB) establishes policy, reviews and approves MREFC Account budgets, and reviews and approves specific large awards for funding, including MREFC projects.<sup>1</sup> NSB is an independent body established by Congress in 1950 to set policies for NSF. Within NSB, the Committee on Programs and Plans (CPP) oversees NSF program initiatives and major new projects and facilities. The NSB sets the priority order of projects recommended for construction.

The NSB oversees NSF and establishes NSF policies within the framework of applicable national policies set forth by the President and the Congress. In this capacity, the NSB identifies issues that are critical to NSF's future, approves NSF's strategic directions, annual budget requests, new major programs and awards, and provides guidance on the balance between initiatives, infrastructure investments and core programs.<sup>2</sup>

The NSB has established a process for reviewing and approving recommended actions and funding requests from NSF regarding large facility projects during facility development.<sup>3</sup> The NSB performs certain reviews and approvals, including an annual review of facilities, and prioritizes projects as necessary. NSB involvement at each life cycle stage includes:

- Sets policies of NSF that determine the administrative framework for overseeing all life cycle stages of NSF's large facilities;
- Is kept apprised of the status of all large facilities funded by NSF through oral and written information items, particularly projects in the development and construction stages. Approves awards for advancement through design phases if above the NSB threshold;
- Approves the release of NSF's annual Facility Plan;
- May provide guidance or expectations for pursuing further development of a project, which, if not realized, could result in terminating further NSF support; and concurs in any recommendation to terminate support;

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<sup>1</sup> The *Proposal and Award Manual (PAM)* requires the following items to be submitted to the NSB for approval: (1) Large Awards. Proposed awards where the *average annual award amount* is 1% or more of the awarding Directorate or Office's prior year current plan (including any funds transferred from other Federal agencies to be awarded through NSF funding actions); (2) Major Construction Projects. NSB approval is required when the resulting cost is expected to exceed the percentage threshold for NSB award approval; (3) Awards Involving Policy Issues or Unusual Sensitivity. NSB interests may include the establishment of new centers, institutes, or facilities that have the potential for rapid growth in funding or special budgetary initiatives.

<sup>2</sup> More about the NSB is available online at <https://www.nsf.gov/nsb/>

<sup>3</sup> See the internal NSF document "NSB MREFC Process" (graphic, NSB-/CPP – 12-18, approved May 4, 2012). See also NSB's meeting minutes with "Annual Timeline for Integration of Board MREFC Process with NSF Budget Process" (NSB-10-66, approved August 2010).

- May recommend augmentation of the budget of the Division originating a candidate new facility, to partially offset the impact on other programs resulting from the need to fully support pre-construction planning;
- Recommends inclusion of a candidate project in a future NSF Budget Request to Congress, after a PDR and NSF Director approval;
- Prioritizes the order of construction start among projects similarly approved for inclusion and not yet started;
- Authorizes the Director to obligate appropriated MREFC construction funding to the recipient;
- Reviews all recommendations for awarding funds to operate large facilities if above the NSB approval threshold; and
- Approves recompetition strategies for operations awards if above the NSB approval threshold.



## 2.2 DEVELOPMENT STAGE

### 2.2.1 Initiation of a Potential MREFC Project

As in all NSF endeavors, inquiry begins with the research communities, whose members alert NSF program staff to the most promising and exciting questions and the most important equipment needed to explore them.

NSF POs, who work closely with those communities, should be attentive to the emergence of breakthrough concepts and actively encourage discussion and planning. In addition, NSF uses National Academies' studies, community workshop reports, professional society activities, Directorate advisory committees and many other methods to identify opportunities and ensure continuous community input.

Ideas and opportunities identified by the research communities typically have a 5- to 20-year forward look and are brought to NSF in the form of a submitted proposal requesting funding for development. When there are competing concepts, it may be appropriate for NSF to issue a solicitation inviting proposals.

In most cases, program staff will take a proactive role in facilitating proposal submission, merit review, recommendations and decision. In so doing, however, a PO should maintain the position of a neutral, unbiased agent of NSF. Project advocacy should rightly come from the community, which also participates in the merit review process and whose input is a significant contributing factor in NSF's funding decisions.

During the early development stage, there should be sufficient investment by the Originating Organization (Directorate and/or Division) so that the project is reasonably well defined and/or described in preparation for the formal design stage.





## 2.2.2 Exit from Development to Design Stage

Formal start of the Design Stage for a facility project occurs once a recommendation of the MREFC Panel and approval by the NSF Director is received. This process is initiated by a request from the sponsoring Directorate and/or Division to the Director's Office once a project is determined to be ready for the Conceptual Design Phase and potential construction with MREFC funds. Generally, such a request is made when the sponsoring organization has determined that: (1) the project is a high priority for further development, (2) the project is eligible for MREFC funding (see criteria) and the MREFC funding route is preferred, and (3) the sponsoring organization is committed to begin explicit investment in more detailed design activities in the current or upcoming budget cycle using Directorate or Divisional funding (R&RA).

The MREFC Panel's recommendation will focus on providing the Director with answers to the following questions:

### Science

- Is there a compelling science case, and are the project's goals well-articulated?
- Does the project fit solidly within the NSF "mission," within the strategic plans of the NSF and that of the sponsoring Directorate or Division, and within the broader NSF facility portfolio?

### Planning

- Is the sponsor's plan for stewardship of the Conceptual Design Phase consistent with the guidelines set out in the Large Facilities Manual?
- Does the preliminary timeline for development and implementation include programmatic, NSB, budget and any necessary partnering milestones, including explicit project off ramps?
- Are potential opportunities for internal and or external partnering being considered, if not already underway?
- Are there any conflicts of interest or other major challenges regarding this project that the Director needs to be aware of?

Based on the Panel's recommendation and any further examination, the Director then approves (or disapproves) the project entering the Conceptual Design Phase as a "candidate" MREFC project. Note that no NSF commitment is implied beyond support for the development of a Conceptual Design. The MREFC Panel or Director might alternatively advise the sponsoring organization to look further into an issue or issues and then return to the Panel for further consideration.



## 2.3 DESIGN STAGE – CONCEPTUAL, PRELIMINARY, AND FINAL DESIGN PHASES

### 2.3.1 Conceptual Design Phase

#### 2.3.1.1 Introduction – Conceptual Design Phase

The goal of this first phase of the MREFC design stage is the creation of a comprehensive Conceptual Design that clearly articulates project elements that NSF will consider, including:

- Description of the research infrastructure and technical requirements needed to meet the science, including a definition and relative prioritization of the research objectives and science questions the proposed facility will address. Technical requirements must flow down from the science requirements. This description may be site-independent or site-specific depending on the nature of the project;
- System-level design, including definition of all functional requirements and major systems;
- Initial risk analysis and mitigation strategy for construction, identifying enabling technologies, high-risk or long-lead items, and research and development (R&D) needed to reduce project risk to acceptable levels;
- Potential environmental and safety impacts to be considered in site selection (see “Compliance with Environmental, Cultural and Historical Statues,” at the end of this section);
- Description of the proposed performance baseline (scope of work, budget and schedule) needed to evaluate readiness and continue planning in preparation for the Preliminary Design Phase. This includes budget and contingency estimates appropriate to a Conceptual Design<sup>1</sup> and based on the initial Risk Analysis and initial projections for the construction and commissioning schedule;
- Description of proposed Educational Outreach and Broader Societal Impact, included in the proposed scope of work, budget and schedule.

Many of these details are included as part of the PEP as described in greater detail in following sections and in Section 3.4. This Phase may take several years depending on development activities.

#### 2.3.1.2 Conceptual Design Phase Activities

During the Conceptual Design phase there may be a number of coordinated and complimentary activities taking place with the various entities involved: (1) community activities, (2) NSF staff activities, and (3) funding considerations.

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<sup>1</sup> The budget information should be provided using a Work Breakdown Structure (WBS) format, identifying the basis for estimates and including a WBS dictionary that defines the scope associated with each WBS element. Contingency estimates should include an explanation of the methodology used to calculate the estimate.



(1) *Community Activities*. Proponents of a project should provide NSF with an early concept proposal that makes a compelling case for the research that would necessitate development of a facility, and that describes, in general terms, its essential characteristics if the proposal is unsolicited. Generally speaking, large facilities projects are solicited. In that case, the proposal must respond to all NSF and programmatic requirements which generally include references to the Large Facilities Manual if it is already known as a candidate MREFC project. These initial proposals identify what is known at that point in project development, as well as what tasks remain to be accomplished in order for NSF to consider a project for eventual funding. In the near term, they also define what work should be done to develop the project to the Conceptual Design level of maturity.

An NSF PO<sup>1</sup> will be assigned to be the primary point of contact with the Principle Investigator (PI) and/or Project Manager. The NSF PO conducts a merit and technical/programmatic review of the proponents' proposal, and either recommends or declines the request for funding. If funded, the PO will work with their Directorate and/or Division to organize an Integrated Project Team to provide coordination on project oversight and assurance.

Proponents should acquaint themselves with NSF's expectations for the essential elements of a construction-ready PEP as described in Section 3. Proponents should also develop a skeletal plan that will result in the future definition of each of these elements, should NSF encourage further pre-construction planning. The plan should address, even if only in the most cursory way, each of the essential elements that should be realized in a formal construction-ready PEP.

For example, proponents may wish to develop a "straw man" PEP that contains sections labeled using each of the entries in Section 3.5, with as much supporting information provided based on the outputs from the Development Stage (if any) and/or the requirements in the solicitation. This serves to illustrate an understanding to all parties of the range and magnitude of the tasks ahead.

(2) *NSF Staff Activities*: In response to the development of an early version of a PEP, the PO, with the advice of the IPT, develops an IMP.<sup>2</sup>

This internal document specifies how NSF will conduct its oversight and assurance of the project, and provides budgetary estimates for developing, constructing and operating the

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<sup>1</sup> Administratively, the Program Officer (PO) is part of a Directorate or Office that provides supervisory oversight and the budgetary authority to fund PO actions. Actions of the PO described here and in subsequent life cycle stages of facility development implicitly recognize the authority of the individuals within this supervisory structure to appropriately guide, direct, and approve the actions of the PO. In particular, when the phrase "PO concurrence" is used in the following text, this assumes concurrence at whatever management level the AD or Office Head has required. Refer to Section 2.1.6 for a brief description of the duties of the PO, AD, and others referred to in the Large Facilities Manual.

<sup>2</sup> See the NSF cognizant PO for a discussion of the internal document "Guidelines for Development of Internal Management Plans for Large Facilities."



facility. It also identifies critical issues and risks facing the project (for example: project management issues, completing essential R&D activities, partnership agreements, termination or divestment liabilities) and lays out a strategy for financing these activities.

The PO develops the IMP with advice and assistance from the IPT. Following consultation, review and approval within the sponsoring NSF Division and/or Directorate, and upon approval of the IMP by the cognizant NSF AD, the IMP is formally reviewed by the LFWG.<sup>1</sup> The LFWG is chaired by the HLFO and includes other NSF staff members experienced in the technical and administrative aspects of large project oversight. The LFWG provides written comments on the IMP, which become part of the review record and are available to the PO, the Originating Organization, the MREFC Panel and the Director.

The IMP describes the plan for NSF management and funding of the project to CDR, proposes transitional steps to be taken if the project is admitted to the Preliminary Design Phase, and lays out NSF's plan to oversee development of the project including internal and external review. Each large project undertaken by NSF has unique characteristics. Accordingly, the IMP should be adapted to meet the specific needs of a particular project. The IMP should state the justification for pursuing alternatives to the guidelines contained in the Large Facilities Manual.

3) *Funding Considerations.* During the Conceptual Design Phase, NSF and/or other institutions and agencies begin to invest research and development funds in design development, and in efforts that promote community building and planning. Investment in fundamental research activities, community building, and initial planning activities may occur over many years, and some are recognized as having contributed to the conceptual design effort only in retrospect.<sup>2</sup>

The cumulative pre-construction investment in research, planning and development that occurs during the Conceptual Design, Preliminary Design, and Final Design phases may range from five to 25 percent of total construction cost, depending on the complexity of the project, and typically amounts to about 10 percent of the construction cost. The technology needed to construct a facility may be uncertain, unproven or immature, requiring substantial development over a period of years.

NSF may decide to fund additional planning and development efforts for particular projects depending on the outcomes of the review and whether or not the Conceptual Design Phase was funded.<sup>3</sup> Such activities might include workshops in one or more disciplines, National

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<sup>1</sup> The composition of the LFWG is given in Section 2.1.6.

<sup>2</sup> Some projects come to NSF very well developed, requiring little in the way of conceptual design phase support. They are subjected to the same rigorous scrutiny, however, as they are developed by the responsible NSF Directorates or Offices.

<sup>3</sup> Relevant program solicitations may be released to announce funding opportunities for these planning and development efforts.



Academies' studies, and research projects related to the development of new technologies.<sup>1</sup> These activities might be funded as part of the Conceptual Design Phase award, or through a separate proposal submission.

### 2.3.1.3 Conceptual Design Review (CDR)

The Conceptual Design Phase is complete when a package containing the Conceptual Design and funding request leading to a Preliminary Design is received, reviewed, negotiated and approved for funding. The funding request will generally be submitted as a supplemental request to the original award.

The package should include the refined PEP and any additional information required by Program to assess the project readiness and management to-date. Components of the PEP are given in Section 3.4.

NSF will subject the Conceptual Design package to external review, applying standard NSF criteria (Intellectual Merit and Broader Impacts) as well as other programmatic and technical criteria as given in the original solicitation and the panel charge. Projects that review well will be further evaluated by NSF to apply the second ranking criteria (agency strategic fit), in accordance with the principles stated in the joint *NSB/NSF Management Report: Setting Priorities for Large Research Projects Supported by the National Science Foundation (NSB-05-77)*. (See Appendix A for discussion of ranking criteria.)

The review panel will, as appropriate, involve external experts, consulting firms, and in-house expertise in the science, technology and business communities to scrutinize and validate the supporting planning documents. The scope of this review includes assessment of the scientific, technical and project-management aspects of the proposal.

The review is organized and conducted by the PO in consultation with the LFO Liaison. The PO has overall responsibility for organizing the review, and throughout the review process acts as the interface between the NSF and the recipient. The PO authors the review charge and organizes the review panel. The LFO Liaison strengthens the review process by specifying language for incorporation within the charge and for aspects of the review agenda pertaining to project management issues, and recommending panelists able to advise NSF in non-science related areas of the review. The PO and the LFO Liaison concur on the implementation of these recommendations. Following the review, the PO and the LFO Liaison will each independently assess the review, confer on areas of concern, share their views, and report their observations through their respective supervisory chains – the PO via the administrative structure of the sponsoring Directorate or Office and the LFO Liaison via the HLFO.

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<sup>1</sup> NSF encourages disciplinary and interdisciplinary science planning by all of the research communities that NSF supports. In particular, NSF encourages formal planning in fields in which scientists and engineers have traditionally not been organized to identify MREFC projects needed for breakthrough advances.



At this point, the conceptual design baseline is likely to have significant uncertainties. Cost estimates at CDR are generally parametric in nature. Contingency estimates, representing work scope not yet defined but nevertheless essential to the completion of the project, will be a significant fraction of the total project budget estimate. Significant unknowns and uncertainties often remain to be addressed in more advanced stages of planning and development. The conceptual design, system requirements, supporting budget estimates, risk analysis, and forecasts of interagency and international partnerships should be detailed enough for NSF program officials to decide whether the project concept warrants further funding for development.

Immediately following CDR, the initial high-level NSF Cost Analysis will be initiated and conducted jointly with key assurance members of the IPT; namely DACS, the Division of Institution and Award Support (DIAS), and the LFO. The Cost Analysis will be conducted following NSF internal Standard Operating Guidance (SOG). Guidance on refinements to the recipient's Cost Book will be provided as necessary in preparation for the Preliminary Design Phase.

#### **2.3.1.4 Exit from the Conceptual Design Phase**

Formal exit from the Conceptual Design Phase typically entails three NSF actions:

1. Successful completion of the CDR as described above,
2. Recommendation for advancement by the sponsoring Directorate, and
3. Approval for advancement to the Preliminary Design Phase by the OD

#### **Recommendation for Advancement by the Sponsoring Directorate**

The AD relies on community inputs, discipline-specific studies, advisory committee recommendations and internal NSF considerations to prioritize the opportunities represented by the project relative to competing opportunities and demands for resources. If, in the judgment of the AD, the scientific merit and relative importance of the proposed facility are sufficiently strong to justify advancement of the project into the Preliminary Design Phase, the AD will submit a memorandum to the MREFC Panel recommending the project for support, that explains how it meets the requirements for MREFC funding and how it satisfies the following criteria:

- The project's science (research) program addresses one or more science objectives in the current NSF Facility Plan, clearly demonstrating a compelling need for the project;
- The project has been reviewed by the research community and by NSF, in consultation with Directorate Advisory Committees, and has been assigned a very high priority;<sup>1</sup> and

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<sup>1</sup> Evaluation by NSF includes external merit review, using the NSF merit review criteria and the 1st ranking Criteria in Appendix A and evaluation by the MREFC Panel, using the 2nd ranking Criteria.



- The project's CDR indicates that: (1) the engineering design and construction plans are appropriately defined at the conceptual design level of project maturity and that the management plans and budget estimates for further planning and development, as well as constructing and operating the facility are reasonable; (2) the sponsoring Directorate endorses the IMP and Project Development Plan<sup>1</sup> (PDP) for further development to the Preliminary Design/Readiness Phase; (3) the technology to create the facility exists or can exist shortly, and can be used without excessive risk; (4) other risks to development are satisfactorily defined and minimized or otherwise addressed in the IMP, and (5) there are no better alternatives to the facility (i.e., with a better mix of cost and quality) that would address the science objectives in a timely manner.

Supporting documentation, including the approved IMP, relevant review evaluations, and any other supporting information should accompany this memorandum. All materials are transmitted to the MREFC Panel by the AD or Office Head of the sponsoring Directorate or Office. On the basis of this documentation, a presentation by and discussions with NSF program staff, the MREFC Panel reviews candidate projects, assessing the relative merit of the candidate scientific or engineering research facility in comparison to other projects and opportunities competing for NSF resources, and recommends to the Director those projects that should move into the Preliminary Design/Readiness Phase.<sup>2</sup>

#### Approval by the Office of the Director (OD)

The Director evaluates the MREFC Panel recommendation and, if satisfied, approves advancement to the Preliminary Design Phase. The project is then included in the Facility Plan, which is released annually.

At its May meeting, the NSB's Committee on Strategy and Budget reviews the portfolio of projects which are being considered for future funding and evaluates relative priorities that guide NSF's investment looking across the entire range of disciplines served by NSF within the constellation of other competing opportunities, existing facilities, and the balance of support for infrastructure, its utilization, and individual investigator-led research. The NSB is asked to concur with the Director's decisions by approving the annual Facility Plan.

More information about the role of the NSB in selecting and prioritizing large facility projects is available in Section 2.1.6 on Roles and Responsibilities.

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<sup>1</sup> The Project Development Plan is part of the PEP, providing the plan to develop the project design and definition to readiness for construction. See Section 3.4 for details.

<sup>2</sup> When an Originating Organization(s) proposes more than one candidate project for consideration by the Panel within a two-year time frame, it should prioritize its slate of projects and provide a rationale for its recommendations to the Director.



## 2.3.2 Preliminary Design Phase

### 2.3.2.1 Introduction – Preliminary Design Phase

The Preliminary Design/Readiness Phase further develops concepts to a level of maturity in which there are: a fully elaborated definition of the motivating research questions; a clearly defined site-specific scope; a PEP and an IMP that address major anticipated risks in the completion of design and development activities and in the undertaking of construction; and an accurate budget estimate that can be presented with high confidence to the NSF Director, NSB, the Office of Management and Budget (OMB), and Congress for consideration for inclusion in a future NSF budget request. Outcomes from the Preliminary Design Review are what establish the project baseline.

NSF has implemented a “no cost overrun policy” on MREFC-funded construction projects. This policy requires that the Total Project Cost (TPC) estimate developed at the Preliminary Design Stage has adequate contingency to cover all foreseeable risks, and that any cost increases not covered by contingency be accommodated by reductions in scope.<sup>1</sup>

To satisfy these requirements, the project is developed to a Preliminary Design<sup>2</sup> level of maturity. Results of this development are reflected in a revised and updated PEP.<sup>3</sup> Components of the updated PEP that deserve particular emphasis at this stage include:

- Update of the project development plan budget and timeline, with major anticipated risks in the completion of design and development activities;
- Refinement of the research objectives and priorities of the proposed facility;

**“Off-ramps”**

Projects may be removed from the Preliminary Design/Readiness Phase by the NSF Director due to:

- Insufficient priority over the long term;
- Failure to satisfy milestones or other criteria defined in the imp/pep;
- Eclipse by other projects;
- Collapse of major external agreements;
- Extensive estimated or actual cost overruns;
- Significant changes in schedule for development;
- Unexpected technical challenges;
- Changes in the research community that indicate eroding support for the project; or
- Any other reason that the director deems sufficiently well-founded.

Specific reasons for removing an MREFC project from this phase will be made public via the NSF Facility Plan.

<sup>1</sup> See the MREFC Section of the NSF’s 2009 Budget Request to Congress, page 3, available online.

<sup>2</sup> NSF utilizes the conventional definition of preliminary design as used by project managers – a site-specific design defining all major subsystems and their interconnections, a level of design completeness that allows final construction drawings to proceed, cost estimation based on construction bidding, and bottom-up estimates of cost and contingency. Preliminary design usually has a specific meaning within a particular industry or discipline, and NSF adopts the definition most appropriate to each particular project, as defined in the Project Development Plan part of the PEP.

<sup>3</sup> See Section 3.4 for a description of the PEP.





- Update of the description of the required infrastructure, site-specific design, and definition of interconnections of all major subsystems;
- Environmental Assessments or Environmental Impact Statement (if applicable);
- Bottom-up budget and contingency estimates for construction, presented using a Work Breakdown Structure (WBS) structure and supported by a WBS dictionary defining the scope of individual elements;
- Updated construction schedule with contingency estimate;
- Updated Educational Outreach and Broader Societal Impact plan that includes the scope of work, required budget and schedule to implement the plan, plus the budget and schedule needed to develop the plan from preliminary design to final design;
- Implementation of a Project Management Control System (PMCS) <sup>1</sup> and inclusion within the preliminary design of a resource-loaded schedule;
- Updated risk analysis, including regulatory issues affecting construction or operation, and time-dependent factors such as inflation indices, price volatility of commodities, etc. (The preliminary design budget estimate will be the basis for a future NSF budget request to Congress if the project successfully emerges from the Preliminary Design/Readiness phase. Costs and risks should be projected forward to the anticipated award date for construction funds.)
- Demonstration that key technologies are feasible and can be industrialized if required;
- Plans for management of the project during construction, including preliminary partnership arrangements and international participation, oversight of major sub-awards and subcontracts, organizational structure and management of change control;<sup>2</sup> and
- Updated estimates for future operating costs, anticipated future upgrades, or possible decommissioning costs of the facility at the end of its operating life.

### 2.3.2.2 Preliminary Design Phase Activities

During the Preliminary Design Phase, the earlier conceptual design evolves into a more mature plan with respect to the baseline and contingency definitions. The WBS elements and resource estimates benefit from additional knowledge and planning. Consequently, budget uncertainty for projected construction is much reduced relative to the earlier conceptual design. At the end of the Preliminary Design Phase, the approved total project cost (performance baseline estimate plus contingency) is capped. (Additional planning and development during the final pre-construction design stage may result in exchanges between contingency budget and

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<sup>1</sup> The PMCS involves both the software tools for development of the project databases and the processes and procedures needed to organize and manage the project; schedule and optimize project resources;; compute and track Earned Value and evaluate project risk factors; and manage the change process by evaluating the effects of alterations to the baseline on the project's planned budget and schedule.

<sup>2</sup> These plans are a preliminary, but relatively mature version of the Project Execution Plan that defines how the project will conduct itself during the construction stage – see Section 3.4.



performance baseline, but the total project cost does not change.) Typically, a significant proportion (often one-third or more) of the total pre-construction planning budget is expended achieving the preliminary baseline.

Interim reviews<sup>1</sup> during the Preliminary Design Phase will be conducted by NSF as described in the IMP. This stage culminates in a Preliminary Design Review (PDR), conducted by NSF, to ensure that all aspects of the project definition and planning are robust. The results of the PDR are reported by the MREFC Panel, followed by a recommendation to the Director for decision on forwarding to the NSB for possible inclusion in a future MREFC budget request.

### **2.3.2.3 Preliminary Design Review (PDR)**

NSF conducts a PDR, organized and led by the PO, to assess the robustness of the technical design and completeness of the budget and construction planning. Like CDR, the review is organized and conducted by the PO in consultation with the LFO Liaison. The PO has overall responsibility for organizing the review, and throughout the review process acts as the interface between the NSF and the recipient. The PO authors the review charge and organizes the review panel. The LFO Liaison strengthens the review process by specifying language for incorporation within the charge and for aspects of the review agenda pertaining to project management issues, and recommending panelists able to advise NSF in non-science related areas of the review. Following the review, the PO and the LFO Liaison will each independently assess the review, confer on areas of concern, share their views, and report their observations through their respective supervisory chains – the PO via the administrative structure of the sponsoring Directorate and the LFO Liaison via the HLFO.

The review scrutinizes the effectiveness of project management through this phase of development, as well as plans for completion of final design and eventual construction and operation. The PDR may utilize, as appropriate, external experts, consultants and outside firms to evaluate proposed plans and budgets. The PDR also examines the management structure and credentials of key staff to assure NSF that an appropriately skilled management organization is ready to complete final design activities and execute the construction phase of the project.

Once the project has satisfied any recommendations made by NSF as a result of external review, and resolved any outstanding issues, the Directorate recommends to the MREFC Panel that the project is ready for advancement to the Final Design Phase of development and is a candidate for NSB approval for inclusion in a future NSF budget request for construction funding. At any time, the MREFC Panel or the OD may request further external review.

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<sup>1</sup> Interim reviews are typically held semi-annually. Exceptions to this, dictated by the needs of a particular project, are justified in the IMP.



Following the PDR, the PO updates the IMP to describe proposed plans for budgeting and oversight, and to finalize commitments from interagency and international partners during final design. The PO directs the recipient to update the PEP to lay out the work scope, budget and schedule necessary to bring the project to Final Design.

Immediately following the PDR, the second, more detailed NSF Cost Analysis will be initiated and conducted jointly with key assurance members of the IPT; namely the Division of Acquisition and Cooperative Support (DACs), the DIAS, and the LFO. The Cost Analysis will be conducted following NSF internal SOG. Guidance to the Recipient on refinements to the Cost Book will be provided as necessary in preparation for the Final Design Phase.

The completion of project planning and development, culminating in a Final Design, should be aligned with the expected time-scale for requesting and appropriating construction funds. The NSF Budget Office is the coordinator for this critical planning activity, bringing projects forward for construction only if OMB and Congress are likely to approve the request and appropriation of funds within the time period in which the Preliminary Design plans and cost estimate remain valid.

#### **2.3.2.4 Exit from Preliminary Design Phase**

A candidate project exits from the Preliminary Design phase and enters the Final Design phase after the following have been completed:

1. A successful PDR and subsequent support from the Directorate,
2. A review and recommendation by the MREFC Panel for advancement to the Final Design Phase,
3. The NSF Director approves advancement and recommends to the NSB inclusion of the project in a future year budget request, and
4. The NSB approves inclusion in a future MREFC budget request.

#### **2.3.2.5 NSF Director's Recommendation for Advancement to Final Design**

The MREFC Panel and the Director should first be satisfied that the following conditions have been met before making a recommendation to the NSB for approval:

- The AD of the sponsoring Directorate continues to assert the high scientific merit and importance of the project and has a sound financial plan for supporting the remaining pre-construction planning activities and the future operations and use of the facility.
- The Preliminary Design has been successfully reviewed internally and by an external panel of experts in order to obtain the best possible objective advice from authorities in the fields and disciplines utilized by the project.



- The MREFC Panel concurs that the Preliminary Design is reasonable and poses an acceptable level of risk, and that anticipated costs for construction and operation are sufficiently well known.
- An appropriate Integrated Project Team (IPT) is in place and has provided assurance that the Preliminary Design Total Project Cost has been satisfactorily analyzed at a high degree of confidence to support the budget request.
- The NSF Director is satisfied that external participation in all phases of the project (other agencies, international and/or private sector entities, etc.) is well planned.
- Updated IMP and PEP have been reviewed and approved by the Large Facilities Working Group (IMP only) and the IPT.
- The MREFC Panel asserts that the proposed MREFC project, when compared to other proposed projects – whether within the same field, across related fields, or across different fields<sup>1</sup> – is among the very highest priorities for potential new facilities.

Based on its review of the information provided and discussions with Program and the sponsoring Directorate, the MREFC Panel forwards one or more projects in priority order to the Director, who makes the decision on advancement and whether or not to forward to the NSB for approval. The rationale and criteria used for the selection and prioritization of these projects is clearly articulated in the Facility Plan.

### 2.3.2.6 National Science Board Approval

The final steps for exit from the Preliminary Design Phase are review and approval by the NSB for advancement into the Final Design phase and inclusion in a request to the OMB for future year funding.

The Originating Organization is responsible for preparing the documentation needed for the NSB to review and approve a proposed MREFC project for advancement to Final Design and inclusion in a future budget request. Prior to NSB submission, the Director's Review Board (DRB)<sup>2</sup> reviews the completeness and appropriateness of the documentation supporting advancement of the project (such as prior phase reviews, committee evaluations, PEP evaluation and reviewed proposal ratings) to ensure adherence to NSF processes and policies.

As NSB considers projects for advancement to Final Design, NSF makes available to the NSB, upon request, the PEP and IMP, and the reviews from the community, the Large Facilities Working Group, the LFO, the MREFC Panel and other relevant parties. The NSB considers the following elements, applying primarily the third ranking criteria (national priorities: see Appendix B), as appropriate:

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<sup>1</sup> In making this determination, the second and third ranking criteria in Appendix A are judiciously applied.

<sup>2</sup> See Section 2 and Section 2.1.6 on Roles and Responsibilities.



- The research and science enabled by the proposed facility;
- Construction plans together with their risks and degree of readiness;
- Budget justification for construction and operation of the facility;
- The likelihood that funding will be available in the next few years; and
- The priority of the project in furthering one or several objectives in the Facility Plan.

As with all NSF proposals, the quality of the Intellectual Merit and Broader Impact activities, including educational outreach, play an important role in funding decisions. If NSB approves a project for future-year funding, it specifies its priority among all projects in the Board-approved stage.<sup>1</sup> If a project is not approved, or if an approved project's plans are no longer deemed to be clearly and fully construction-ready, NSB will remand that project to the Preliminary Design phase for further work, or recommend that the project be terminated.

#### **2.3.2.7 Inclusion in an NSF Budget Request**

Each year, the NSF Director proposes, in priority order, the NSB-approved construction-ready projects for the MREFC Account. If an MREFC "new start" is approved for inclusion in the President's Budget Request to Congress, then Congress may ask for additional information through formal hearings and/or informal briefings. Once Congress passes an appropriations act for NSF and the President signs it into law, NSF may request authority to obligate funds.

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<sup>1</sup> The Board assigns the very highest priority to projects that are under construction. There is no priority among active projects; they should all move forward at a suitable pace.



## 2.3.3 Final Design Phase

### 2.3.3.1 Introduction – Final Design Phase

The goal of the Final Design Phase is to meet the requirements necessary to advance the proposed project to the subsequent Construction Stage. Budgetary and administrative requirements for entry include NSF review and approval of the project’s preliminary design as described in the PEP, and NSB approval to include the project in a future NSF budget request.

Technical requirements include:

- Delivery of designs, specifications and work scope that can be placed for bid to industry;
- Refined bottom-up cost estimates and contingency estimates;
- Implementation of a PMCS for project technical and financial status reporting;
- Completion of recruitment of key staff and cost account managers needed to undertake construction of the project;
- Industrialization of key technologies needed for construction;
- Finalization of commitments with interagency and international partners; and
- Submission to NSF of a PEP<sup>1</sup> for construction.

Successful exit occurs after the following steps are completed:

1. Successful review of the final design baseline including any receipt of bids;
2. Joint review by the DRB/MREFC Panel;
3. NSB review and approval for the NSF Director to obligate construction funds; and
4. Final negotiation of the terms and conditions of the award instrument for the activities in conformance with the final baseline.

### 2.3.3.2 Final Design Review (FDR)

Projects should continue to receive pre-construction development funds in order to produce a Final Design, which includes the following elements:

- A final construction-ready design;
- Tools and technologies needed to construct the project;
- A project management plan describing governance of the project, configuration control plans, and plans for reporting technical and financial status, managing sub-recipients and working with interagency and international partners;
- A fully implemented PMCS, including a final version of the resource-loaded schedule and mechanisms for the project to generate reports – using the Earned Value Management

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<sup>1</sup> Refer to Section 3.4 for details of the PEP.



System (EVMS)<sup>1</sup> – on a monthly basis and use them as a management tool. Path dependencies, schedule float, and critical path are defined;

- Updated budget and contingency, including risk analysis, presented in a detailed WBS format accompanied by a WBS dictionary defining the scope of all entries;
- An updated Educational Outreach and Broader Societal Impact plan (including the scope of work, budget and schedule) that also includes the capital investment required to meet the needs of the proposed Educational Outreach and Broader Societal Impact plan;
- A significant proportion of the budget based on externally provided information such as vendor estimates or quotes, publically available supplier prices, and the like;
- All necessary partnership agreements and MOUs;
- Fit-up and installation details of major components and commissioning strategy;
- Plans for Quality Assurance and Safety;
- Updated operating cost estimates; and
- Certification that all of the pre-construction planning topics, including those listed in Section 3, are fully complete and determined to be adequate.

Due to the Federal appropriations process, there may be one or more years between the PDR and the start of construction, which is predicated on successful completion of the FDR. During this time the NSF will review the project at least annually to ensure that the total project cost and basis of estimate (BOE), acquisition strategies, schedule, and risk management plan presented at the PDR are still valid.

The PO is responsible for organizing and leading the FDR. The review is conducted according to the same standards and with the same respective roles for the PO and LFO Liaison as described previously for the CDR and PDR.

The scope of the FDR includes assessment of the technical and project-management components of the proposed project. A review panel may provide an objective view of the project and a critical evaluation of the plans and risks embodied in the proposed program as the schedule permits. In consultation with the IPT, the IMP should continue to be assessed annually by the Program Officer and updated as required to ensure that the underlying assumptions about the project remain valid. If construction funds fail to be appropriated as planned, the NSF Director may choose to mandate annual project status reviews to assure NSF of the continued viability of the project's plan and budget for construction.

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<sup>1</sup> During construction, progress should be tracked and measured using the Earned Value method (this method is required by OMB in *Planning, Budgeting, Acquisition, and Management of Capital Assets, OMB Circular No. A-11 (2014)*). A discussion of Earned Value is included section of Section 8, Guidelines for Earned Value Management.



Following the review, the PO and the LFO Liaison will each independently assess the review, confer on areas of concern, share their views, and report their observations through their respective supervisory chains.

In the event the project's construction plans are determined to be inconsistent with the pending budget request, NSF will undertake remedial action. Should remedial action be necessary following the review, the sponsoring Directorate recommends this to the OD after consultation with the IPT, internal deliberation, and if appropriate, consultation with the MREFC Panel. Remedial action may include, for example, revision of the project's budget, scope, and/or schedule, or withdrawal of NSF's request for construction funding (off ramp).

### **2.3.3.3 Exit from the Final Design Phase**

Following a successful review of the final design baseline, the Director recommends to NSB that it approve construction award(s).<sup>1</sup> NSB reviews the recommendation and authorizes the making of the award(s). Following this approval, an award instrument, generally a CA (s), between NSF and the recipient institution(s) is negotiated, and construction activities begin in conformance with the final baseline.

Following the approval to obligate funds and as part of NSF's final negotiation of the award instrument, the award-level NSF Cost Analysis will be initiated and conducted jointly with key assurance members of the IPT; namely the Division of Acquisition and Cooperative Support (DACS), DIAS, and the LFO. The analysis will encompass such things as negotiated sub-awards and sub-contracts associated with initiating construction and negotiation of final indirect cost and labor rates. The Cost Analysis will be conducted following NSF internal Standard Operating Guidance.

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<sup>1</sup> See Appendix B for documentation required for recommendations.





## 2.4 CONSTRUCTION STAGE

### 2.4.1 Construction Award Management and Oversight

After Congress appropriates funds for an MREFC project, NSF proceeds to award the cooperative agreements (CAs) or contracts for construction of the facility. The policies and procedures in the publically available *NSF Proposal and Awards Policy and Procedures Guide*, and in the internal document *NSF Proposal and Award Manual (PAM)*, apply to MREFC projects. The PAM (available to the PO) covers the internal award process from proposal generation through merit review, DRB and NSB reviews, and final award. The recipient(s) provides periodic financial and technical status reports to NSF according to the terms and conditions of the CA or contract. The project is subjected to periodic post-award reviews that may examine any or all of the following topics: technical performance, cost, schedule, and management performance. These reviews are typically held at the facility and are conducted at least annually. More frequent reviews may take be scheduled based on the project's expenditure rate or due to any other technical or management issues that arise.

NSF selects the annual review panel members who are typically external experts covering all aspects of the project, and assess technical progress, cost, schedule, and management performance. These panels report directly to NSF and provide advice on project direction and any needed changes. The reviews are organized and conducted by the PO in consultation with the LFO Liaison. The PO has overall responsibility for organizing the review, and throughout the review process acts as the interface between the NSF and the recipient. The PO authors the review charge and organizes the review panel. The LFO Liaison strengthens the review process by specifying language for incorporation within the charge and for aspects of the review agenda pertaining to project management issues, and recommending panelists able to advise NSF in non-science related areas of the review. Following the review, the PO and the LFO Liaison will each independently assess the review, confer on areas of concern, share their views, and report their observations through their respective supervisors. (Note: Many projects invite panels of experts to review and advise on project plans and progress. Such panels report to the Project Director, and are not a substitute for NSF-organized external oversight reviews.)

Generally, when cost and/or schedule performance begin to deviate from plans, change control is exercised by the project through a Change Control Board (CCB)<sup>1</sup> action, resulting in modifications to the project's budget or schedule contingency. It is also normal practice for a project to update its budget and schedule Estimates to Complete (ETC), which also may result in baseline changes.

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<sup>1</sup> A CCB comprises the senior project managers responsible for defining the project's resource requirements and allocating or expending those resources. It typically consists of the Project Director, Project Manager, Business Manager, cost account managers of principal work breakdown structure elements, chief scientist and engineer, and systems engineer. It may include other project staff whose authority pertains to the range of activities considered by the Board.



Whenever a project approves a change control action that results in allocating or returning contingency to the pool of contingency funds, the Performance Measurement Baseline (PMB) budget may also change.

Similar change-control actions affect the PMB schedule. They revise the baseline project schedule and the available schedule contingency or “float” time – that is, the difference between milestones on the schedule’s critical path and the expected completion dates for activities that lead to the accomplishment of those milestones.

Modifications to the performance baseline that are within the defined scope and do not change the project end date or total project cost are referred to as “re-planning”. Re-planning may be due to adjustments or re-organization of the project plan and/or may signify that contingency funds are being expended in an expected manner. If the allocations of budget and schedule contingency are below the budget or schedule thresholds identified in the CA between NSF and Recipient, the change requests are approved unilaterally by the project. NSF approval is required when the CCB recommends re-planning change actions that exceed the budget or schedule thresholds identified in the CA between NSF and Recipient. Each will have a different threshold for approval. Approval levels for scope changes are generally outlined in the CA.

It is essential for the project management to respect the project baseline rigorously, maintaining each adjusted baseline in the project’s database along with the attributed CCB actions. This allows the project and NSF to systematically track the evolution of the baseline from its initial release through all subsequent changes.

“Re-baselining” occurs when the changes involve:

1. Increases in the NSB-approved TPC,
2. An extension beyond the approved end date, and/or
3. Major changes in scope.

When the proposed changes reach the re-baselining level, the approval process involves NSF and may involve the NSB. Changes in end date follow NSF’s No-Cost Extension (NCE) policies. An increase in TPC exceeding 20 percent of the NSB-approved baseline cost or \$10 million (whichever is smaller) must be reviewed and approved by the NSB following a recommendation by the MREFC Panel and the Director.<sup>1</sup> Prior to requesting approval to re-baseline, a new external baseline review should be conducted to examine the nature of the problems encountered, and to determine whether de-scoping should be exercised per the approved scope contingency plan in the PEP or, if not, whether the problems can be solved by use of budget contingency or other means. Upon review and approval, cost and schedule are stabilized, and the contingency adjusted to an appropriate level.

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<sup>1</sup> Open Session Approved Minutes, 418th Meeting of the National Science Board, Resolution NSB-11-1, Adopted February 16, 2011.



Whenever significant cost increases are foreseen, it is most important that the LFO Liaison is consulted early, concurs with the PO on the details of the Originating Organization's plan, and advises and concurs on details of the external re-baselining review. Similarly, when there are indications that the project contingency will fall below reasonable standards,<sup>1</sup> the PO should discuss plans for dealing with the variance with the Project Director. This information should be clearly noted in the monthly status report that goes to the HLFO. The LFO is a resource for helping to deal with such problems and for helping to identify steps that can be taken to restore adequate contingency.

In addition to supplying regular status reports required in the terms and conditions of the CA, it is essential that project staff inform the PO and/or the G/AO in a timely manner of major issues or significant changes in project status, such as a potential re-baselining, problems with partnerships, or surprising research and development results. NSF management, the MREFC Panel and the NSB should in turn be informed of such developments by the PO. The primary mechanism for coordinating both the transfer of information and the coordination of any required actions by NSF is through the NSF Integrated Project Team (IPT).

On rare occasions, MREFC projects under construction may encounter unforeseen budget or programmatic challenges that are of a substantial enough level to be considered grounds for termination or significant modification to the original project goals. NSF will provide the NSB with appropriate information and a recommendation via the MREFC Panel and the Director. The NSB will decide whether termination or significant modification to the original project goals is warranted.<sup>2</sup>

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<sup>1</sup> See details in Section 4.5, Requirements for Performance Oversight, Reviews and Reporting.

<sup>2</sup> Joint NSB-NSF Management Report: Setting Priorities for Large Facility Projects Supported by the National Science Foundation ([NSB-05-77](#)); September 2005.



## 2.4.2 Commissioning Plan

The transition from construction to operations is rarely abrupt. Many facility projects require a testing and commissioning phase, funded through the MREFC Account. The scope of these activities is defined in the PEP and included in the initial MREFC budget request as part of the performance baseline. The PEP is included by reference in NSF's CA or contract with the Recipient institution, documenting the mutual understanding of the work scope funded by MREFC funds. In some cases, particularly with distributed facility projects, early operations funding begins to increase as aspects of a facility come on line, although full construction funding may not have concluded. Although these phases overlap in time, they must be budgeted and managed separately due to segregation of funds requirements.

NSF will ask for a commissioning plan at least one year prior to initial commissioning activities. The scope of commissioning work is to undertake initial operation of the facility and bring it up to the design level of operation in accordance with the IMP. The IMP is updated prior to the operations stage to define reviews, decision points, strategies for renewal or recompetition, plan for advanced R&D or technology refresh, upgrades, etc.

The content of the commissioning plan will be adapted to the specific nature of the facility, but at a minimum it should include:

- A detailed bottom-up cost estimate for operations.
- A detailed management plan for operation of the facility, including the roles of key staff and plans for advisory committees.
- Education and outreach plans and their associated costs, including the scope to work, associated budget and schedule.
- The costs of an in-house research program, if applicable.
- A detailed set of acceptance criteria that establish that the facility is finished and ready to commence routine operations.
- A listing of which environmental safety and health (ES&H) standards will be followed by the recipient and a description of how adherence to those standards will be verified. A policy for reporting to the NSF accidents or environmental releases should also be given. This may be given as a reference to an existing ES&H plan for the project.
- A listing of which cyber-security standards will be followed by the recipient and a description of how adherence to those standards will be verified. A policy for reporting to NSF of any breaches of cyber-security should also be given. This may be given as a reference to an existing cyber-security plan for the project.
- A discussion of how major maintenance issues (such as budgeting for periodic replacement of long-lived capital assets whose useful life extends beyond the duration of the CA) will be handled
- A discussion and a preliminary cost estimate for decommissioning the facility.



- A set of performance goals and metrics sufficient to establish that the facility is operating successfully. These will be updated in each year's Annual Work Plan (see below).

Once the commissioning plan is complete, an Operations Readiness Review (ORR) will be held to examine and comment on the plan. This can be considered as one of the required annual reviews. The review is organized and conducted by the PO in consultation with the LFO Liaison similarly to other reviews described above.



## 2.4.3 Construction Award Close-out

### 2.4.3.1 Project Close-out Process

*(Intentionally left blank – this section to be written)*

### 2.4.3.2 Request for No-Cost Extension

Under NSF policy, the Program Officer (PO) has the authority to approve the first No-Cost Extension (NCE). However, the PO will generally work closely with members of the NSF Integrated Project Team (ITP) to ensure the request meets the requirements for large facility projects as described herein. Any subsequent NCE's must be approved by the Grants and Agreements Officer (G/AO) who is also an integral member of the IPT. As the project nears completion, close-out activities will become a discussion item for the IPT.

Only tasks within the approved project scope may be included in the NCE. As stated in Section 4.2.5, Budget Contingency Planning for the Construction Stage, any unused funds (either contingency or positive cost variance) must be returned to the agency.

Many intended tasks will already be clearly contained within the approved project scope and can be directly associated with a particular WBS element. Tasks which cannot be found to fall within an approved WBS element will be allowed only after they have been reviewed and approved as new scope through the change and/or configuration control processes contained in the Project Execution Plan. Depending on the magnitude, this may require very high level approvals within the agency. It is highly recommended that the discussion of scope, and the ability to assign to an approved WBS element, takes place prior to the NCE request.

Good practice suggests that all other project tasks, i.e. those not included in the NCE request, should be closed out by the original project end date. This means that all risks and liens for those tasks are also closed out, and that no funds are carried forward for remediation of problems that arise in the future. The close-out of completed tasks also allows for a more precise calculation of remaining cost variance and/or contingency which facilitates good decisions making on the part of the Project and NSF. If any tasks slated for close-out are not completed by the original end date, then NSF must be notified that the tasks will be carried over into the extension period as part of the NCE request.

It is anticipated that the list of tasks to be performed during the extension may change with time as final negotiations and decisions are made and actual costs are realized. Some tasks may be held back and subsequently removed as scope contingency options when available resources or priorities change. Other tasks within the approved scope of the project may be added (for example, as a result of a reprioritization exercise following final acceptance reviews or because they are delayed past their close-out dates). Tasks may be added or removed from the list with adequate justification and with the written approval of NSF. All final close-out documentation will be saved to the official record by the PO.



Written requests for NCEs should be submitted to the PO and should include the information in the following list:

1. List of the tasks to be completed during the extension period and justification that they are within project scope.
  - a. Link the tasks to the associated WBS element and give a short justification of how they fit within existing project scope. Risk mitigation effort should be associated with an identified and documented risk element.
  - b. Provide the total burdened estimated cost for each task. Detailed cost estimates do not have to be provided, but should be documented and available if requested.
  - c. The justification for each task will typically fall into one or more of several categories: (1) open purchase orders and invoices associated with items whose delivery is delayed beyond the current period of performance, for example due to subcontractor performance, (2) rework of existing tasks within the approved scope, for example due to workmanship or performance issues, (3) existing tasks within the approved scope that have not yet been completed, and (4) risk mitigation to address in-scope performance issues. An example of a task list with justifications is given in the sample Table 2.4.3-1 on the following page.
2. Indication of which tasks provide scope contingency options<sup>1</sup> if resources (time, staff, budget, etc.) become limited. Briefly indicate why each task is a candidate for de-scoping and give any deadlines for exercising the de-scope option. NSF must be notified when and if the scope contingency option is taken and tasks are removed from scope, including the impact on project deliverables or performance, if relevant.
3. Description of what funds will be used to cover the proposed tasks – remaining contingency, unexpended baseline budget, positive Cost Variance, partner funds, etc. Give the project performance baseline ETC with all tasks included and compare to remaining contingency and TPC. State a confidence level for completing all work within budget, including the use of any scope contingency options. Indicate if any tasks involve already obligated funds and give the amount of those funds.
4. Summary schedule or schedule highlights of the extended tasks, including significant milestones and the new end date. Provide (BOE) for the new end date, including schedule contingency, and give a confidence level for completing by that date.

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<sup>1</sup> Scope contingency is defined in Section 5.2.3.

2.4.3 Construction Award Close-out

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)



Table 2.4.3-1 Sample of a No-Cost Extension Tasks Table

Task #	Task Description	Burdened Subtotals (\$K)	WBS	Justification
1	Modifications to electronics control boards	40.5	3.7 Environmental Systems ADCs	Rework of existing in-scope task; technology not performing as intended
2	Delivery of 3 cryo-pumps	114.9	4.2 Vacuum Systems	Existing in-scope task; Late delivery on open contract with obligated funds
3	General purpose utility carts	25.8	2.4.5 Monitoring and Maintenance Equipment	Existing in-scope task; Late delivery; 1 unit added based on revised needs estimate
4	Vendor contract to test relationship of performance versus temperature on sample size widgets	32.4	5.2.3 Sys Eng: Integrated testing	Risk mitigation added to address in-scope performance issues for integrated systems. Risk Register ID #14-31.
5	Labor extensions for project management and business offices	184.2	1.2 Project Controls	Existing in-scope task; revised effort, salary, and overhead estimates, including escalation
<b>TOTAL (\$K)</b>		<b>\$397.8</b>		





## 2.5 OPERATIONS STAGE

### 2.5.1 Operations Management and Oversight

Although NSF does not directly manage the operations of the facilities it supports (with the exception of Antarctic activities), the agency engages in oversight and assurance of facility awards during each stage of the facility's life cycle. In oversight, NSF employs a team-oriented approach in which scientific and engineering staff work closely with business operations staff. Additional detail on facility operations may be found in Section 3.5 of this manual<sup>1</sup> and among the special topics found in Section 4, Key Management Principles and Requirements for Large Facilities.

The recipient responsible for construction or acquisition of a new facility is normally the entity that submits a proposal for operation of the facility during the construction stage. However, the Operations Stage may be managed by a different entity, depending on circumstances stated in the IMP.

The operations proposal is merit-reviewed following NSF's guidelines. Operations activities are funded through NSF's R&RA and/or Education and Human Resources (EHR) account. Testing and acceptance, user training and engineering studies occur as the facility transitions to full operation. Operations include the day-to-day work required to: support and conduct research and education activities; ensure that the facility is operating efficiently and cost-effectively; and provide small- and intermediate-scale technical enhancements when needed to maintain state-of-the-art research capabilities.

Given the long operations stage of most large facilities, upgrades and refurbishment of equipment may be required over time in order to stay at the research frontier. In the case of an observatory, this may include new instruments and cameras. For a sensor network, it may include the deployment of additional sensors or renewal of cyber-infrastructure. At an accelerator facility, the upgrades may take the form of higher energy or luminosity or new detectors. In general, these upgrades and renewals will be funded from R&RA funds, either from a portion of the operating funds designed for such purposes or from separate equipment and instrumentation programs. Funding for more significant upgrades (if they exceed the MREFC threshold) may come from the MREFC account. In that case, the approval process is the same as that for a new MREFC project.

Three key aspects of NSF oversight and assurance of large facility operations, *which (if applicable) are referenced in and required by the CA*, are: (1) Annual Work Plans, (2) Annual Reports, and (3) Annual Operations Reviews. NSF or the cognizant agency may also conduct periodic audits.

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<sup>1</sup> These sections are in preparation.



### Annual Work Plan

The Annual Work Plan describes what the facility expects to accomplish in the coming fiscal year. The Annual Work Plan should include a series of high level performance goals (clear and agreed upon goals and objectives, performance measures and, where appropriate, performance targets) for the coming year. The goals should include both scientific and operations issues (i.e., installation of new equipment or commissioning of new buildings, maintenance, Education and Oversight Training [EOT] and ES&H). The goals will naturally vary from facility to facility and should be agreed upon between the recipient and the NSF Program Officer (PO). Goals in the Annual Work Plan should meet the standard of being specific, realistic, measurable and time-based. The LFO Liaison will review the goals to ensure they meet this standard.

### Annual Report

The Annual Report describes in detail the activities of the facility in the previous twelve months. This report is required to review progress on that year's performance goals (as described in the Annual Work Plan). Due to changing research priorities or external forces not all performance goals may be met each year but an explanation of progress on each goal is required. The PO reviews and approves the Annual Report.

### Annual Operations Reviews

In most cases, NSF will annually conduct Operations Reviews of its major multi-user research facilities, utilizing an external panel of experts spanning the principal range of functions necessary to sustain facility operations, or carry out or participate in an alternate activity that accomplishes an equivalent purpose. Exceptions to the annual review (or its alternate) occur when NSF partners with other entities to fund operations. In those instances, the MOU between the partners defines the process for monitoring: (1) identification and accomplishment of programmatic goals; (2) fiscal accountability; (3) stewardship of NSF assets; and (4) compliance with laws and regulations. These reviews (or their alternates) should determine the extent to which the facility is meeting the goals of its Annual Plan, discuss any upcoming challenges for operations, and highlight best practices that could be applied to other large NSF facilities. Metrics and performance goals or targets should include objectives related to educational outreach and broader societal impacts, in addition to research goals of the operating facility. Whenever possible, the review should be conducted at the facility itself by an external panel comprised of experts in the operations of similar large scientific facilities and representatives of the user community served by the facility. The panel should produce a formal written report. Results of the review are used by NSF to provide feedback to the facility operator in the formulation of goals or targets for the coming year. (The Operations Review is



not meant to compete with the Business Systems Review<sup>1</sup> (BSR) which looks at business processes.)

- The review is organized and conducted by the PO in consultation with the LFO Liaison. The PO has overall responsibility for organizing the review (or representing NSF's interests in the case of a partnership), and for acting as the interface between the NSF and the project's proponents throughout the review process. The LFO Liaison advises the PO during the planning and execution of the review to ensure that there is consistent practice across NSF in the formulation of performance goals, that goals and objectives are clearly stated and represent quantifiable performance measures or targets where practical, are periodically reported, and that an evaluation and feedback mechanism is implemented as an essential part of an ongoing program of continual performance enhancement.
- Following the review, the PO and the LFO Liaison will each independently assess the review, share their views, confer on areas of concern, and report their observations through their respective supervisory chains.
- In most cases, observers of the review shall include the Program Officer, the Grants and Agreements Officer, the LFO Liaison and other staff from the Large Facilities Office, and possibly other NSF staff from the Integrated Project Team. Budget considerations, logistical constraints, or alternate processes for review agreed to by NSF and its funding partners may result in exceptions to the number and range of NSF staff participating.

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<sup>1</sup> See Section 4.5.3.3 for discussion of the BSR process as well as the NSF BSR Guide. To avoid duplication of effort, the scope of the BSR is adapted to utilize relevant information stemming from other reviews and audits.



## 2.5.2 Renewal/Recompetition

Most NSF facilities will be operated by a managing organization. Because facility lifetimes are long (some current facilities have operated in excess of 40 years), recompetition of management is appropriate at intervals. Whenever practical, NSF seeks to make competitive renewal awards for operation of large facilities after external merit review. See Section 3.5.2 for procedures for Renewal and Recompetition. The NSB issued a statement requiring full and open recompetition of awards for operation of major facilities upon their completion and after an appropriate time period to bring the facility to sustainable operations.<sup>1</sup> The goal of competition is to stimulate new approaches toward more effective management that may offset any potential for increased costs, and ideally may achieve some cost savings. Important considerations beyond performance of current management include how recompetition might affect the scientific productivity of the facility and the burden it would place on the community. Even in cases where the existing management has been explicitly and rigorously reviewed and found to be effective, the benefits of competition may outweigh any short-term disadvantages of recompetition. The determination of whether to compete the effort is based on the expert advice of NSF staff and, where applicable, external sources using the facility, and should be presented to the NSB for approval.

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<sup>1</sup> See NSB Statement on Competition, Recompetition, and Renewal of NSF Awards, [NSB 08-16](https://www.nsf.gov/nsb/publications/2008/nsb0816_statement.pdf), [https://www.nsf.gov/nsb/publications/2008/nsb0816\\_statement.pdf](https://www.nsf.gov/nsb/publications/2008/nsb0816_statement.pdf).



## 2.6 DIVESTMENT STAGE

To remain at the research frontier and support new facilities, NSF will consider retiring existing facilities when the science they enable is of a lower strategic priority than science that could be enabled by alternate use of the funds. Such decisions will be difficult to make, in part because of the number of stakeholders and interested parties, and will require extensive community consultation and input, which may come from “blue ribbon” panels, National Academies committees and professional societies. In some cases in which a facility can continue to be productive, it may be possible to transfer ownership to another agency, a university or a consortium of universities. It is the responsibility of the Directorates and Divisions to periodically review their facilities portfolio and to consider which facilities may have reached an appropriate end of NSF support.

When the decision is made to close or transfer ownership of a facility, a transition plan will be developed, which includes all divestment costs and liabilities, including disposal of equipment, environmental and site remediation or restoration, pension and health care responsibilities, etc.



## 2.7 APPLICATION OF MREFC PROCESS TO NON-MREFC FUNDED PROJECTS

### 2.7.1 Flexible Requirements for Non-MREFC Facility Projects

The project management processes and principles described in the preceding section are generally applicable to all large facility projects, irrespective of the source of construction funding. However, considerable flexibility is allowed in the management approach to adapt the process to the requirements and scope of any particular project.

This section provides guidelines for planning and managing new facility projects that are *not* constructed with funding from MREFC accounts.<sup>1</sup> This is usually the case when the project does not qualify for MREFC funding<sup>2</sup> and/or the sponsoring Directorate or Office chooses not to apply for MREFC funding.

This section applies to non-MREFC facility projects that take a multi-stage design approach similar to that described in Section 2, and that are large enough to require multiple levels of approval within NSF beyond the level of the Originating Organization. (It does not pertain to awards for centers, or other types of awards unrelated to facilities which require approval merely because of their large size.) The total cost of a non-MREFC facility project generally ranges from millions to tens of millions of dollars or more. The majority of these projects will require NSB award approval.<sup>3</sup>

Non-MREFC projects are not subject to the same requirements for Conceptual Design, Preliminary Design, and Final Design reviews outlined in Section 2. Nor are they required to use the three sets of ranking criteria in Appendix A or subject to review by the MREFC Panel. However, the elements described in Section 2 make a useful toolkit for a Directorate or Office to use in planning and managing all large facilities that proceed through these design stages. How the elements might apply is the focus of this section.

As in the case of MREFC projects, NSF is committed to the principle that flexibility does not preclude rigor. For projects that do not require a multi-stage design approach, the PO should explain the variation and define the management approach taken in the project's IMP.

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<sup>1</sup> R&RA (and possibly EHR) appropriations accounts are used to support the construction of non-MREFC large facilities. In addition, non-construction activities of MREFC-funded construction projects, including research, design, development, and operations costs, are normally funded through the R&RA and/or EHR appropriations accounts.

<sup>2</sup> See the previous Section 2.1.2 for eligibility requirements for MREFC funding.

<sup>3</sup> See the description of NSB roles and responsibilities in Section 2.1.6.



**Selection Criteria:** Both MREFC and non-MREFC facility projects should depend on a proposal-driven process with external and internal merit review. Other factors to consider might include:

- Exceptional opportunity to enable frontier science and engineering (S&E) research and education;
- Urgent contemporary research and education need;
- High priority within the relevant S&E communities;
- Accessibility to an appropriately broad user community;
- Partnerships well defined;
- Technical feasibility and risks thoroughly addressed; and
- A well-developed PEP.

**PO Oversight:** At the earliest practical point, each large-facility project is assigned an NSF PO<sup>1</sup> with primary responsibility for award management and project oversight. As noted in Section 2, NSF restricts the choice of POs overseeing MREFC-funded activities to permanent NSF employees<sup>2</sup> to assure continuity of oversight. POs overseeing non-MREFC funded projects are exempt from this statutory requirement. However, the principle should be taken into consideration for non-MREFC projects by matching the term of assignment of the cognizant NSF oversight staff to the duration of the late-stage planning and construction activity. Alternatively, assigning a team of POs with a mix of permanent and rotating staff may help ensure continuity.

**Large Facilities Working Group:** The Large Facilities Working Group<sup>3</sup> is available to review and provide comments on the IMP for a large facility project, independent of the source of construction funds.

**Interaction with Head, Large Facility Office:** The HLFO is available in an advisory capacity to NSF staff working on non-MREFC funded projects as a resource for best practices for project management and business oversight. But the HLFO's involvement is not mandatory unless so directed by the Director, the Deputy Director or the AD/ Office Head of the Originating Organization(s). The HLFO may be asked by the Director or Deputy Director to review DRB and NSB packages for non-MREFC facilities.

**Integrated Project Teams:** At the earliest opportunity, the originating Directorate or Office should coordinate with the PO to organize an IPT<sup>4</sup> to provide advice and help coordinate NSF's oversight and assurance.

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<sup>1</sup> Also referred to within NSF as Program Director or Program Manager.

<sup>2</sup> See Public Law 107-368, Section 14(c).

<sup>3</sup> The functions of the Large Facilities Working Group are described in "Roles and Responsibilities" in Section 2.1.6.

<sup>4</sup> Ibid.



**NSB Budget Approval:** Unlike MREFC projects, non-MREFC projects do not require formal NSB approval as part of the budget process in order to be included in future NSF budget requests. Rather, the non-MREFC projects are considered by NSB in the course of reviewing the entire NSF budget request. However, both MREFC projects and non-MREFC facility projects above the NSB approval threshold require both DRB and NSB approval before an award is made.

**NSF Office of the Director:** Providing information early in the planning process to the Office of the Director is advisable. The Director may wish to share information items periodically with the NSB.





## 2.7.2 Pre-construction Planning and Development of Non-MREFC Projects

As is the case with most MREFC projects, pre-construction planning and development of non-MREFC facility projects may progress through sequential stages of increasing investment, planning, assessment and oversight. At each stage, the technical evolution of the project and NSF's preparatory planning and budgeting are coordinated and synchronized to achieve an orderly evaluation process that results in eventual construction funding for the most meritorious projects.

The sponsoring Directorate decides upon the appropriate degree of rigor and formality in pre-construction planning necessary to ensure that the project is well defined and appropriately budgeted. These decisions are based upon the size and complexity of the proposed project, and are documented and justified in the project's IMP.

As with MREFC projects, most non-MREFC funded projects begin when NSF responds to a community initiative (exceptions may include infrastructure replacement and/or addition). Such initiatives may take different forms – for example, a report from a community planning activity or a formal proposal. The sponsoring Directorate or Office's decisions and strategies for project review, funding and oversight are delineated in the IMP. The IMP specifies how NSF will supervise management of a project, and provides budgetary estimates for developing, constructing and operating the facility. It also identifies divestment liabilities and lays out a strategy for financing these activities as well as the concomitant NSF oversight requirements.

The PO in the sponsoring Directorate or Office prepares the IMP in the early stages of the project's conceptualization. It is reviewed and approved by the AD/Office Head of the Originating Organization(s). The Originating Organization(s) may design and adopt oversight processes and procedures that are flexibly tailored to the needs of the particular project.

Very large or complex projects will require more formalized pre-construction planning and frequent status reporting. Smaller projects will have appropriate requirements.<sup>1</sup> The project management approach used must be scaled to the needs of a particular project. For example, project management controls used to manage project resources, document project activity and plan alternate courses of action to mitigate risk will be much more sophisticated and costly for a large-scale project than for a small one.

Budgets, schedules, risk assessments, and project management plans will be similarly scaled. The IMP defines NSF's expectations for the appropriate level of scaling that optimally matches oversight requirements to project needs. NSF conveys these expectations to the project proponents for incorporation in their PEP as appropriate.

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<sup>1</sup> Refer to Section 3.3 "Guidelines for Development of Internal Management Plans for Large Facilities" (an internal NSF document) for a description of the intent and content.



### 3 LIFE CYCLE MANAGEMENT PLANS FOR LARGE FACILITIES

#### 3.1 INTRODUCTION TO MANAGEMENT PLANS

Section 3 contains descriptions and guidelines for creating the plans that NSF and Recipients use in the management and oversight of Large Facilities. They include two plans produced by NSF and three plans that are the product of the facility designers, constructors, and operators.

The NSF Facility Plan, as described in Section 3.2, is a yearly exposition of the status and intentions for the NSF portfolio of existing and candidate MREFC facility projects, in the context of the current climate of science opportunities and priorities. It also lays out the objectives and compelling needs for major facilities, given the frontier research opportunities of the time. The NSF Facility Plan informs decision-making in the Executive Branch and Congress, as well as serving as a vehicle for communication with scientific communities. It is available to the public on the NSF web site.

Section 3.3 describes and points to an internal NSF document with guidelines on creating an Internal Management Plan (IMP), the NSF document that captures how NSF will oversee awards for large facilities throughout the life cycle, from candidate MREFC facility projects in design, through construction and operation, and ultimately through divestment. An IMP also provides financial strategies for funding given the estimated budgetary estimates. Both the guidelines and the created IMPs are internal NSF documents.

The Project Execution Plan (PEP) is produced by the Recipient to detail how management and execution of design and construction of a major facility will be accomplished. The PEP advances in maturity from a rudimentary form required at the Conceptual Design Review to a fully mature document ready to support construction at the Final Design Review. Section 3.4 provides a list of the required components of a PEP and guidelines for creating those components.

Operations Plans are addressed in Section 3.5, including timelines for submission and review of operations proposals from prospective Recipients and guidelines for content of proposals and plans. Operation Plans cover all aspects of operations, maintenance, upgrades, and research and education programs. Guidelines are also given for the procedures for renewal or recompetition of an award for an operating facility.

Guidelines for plans to terminate operations under NSF awards are in development, with Section 3.6 provided as a placeholder. Divestment, termination of NSF funding and oversight of a facility, may be accomplished through transfer to another agency or funding source or through decommissioning and deconstruction.



### 3.2 NSF FACILITY PLAN

The NSF *Facility Plan*, which is updated annually and publicly available, serves as valuable planning tool both within and outside NSF. It also provides a comprehensive exposition of needs and plans to inform decision-making in the Executive Branch and Congress, and serves as an important vehicle for communicating with research communities.

The first section of the Facility Plan provides an extensive discussion of the frontier research objectives and opportunities that provide the context and compelling need for major facilities. The contents of this section derive from workshops, advisory committees, National Research Council (NRC) reports, expertise of visiting and permanent scientific staff, and unsolicited proposals from the community. The Facility Plan's second section provides annual updates on the status and progress of each Major Research Equipment and Facilities Construction (MREFC) project and candidate project. It also maps these projects against the objectives and opportunities contained in the first section. In particular, this section addresses:

- **Preliminary Design/Readiness Stage Projects** – Projects in various stages of readiness, including those that will be ready to go the National Science Board (NSB) for approval within approximately the next year, and those that the MREFC panel has recommended for advancement to the Preliminary Design Phase.
- **NSB Approved Projects** – Projects that the NSB has approved for funding in a future budget request.
- **Possible New Starts** – Facilities for which initial MREFC funding is requested in NSF's annual budget request.
- **Ongoing MREFC Projects** – Facilities already in operation or under construction.

In addition to providing regular status reports, the Facility Plan reflects the Administration's priorities for new start projects, NSB priorities for NSB-approved projects, and the NSF Director's priorities for projects in the Preliminary Design Phase. Ongoing MREFC projects are always given the highest budget priority.

Every year new science and engineering opportunities arise and new priorities assert themselves. As a result, no roster or ranking of potential MREFC projects is ever final. Responsible stewardship of public funds demands that all candidate efforts be evaluated and reevaluated constantly in the context of the latest, most pressing research goals and the most profoundly important unanswered questions.

It is the responsibility of the Head, Large Facility Office (HLFO) to develop and maintain the Facility Plan. The plan is approved by the Director and submitted to the NSB in March of each year.



### **3.3 INTERNAL MANAGEMENT PLANS FOR THE LARGE FACILITY LIFE CYCLE**

Please contact the cognizant NSF program officer for details, which are given in the internal NSF document *Guidelines for Development of Internal Management Plans for Large Facilities*.

This document provides guidance to the PO on topics to be included in an Internal Management Plan (IMP), grouped by life-cycle stage. The IMP is the primary document that describes how NSF will oversee development, construction, operation and eventually divestment and termination of support for a major facility. The requirement to develop an IMP is described in Section 2.3.1 for MREFC and in Section 2.7 for non-MREFC projects. Two primary purposes are served by development of an IMP:

- It defines in specific detail how NSF will conduct oversight of a project; and
- It provides budgetary estimates for developing, constructing and operating the facility, identifies divestment liabilities, and lays out a strategy for financing these activities as well as the concomitant NSF oversight requirements.



### 3.4 PROJECT EXECUTION PLAN

#### 3.4.1 Components of a Construction-ready Project Execution Plan

Essential components of a construction-ready Project Execution Plan (PEP), common to most plans for construction of large facilities, are listed in Table 3.4.1-1 below, as an example of the extensive nature of the pre-construction planning that should be conducted prior to expending MREFC funds to execute the project. Additions or alterations to this list are likely, due to the unique nature of each specific project. While many of the listed topics cannot be substantively addressed at the earliest stage of project planning, it is important that project advocates are aware, at the outset, of the full scope of pre-construction planning activities that should be undertaken and the consequent pre-resources required. As the project matures through Conceptual Design, Preliminary and Final design, these topics become correspondingly better defined.

Table 3.4.1-1 List of the Essential Components of a Project Execution Plan, with Sub-Topics and Descriptions

Component	Sub-Topics	Description of Sub-Section Requirements
1. Introduction	1.1 Scientific Objectives	Description of the research objectives motivating the facility proposal.
	1.2 Scientific Requirements	Comprehensive statement of the Requirements Matrix/ Key Science Requirements to be fulfilled by the proposed facility (to the extent possible identifying minimum essential as well as desirable quantitative requirements), which provide a basis for determining the scope of the associated infrastructure requirements.
	1.3 Facility / Infrastructure	Description of the infrastructure necessary to obtain the research and education objectives.
	1.4 Community Outreach and Impacts	Description of the Educational Outreach and Broader Societal Impacts associated with the purpose of the facility, including the scope of work, budget and schedule related to community or society related actions or interactions.



Component	Sub-Topics	Description of Sub-Section Requirements
2. Organization	2.1 Project Governance	Project Governance, showing Oversight and Advisory Plans with clear lines of authority, responsibility, and communication between Internal and institutional governance and oversight and advisory committees.
	2.2 Project Organization	Project Organizational Structure, showing clear lines of authority, responsibility, and communication between NSF, any partners, and the Recipient.
	2.3 Partnerships	Role of interagency or international partners in future planning and development and/or construction. Plans, agreements, and commitments for interagency and international partnerships. Description of the project's stakeholders and their roles, responsibilities and meeting schedules.
	2.4 Roles and Responsibilities	Roles and Responsibilities of key project personnel and governance groups.
	2.5 Community Relations and Outreach	Community Relations and Outreach plans for building and maintaining effective relationships with the broader research community that will eventually utilize the facility to conduct research. Description of scientific and educational outreach programs.
3. Design and Development	3.1 Project Development Plan	Description of activities that will be undertaken in order to achieve readiness for construction, such as design, prototyping, manufacturing process validation, vendor qualification, modeling and simulation, creation of required project management plans, forming partnerships, etc.
	3.2 Development Budget and Funding Sources	Estimate of total budget required to perform Design and Development, including NSF funding and any contributions from partners and other outside sources.
	3.3 Development Schedule	Schedule of design and development activities and milestones, at a level of detail appropriate to the maturity and complexity of the work.

3.4.1 Components of a Construction-ready Project Execution Plan

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)



Component	Sub-Topics	Description of Sub-Section Requirements
4. Construction Project Definition	4.1 Summary of Total Project Definition	Summary at Work Breakdown Structure (WBS) level II of total construction project scope, cost, and schedule required to complete the construction or implementation project, indicating the Performance Measurement Baseline (PMB) and contingencies funded by NSF as well as any associated scope supported by other funding sources.
	4.2 Work Breakdown Structure (WBS)	WBS contains a product-oriented, hierarchical framework that organizes and defines the total scope of the project into individual project component that represent work to be accomplished, aggregating the smallest levels of detail into a unified project description. The WBS integrates and relates all project work (cost, schedule and scope) and is used throughout the project management to identify and monitor project progress.
	4.3 WBS Dictionary	WBS dictionary defining scope of each WBS element, through all levels.
	4.4 Scope Management Plan and Scope Contingency	The plan describes how the scope will be defined, developed, monitored, controlled, and validated, and how up-scoping opportunities and de-scoping options will be realized. Scope Contingency complies with savings from potential de-scoping options, with decision points for exercising options and time-phased cost and schedule.
	4.5 Cost Estimating Plan and Baseline Budget	A plan describing how the cost estimating guidance in this manual will be implemented, how the cost estimate will evolve over time, and how the “Cost Model Data Set” will meet the various needs of the project. The CEP should typically include a narrative and sufficient detail explaining the ground rules and assumptions, practices, systems, and calculations used to develop the baseline budget for the PMB, by WBS element.
	4.6 Budget Contingency	Contingency budget and description of method for calculating contingency, including confidence level for completing within budget.
	4.7 Cost Report, Cost Model Data Set, and Basis of Estimate	The Cost Book Report is the compilation of Cost Book Sheets, typically used to present total project cost, but may be used to present rolled-up costs for smaller elements or sub-elements The cost model data set is used as input to software tools and/or project reports to organize, correlate, and calculate different project management information. The Basis of Estimate provides supporting documentation outlining the details used in establishing project estimates such as assumptions, constraints, level of detail, ranges, and confidence levels.
	4.8 Funding Profile	Show the proposed NSF Funding Profile by year with baseline commitment and anticipated contingency allocation profiles. Also provide a total funding profile from all sources if applicable.

3.4.1 Components of a Construction-ready Project Execution Plan

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)



Component	Sub-Topics	Description of Sub-Section Requirements
	4.9 Baseline Schedule Estimating Plan and Integrated Schedule	Schedule (without contingency) for the overall project and each major subsystem, including system integration, commissioning, acceptance, testing and transition activities; as well as major milestones and milestones for reviews, critical decisions and deliverables. It uses formal scheduling programs, is based on the WBS hierarchy, and is resource-loaded before the construction/implementation stage. Baseline schedule does not include schedule contingency.
	4.10 Schedule Contingency	Schedule contingency amounts and project end date with contingency; state method of calculating contingency, including confidence level for meeting project end date.
5. Staffing	5.1 Staffing Plan	Staffing FTE plan, per NSF and other project-specific job categories, over time.
	5.2 Hiring and Staff Transition Plan	Schedule and requirements for hiring and training staff, including timelines for increasing or decreasing staffing levels. Required qualifications for key staff.
6. Risk and Opportunity Mgt	6.1 Risk Management Plan	Risk Management Plan describes the methodology/process for identifying, ranking, analyzing, tracking, controlling, and mitigating risks.
	6.2 Risk Register	A tracking document or tool that provides a ranked list of identified risks, with risk impact analysis and prioritization, responsibilities, mitigation plans and opportunities of risk reduction, and risk status over time.
	6.3 Contingency Management Plan	Contingency management plans and approval process using change control. Describe NSF approval requirements per cooperative agreements (CAs).
7. Systems Engineering	7.1 Systems Engineering Plan	Systems Engineering Management Plan; roles and responsibilities.
	7.2 Systems Engineering Requirements	System-level design and technical feasibility study, including definition of all functional requirements and major systems.
	7.3 Interface Management Plan	Identification of interfaces between major components or WBS elements and plans for managing communication, interferences, and interactions. Interface Management Plan and Documentation.
	7.4 QA/QC Plans	Quality assurance and quality control requirements and description of processes.
8. Configuration Control	8.1 Configuration Control Plan	Configuration Control plans.
	8.2 Change Control Plan	Change Control Plan to manage accounting changes and changes in the baseline plan: changes in scope, modifications to budget or schedule, and movement of contingencies into or out of the baseline. Includes approval and documentation processes plus roles and responsibilities.
	8.3 Document Control Plan	Document Control Plan for managing version control, access, and archiving of project related documentation.



**3.4.1 Components of a Construction-ready Project Execution Plan**

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)



Component	Sub-Topics	Description of Sub-Section Requirements
9. Acquisitions	9.1 Acquisition Plans	Describe acquisition plans, processes, sub-awards, and subcontracting strategy. Provide a time based list of acquisitions and procurement actions.
	9.2 Acquisition Approval Process	Describe the approval process for acquisitions (NSF, internal), and create a year by year Acquisition Plan of actions that are estimated to require NSF approval.
10. Project Mgt. Controls	10.1 Project Management Control Plan	Description of the project management organization and processes.
	10.2 Earned Value Management System (EVMS) Plan	Description of the EVMS plans, processes, software, and tools.
	10.3 Financial and Business Controls	Description of Financial and Business processes and controls.
11. Site and Environment	11.1 Site Selection	Site selection criteria and description of selected site(s).
	11.2 Environmental Aspects	List need for any Environmental Impact Statements, permitting, site assessments, etc.
12. Cyber-Infrastructure	12.1 Cyber-Security Plan	Plan for maintaining security of data, hardware, and networks during all stages of project life cycle.
	12.2 Code Development Plan	Plans for writing, testing and verifying, deploying, and documenting software, including configuration control during the stages of development.
	12.3 Data Management Plan	Plans for managing data, including infrastructure, archiving, open data access plans, etc.
13. Health and Safety	13.1 Health and Safety Plans	Safety and Health plans.
14. Review and Reporting	14.1 Reporting Requirements	Statement of reporting requirements, including notifications for specific events and periodic reports on progress and project technical and financial status per NSF requirements or CAs.
	14.2 Audits and Reviews	Statement of the required and proposed reviews, audits, and assessments for progressing during project life cycle through project close-out.
15. Integration and Commissioning	15.1 Integration and Commissioning Plan	Plans for systems integration, testing, and commissioning.
	15.2 Acceptance / Operational Readiness Plan	Plan for operational readiness, including acceptance criteria and acceptance procedures.

**3.4.1 Components of a Construction-ready Project Execution Plan**

*Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)*



Component	Sub-Topics	Description of Sub-Section Requirements
16. Project Close-out	16.1 Close-out Plan	Procedures and criteria for closing out the project. Includes acceptance of verification of technical performance as well as documented completion of all scope contained in the WBS dictionary. Includes procedures documentation for closing out all acquisitions and financial accounting.
	16.2 Transition to Operations Plan	Plans for transitioning to operational status.
	16.3 Concept of Operations Plan	Estimate of annual operations and maintenance staffing and funding that will be needed when the facility is constructed and operated.
17. Facility Divestment	17.1 Facility Divestment Plan	Description and estimate of divestment liabilities at the end of facility life for transfer, demolition, site remediation, decontamination, etc., where appropriate.



### **3.4.2 Detailed Guidelines for Project Execution Plans**

Please contact the cognizant NSF program officer for details, which are given in the internal NSF draft document, *Guidelines for Development of Project Execution Plans for Large Facilities*.

This document provides an overview of NSF's expectations about Project Execution Plans (PEP) for Program Officers (POs), Grants and Agreements Officers (G/AOs) and others involved in overseeing a large facility project and assessing the project management plans of a Recipient. These plans are usually provided, at least in preliminary fashion, as part of the proposal for construction of a large project. This plan can be fine-tuned during the period following approval of the award and prior to undertaking construction activities, through interactions between the Recipient, the NSF PO, and the G/AO that define NSF's expectations.



## 3.5 OPERATIONS PLAN

### 3.5.1 Preparation of Proposals for Operations and Maintenance

In order to avoid funding gaps, formal proposals to operate a facility should be prepared well in advance of the anticipated start date for operations: as much as two years prior to the end of construction and commissioning activities. Program Officers (PO) and Directorates/Offices are encouraged to take into account the time needed for internal NSF review, including NSB review, and offer guidance to the community. Estimates of the funds for operations and maintenance are provided even in the planning stages of a facility. The potential Recipient and/or the PO need to establish a dialogue with the user community to determine the resources needed to fully exploit the facility. In addition, the proposal should include:

- All costs to operate, maintain and periodically upgrade the facility, its instrumentation and the IT components, including cost and approximate time of investment (Note: A PO can expect that IT components will need to be upgraded at least every 3 to 5 years);
- The costs of an in-house research program (as a separate line item in the budget), if applicable, including an indication of how the overall research program will be managed and how research program resources will be allocated;
- Education and outreach plans and costs;
- A detailed management plan for operations of the facility, including the roles of key staff and plans for advisory committees.

Note that cost estimating methods should follow the Government Accountability Office (GAO) Cost Estimating Guidelines, per Section 4.2.

The review of the proposal includes a realistic assessment of the costs to operate and maintain the facility in a safe and effective manner. The PO is also responsible for oversight of operational facilities through the various reviews and reports described in the Internal Management Plan (IMP). In addition to following the procedures referenced as appropriate to Chapters V and VI of the *Proposal and Award Manual (PAM)*, the PO considers (with the assistance of external reviewers with expertise in managing comparably scaled facilities) these questions:

- Is the facility ready for reliable operations and is the infrastructure (including personnel requirements) adequate to execute the proposed work plan?
- Do the operations and maintenance plans allow for optimal utilization of the facility by users (e.g., scheduled operating time versus down-time)?
- Is there an appropriate balance between in-house research and research of external users?
- Are safety (including IT security and security of the physical plant), environmental and health issues, if any, addressed?



- Are plans for securing human subjects and/or vertebrate animal clearances included, if applicable (e.g., assessments of education-related activities)?
- Are the Educational Outreach and Broader Societal Impact plan and cost reasonable and include an appropriate strategy to evaluate the outcomes?
- Have all costs been considered and estimated and is the available funding sufficient, or is some adjustment needed?

Throughout the operational stage, the Recipient operates and maintains the facility in accordance with the terms and conditions outlined in the CA. The PO, together with the Division of Grants and Agreements (DGA) or the Division of Acquisition and Cooperative Support (DACS), drafts the CA that will govern the operational phase of the project in accordance with the procedures contained in Chapter VIII of the PAM. The CA will include plans for NSF oversight, reflect the needs of the facility users, and address how the user program will be managed and how user time will be allocated. The PO provides oversight for all aspects of operations, maintenance and the research and education program. The PO also maintains an awareness of emerging technical, managerial and financial issues through contact with the facility managers and users, and through oversight, reviews and reports.



### 3.5.2 Procedures for Renewal or Recompetition of an Operating Large Facility

At least two years prior to the expiration of an award for operations of a facility,<sup>1</sup> the Program Officer (PO) will plan a review of the results of research and education, the affected community's needs, and the facility's management, including the performance of its managing organization. The reviews will be used to determine whether to renew the award, upgrade the facility, recompute the award or terminate operation of the facility. If the reviews show that the facility is of low priority relative to other funding opportunities within the field(s) of research served by the facility, or is otherwise not meeting its goals and objectives, the PO, working with the Division Director (DD) and Assistant Director (AD)/Office Head, will prepare a plan for either upgrading the facility's capabilities or divesting/terminating support.

The review should analyze the costs and benefits of the facility, taking into consideration the following issues:

- How much does the community need the facility, and is the community strong and actively engaged in utilizing it?
- Is the facility meeting the research, educational outreach and broader societal Impact goals and objectives originally proposed?
- Has the facility reached its annual performance goals, and if not, what are the reasons for not meeting any goals?
- Will meeting the goals and objectives place the United States in a leading position within the research areas served by the facility?
- Is the facility a high priority of the field, as established by long-range planning?
- Is the facility operating in an efficient and cost-effective manner, or are there alternative, more efficient and cost-effective ways to meet the need?
- What research opportunities and education opportunities elsewhere are being lost by continued support of this facility?

Federally Funded Research and Development Centers (FFRDCs) follow a slightly different process and cannot be renewed or divested until a comprehensive review is performed. The review should meet the requirements outlined in the Federal Acquisition Regulations (FAR Part 35.017-4, Reviewing FFRDCs): An FFRDC review should include the following: (1) an examination of the sponsor's special technical needs and mission requirements that are performed by the FFRDC to determine if and at what level they continue to exist; (2) consideration of alternative sources to meet the sponsor's needs; (3) an assessment of the efficiency and effectiveness of the FFRDC in meeting the sponsor's needs, including the FFRDC's ability to maintain its objectivity, independence, quick response capability, currency in its field(s) of expertise, and familiarity with the needs of its sponsor; (4) an assessment of the adequacy of the FFRDC management in ensuring a cost-effective operation; and (5) a determination that the criteria for

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<sup>1</sup> The PO should exercise judgment and consider the complexity of the facility in determining whether to begin the review process earlier.



establishing the FFRDC continue to be satisfied and that the sponsoring agreement is in compliance with FAR 35.017-1.

If the reviews show that the facility remains a high priority and has been successful in meeting its goals and objectives, the Originating Organization considers whether renewal of the operating agreement with the Recipient institution, or recompetition, is in the best interests of NSF and the affected community. In deciding whether to renew or recompute, the PO will take into consideration that the NSB has expressed its preference for recompeting all awards periodically. Awards may be renewed without recompetition or with only limited competition if there is sufficient justification (e.g., facilities or facility sites with special features that preclude relocation or recompetition, or partnership-related complexities that prevent recompetition).

After the appropriate review has been completed, the PO analyzes what can and what needs to be done in light of the available funding, and recommends one of the following actions:

- Recompete the award;
- Renew NSF support;
- Renew NSF support and plan upgrades to the facility;
- Renew NSF support to allow operations to transition to self-sufficiency (through, for example, institutional, industrial or other modes of support);
- Renew NSF support to allow operations to ramp-down, leading to divestment; or
- Terminate NSF support and divest.

In the event that a decision is made to recompute or to terminate support for a facility, the PO will give the incumbent Recipient as much notice as possible, but not less than one year, so that all necessary arrangements to transfer (in the case of unsuccessful recompetition by the incumbent management entity) or terminate obligations to vendors and employees can be planned and implemented.

In most cases of recompetition, the managing organization of a facility is required to compete with other organizations for continuation of the management of the facility and renewal proposals are received from the Recipient institution and/or from other institutions. The proposal(s) is (are) merit reviewed in accordance with procedures in Chapters V and VI of the PAM. The normal thresholds for Director's Review Board (DRB) and NSB award approval apply.<sup>1</sup>



<sup>1</sup> Refer to the footnotes in Section 2.1.6 and 2.7.1 on award thresholds requiring DRB and NSB approval.



### **3.5.3 Detailed Guidelines for Oversight of Operations**

Please contact the cognizant NSF program officer for details, which are given in the internal NSF draft document *Guidelines for Operations*.

This document provides guidelines conducting oversight of the operational phase of NSF's large facilities. It elaborates on the principles outlined in the large facilities manual, and offers additional information and examples that should be especially helpful to individuals newly involved in operational oversight.





### **3.6 FACILITY DIVESTMENT PLAN**

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## 4 KEY MANAGEMENT PRINCIPLES AND REQUIREMENTS FOR LARGE FACILITIES

### 4.1 INTRODUCTION

This section provides greater detail about key management, budgeting, and reporting activities that should be carried out throughout a project's life cycle stages, for both Major Research Equipment and Facilities Construction (MREFC) and non-MREFC projects, to ensure adherence to principles established by National Science Foundation (NSF).

Some of these activities will be funded via MREFC and others via R&RA, depending on lifecycle stage.



## 4.2 COST ESTIMATING AND ANALYSIS



### 4.2.1 Cost Estimating and Analysis Overview

This guidance clarifies NSF expectations for the format, content, supporting justification, and best practices for Recipient cost estimates. This guidance also explains the NSF cost analysis process and timeline. By following this guidance Recipients should expect a better estimate and a more efficient review by NSF, facilitating achievement of the science mission. Recipients should note any departures from this guidance and explain their rationale. For existing awards, the Recipient should consult with the PO.

NSF uses internal staff, outside experts, and panel reviews to analyze estimates and ensure construction and operations awards are allowable, allocable, reasonable, and realistic. Allowable costs are defined by federal guidelines and relevant cost principles. Allocable costs must be logically related to the particular award. Reasonable costs are what a prudent individual would pay in a competitive marketplace (i.e., costs are not too high). Cost realism defines whether the costs are realistic for the work to be performed, reflect a clear understanding of the requirements, and are consistent with the methods of performance and materials described in the Recipient's technical proposal (i.e., costs are not too low).

As described in Section 2 of this manual, Recipients must develop estimates for design, construction, operation and decommissioning of facilities. Estimates should be well documented, comprehensive, accurate, and credible and should facilitate appropriate analyses from a wide variety of reviewers at the various life cycle stages. It is understood that cost estimates will undergo further refinement at each stage-gate review and the materials required herein will evolve accordingly. NSF will review estimates at an appropriate level as the project advances through the design stage.

The NSF PO, G/AO, and Cost Analyst conduct a detailed analysis of the Recipient cost estimate. NSF also utilizes external panel reviews and independent cost estimate reviews to inform the analysis. The G/AO and Cost Analyst review includes the detailed sub-elements, cost categories, and supporting basis of estimate discussed in this section of the manual. The PO review includes the technical scope, risk, level of effort, and schedule assumptions. The LFO supports analysis of the proposed contingency budget. The inputs from the various sources are integrated and reconciled with the Recipient estimate. The PO ultimately recommends the budget, funding profile, and internal and external sources of funds based on the results of the cost analysis and the availability of funds.

Figure 4.2.1-1 and Figure 4.2.1-2 below depict when cost analyses are performed during the design and operations stages. NSF may also perform cost analyses at other times, as necessary, based on a risk-based assessment. For example, cost analyses may be needed to support significant changes in scope, schedule, or cost (e.g., for large dollar amounts or relative percent increases in expected costs), or when upcoming annual project plans include items that are



considerably risky or complex. These latter types of analysis may only require review of targeted subset of information for specific changes.

NSF typically requires 90 to 180 calendar days to complete a full review and detailed cost analysis of a proposal budget prior to proceeding to the next design phase or prior to award for operations or construction. This time will vary depending on project scope, cost, risk, complexity, and relative importance. During this time, 60 calendar days should be allocated for the cost analysis by the CAAR Cost Analyst.

If the Recipient provides insufficient or conflicting information, the G/AO or CO and Cost Analysts may require additional documentation and justification and further interaction with the Recipient prior to making a recommendation. Communication among all parties as well as a sound initial basis of estimate are essential for timely and successful completion.

When submitting packages for cost analysis, Recipients must submit the following as a minimum:

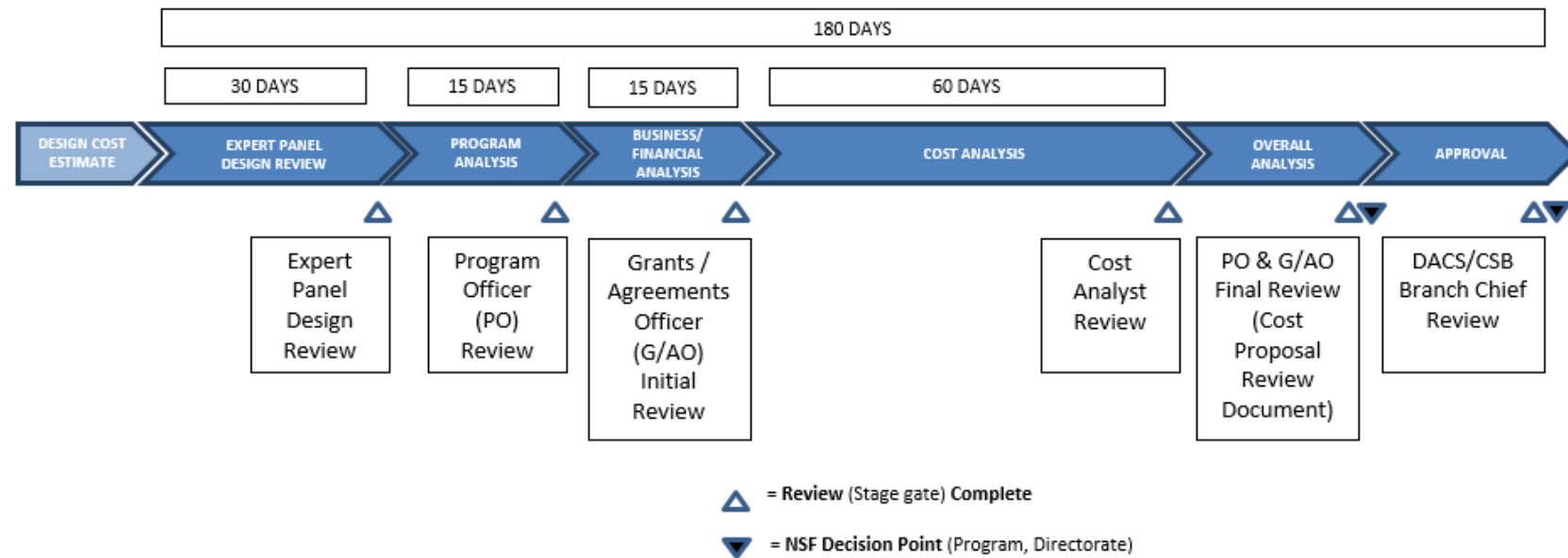
- Cost Estimating Plan per Section 4.2.2.1.
- “Cost Model Data Set” per Section 4.2.2.1.
- Reports and Proposals per Sections 4.2.2.2 and either 4.2.3.2 or 4.2.4.2.
- The Work Breakdown Structure (WBS) and WBS Dictionary per either Sections 4.2.3.3 or 4.2.4.3.
- Supporting information forming the Basis of Estimate (BOE) per Sections 4.2.2.4, 4.2.2.5, 4.2.2.6, and either 4.2.3.4 or 4.2.4.4

4.2.1 Cost Estimating and Analysis Overview

Prepared by Budget, Finance, and Awards Management, Division of Acquisition and Cooperative Support (BFA-DACS), & The Large Facilities Office (BFA-LFO)



Figure 4.2.1-1 Cost Analysis Process during Design Phases for Construction Awards (Post – CDR, PDR, FDR to Support MREFC Stage-Gate Review Process)

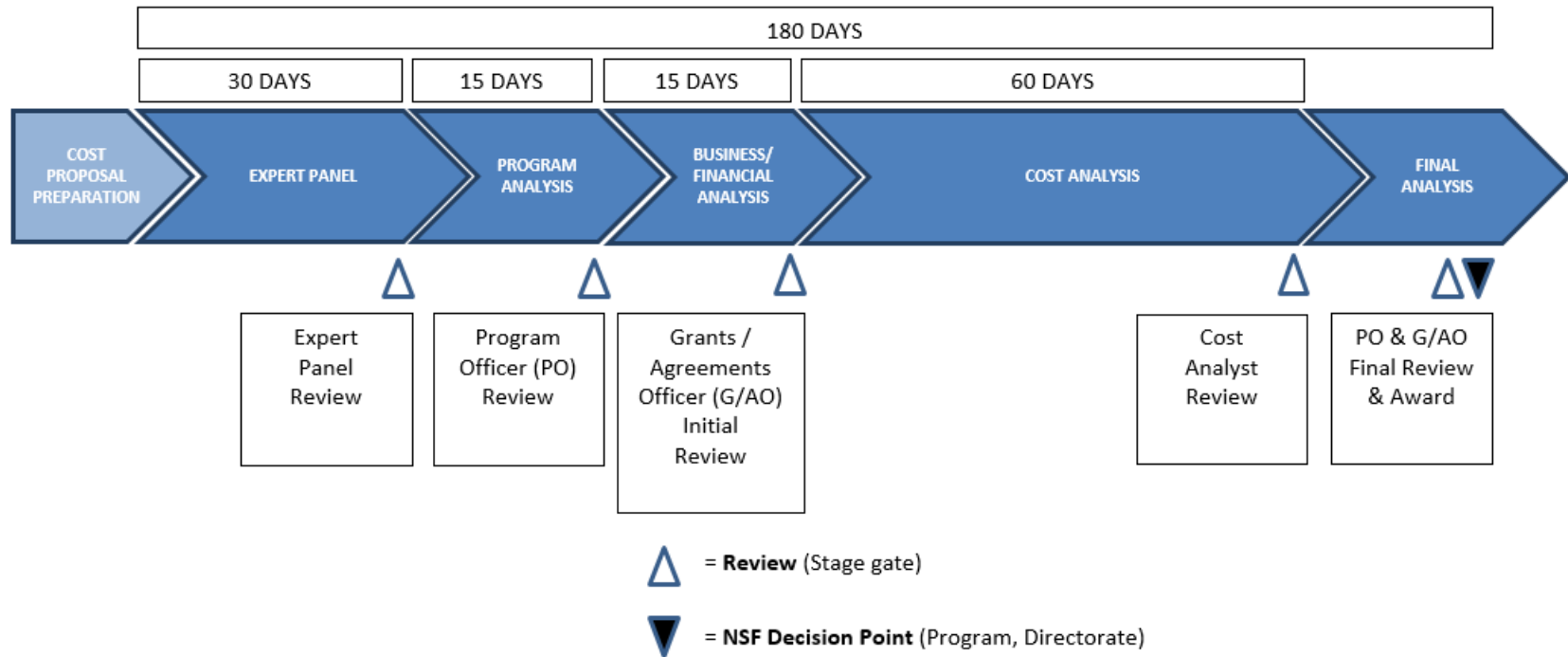


4.2.1 Cost Estimating and Analysis Overview

Prepared by Budget, Finance, and Awards Management, Division of Acquisition and Cooperative Support (BFA-DACS), & The Large Facilities Office (BFA-LFO)



Figure 4.2.1-2 Cost Analysis Process for Operations Awards





## 4.2.2 Cost Estimating and Analysis Process

### 4.2.2.1 Cost Estimating Plan

For new awards, Recipients must develop and submit a Cost Estimating Plan (CEP) to clearly articulate cost estimate assumptions in order to support the cost analysis. NSF will review the CEP to ensure the Recipient plans are aligned with NSF expectations outlined herein. The CEP should address the general guidance in Section 4.2.1 and the specific guidance from either Section 4.2.3 or 4.2.4 for construction projects or operational awards, respectively. For construction awards, the CEP must explain how the Recipient will follow “The Twelve Steps of a High-Quality Cost Estimating Process” from the GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs (GAO-09-3SP March 2009, or subsequent revision). For existing awards, the Recipient should consult with the PO regarding the CEP.

In general, the CEP should describe how the guidance in Section 4.2 of this manual will be implemented, how the cost estimate will evolve over time, and how the “Cost Model Data Set” will meet the various needs of the project. The “Cost Model Data Set” is the cost data used as input to software tools and/or project reports to organize, correlate, and calculate different project management information. The CEP should also typically include a narrative and sufficient detail explaining the ground rules and assumptions, practices, systems, and calculations used to develop the cost estimate. The CEP should describe the expected cost estimating methodology at each stage (e.g., expert opinion, analogy, parametric, or engineering build-up). Recipients should also discuss their own independent estimates and reviews, if any, planned to validate the project estimate.

Figure 4.2.2-1 provides an example of a how a “Cost Model Data Set,” Work Breakdown Structure, and a Recipient’s institutional accounting systems can be used as inputs in conjunction with scheduling, earned value, and risk analysis tools to generate a variety of output reports for project management purposes. Sections 4.2.3 and 4.2.4 of this manual refer specifically to the “Cost Model Data Set” and “Cost Reports” blocks encircled with dashed lines in Figure 4.2.2-1. The CEP is included as part of section 4.7 of the PEP as described in Section 3.4 of this manual.

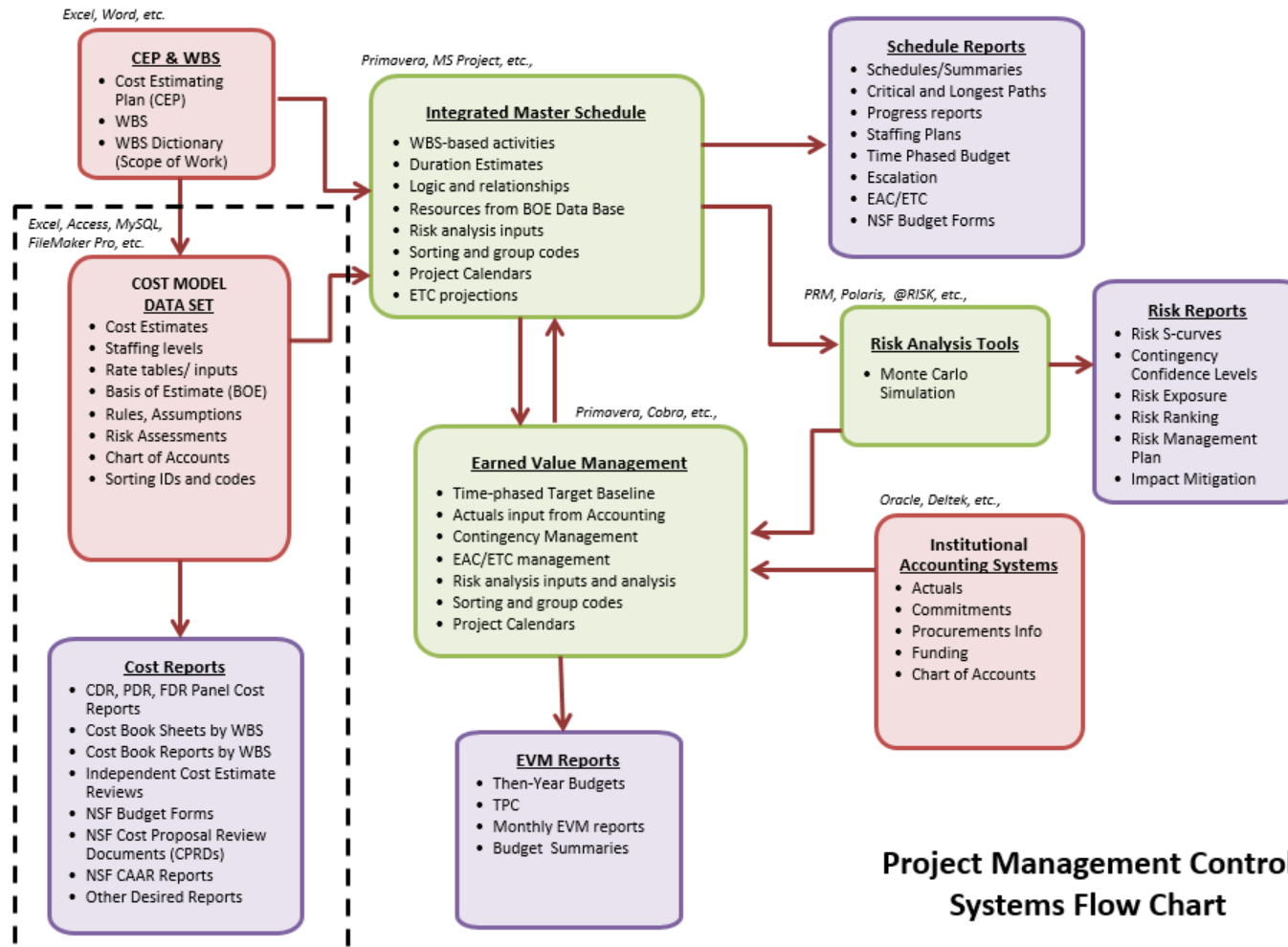
The CEP should be tailored to address all relevant stages and costs of the facility lifecycle, from Development and Design through Construction, Operation, and Termination. For example, the expected level of funding needed for the Operations Stage should be identified at the Conceptual Design Review. Operating costs estimates will be updated throughout the design and construction process as further discussed in the Concept of Operations Plan developed as part of the PEP described in Section 3.4 of this manual.

4.2.2 Cost Estimating and Analysis Process

Prepared by Budget, Finance, and Awards Management, Division of Acquisition and Cooperative Support (BFA-DACS), & The Large Facilities Office (BFA-LFO)



Figure 4.2.2-1 Sample Project Management Control Systems Flow Chart







#### 4.2.2.2 Relevant Guidance and Reporting Formats

Proposed budgets must comply with the applicable federal regulations, as implemented by NSF in the Proposal and Award Policies and Procedures Guide (PAPPG), including Grant Proposal Guide (GPG) and Award and Administration Guide (AAG). Recipients are required to follow the best practices within the GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs (GAO-09-3SP March 2009, or subsequent revision) and GAO Schedule Assessment Guide: Best Practices for Project Schedules (GAO-16-89G December 2015, or subsequent revision), taking into consideration NSF policy and practice as provided in this manual. Recipients must note any departures from these GAO guides and explain their rationale. The Recipient should also be prepared for a review of all of its business systems as described in Section 4.5.3.3 in accordance with NSF's *Business Systems Review (BSR) Guide*.

The "Cost Model Data Set" must be capable of providing cost information in multiple formats and reports, including but not limited to the following:

- Reports based on a deliverable-based work breakdown structure (WBS) for construction and a functional activity and/or deliverable based work breakdown structure for operations, as further described in Sections 4.2.3.3 and 4.2.4.3 below. These reports support project management and execution and detailed cost analysis of sub-elements and are referred to as "Cost Book Reports."
- In the standard NSF budget format, depicted in Figure 4.2.2-2 and Section 4.2.2.4 below, per NSF budget and budget justification guidance from the GPG in the PAPPG. This format supports cost analysis of broad NSF budget categories.

The estimate is built-up from the individual WBS elements and sub-elements. If the costs associated with each WBS element are binned into the appropriate NSF budget categories, then both of the above reporting formats can be readily produced. For example, costs can be coded with NSF budget format letters (A through I per Figure 4.2.2-2) in the "Cost Model Data Set" to populate rolled-up NSF budget format summaries as well as "Cost Book Reports" organized by WBS. Actual expenditures can then be later compared to budgeted amounts using earned value management (EVM) during construction.

The cognizant NSF PO or G/AO can be contacted with questions or for other specific programmatic requirements.



Figure 4.2.2-2 NSF Budget Categories Sample Format

A – Senior Personnel
B – Other Personnel
B.1 – Postdoctoral Scholars
B.2 – Other Professionals (Technicians, Programmers, Etc.)
B.3 – Graduate Students
B.4 – Undergraduate Students
B.5 – Secretarial – Clerical
B.6 – Other
C – Fringe Benefits
D – Equipment
E – Travel
E.1 – Domestic
E.2 – Foreign
F – Participant Support
F.1 – Stipends
F.2 – Travel
F.3 – Subsistence
F.4 – Other
G – Other Direct Costs
G.1 – Materials and Supplies
G.2 – Publication, Documentation, Dissemination
G.3 – Consultant Services
G.4 – Computer Services
G.5 – Sub-awards
G.6 – Other
H – Total Direct Costs
I – Indirect Costs

#### 4.2.2.3 Funding Sources and Award Instruments

For most large facilities projects, funding is derived from the appropriate NSF budget account depending on the Stage: typically the Research and Related Activities (R&RA), Education and Human Resources (EHR) or MREFC account. Barring documented exceptions, the R&RA (and possibly EHR) account will be used to fund the Development, Design, Operations, and Termination Stage costs. The MREFC account will be used to fund construction, acquisition and commissioning costs as part of the Construction Stage.



For non-MREFC projects, the R&RA (and possibly EHR) account also funds the construction, acquisition and commissioning costs, as discussed in Section 2.7 of this manual.

All lifecycle Stages are funded through the appropriate award instrument (typically a Cooperative Agreement (CA)) between NSF and the managing organizations (i.e., the Recipient). Infrastructure utilization is typically supported through grants (R&RA or EHR) funded by NSF and/or other agencies to conduct research and education activities using the facility.

For projects to be funded through assistance awards (CAs or grants), the PO recommends award or decline in accordance with the proposal processing procedures contained in Chapter VI of the Proposal and Award Manual (PAM). The PO, together with staff from NSF's Division of Acquisition and Cooperative Support (DACS) and LFO, drafts the award instrument that will govern the project in accordance with the procedures contained in Chapter VIII of the PAM. For projects funded through contracts, the Federal Acquisition Regulations apply. Before proposals for large facilities projects can be awarded, funds for the project must be approved by NSF at the appropriate level and appropriated by Congress.

Proposed budgets shall also describe any contributions from other agency or international partners. For awards involving property, the PO consults with the OGC, the Division of Financial Management, the Property Office, and the LFO Liaison to determine whether the value of the property should be included on NSF's financial statements. The LFO Liaison coordinates help with other BFA management divisions as required.

#### **4.2.2.4 Supplementary Guidance for Construction and Operations Awards**

This section discusses additional detailed information needed for cost analysis of broad NSF budget categories to determine if Recipient proposals are allowable, allocable, reasonable, and realistic. This information is intended to supplement the standard grant guidance for the NSF budget categories described in the GPG in the PAPPG as depicted in Figure 4.2.2-2 (NSF Budget Categories Sample Format). This guidance is intended to clarify NSF expectations, assist Recipients, facilitate NSF review with fewer iterative resubmissions, and prevent recurrent issues. Additional guidance on the importance of justifying individual work breakdown structure elements is provided in Sections 4.2.3 and 4.2.4. Along with the CEP, Recipients should provide the following supplementary information to support their BOE:

##### **Documentation and Cost Models**

Supporting source documentation should be provided, such as current payroll registers, vendor quotes for items of equipment where available, historical costs, and scaling factor justifications. The "Cost Model Data Set" should allow for mathematical checks of the proposal budget calculations and should contain formulas and allow manipulations to check calculations (i.e., the model should not be locked).



For all salary data provided, Personally Identifiable Information should be removed from the documentation described below. If not already covered in the CEP, Recipients should provide a salary escalation rate for multi-year proposals, which can include a component for annual raises similar to Cost of Living Adjustments (COLAs) and other pay increases for promotions within the position classification. Recipients should provide the rationale behind the salary escalation rate. In some cases, NSF may provide a base escalation rate in the solicitation for guidance, but Recipients should follow Section 4.2.2.6 of this manual when proposing rates.

#### A – Senior Personnel

- Recipients should provide verification of actual salaries paid for named senior personnel. Salary rates should be based on actual costs per current rate paid by payroll register, W-2s, or appointment letters. Recipients should note Academic Year (9-10 month) versus Calendar Year (12 month) appointments or time available to conduct independent research if such appointments so provide. The Recipient should also provide documentation to support reasonableness of the salary rate paid, such as salary rate surveys, salary comparators, Human Resource Department analysis, or other information.
- NSF has a policy which typically limits senior personnel to two months effort in any given year for standard NSF-funded grants. However, most grants and cooperative agreements for large facility projects (both construction and operations) have senior personnel effort well in excess of two months. Compensation in excess of two months, if anticipated, should be disclosed in the proposal budget, and explained in the budget justification.

#### B.1 – Postdoctoral Scholars

- Recipients should provide the average salary rate or rate range for postdoctoral students at the organization in the field of science. Actual payroll data may not be available as these may be To-Be-Hired (TBH) positions.

#### B.2 – Other Professionals, Technicians, Programmer, Etc.)

- This category is of special concern in both construction and operations proposals for large facility projects. The level of effort will likely need to be obtained by individual or by position for salary calculations. Since the NSF budget format poses this as a total number of individuals for a total number of months, additional explanation is generally required to disaggregate the total for cost analysis. Recipients should also provide a spreadsheet with the budget justification that includes: name or position number, location, activity or function (operations awards see Section 4.2.4.3) or WBS (construction awards see 4.2.3.3), title, salary rate and period, level of effort as a percentage or in person-months, and calculation of amount for each award year.



- Recipients should provide supporting documentation for the salary rates of the technicians, programmers, and other professionals proposed. For these types of positions, NSF recommends the use of Bureau of Labor Statistics (BLS) Standard Occupation Classification Codes (SOC) by position title and referencing their positions to BLS salary rates to establish reasonableness of proposed salary rates. The BLS data is also available by region or city. Other salary rate survey data may be used and larger Recipient organizations may already have established salary ranges and qualification bases established internally by their Human Resources Departments.

### B.3 – Graduate Students

- Recipients should provide the average salary rate or rate range for graduate students at the organization in the field of science. Actual payroll data may not be available as these may be TBH positions.

### B.4 – Undergraduate Students

- Recipients should provide the average salary rate or rate range for undergraduate students at the organization in the field of science. Actual payroll data may not be available as these may be TBH positions.

### B.5 – Secretarial – Clerical

- Recipients should provide the average salary rate or rate range for secretarial clerical personnel at the organization.

### B.6 – Other Personnel

- Generally the same as B.2 above but special classifications could justify different treatment.

### C – Fringe Benefits

- Most Recipient organizations utilize a single tier fringe benefit rate or fringe benefit rate by class of employee. Occasionally these fringe benefit rates are approved in the Negotiated Indirect Cost Rate Agreement (NICRA). In such cases, the Recipient can verify the rate and provide a fringe benefit calculation (rates by class) for a sample project year. These cases should be noted in the CEP.
- Some organizations use an actual fringe benefit amount by class of employee. These amounts vary greatly by employee salary levels. While some fringe benefit costs are based on a percentage of salaries (such as statutory withholding or contributions to retirement and Paid Time Off (PTO)), other fringe benefits such as medical insurance may be a lump sum amount and are not directly tied to salary paid. The Recipient should provide an estimate of each fringe benefit provided as a percentage to salaries paid along with a description of the fringe benefit provided as a means to gauge the reasonableness of the fringe benefit package provided.



- In both cases, Recipients should explain differences in the treatment of PTO. Some organizations include this as a component of the fringe benefit rate and others include the full cost of salary (including PTO) in the salaries as budgeted.

#### D – Equipment

- Equipment is defined as items with an acquisition cost and a useful life above established thresholds. The acquisition cost includes modifications, attachments and accessories necessary to make the property useful for the purpose for which it was purchased. There can be equipment expenses or materials and supplies that individually are less than the threshold but taken together exceed the equipment threshold, particularly when installed or fabricated by a Recipient.
- Recipients should list each item of equipment individually and include a description, estimated cost, and justification of need. Recipients should provide vendor or catalogue quotes for each item of equipment. These quotes should be indexed and numbered to the equipment items proposed. For items of equipment exceeding the small purchase threshold, three or more vendor quotes or sole source justification should also be provided. For unique scientific instrumentation or other equipment components where vendor quotes are not readily available, a clear basis of estimate should be provided.
- General purpose equipment is generally not supported by NSF funding unless used primarily on the actual conduct of the NSF-funded project.

#### E – Travel

- Travel activities should be documented by individual's destination and cost. Generally the cost should be broken out by transportation (airfare or mileage), per diem (lodging and meals) and other associated expenses. The relation of the travel to the proposed activities should also be included. For renewal projects, historical costs can be considered as a means of assessing the reasonableness of travel costs. Where there are large numbers of trips and the actual locations may not be known in advance, then cost estimating relationships (e.g., average of \$1,500 per traveler per trip) may be used.

#### F – Participant Support

- This category includes stipends, travel, subsistence, and other costs for participants in an NSF sponsored conference, workshop or other training activities. Justification should include the number of participants, stipend amount, travel cost estimate, and subsistence costs per participant. Recipients should also provide the number of days or weeks of the training activities to provide a basis for determining reasonableness of the proposed payments.
- Participant support costs may not be used for personnel at the Recipient institution.

#### G.1 – Materials and Supplies

- The general types of expendable materials and supplies should be indicated. An itemized listing is not necessary unless an item represents a substantial amount of costs. Vendor or catalogue



quotes, historical costs, or other cost estimating relationships may be used to establish reasonableness of the cost estimate.

#### G.2 – Publication, Documentation, Dissemination

- Recipients should provide an estimate of publication and dissemination costs.

#### G.3 – Consultant Services

- For each consultant identified, the Recipient should provide the individual’s expertise, primary organizational affiliation, normal daily compensation rate, number of days of expected service, and justification that the proposed rate of pay is reasonable. Consultant travel and subsistence costs may also be included.

#### G.4 – Computer Services

- Where it is established institutional policy to direct charge computer services, the Recipient may justify and include such costs in the budget. Generally such recharges should be based on established internal institution usage rates. Recipients should provide a statement or policy document and rates by units of actual usage.

#### G.5 – Sub-awards (Sub-recipients)

- Recipients are expected to conduct a pre-award review of the Sub-awards to include both cost and price analysis and to identify risk as outlined in the Uniform Guidance, 2 CFR section #200.331.
- Recipients should provide NSF with their pre-award analysis of each of the proposed Sub-awards. Such Recipient pre-award analysis should include a determination of Sub-award risk. This should include an assessment of adequacy of accounting system, financial capability, and ensuring the Sub-recipient is not on any Federal Government “do not pay” listing. The Recipient should also have performed a price or cost analysis of the Sub-recipient’s proposed work to ensure the reasonableness of costs. Sole source awards should also be adequately justified. NSF reviews the Recipients documentation on each Sub-recipient to ensure sufficient rigor and detail was performed. Sub-recipient analysis should typically be performed by internal cost analysis and budgeting personnel.

#### G.6 – Other

- Budget contingency should also be presented as a part of the total amount of Other Direct Costs and included in section G.6 on the standard NSF budget form. Budget contingency budget estimates should be developed in accordance with Sections 4.2.5 and 5.2 of this manual. Budget contingency and allocations of contingency will be called out in the Cooperative Support Agreement by the G/AO under the “Contingency” section, based on information provided in the negotiated budget justification.



- Itemized Other costs, including the budget contingency, should be listed separately in the Comments area of the form.

#### I – Indirect Costs

- When the Recipient has a NICRA established with a cognizant federal agency, the rate and base in that agreement should be used to compute indirect costs. A copy of the NICRA should be included in the CEP.
- When a Recipient does not have a NICRA, the Recipient should provide a calculation and an indirect cost rate proposal. The Recipient should ensure that indirect costs are in accordance with NSF policies in NSF's Indirect Cost Rate Proposal Submission Procedures. Recipients should provide a clear description of rates and application bases. Recipients should also provide spreadsheet calculation of rate or rates by year clearly showing exclusions such as sub-awards greater than \$25,000, equipment or capital expenditures, and participant support. If a Recipient has different indirect cost rates across NSF budget categories in Figure 4.2.2-2, these rates should be clearly identified and justified. Any deviation to a Recipient's normal rate should also be justified.

#### **4.2.2.5 Management Fees**

Management fee is an amount of money paid to a recipient in excess of a cooperative agreement's or cooperative support agreement's allowable costs. Generally, NSF does not permit the payment of fee (profit) to organizations under financial assistance. However, a management fee may be authorized for awards in the limited circumstances of construction or operations of a large facility as the responsible organization is likely to incur certain legitimate business expenses that may not be reimbursable under the governing cost principles. NSF provides for a management fee in these limited circumstances, as appropriate, for example recognizing that the recipient may only incur such expenses as a result of its support of the NSF-funded activity.

**Prior Approval of Management Fees** - A management fee proposal must be submitted to NSF that provides sufficient visibility into each expense category to identify its intended purpose. Agreement on management fee amounts shall be completed and a specific dollar amount established prior to the initiation of work under an award, or any subsequent period not authorized as part of the initial award. Any amount negotiated shall be expressly set forth in the terms and conditions of the award. Recipients may draw down the management fee in proportion to the amount incurred during the performance period. Fee established for a period longer than one year shall be subject to adjustment in the event of a significant change to the budget or work scope.

The following expense categories will be used in the negotiation and award of a management fee:





- **Working capital necessary to fund operations under an award** - An amount for working capital may be necessary to ensure a level of retained earnings available to the organization in order to secure credit and borrowing to assure the financial health of the organization.
- **Facilities capital necessary to acquire assets for performance** - An amount for facilities capital may be necessary to allow the organization to acquire major assets and to address expenses that require immediate substantive financial outlays but that are only reimbursed through depreciation or amortization over a period of years.
- **Other ordinary and necessary expenses for business operations that are not otherwise reimbursable under the governing cost principles** – An amount for other expenses that are ordinary and necessary but not otherwise reimbursable may be appropriate to provide a reasonable allowance for management initiative and investments that will directly or indirectly benefit the NSF-funded activity. Inclusion of amounts under this category warrants careful consideration of the benefits that may be obtained when providing management fee. Examples of potential appropriate needs include expenses related to contract terminations and losses, certain appropriate educational and public outreach activities, and financial incentives to obtain and retain high caliber staff.
- **Prohibited Use of Management Fees** - Although not an exhaustive list, the following are examples of expenses that are not appropriate uses of a management fee:
  - Alcoholic beverages
  - Tickets to concerts, sporting and other events
  - Vacation or other travel for non-business purposes
  - Social or sporting club memberships
  - Meals or social activities for non-business purposes
  - Meals or social activities for business purposes that are so extravagant as to constitute entertainment
  - Luxury or personal items
  - Lobbying as set forth at 2 CFR § 200.450 and FAR 31.205-22, as appropriate to the recipient type

In addition, costs incurred under the award that are otherwise allowable under the governing cost principles must be classified as direct or indirect charges to the award and shall not be included as proposed management fee elements.

**Documentation Requirements on Use of Management Fees** - Even though the management fee represents an amount in excess of allowable cost and is therefore not subject to the governing cost principles, NSF, as a matter of policy, has determined that review of appropriate use of such funds is necessary. Information available on actual uses of management fee



previously awarded by NSF in the preceding five-year period under any award shall be included in the proposing organization's fee proposal. As a term and condition of the award, the recipient will be required to provide information (typically annually) on the actual use(s) of the management fee. NSF will conduct reviews of this information regarding the extent to which the recipient fee proposals have proven reliable when compared with actual uses of management fee (both as to the fee amount as well as the planned uses of the fee). Unexplained failure to reasonably adhere to planned uses of fee will result in reduction of future management fee amounts under the award.

#### 4.2.2.6 OMB Inflators

Recipients are not limited to using the publically available economic assumptions and broad OMB inflators (<https://www.whitehouse.gov/omb/budget/Supplemental>) when doing cost estimates. NSF encourages organizations to use inflators appropriate for the known situations or a particular industry as long as they can be justified. For example, specialized data may be available from the Department of Energy, Department of Defense, BLS, industry metrics, and/or historic experience with similar items. The justification for all inflators (including use of standard OMB inflators) should be included in the CEP and inflators should be used consistently throughout the BOE in accordance with the CEP.

Estimates should preferably be based on current information, but may include appropriate escalation calculations and justifications to support the planned execution timeframe. Escalation for raw materials and equipment in technological projects often runs higher than broad measures of inflation (e.g., the consumer price index) due to inelasticity in pricing (i.e., there are few or no substitutes available in the marketplace and demand remains constant). Recipients should consider establishing risks and associated contingency for future price variability and developing mitigating actions such as periodic validation of prices.



## 4.2.3 Cost Estimating and Analysis for Construction Awards

### 4.2.3.1 Purpose and Process

NSF utilizes internal staff, outside experts, and expert panels at the Conceptual Design, Preliminary Design and Final Design Reviews and during the Construction Stage to assure that proposed construction cost estimates and budgets meet expectations and are allowable, allocable, reasonable, and realistic. Cost Estimating Plans and Cost Reports should be updated as necessary during each of the Phases in preparation for the Reviews. These Cost Reports include Construction Cost Book Reports, MREFC Panel Reports, and others as depicted on Figure 4.2.2-1. NSF also generates various Cost Reports such as the Cost Proposal Review Document (CPRD) for cost analysis as part of its oversight and assurance roles.

The PDR estimate and subsequent NSF analysis must be sufficient to give NSF confidence in the Not-To-Exceed estimated Total Project Cost (TPC) that advances for National Science Board approval and potential inclusion in a future budget request. The FDR estimate and analysis must be sufficient to give NSF confidence in constructing and commissioning the facility within the TPC.

As denoted in Section 4.2.2.2, Recipients must follow the best practices within the GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs (GAO-09-3SP March 2009, or subsequent revision) and GAO Schedule Assessment Guide: Best Practices for Project Schedules (GAO-16-89G December 2015, or subsequent revision), taking into consideration NSF policy and practice as provided in this manual. Recipients should note any departures from these GAO guides and explain their rationale. Some specific GAO best practices are highlighted below to show how they should be integrated with NSF processes.

- Define the estimate's purpose, develop an estimating plan, and identify ground rules and assumptions as described further by the CEP in Section 4.2.2.1.
- Define project characteristics as described further by the PEP in Section 3.4.
- Present the estimate in accordance with the project WBS as described further in Sections 4.2.3.2 and 4.2.3.3 below.
- Obtain data and develop a point estimate. The estimating method, level of detail, and accuracy range will evolve and improve through the design Phases of the project as described further in Sections 4.2.3.4 below. Far in advance of stage gate reviews, POs should work with LFO and DACS to determine the estimating methods appropriate for each project.
- Conduct a sensitivity analysis to examine the effects of changing assumptions and ground rules so that decision makers know the range of potential costs that surround a point estimate and the major cost drivers.
- Conduct a risk and uncertainty analysis as described further in Sections 4.2.5 and 5.2 below.



- Use the “Eight Types of Independent Cost Estimate Reviews” as overarching guidance for independent cost estimate reviews of large facilities projects. These reviews validate the estimate and help determine whether the estimate is well documented, comprehensive, accurate, and credible. Recipients may choose to perform their own independent cost estimate reviews before submitting proposals to NSF. Far in advance of stage gate reviews, POs should work with LFO and DACS to determine the type of review appropriate for each project.
- The results of an independent cost estimate review will be factored into the NSF cost analysis. To ensure maximum usefulness of the review, it will generally be done as part of the Preliminary Design Phase. This will ensure that analysis is available for feedback to the Recipient prior to commencing the Final Design Phase and to help establish the MREFC budget request to the NSF Director, the NSB, OMB, and Congress post-PDR. The review will be reconciled with the Recipient’s Preliminary Design Phase Cost Estimate in the CPRD and all findings and conclusions should be substantially resolved prior to any agreement for construction being awarded.
- Document the estimate and present the estimate for review as described further in Sections 4.2.2.4, 4.2.2.5, and 4.2.2.6 above and 4.2.3.2, 4.2.3.3, and 4.2.3.4 below.
- Update the estimate to reflect changes and actual costs including EVM, as support by Sections 4.2.3.3 and 4.2.3.4 below, and further described in Sections 3.4.1 and 5.7.

#### 4.2.3.2 Construction Cost Reports Overview

Construction Cost Reports are necessary at the CDR, PDR, and FDR, at minimum, to provide a comprehensive, consolidated estimate of construction costs, including baseline costs and contingency.

The Project Execution Plan described in Section 3.4 of this manual includes a Construction Cost Book Report as one component of the overall Construction Project Definition. The Cost Estimating Plan and Construction Cost Book Reports provide assumptions and detailed information forming the Basis of Estimate. The following additional high level information should typically be provided as an overview and executive summary to assist with the review process described in Section 2 of this manual. Recipients should consult with the PO and G/AO as necessary to identify any other specific cost reports and content required to support the review.

- An executive summary of the overall project, including a narrative explaining the project scope (description, location, facility/vessel(s), planned science work, timeline, stakeholders), the overall basis of estimate, common assumptions across all WBS areas, and any other significant factors or considerations.
- A comparison of the current estimate to the approved cost, schedule and scope requirements defined in the project baseline, and an explanation and corrective action for any deviations.



- Reference to the Scope Contingency portion of the PEP, reinforcing how de-scoping strategies are possible and realistic without impairing the project's scientific value.
- Reference to the CEP cost inflators and estimate methodology.
- The overall WBS and WBS Dictionary should be provided, highlighting any changes (A sample WBS Format is provided in Figure 4.2.3-1 below).
- Overall high level cost summary charts, tables, profiles, and reports; depicting total and annual costs; reported both by WBS and in NSF budget format; providing both Current Year and Then Year costs.
- Explanation of how project costs by WBS map to the NSF budget format, including detailed traceability or crosswalk matrix, described further below.
- Overall High Level Schedule Phasing for the Project (planning, design, engineering, contracts, permitting, construction phasing, commissioning, start-up)
- Budget contingency estimate amounts, including overall contingency as a percentage of the performance baseline, rolled up from specifically assigned contingencies from a deliverable at the WBS level, per Sections 4.2.5 and 5.2 of this manual.
- Other reports, as needed, e.g. costs by resource types (subcontract, labor, materials, travel), cost profiles (total, labor, non-labor, by WBS sub-element), personnel profiles (Full-time-equivalents by WBS sub-element).
- Other Relevant Information, as needed, e.g., description of acquisition strategy, contract type(s), source(s) of funds.
- A statement positively affirming Recipient compliance with applicable federal regulations and NSF policy, including the LFM and GAO Cost Estimating and Assessment and GAO Schedule Assessment Guides.

#### 4.2.3.3 Construction Cost Book Report Format and Work Breakdown Structure

As described in the GAO Cost Estimating and Assessment Guide, the WBS is the essential cornerstone of every project because it defines in detail the work necessary to accomplish a project's objectives. The WBS is a **deliverable-based** and hierarchical framework structure that provides specific, manageable and schedulable baseline tasks and may be composed of products, material, equipment, services, data, and support facilities that the project must yield. The WBS provides a consistent framework for planning, estimating costs, developing schedules, identifying resources, and determining where risks may occur. The WBS is a valuable communication tool and provides the means for measuring program status using Earned Value Management. WBSs are developed at varying levels of detail. Generally, the number of levels employed should be sufficient to identify and measure progress towards achieving deliverables, assign responsibility, and enable effective management and reporting. The number of decomposition levels varies depending on the project's size and complexity, technical maturity, organizational constraints, acquisition and construction strategies, and management's assessment of need.



Guidance and examples of common WBS elements can be adapted from GAO, DOE, DOD and other guidance and tailored for NSF projects (U. S. Department of Energy WBS Handbook dated August 16, 2012) (DoD Standard Practice WBS for Defense Materiel Items, MIL-STD-881C, dated 3 October 2011). The benefits of developing consistent or similar WBSs across projects within an organization include:

- Consistent, clear, and familiar reporting structures and organizational relationships
- Improved efficiency and effectiveness of NSF cost analyses
- Better characterization of project schedule, scope, and cost
- Ease of judging completeness and reasonableness
- Better collection and sharing of data and analysis methods across multiple contractors and projects
- Better cost tracking over time, and identification of major cost drivers and systemic problems across contractors and projects

Examples of potential components of a WBS, common to many NSF plans for construction of large facilities, are listed in Figure 4.2.3-1 and further described below. Additions and/or alterations to this list are likely, due to the unique nature of each specific project.

A basic description of each WBS is as follows:

- 1.0 Project Administration and Management Office – Include activities related to the management and administration of the project. This includes quality assurance and safety, reliability, document control, cost/schedule reporting and control systems, and configuration management.
- 2.0 Facility Infrastructure and Civil Construction – Includes the design, procurement, construction, and integration, of the supporting infrastructure. One example is a telescope and site construction, consisting of the facility enclosure, dome, and telescope mount.
- 3.0 Scientific Equipment and Instrumentation – Includes unique and specialized scientific equipment. For example, field sensors and gages.
- 4.0 Computers and Cyber-Infrastructure – Includes hardware and software needed to operate the system and collect and analyze data.
- 5.0 Systems Integration, Testing, and Commissioning – Includes the overall systems infrastructure and personnel needed to integrate other WBS elements to ensure they work correctly together for testing, commissioning, training, and operations.



Figure 4.2.3-1 Construction WBS and Cost Book Report Sample Format

- 1.0 Project Administration and Management Office
  - 1.1 Project Management Office
  - 1.2 Site Office
  - 1.3 Science Office
  - 1.4 Education and Public Outreach
  - 1.5 Safety and Environmental Assurance
- 2.0 Facility Infrastructure and Civil Construction
  - 2.1 Sub-element X
  - 2.2 Sub-element Y
  - 2.3 Sub-element Z
- 3.0 Scientific Equipment and Instrumentation
  - 3.1 Subcomponent X
  - 3.2 Subcomponent Y
  - 3.3 Subcomponent Z
- 4.0 Computers and Cyber-Infrastructure
  - 4.1 Data Infrastructure
  - 4.2 Data Products
- 5.0 Systems Integration, Testing, and Commissioning
  - 5.1 Common Utilities and Support Equipment
  - 5.2 Early System Assembly, Integration, and Testing
  - 5.3 Acceptance Testing
  - 5.4 Training
  - 5.5 Science Verification

#### 4.2.3.4 Construction Cost Book Detail and Supplementary Guidance

This section discusses additional detailed information needed for cost analysis of the WBS deliverable-based and hierarchical framework to determine if Recipient proposals for construction awards are allowable, allocable, reasonable, and realistic. This information is intended to supplement the standard GAO best practices and grant guidance from the GPG in the PAPPG. The guidance should improve project execution, clarify NSF expectations, assist Recipients, facilitate NSF review with fewer iterative resubmissions, and prevent recurrent issues. Recipients should note any departures from this guidance and explain their rationale. It is understood that this information will become further refined as the Design Stages advance.



### Presentation and Linkages

- Individual WBS element costs must have a sound, fully justified and documented, and sufficiently detailed Basis of Estimate. Figure 4.2.3-2 below provides an example Construction Cost Book Sheet depicting the format and content typically needed to consolidate the “Cost Model Data Set” and to provide the appropriate level of detail and BOE. This sheet includes the following information:
  - WBS and activity codes and descriptions, per the WBS Dictionary, to index the cost estimate to a specific deliverable
  - Statement of Work describing the scope
  - Estimator Name and Date of Estimate
  - Resource Descriptions
  - Cost Basis Codes describing the estimate methodology (e.g., expert opinion, analogy, parametric, or engineering build-up)
  - Direct Costs with Units and Hours
  - Associated Fringe and Indirect Costs
  - NSF Budget Category Code corresponding to the budget categories depicted in Figure 4.2.2-2 and Section 4.2.2.4 above, to allow mapping between WBS sub-elements in Construction Cost Book Reports and NSF Budget Categories on NSF Budget Forms
  - Basis of Estimate source data, with breakout of sub-elements, typically including direct input from technical experts in that area with calculations using material and labor quantities and unit prices, with clear assumptions and sources referenced
  - Risk and uncertainty identification and determination of parameters used in risk assessment and contingency estimation
  - Contingency estimate amounts and/or percentage of baseline, either by cost item, activity level, or WBS element (optional, may be determined elsewhere)
- Estimates must have clear traceability, including the following, as appropriate, for CDR, PDR, FDR, and Construction:
  - The total estimated cost must correlate to construction drawings and specifications, material take-offs and bills of material, and estimated schedule durations.
  - Lower levels of the WBS must correctly roll-up to the higher levels, and the application of rates and factors must be consistent with the cost estimating plan, basis of estimate, supporting rate agreements, and Recipient accounting practices.
- WBS sub-element costs must be readily mapped to NSF Budget Categories depicted in Figure 4.2.2-2 and Section 4.2.2.4 above; for example:
  - If each cost element on the Figure 4.2.3-2 Cost Book Sheet is assigned an NSF Budget Category Code (e.g., “A for Senior Personnel,” “E for Travel,” “G4 for Computer Services,” “I for Indirect Costs”), then the WBS elements can readily be compiled into standard NSF Budget Forms, which depict total cost types





- across all WBS elements (e.g., all personnel, equipment, travel, indirect, or computer services costs across all WBS elements)
- If databases are sufficiently detailed, documented, and traceable, then automatic sorting and summarizing of costs will be facilitated for various purposes and for different reporting formats.
- Cost estimates may be directly linked to scheduling tools, to allow automatic cost updates with schedule changes.

#### BOE Refinement Process

- Because of the hierarchical nature of the WBS, it is possible, over time, to refine the level of detail at which the project scope, schedule, and task-based costs are captured. Throughout the Design Stage the task and cost fidelity will increase, and eventually, during the construction of the Project, the plans will be fully detailed. As the project moves through the phases, detailed engineering build-up estimates using current quotes and prices should be collected, such that the proportion of estimated costs based on expert opinion, analogy, or parametric estimates is reduced. As the project finalizes plans for the start of construction the basis of estimate should include more vendor contract prices.
- Direct labor rates, quantities, and skills mix should be justified, including information from sub-awards.
- If using Consultants and Subcontractors, Recipients should carefully justify substantial consulting costs, including the type of work performed, quantity of time proposed, and its cost, as compared to potentially less expensive current employee labor to accomplish the proposed work.
- Cost estimates should include adequate funding for project management, including the use of appropriate project management tools such as project management control software and associated staff support.
- The MREFC construction cost estimate should typically include commissioning, testing and acceptance of the facility and transition from construction/acquisition to operations, including funding for staff to perform these activities and train the operations personnel. Roles change as a project progresses from construction through commissioning and eventually to operations; time and staffing requirements need to be carefully calculated in advance, with clear demarcation between MREFC funded scope and R&RA or EHR funded operations.
- Where partnerships are involved, monetary contributions acquisition and eventual operations and usage should be timely, sufficient, and well documented in the PEP and IMP.
- Cyber-infrastructure technical requirements and costs (both initial cost and continuing costs of hardware, software, maintenance, upgrades and operations) should be carefully considered and periodically validated. Rapid advances in computing may require upgrades as often as every 3 to 5 years.



Figure 4.2.3-2 Construction Cost Book Sheet Sample Format

Activity Summary										Year	
Institution:		Funding Source:		WBS Element:		Estimator:		Date:		Year	
Activity:		Activity Description:		Provide WBS element number and description per WBS Dictionary		Estimator Name, Date		FY of Estimate			
Personnel Costs Detail		Equipment, Travel, Participant Support Costs Detail		Materials/Supplies, Publication, Consultants, Computer Services, Subawards, Other Costs Detail		Total Base		Contingency		Total W/Contingency	
(A + B + C) + I		(D + E + F) + I		(G1 + G2 + G3 + G4 + G5) + I		\$0.00		\$0.00		\$0.00	
Personnel Costs Detail (A + B + C) + I											
Exp Code	NSF Code	Resource ID - Price Group	Resource Description	Cost Basis*	Labor Hours	Direct Labor	Fringe	Indirect Cost	Total Burdened Labor Cost		
Label NSF Budget Category Codes, e.g., A for Senior Personnel, D for Equipment, G.5 for Subawards		Provide Labor Resource Descriptions, e.g. Manager, Mechanical Engineer, Electrical Technician			Provide associated Fringe and Indirect Costs						
*Cost Basis: CP-Catalog Price OR-Cost Relationship EE-Engineering Estimate HD-Historical Data VQ-Vendor Quote VE-Vendor Estimate											
Equipment, Travel, Participant Support Costs Detail (D + E + F) + I											
Exp Code	NSF Code	Resource ID - Price Group	Resource Description	Cost Basis*	Material Units	Direct Material	Indirect Cost	Total Burdened Material Cost			
Provide Other Direct Cost Resource Descriptions, e.g. Concrete, Design Consultants, Computer Software, Construction Contracts				Show Direct Cost Calculations with Labor Hours and Material Units							
*Cost Basis: CP-Catalog Price OR-Cost Relationship EE-Engineering Estimate HD-Historical Data VQ-Vendor Quote VE-Vendor Estimate											
Materials/Supplies, Publication, Consultants, Computer Services, Subawards, Other Costs Detail (G1 + G2 + G3 + G4 + G5 + G6) + I											
Exp Code	NSF Code	Resource ID - Price Group	Resource Description	Cost Basis*	Material Units	Direct Material	Indirect Cost	Total Burdened Material Cost			
Provide Equipment, Travel, and Participant Cost Resource Descriptions, e.g. Specialized Equipment, Foreign Travel			Provide Cost Basis Code for estimate methodology, e.g., expert opinion, analogy, parametric, or engineering build-up								
*Cost Basis: CP-Catalog Price OR-Cost Relationship EE-Engineering Estimate HD-Historical Data VQ-Vendor Quote VE-Vendor Estimate											
Risk Assessment and Contingency Calculation (G6)											
Risk:	Risk Factors		Risk Multipliers		Risk Adjustments		Total Risk Multiplier:		Estimated Contingency Amount:		
Technical:							Override Multiplier:		\$0.00		
Cost:											
Schedule:											
Provide associated Risk number from Risk Management Plan in PEP, Calculations, and Estimated Contingency Amount											
Statement of Work											
This activity includes:											
Describe the scope of the specific activity and clarify any items not included and covered elsewhere											
Basis of Estimate											
Provide a narrative explaining the approach to the estimate and any assumptions, research, sources, references, calculations, etc.					Directly attach, reference, or electronically link to any additional supporting information and references, e.g., drawing numbers, technical specification sections, technical requirements, catalog price sheets, vendor quotes, labor rate sources, RSM means tables, etc.						
Provide Source Data and Calculations for the Basis of Estimate, e.g., Labor Rates and Unit Prices referencing Source Material											



## 4.2.4 Cost Estimating and Analysis for Operations Awards

### 4.2.4.1 Purpose

In addition to the specialized scientific expertise required for operations, award solicitations can also include expectations for budgeting and business systems and operational or financial reports. As discussed in the NSF PAPPG, individual solicitations, and Section 2.5, these systems and reports help ensure the science mission can be met in a cost effective way.

NSF utilizes internal staff, outside experts, and panel reviews to ensure cost estimates and budgets meet expectations and are allowable, allocable, reasonable, and realistic. It is incumbent on NSF to plan and budget for effective research and educational use of facilities, as well as the costs to operate and maintain the facility long term. The PO will generally refer to the funding profile and cash-flow analysis developed by Program or in collaboration w/an existing Recipient to make budgeting and funding decisions. If anticipated by NSF and as discussed in Section 2.6 of this manual, proposals will be requested to address partial or full termination of the facility during the award period, including property decommissioning and disposition costs and other costs related to employee separations. It is incumbent upon the Recipient to ensure their operations proposal is complete, appropriate, and reasonable.

### 4.2.4.2 Operations Awards Proposals Overview

In addition to the Annual Work Plans, Annual Reports, and Annual Operations Reviews described in Section 2.5.1 of this manual, the following information may be requested via the operations and management award solicitation:

- Periodic plans that may include an executive summary, narrative overview, strategic and annual objectives correlated to NSF mission needs, and an annual operating budget focusing on any significant changes from previous plans. Plans may also include expected scope, milestones, outcomes and impacts, developments, challenges and opportunities, as necessary.
- A functional activity and/or deliverable based work breakdown structure. A sample format for operating facilities is provided below in Figure 4.2.4-1, if not otherwise specified in the Programmatic requirements or the solicitation.
- Explanation of how program costs within functional areas are coded or otherwise related to the NSF Budget Categories depicted in Figure 4.2.2-2 and Section 4.2.2.4 above.
- Other reports, such as annual cost by resource types (subcontract, labor, materials, travel), cost profiles (total, labor, non-labor, by sub-element), and personnel profiles (Full-time-equivalents by sub-element).

### 4.2.4.3 Operations Awards Proposals Format

As discussed in Section 4.2.3.3, there are numerous benefits of standardizing the work breakdown structure across projects within an organization. An example of a hierarchical work



breakdown structure for an operations award is provided in Figure 4.2.4-1 below. Additions and/or alterations to this list are likely, due to the unique nature of each specific project. The level of detail contained in the cost reports may vary depending on Programmatic management requirements and cost analysis effort.



Figure 4.2.4-1 Operations WBS and Budget Sample Format (For Each Physical Site Location or Decentralized Overall Research Activity)

- 1.0 Project Director, Management, and Administration Office
  - 1.1 Director's Office
  - 1.2 Project Management Office
  - 1.3 Site Office
  - 1.4 Education and Public Outreach
  - 1.5 Safety and Environmental Assurance
  - 1.6 Administrative Services
- 2.0 Science Operations
  - 2.1 Principal Investigator(s)
  - 2.2 Scientists
  - 2.3 Postdoctoral Scholars
  - 2.4 Students
- 3.0 Significant/Important Infrastructure Modernization, Overhaul, Upgrade, Replacement, Expansion
  - 3.1 Equipment
  - 3.2 Facilities/Infrastructure
  - 3.3 Computer Systems, Instrumentation
- 4.0 Facility and Equipment Operations, Maintenance, Engineering, and Support Services
  - 4.1 Operations
    - 4.1.1 Scheduling
    - 4.1.2 Operating
    - 4.1.3 Testing
  - 4.2 Maintenance
    - 4.2.1 Corrective Maintenance
    - 4.2.2 Preventive Maintenance
  - 4.3 Utilities
    - 4.3.1 Energy (e.g., electricity, natural gas, central heating, central cooling)
    - 4.3.2 Information Technology, Communications
    - 4.3.3 Security
    - 4.3.4 Water
  - 4.4 Other/General Support Services
- 5.0 Contingency (If Requested)



#### 4.2.4.4 Operations Awards Proposals Supplementary Guidance

This section discusses additional detailed information typically needed by NSF to determine if Recipient proposals for operations awards are allowable, allocable, reasonable, and realistic. This information is intended to supplement the standard GAO best practices and grant guidance from the GPG in the PAPPG. The guidance should improve project execution, clarify NSF expectations, assist Recipients, facilitate NSF review, and prevent recurrent issues with fewer iterative resubmissions. Recipients should note any departures from this guidance and explain their rationale. For existing awards, the Recipient should consult with the PO.

- It is the Recipient’s responsibility to manage and maintain the NSF-funded facilities, equipment, and instrumentation used in the conduct research. However, NSF rarely maintains ownership to major research equipment and facilities it funds. This stewardship responsibility is necessary to protect the U.S. Government’s and the public’s investment in these unique research facilities. In accordance with federal guidance for property that NSF owns, leases, or otherwise manages [41 CFR 102-84 “Annual Real Property Inventory”, GSA Guidance for Real Property Inventory Reporting], Recipients should annually provide a brief discussion, cost estimate, and actual expenditures at a high level for the following:
  - Recurring routine maintenance and repair.
  - Significant infrastructure changes, including modernization, overhaul, upgrade, replacement, and/or expansion for science facilities, equipment, utilities, and/or instrumentation.
  - Utilities (including facility operation and purchase of energy)
  - General support services (such as grounds and waste management).
- For property that NSF does not own, lease, or otherwise manage, Recipients should consider federal guidance when developing their operational cost proposals.
- When power costs are significant and volatile, a strategy for dealing with price fluctuation should be developed as part of the operations plan. Other examples of items that may require separate consideration are expendables – such as cryogenes, gases and spare parts – and ancillary equipment such as refrigerators and IT equipment.
- Separate funding sources and revenue streams (e.g., visitor center fees) should be clearly delineated.
- Education and Public Outreach opportunities and associated costs should be explicitly identified and explained.
- Multiyear budgets should take inflation into account, using factors discussed in Section 4.2.2.6 above. However, when NSF budgets are flat, NSF may not be able to afford inflationary increases in operations funding for facilities, and reductions in staff and/or operations may be required.

Contingency, if requested, must be in compliance with Section 4.2.6 of this manual.



## 4.2.5 Budget Contingency Planning for the Construction Stage

### 4.2.5.1 NSF Policy Positions

1. “Management reserve” is not allowable in the risk-adjusted Total Project Cost (TPC) estimate; only “contingency.”
2. Directorates shall be responsible for the first 10% of cost overruns which exceed the Board approved TPC.
3. At the Preliminary Design Review (PDR), projects shall have a prioritized de-scoping plan that equates to at least 10% of the performance baseline.
4. In support of NSF’s “No Cost Overrun” policy, projects shall use a confidence level for contingency estimates between 70 and 90 percent (under a probabilistic approach) based on the particulars of the project and the inherent ability to de-scope.
5. NSF will hold budget contingency through project completion, in an amount up to 100% of the total NSF-approved contingency budget, until it can be justified for obligation.

### 4.2.5.2 Introduction

NSF’s “No Cost Overrun” policy was originally codified in the Fiscal Year (FY) 2009 budget request to Congress which reads:

*“NSF is implementing a ‘no cost overrun’ policy, which will require that the cost estimate developed at the Preliminary Design Stage have adequate contingency to cover all foreseeable risks, and that any cost increases not covered by contingency be accommodated by reductions in scope. NSF senior management is developing procedures to assure that the cost tracking and management processes are robust and that the project management oversight has sufficient authority to meet this objective. As project estimates for the current slate of projects are revised, NSF will identify potential mechanisms for offsetting any cost increases in accordance with this policy.”*

The policy has been continually reinforced in subsequent budget requests to Congress and although the wording has changed slightly, the intent has remained the same.

“Contingency” is a critical component of the comprehensive planning and execution of the construction of large research facilities. This document describes the policies and procedures concerning the planning, use, and oversight of budget contingency in the construction of facilities fully funded by NSF and to the NSF-funded component of the scope when NSF partners with other entities. It also describes the NSF’s process for assessing the sufficiency of contingency, evaluating the effectiveness of management plans used for administration of contingency, and NSF’s oversight role in the use of contingency funds.

This document applies only to award instruments (assistance awards or contracts) between NSF and academic institutions or non-profit organizations. For assistance awards (CAs or grants) with academic institutions and non-profit organizations, contingency is held by the Recipient in



accordance with the Uniform Guidance (§ 200.433). Contract regulation governs the planning, use and oversight of contingency for contracts with commercial organizations. Regardless of where contingency is held, the requirement for a well substantiated risk assessment and contingency estimate, as well as a robust oversight and administration is essential. Estimating contingency and managing risk is an integral part of the project planning and execution process. NSF positions on contingency, management reserve and de-scoping must be considered by the Program and the Recipient as part of that process. **Although strategies for other types of contingency are mentioned here, this document is only intended to address management of the budget contingency.**

The definition of contingency varies widely among project management practitioners and federal agencies. For NSF,<sup>1</sup> budget contingency covers the “known unknowns” and is used to mitigate identified cost or schedule risks as described in the Project Execution Plan<sup>2</sup> (PEP). The estimated risk-adjusted TPC, which is the sum of the performance baseline and the budget contingency, is developed in accordance with the GAO Cost Estimating and Assessment Guide,<sup>3</sup> as explained elsewhere in this manual. OMB’s cost principles in the Uniform Guidance address budget contingency, and define it as:

*... that part of a budget estimate of future costs (typically of large construction projects, IT systems, or other items as approved by the Federal awarding agency) which is associated with possible events or conditions arising from causes the precise outcome of which is indeterminable at the time of estimate, and that experience shows will likely result, in aggregate, in additional costs for the approved activity or project. Amounts for major project scope changes, unforeseen risks, or extraordinary events may not be included.*

In contrast, “Management Reserve”<sup>4</sup> is often used by industry and other organizations to cover the unforeseen risks, or the “unknown unknowns.” **However, NSF has no mechanism for holding management reserve. As a result, the Directorate is responsible for the first 10% of costs which exceed the approved TPC.** To mitigate this risk, the project’s prioritized and time-phased de-scoping plan must equal **at least 10%** of the performance baseline when established

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<sup>1</sup> NSF terminology aligns with that of AACE International, the Association for the Advancement of Cost Engineering, and of the Project Management Institute’s *Project Management Body of Knowledge (PMBOK Guide)*. See Section 5.2.3 for NSF definitions of contingency and management reserve.

<sup>2</sup> See Section 3.4 for details regarding the PEP. Note that the PMBOK guide refers to “Project Management Plan” rather than PEP, but the NSF definition of PEP is equivalent.

<sup>3</sup> Note that the NSF definitions and treatment of contingency and management reserves differ from those used in the GAO Cost Estimating and Assessment Guide.

<sup>4</sup> The GAO Cost Estimating and Assessment Guide (GAO-09-3SP, March 2009) uses the term “management reserve” for funds held for mitigation of “known unknowns” whereas NSF uses the term “contingency.” For GAO, management reserves are included in the budget baseline and are managed at the contractor level. The value of the contract includes these known unknowns in the budget base, and the contractor decides how much money to set aside.





at PDR. The ability to de-scope varies widely by project and the impacts on the eventual scientific capabilities of the facility will also vary. The scope contingency plan should be well considered and strive to minimize negative impacts. The Directorate may also choose to cover the cost overrun from programmatic funding (and increase the TPC) in lieu of de-scoping if it deems the science-support capabilities of the facility would be too severely impacted.<sup>1</sup> See Section 2.4.1 of this manual for required approvals.

The PEP describes a construction project's scope, budget, schedule, and identified risks. It also articulates the project's plans for accomplishing the intended scope while satisfying the constraints of budget and schedule, and managing those risks. An essential component of the PEP is the Risk Management Plan (RMP), which describes the project's procedures for risk identification, analysis, monitoring, and handling (including de-scoping if required) so that the project has a high likelihood of being accomplished within the total available budget. Budget contingency is only one tool used to control project risk. The RMP will also include methods and tools to manage scope contingency, schedule contingency, and provide robust risk handling and monitoring processes. Refer to Section 5.2, Risk Management Guidelines, for additional information.

The development of budget contingency entails estimating the future potential impacts of identified possible adverse events to the project (i.e. risks) if those events are ultimately realized. In accordance with the Uniform Guidance, NSF requires the use of widely accepted risk management practices (including parametric and probabilistic methods depending on project maturity) to estimate a range or distribution of contingency. An appropriate value is then selected from that range that will enable the project to successfully complete the required scope within the TPC that is sent forward for National Science Board (NSB) for approval. **In support of NSF's "No Cost Overrun" policy, confidence levels must be in the 70-90%<sup>2</sup> range when the project baseline is set following PDR depending on the nature of the project; including the ability to de-scope.** This applies even for higher risk projects. The resulting TPC estimate, including estimated contingency required, will ultimately factor into NSF's decision on whether or not to proceed with the project. **This policy position is in no way intended to discourage the construction of cutting-edge, high risk facilities needed to advance scientific understanding. It is intended to give a high degree of confidence that the project will come in on budget and clearly articulate the level of risk involved so that sound decisions can be made.** Following construction start, if subsequent analysis shows that confidence is declining and the TPC will be exceeded, NSF requires that a reduction in scope be considered as the initial strategy to bring the costs back in line with the budget.

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<sup>1</sup> Directorates are able to do this as a result of NSF's "transfer authority" which is dependent on continued inclusion in the appropriation act. The language may require that congressional appropriation committees be notified in advance of any reprogramming. Directorates should consult with the Budget Office during the decision-making process.

<sup>2</sup> GAO Cost Estimating and Assessment Guide (GAO-09-3SP, March 2009, pg. 158) states that the use of confidence levels of 70 to 80 percent is now common practice, particularly with projects having higher design complexity and technology uncertainty as with NSF-funded facilities.



**Since development of contingency is statistically-based, there is a chance that not every risk will be realized at its maximum impact. Therefore, even when properly managed, it is possible that contingency dollars will remain at the end of the project.** Once project objectives are met and the project completed, **any residual funds must be de-obligated and returned to NSF** at which time NSF will request possible re-allocation of those dollars to other agency priorities. Awarded contingency shall be held by the Recipient until project completion, but no later. Budget, Finance and Award Management (BFA), the Large Facilities Office (LFO), and the Program Office will conduct a project close-out with the Recipient in accordance with NSF policy and as described in Section 2.4.3 of this manual.

Major strategies used by NSF to ensure accountability in the management of contingency budgets include:

- Contingency budgets are developed in accordance with widely accepted standards for risk assessment and planning. Contingency budget, scope, and schedule are similarly derived from probabilistic, bottom-up assessments of the entire project scope.
- Contingency budgets are evaluated for reasonableness by NSF through use of expert review panels convened by the Program that examine the BOE and methodology, and compare the cumulative contingency reserve amounts with historical experience on similar projects. This happens at each phase of the project (Conceptual, Preliminary, and Final Design) at increasing levels of refinement. Other divisions within NSF, and potentially contracted experts, will also evaluate the contingency estimate as part of the total project cost assessment as it moves through these phases.
- The overall status of remaining contingency, future liens on contingency, and all allocations and returns of contingency funds (as risks are realized or retired) are reported on a periodic basis as specified in the award instrument. This is part of the standard project reporting and requires archiving in the permanent electronic record used by NSF (FastLane/e-Jacket).
- Management and use of contingency is documented separately through the configuration and change control process and must reference the associated Work Breakdown Structure (WBS) elements and/or the previously identified Risk. The Earned Value Management (EVM) framework for financial status reporting will eventually reflect movement of contingency into the baseline budget (increase or decrease in Budget at Completion; BAC). Although traceable as allocations or returns to the contingency budget, contingency dollars become part of the baseline and are no longer separately identifiable as contingency once incorporated.
- All project expenditures must be used only for scope as defined by the elements of the NSF approved performance baseline, and all are subject to financial audit.
- Management of contingency is described in the Configuration and/or Contingency Management Plan as part of the PEP. In this plan, thresholds are established (based on



the nature of the project) on who has the authority to approve the use of contingency. These thresholds are also documented in the award instrument. Below the thresholds, the Recipient has authority to manage and allocate contingency budget to specific in-scope elements of the project WBS following the Configuration Change Control Process. Above these thresholds, approvals from NSF are required, with the level of approval corresponding to the magnitude of the proposed change.

- Financial controls prevent the cumulative Recipient cash draws from exceeding the obligated spending authority in NSF's financial system.

#### **4.2.5.3 Contingency Planning and Assessment during Conceptual Design**

A budget estimate, like the measurement of a physical quantity, has a value and an uncertainty dependent on where the project is in the design process. The uncertainty in the budget estimate is a consequence of identification of foreseen project risks and other “known unknowns” that are under the control of the project; including scope that is not cost effective to define in detail during preconstruction planning or the earlier phases of design. The ability to estimate these risks and uncertainties naturally changes over time as the design is refined and the understanding of the project matures. Recipients are required to develop methods for qualitative and quantitative assessment of these risks, and to develop an optimized risk handling strategy that evolves with the project.<sup>1</sup> Regardless of the phase, the BOE for contingency development must be sound and well documented, but remain appropriate for that phase.

For the Conceptual Design Phase, both the performance baseline estimate and the uncertainty of that estimate should be based on expert judgment and parametric models developed by the project planners based on scaling and extrapolating historical data from projects with similar characteristics. When NSF conducts the Conceptual Design Review (CDR), it expects that Recipient will have developed a risk-based, budget contingency estimate at a similarly refined level of detail; one that is based on estimates for major elements or functional components of the proposed facility. NSF will conduct the CDR using a panel of experts able to apply prior experience to assess the reasonableness of the budget and contingency estimates. The budget contingency estimate will be evaluated by NSF as part of its first internal cost analysis for the project based on the CDR deliverables. This initial cost analysis will help inform the cost book and other deliverables developed during the Preliminary Design Phase.

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<sup>1</sup> See Section 5.2, Risk Management Guidelines, for more information about formulating and implementing Risk Management Planning, and standard references on project management, such as the PMBOK Guide, for a detailed explanation of the individual steps in Risk Management Planning: risk identifications, qualitative and quantitative risk analysis, risk handling, and risk monitoring.



#### 4.2.5.4 Contingency Planning and Assessment during Preliminary Design

During the Preliminary Design Phase, NSF requires Recipients to develop budget estimates and associated risk estimates that are “bottom up” assessments<sup>1</sup> that consider every element of the entire project, using as inputs the definitions of the lowest appropriate WBS elements. For each lowest level element, the project should estimate its expected cost, **excluding** unusual risks or occurrences that are outside the control of the project (unknown unknowns normally covered by de-scoping). The project should also separately estimate, at the appropriate WBS element for the risk described, the technical, cost and schedule risks or uncertainties using a widely accepted method that is employed by all estimators. NSF expects to see the project utilize a probabilistic method of calculating a range of risk exposures appropriate to the project area in question and the maturity of the risk assessment. Expert judgment should always be applied to both the inputs (BOE) and outputs of this process, to the reasonableness of potential cost and schedule impacts, and to the applicability of the process to specific areas of the project. In some circumstances, such as where specialized knowledge of a particular technical area or market condition exists, it can be appropriate to override the outputs based on expert intervention. Supporting documentation should clearly articulate which risks elements were considered and how they were modified when making any adjustments to the model outputs.

It is not always realistic or even feasible to mitigate all anticipated risks. It is extremely unlikely that typical projects will encounter all of the risks and the full extent of possible consequences that have been identified. The contingency estimate should be appropriate to manage only the ensemble risk, which is much more likely to occur than the sum of the individual risks. This approach produces a more likely estimate for the TPC compared to an approach where Cost Account Managers increase individual WBS elements to cover risk. **Use of rigorous probabilistic cost estimating methods that estimate confidence levels for the TPC (such as Monte Carlo methods based on probability distributions for risk) are preferred and NSF highly encourages application of these methods where practical.** As a result of these estimating activities, the project should develop the contingency estimate that provides a high degree of confidence that the project can be completed within budget per NSF’s “No Cost Overrun” policy.

Budget, scope, and schedule risk are usually correlated to some extent. A change in scope, for instance, may mean more costs and additional schedule. Risk analysis and budget and schedule contingency estimation methods must consider the degree of correlation in estimating an appropriate level of budget contingency.

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<sup>1</sup> See Section 5.2, Risk Management Guidelines, for more information about formulating and implementing Risk Management Planning, and standard references on project management, such as the PMBOK Guide, for a detailed explanation of the individual steps in Risk Management Planning: risk identifications, qualitative and quantitative risk analysis, risk handling, and risk monitoring.



Budget contingency is developed based on risk assessment of individual WBS elements, but once defined; it loses its identification with any specific cost element and is fungible throughout the project to manage the overall project risk. Until then, contingency is held separately from the project baseline budget estimate<sup>1</sup> that is used for Earned Value Management reporting, but is included in the Total Project Cost, regardless of the award instrument.

NSF requires the PEP to contain a performance baseline that defines the project's intended scope, budget, schedule, risk, and management plans. The PEP will include provision of schedule and scope contingency<sup>2</sup> for use by the Project Manager, developed according to the following additional considerations:

*Schedule contingency:* The construction schedule should be developed in the same manner as the budget contingency estimate, following the WBS structure at the lowest available level of detail. The project should make a technical estimate for each task's duration and its dependence on other tasks.

*Scope contingency:* NSF requires projects to assess possible use of scope contingency and develop a plan to make effective use of scope contingency, if necessary, during construction. This provides the project with an additional tool to manage the overall project given the lack of Management Reserve within NSF.

NSF requires, at Preliminary Design Review (PDR), that the contingency budget, schedule, and scope are the outcome of detailed planning by the project for how best to handle the various risks that have been identified. Some risks are most effectively handled proactively by investing in additional developmental and design activities or resources intended to prevent the risk from occurring.

At the PDR, NSF requires a funding profile by fiscal year that includes the commitment and obligation of funds, plus anticipated contingency needs. The profile should be a consequence of the project's formulation of a resource-loaded schedule for EVM reporting. Since PDR sets the project baseline budget and informs the budget request to Congress, this allows NSF to determine the year-by-year construction funding profile. The annual Congressional appropriation must be sufficient to accomplish the work proposed and provide the financial resources needed to manage the risk activities foreseen during that period.

The budget contingency estimate will be further evaluated by NSF as part of its second internal cost analysis for the project based on the PDR deliverables. This second cost analysis will give

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<sup>1</sup> That is, contingency is not included within the Budget at Completion (BAC). TPC = BAC + contingency.

<sup>2</sup> See Section 5.2.3 for definitions.



assurance on the TPC brought forward to the NSB as well as help inform the cost book and other deliverables developed during the Final Design Phase in preparation for award.

#### **4.2.5.5 Development of the Contingency Use Process**

NSF examines the RMP at PDR to ensure that the PEP describes a formal process for Change Control<sup>1</sup> that includes the allocation of contingency within the project during construction. NSF approval of the RMP, including the change control process, must be documented and maintained in the agency's permanent record. Under the RMP, the Project Manager (or other designated individual) should have budget authority to transfer to or from<sup>2</sup> the contingency category to specific WBS elements, via a process that follows the project's Configuration Change Control Plan. A typical change control process, for example, may involve written application to the Project Manager by the affected Cost Account Manager(s) and formal review and recommendation by a Change Control Board (CCB) consisting of all other system leads. The Project Manager must have the authority to then grant the requested funds, reject the request, or request a change in schedule, technical scope or other corrective action. All CCB change requests are to be logged, documented, and archived by the project, with the logs and documentation provided on a periodic, pre-determined basis to NSF for review. The defined CCB process must include a provision for seeking prior written approval from NSF (Program Officer or higher depending on the magnitude) for all actions that exceed the thresholds specified in the award instrument or NSF policy.

The CCB change request document, whether forwarded to NSF for approval or not, must have the minimum content requirements necessary to comply with relevant cost principles as well as to maintain an audit trail. See SAMPLE CHANGE CONTROL REQUEST FORM at the end of this section. This process must be examined by NSF for compliance before approval of the Change Control Plan. CCB documentation shall specify all control accounts that budget is being allocated to or recovered from, and tie to budgets itemized by cost element (i.e., labor, materials, supplies, etc.). Contingency allocations must be supported by analysis demonstrating that the proposed amounts to be allocated are considered reasonable and allowable. Allocations from contingency and returns to it may have the effect of changing the baseline budget. Therefore, it is essential that historical information be logged and maintained in a manner that allows NSF to systematically track the evolution of the baseline from its initial release through all subsequent changes. In other words, baseline budgets must be traceable through historical records to the initial baseline release.

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<sup>1</sup> Section 2.4, Construction Stage, contains additional information about NSF expectations for conducting change control.

<sup>2</sup> Some realized costs will be lower than initial estimates. Once a work package is complete, any savings should be removed from association with specific WBS elements and added to the contingency pool available to the Project Manager.



#### 4.2.5.6 Contingency Planning and Assessment during Final Design

NSF requires the project to refine its cost estimates following PDR, adding additional definition and improved confidence with the tasks associated with accomplishing the project deliverables. At the Final Design Review (FDR) the budget estimate should be substantially based on externally obtained cost estimates (vendor quotes, bids, historical data, etc.). This added definition is expected to result in an increase in the project's estimated Budget at Completion (BAC) and a reduction in its budget contingency, while TPC remains constant. Also as part of the FDR, NSF assesses the methodology employed by the project to further refine its cost and contingency estimates including schedule and scope adjustments. All of this information would then factor in to the total project cost assessment being refined and evaluated by other divisions within NSF to make the initial construction award.

#### 4.2.5.7 Contingency Use and NSF Oversight during Construction

NSF will negotiate the award instrument with the Recipient to fund project construction activities (Construction Stage). This instrument will specify the contingency amounts and include thresholds above which prior written NSF approval is required before the Project Manager may allocate contingency (as described in the approved Change Control Process in the PEP) to, or from, specific WBS elements.<sup>1</sup> The thresholds will vary depending upon the particulars of each project. Working with the Recipient, NSF will employ the following criteria when establishing the threshold or thresholds. These considerations shall be documented in the award file as well as the PEP and the IMP.

- **Award and Sub-Award amounts** – A larger award amount may warrant establishment of higher thresholds to lower administrative burden.
- **Sufficiency of project plans and designs** – More detailed project plans, specifications and designs generally lead to higher confidence and better bids which may allow the thresholds to be higher.
- **Nature of identified project risks** – The more risk associated with the nature, timing and the severity of certain project work packages may increase the need for establishing a lower threshold.
- **Review Recommendations** – Expert panel findings and recommendations should be considered in setting thresholds.
- **Recipient or Sub-recipient past performance history** – Available past performance information may help to indicate whether a Recipient's change control process is adequate or whether the Recipient has been successful in identifying contingencies, e.g., use and accuracy of contingency logs, and therefore support a corresponding appropriate threshold. Poor performance would support a lower threshold.

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<sup>1</sup> Thresholds are necessary to allow the project to respond in a timely way to small, immediate needs for use of contingency, such as field changes during construction. This avoids potential cost escalation that could result from delay.



- **Known audit findings and their disposition** – Relevant audit findings/dispositions should be considered in establishing thresholds.
- **Sufficiency of Recipient administrative systems** – The adequacy of compliance with financial and administrative systems including accounting systems, historical cost data, and financial reports may impact the thresholds.
- **Degree of NSF substantial involvement in the project** – The complexity and risks associated with the project may warrant more NSF involvement and hence lower thresholds.

Once construction begins, the actual cost for some specific WBS elements may exceed the estimated cost and the Project Manager can choose to allocate contingency in accordance with the process defined in the PEP for Change Control. In other cases, the actual cost will be less than the estimates, and the Project Manager may decide to transfer budgeted funds from the affected WBS elements to contingency. In case, whether it's a risk realized or a risk retired, the Change Control documentation must tie this transfer back to an identified risk element in the Risk Management Plan to be allowable.

Contingency funds are to be used only to support scope that is part of the NSF-approved project baseline, as defined in the PEP and successive CCB actions. Depending on the thresholds, Project Manager, CCB, NSF, and NSB approvals are required to modify the project scope. **Unexpended contingency funds may not be used to support operations or other out-of-scope activities.**

#### **4.2.5.8 Reporting Requirements**

Each project in construction must report monthly to NSF on the status of the project, while projects in the Design stage are highly encouraged to submit a monthly report. At a minimum, the monthly report will include: (1) the amount of available budget and schedule contingency, as a total amount, and as a percentage of the estimated cost to complete (ETC) the project; (2) updated projections for major milestones and project end dates; (3) an updated BAC and Estimate at Completion (EAC) for each second level element; and (4) an updated change log indicating all contingency allocations (“puts and takes”) and a “liens” list of projected amounts of possible future calls on contingency. Projects are expected to periodically compute and update the risk exposure, ETC, and EAC, and compare these quantities to the BAC and TPC. NSF will monitor the financial information provided and compare the available contingency to the estimated remaining risk exposure. NSF may request corrective action if the contingency budget appears inadequate to manage remaining risk.

All CCB actions, irrespective of amount, or whether they increase or decrease the BAC, must be reported directly to Program Officer at least quarterly. All CCB actions exceeding defined thresholds for allocation of budget, schedule, or scope contingency shall be approved by NSF as codified in the PEP and the CA. NSF-approved CCB actions must be made part of the award's





permanent record. For assistance awards (CAs or grants), CCB documentation is maintained in NSF's electronic record system (e-jacket) in accordance with the award terms and conditions.

NSF's financial system controls prevent the cumulative Recipient cash draws from exceeding the obligated spending authority. All funds are retained within NSF's obligated award amount to be drawn down by the Recipient for allowable expenses once needed. NSF conducts various post-award monitoring activities, such as periodic external reviews (whose scope includes financial as well as technical status), site visits, and single and program-specific audits to monitor compliance.

#### **4.2.5.9 Partnership Considerations**

NSF may partner with other entities to plan and construct a major facility. The guidelines within this document are applicable when NSF funds a particular scope of work within a larger overall project. Risk assessment and contingency development processes are to be applied to those WBS elements funded by NSF. Similarly, the Recipient managing construction must report on the use of contingency during construction in accordance with the requirements regarding use of contingency funds.

More complex situations may arise when NSF funds a proportion of the total project cost, or where NSF contributes along with others to a common fund to build specific WBS elements within the context of a larger project. Because overall project risk is reduced as more WBS elements are aggregated into the risk analysis and managed through a centrally held contingency fund during construction, NSF encourages the development of unified management for project planning and execution of the entire project scope wherever practical. However, NSF recognizes other partners may have different processes for planning, funding, and conducting oversight, making it challenging to form a unified management structure. Consequently, the award instrument must define the specific procedures for handling contingency in those circumstances. Program Officers are advised to consult with the Division of Acquisition and Cooperative Support to determine an effective approach consistent with the principles of federal laws and regulations. The Large Facilities Office may be able to provide models of various approaches that have been used successfully in other projects.



Figure 4.2.5-1 Sample of a Change Control Request Form, with instructions for filling out the various sections

## Sample Change Control Request

**Change Request #:** CR- \_\_\_\_\_ All change requests, whether approved or not, should be assigned a number, entered into a change log, and archived. NSF must be notified of all pending and approved change requests. **Date:** \_\_\_\_\_

**Change Request Title:** \_\_\_\_\_

**Impacted WBS:** \_\_\_\_\_ List the WBS IDs and titles for the elements impacted by this change, using the most appropriate summary levels as necessary. **Associated Risk ID #:** \_\_\_\_\_ List the Risk Register IDs and titles of the risks or opportunities associated with this change.

**Originator Name:** \_\_\_\_\_ **Project Controls Rep:** \_\_\_\_\_ Identify any other personnel instrumental to this change, as desired. Examples are: management sponsor, preparer, the project controls implementers, etc.

**Originator Signature:** \_\_\_\_\_ Name and signature of the person making the request for this change.

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**Summary Change Description:**

Give a summary description of the change request, including the nature of the change with respect to scope, cost, schedule, or performance; justification or motivation, including link to Risk Register opportunity or risk for contingency adjustments; and any net adjustments to contingency amounts.

Use check boxes or other means to indicate a need for any additional approvals per the Cooperative Agreement terms and conditions or the approved Project Execution Plan (PEP)

NSF approval required

Technical Review Board approval required

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**Scope or Technical Impact:**

Give a description of requested scope or technical changes by Work Breakdown Structure (WBS), including any resulting impacts on other WBS elements.

Give details of justification and cite any pre-approvals, such as technical review board or advisory board recommendations.

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**Budget Impact:**

Give a description of the budgetary impacts of the change, by WBS element. Identify net adjustment to project budget contingency. It is good practice to include a detailed basis of estimate as an attachment to the change request.

Provide a table with budget adjustments by WBS element. Cost control accounts may be included for traceability in the accounting system. Identify net adjustments to total project budget contingency. Including budget summary totals at WBS Level II and for the total project is helpful for monthly reporting of contingency usage.

**Budget Impacts by WBS and Control Account**

WBS Element	Control Account	Current Budget	Revised Budget	Change Amount	Change Description
WBS II Sub-Total		0.00	0.00	0.00	
WBS II Sub-Total		0.00	0.00	0.00	
WBS Sub-Total		0.00	0.00	0.00	
<b>Total</b>	<b>Project Level Impact</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>Net Project Contingency Adjustment</b>



## Sample Change Control Request

**Schedule Impact:**

Give a description of the impact on milestones and critical path for the project baseline schedule at a level low enough to reflect the effects of the change on all impacted tasks. Identify any adjustments to schedule contingency amounts.

It is good practice to provide a table or a schedule chart with schedule changes, showing WBS and activity IDs.



Changes to Project Milestones					
WBS	Activity ID	Activity Name	Baseline Dates	Change Request Baseline Dates	Revision in Work Days

**Project Acknowledgement and Concurrence Signatures:**

Title/Name	Signature	Date
Titles and signatures of concurring staff – typically WBS Level II managers, the lead systems engineer, the configuration control manager, project controls manager, safety officer, quality control officer, and other key individuals appropriate to the unique needs of the project. Note that these individuals acknowledge and concur with the recommendation. Approval is retained by the chair of the Change Control Board.		

**Project Management Approval and Disposition:**

- Change Approved
- Change Rejected

Signature: \_\_\_\_\_ Date \_\_\_\_\_  
(CCB Chair)

**Disposition:**

Approval / disapproval and disposition is retained by the chair of the Change Control Board, usually the Principal Investigator or Project Director, as this is the individual held accountable by the NSF for the performance of the project.



## Sample Change Control Request

### NSF Program Officer Approval (If required):

Program Officer Signature \_\_\_\_\_ Review Date \_\_\_\_\_

#### Comments:

Approval is given by the cognizant NSF Program Officer, if required by the terms of the Cooperative Agreement or PEP. This typically applies for major scope or performance changes and for changes above a specified threshold for contingency amounts.

### Project Controls Implementation:

(Describe Actions Taken in Cost and Schedule Baseline)

Project controls staff documents actions taken to implement the change request.

Project Controls Staff \_\_\_\_\_ Implementation Date \_\_\_\_\_

### Additional Documentation:

It is recommended that projects include or attach detailed supporting material, including basis of estimates for budget and schedule changes, calculations or other analysis, and any other relevant source documents providing justification or additional details of the change.



## **4.2.6 Budget Contingency Planning during the Operations Stage**

Any request for contingency must comply with paragraph 200.433 of the Uniform Guidance. As a result, it is generally more appropriate for operating budgets to include only explicitly identified allowances for repairs, maintenance and other factors such as “technology refresh” for cyber-infrastructure or other similar up-grades. Unless a formal risk assessment is conducted and a Risk Management Plan for operations implemented, it is recommended that each project have in place a systematic program to identify the potential cost and operations impacts of both recurring and non-recurring events to develop these allowances and include this information as part of the operating plan.

A Program Officer (PO) may request a periodic formal Condition Assessment report (an evaluation of capital assets requiring significant expenditures for periodic replacement or refurbishment and having a lifetime longer than the usual five-year award cycle), accompanied by an Asset Management Plan (a strategic plan for dealing with these issues), to inform NSF and the facility management of anticipated major and infrequent maintenance expenses that cause a significant departure from the routine funding profile. This allows NSF, as part of its budget allocation process, to proactively address these issues before they become immediate needs.

Operating budgets should include, when appropriate, resources to provide a continuing program of advanced research and development (R&D) that will enable a facility to evolve its scientific program and best meet the needs of the research community. Funding for these kinds of up-grades may also come from separate equipment and/or instrumentation programs within the Directorate or Division. The PO should be closely involved in monitoring and assessing the facility’s evolution and in supporting advanced R&D planning and budgeting. Evaluation of each large NSF facility, as part of its yearly operations review, should include a section on the plans for advanced R&D and should relate these plans to the anticipated evolving mission of the facility. This evaluation helps guide the PO in formulating a budget strategy for funding advanced R&D efforts.

It is important that NSF identify and devise plans to address the specific issues that arise as part of the divestment and closeout of a facility at the end of its scientifically competitive life. It is recommended that the PO develop a process for projecting the anticipated divestment of the facility along with the costs and legal requirements of this action. For example, annual review of an evolving plan for the decommissioning and disposal of the facility assets and environmental obligations needs to be systematically considered as part of the facilities operations mission. This process should create and keep current a plan for the facility’s divestment and closeout, along with its associated budget liability. While not part of the annual budgeting process, this information informs the longer-term strategic planning at the NSF Division and Directorate levels.



### 4.3 SYSTEM INTEGRATION, COMMISSIONING, TESTING AND ACCEPTANCE

System integration, commissioning, testing and acceptance are recipient functions, and are an essential part of complex construction/acquisition projects. Failure to perform them, or to adequately plan for them, can lead to serious cost and schedule overruns. The recipient is required to describe its plans for system integration, commissioning, testing and acceptance in the PEP. The Program Officer (PO) approves these plans, but is also required to include periodic review of progress in these areas:

- **System Integration** – combining and coordinating the many physical and performance interfaces in a project;
- **Commissioning** – substantiating the capability of the facility to function as designed by bringing various system components on line first sequentially and then in simultaneous operations to study and affirm the interaction among subsystems;
- **Testing** – assessing the operation of the facility by applying the criteria established in the PEP to measure acceptable performance; and
- **Conditions for Acceptance** – specifying the expected condition of the facility, its performance attributes, the tests the recipient will perform, and the data it will consider prior to accepting the facility or components of the facility and declaring it ready for Operations and Maintenance. In some cases, a phased approach to acceptance will be required. For example, for distributed-but-integrated facilities or for facilities with complex instrumentation and equipment, the PO will want the recipient to demonstrate performance and perform acceptance procedures for part of the system prior to proceeding with construction and/or acquisition of other systems. The PO, in consultation with the Integrated Project Team (IPT), will determine whether the recipient will conduct the tests and accept the facility or whether the PO will participate in the testing and accept the facility on behalf of the government.

Frequently, some aspects of construction and/or acquisition overlap with initial operation. A detailed Transition Plan should be developed by the Recipient and incorporated into the PEP at least one year prior to the anticipated commencement of commissioning activities. Elements of the Transition Plan are first addressed during Conceptual Design, and become progressively more detailed as planning evolves. During construction, the PO reviews the plan, utilizing internal staff, external experts, consultants, external review panels and the resources of the Large Facilities Office.<sup>1</sup> The review of the Transition Plan considers the following questions:

- Will the project have parallel periods of construction/acquisition and operations, with some components coming on line earlier than others?

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<sup>1</sup> Optional for projects not constructed with MREFC funds.



- What is the project's strategy for facility acceptance, operational readiness review, site safety and security, and training of operational staff and members of the research community utilizing the facility?
- What are the project plans for transitioning staff from construction to operational support activities? Is there a plan to bring in personnel with the requisite technical skills to operate and support the facility at appropriate times? Have training needs been addressed?
- What risks to the project might result from contractor interference during periods of beneficial use or occupancy as construction activities conclude?
- What contracting strategies are employed to ensure that priority tasks are completed in a timely way and do not delay operational readiness?
- What are project plans for obtaining use and occupancy permits, or satisfying other local regulatory criteria?
- Do the budgets reflect a proper allocation between construction/acquisition and operations?

For projects funded through the MREFC account, even if limited operations are undertaken, the changeover from MREFC funding to Research and Related Activities (R&RA) and/or EHR funding does not have to occur until the facility has been accepted and the PO ensures that the budget is estimated accordingly. Where R&RA and/or EHR funding will be used prior to acceptance, the PO will ensure that the budget justification clearly describes the changeover and that the earlier changeover is estimated and budgeted accordingly.



#### 4.4 DOCUMENTATION REQUIREMENTS

The Recipient is responsible for ensuring that a document management system is in place that provides for retention and retrieval of essential and significant documentation related to the project. Recipient documentation may take many forms, from informal e-mail communications to formal letters, bids and contracts. NSF strongly prefers that this system be electronically accessible via Internet, rather than paper-based, but recognizes that some paper records are necessary. The documentation system should not only aid in identifying the types of documents to retain, but should also contain appropriate controls over official documents such as drawings to ensure that only the most recent drawings are being used and that only authorized personnel are able to access and modify them. A sound document management system will help prevent miscommunications and misunderstandings and will ensure that the facility operators have the information required to maintain the facility.

Recipients should retain financial records, supporting documents, statistical records and other records pertinent to the award instrument (CAs, grants, subawards, and subcontracts) for a period of three years after submission of the Final Project Report. In addition, access to any pertinent books, documents, papers and records should be made available to the NSF Director and the Comptroller General of the United States or any of their duly authorized representatives to make audits, examinations, excerpts and transcripts in accordance with either the Uniform Guidance or FAR requirements.

The documentation required, and the responsibility for producing and maintaining it, varies within the facility life cycle. During the Design and Development Stage, the Program Officer (PO) is responsible for producing and maintaining documentation related to review and approval of awards. Managing the documentation pertaining to the review and processing of proposals and awards is the PO's responsibility throughout the life of the project. Chapter VI of the *Proposal and Award Manual (PAM)* requires that proposal decisions be clearly documented. Chapter XII of the PAM requires that NSF award records be retained and either retired or disposed of in accordance with Federal law and regulation. NSF documentation should include all partnership and other agreements, standard eJacket submission in the NSF-required format, the Internal Management Plan (IMP), the Baseline Project Definition (typically defined in the PEP), the record of oversight (including all reviews and reports), and all significant project correspondence.

During the Construction Stage, essential and significant documentation includes the record of any decision affecting the cost, schedule or performance baseline. At a minimum, the following forms of documentation should be retained:

- Memorandum of Understanding (MOU) and any other project agreements or deals;
- Architectural, engineering, shop and as-built drawings;
- Correspondence identifying problems, the resolution process, and the final decision;
- Contingency use log;





- Change requests and approvals; and
- System integration, commissioning, testing and acceptance plans and results.

During the Operations & Maintenance Stage, the Recipient documents facility performance in terms of:

- The facility itself – e. g., historical record of all costs related to maintenance (preventive, deferred, repairs and/or emergency), operating time, and scheduled as well as unscheduled downtime, and
- Use of the facility for research and education (including a record of users that includes the name, affiliation, funding agency, award number and annual award amount for each user).



## 4.5 REQUIREMENTS FOR NSF PERFORMANCE OVERSIGHT, REVIEWS, AUDITS, AND REPORTING

### 4.5.1 Introduction to Oversight, Reviews, Audits and Reporting

Oversight, reviews, audits, and reporting requirements change as a facility moves through its life cycle and differ substantially between the Design, Construction, and Operations Stages. The Recipient is responsible for complying with the reporting requirements contained in the award instrument (e.g., technical and financial reporting), this manual, and in the Proposal and Award Policy and Procedures Guide (PAPPG) – particularly with respect to property management and final reporting and closeout requirements for termination of the award. The Recipient is also responsible for providing internal oversight of its own activities. This may require internal reporting and reviews by committees established by the Recipient institution for the purpose of oversight. NSF is responsible for reporting its performance goals for construction projects based on Recipient EVM reports, per the Government Performance and Results Act (GPRA) of 2010.

Reviews and reporting are an important part of the oversight process that allows the PO to monitor performance and compliance with project goals. Due to the complex nature of facilities, the level of oversight will be considerably greater than for a typical NSF research grant. The Program Officer (PO) has continuous responsibility for oversight of the facility in accordance with the Internal Management Plan (IMP) and through various reviews and reports, such as consultation and coordination with the Large Facilities Office, coordination of assurance through the NSF Integrated Project Team (IPT), and periodic updates to the MREFC Panel (if applicable) and the NSB.

Reviews and reporting incur certain costs. Depending on the size of the project and the distribution of the information, these costs may be significant enough to warrant explicit inclusion in the project budget. Review and reporting plans and costs should be identified in the PO's IMP and in the Recipient's PEP so that they can be adequately considered in the project budget and schedule. The PO should clearly define the reporting requirements that are the responsibility of the Recipient in the award instrument and these requirements should be noted as milestones on the project master schedule for construction. The Recipient's Project Director adheres to their internal practices regarding financial and business operations controls,<sup>1</sup> and internal reporting (e.g., to the Principal Investigator, Dean, etc., as applicable and required).

It is important that consideration be given to Conflict of Interest rules and Privacy Act restrictions when distributing and sharing reports containing proprietary or confidential information.

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<sup>1</sup> See NSF "*Business Systems Review (BSR) Guide*."



## 4.5.2 Recipient Performance Reports

Reporting requirements vary by project life-cycle stage (Design, Construction, Operation, and Divestment) and are specified, either explicitly or by reference, in the Terms and Conditions associated with the grant or award instrument between NSF and the recipient. Performance reports are generally provided on a monthly and/or quarterly basis, with a comprehensive annual report provided by a predetermined date. Separate reporting activities are required for MREFC funds used for construction activity if the facility also receives Research and Related Activities (R&RA) funds. These are specified in the Terms and Conditions of the separate cooperative agreements for each type of funding.

NSF may occasionally request that Awardees provide additional information on a specific activity, often as a result of a unique request from within the government. Such requests may not be specifically included in the cooperative agreements due to their ad hoc and individual nature, nevertheless an awardee must be prepared to respond. Examples include responses to audit requests from the Office of Inspector General and queries from the US Congress and Executive Branch agencies. Some projects, particularly those with construction activities or frequent changes in design, will need more frequent reporting intervals. For example, providing the written minutes from a weekly construction meeting is common practice.

During the Construction Stage, the Project Director, who is responsible for executing and controlling the project in accordance with the PEP and the award instrument, reports to the Program Officer (PO) on a periodic basis (monthly for MREFC-funded projects and no less than quarterly in other cases). Those reports should include the following:

- Summary of financial and technical status – work accomplished during the reporting period, including major scientific and/or technical accomplishments and milestones achieved;
- Comparison of actual cost and schedule to planned cost and schedule, at least at the second level of detail in the WBS, using Earned Value Management System (EVMS) methodology;
- Variance reports at an appropriate cost account or work package level for all cost and schedule variances  $> \pm 10\%$ , including explanation of causes and remediation/recovery plans<sup>1</sup>;
- Status of cost and schedule contingency and risk exposure, as listed in Section 4.2.5.8 Reporting Requirements;
- Review of current or anticipated problem areas and corrective actions;
- Management information such as changes in key personnel, sub-contracts/awards and sub-contractor/recipient performance, as well as any other information about which the PO needs to be aware; and

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<sup>1</sup> Variance reports provided by recipients are used by NSF in its metrics for construction project performance goals, in accordance with the GPRA Modernization Act of 2010. See Section 4.5.4, NSF Performance metric for Construction.



- Concerns, upcoming milestones, or project deliverables.

For MREFC projects in the Construction Stage, the PO is responsible for providing the LFO a written monthly summary of this information in a standard format provided by the Head, Large Facility Office (HLFO). Smaller-scale projects that are not funded through the MREFC account will provide status reports to the PO with a frequency and level of detail defined in their respective Internal Management Plans (IMPs). In every case, the PO is responsible for keeping the appropriate NSF staff (Grants and Agreements or Contracting Officer, Division Director (DD), Assistant Directors (ADs), Integrated Project Team [IPT] members, etc.) informed of the project status.

In executing and controlling the project, the Recipient manages the project to the Baseline Project Definition and cost and schedule. Per Section 4.5.4 NSF's Performance Metric for Construction, the Recipient will notify the PO of total project cost and schedule variances exceeding -10%, including explanations of causes, recovery plan, and timeline for correction, as part of the routine reporting process.



### 4.5.3 Recipient Performance Reviews and Audits

#### 4.5.3.1 Recipient Internal Reviews

The Recipient will demonstrate appropriate internal management by conducting reviews and internal audits in conformance with generally accepted accounting and project or operations management practices and standards. These reviews include, but are not limited to, technical merit reviews, design reviews, procurement readiness reviews, progress and planning reviews, risk reviews, safety reviews and walkthroughs, acceptance reviews, and self-audits. The kinds and frequency of all reviews and audits should be addressed in the Project Execution Plan. Although internal review teams are typically populated by project staff, consideration should be given to the inclusion of outside subject matter experts on review teams, who can provide a valuable independent perspective.

#### 4.5.3.2 NSF External Reviews

NSF requires periodic external reviews that provide advice on the status and anticipated future performance of the facility activities. The frequency and content of these reviews are specified in the terms and conditions of the award instrument. Typically, Annual Operations or Project Reports and Final Project Reports, or activities with the equivalent purpose, are required to evaluate progress and provide feedback. Additional ad hoc reviews may be requested by the PO under certain circumstances, such as significant re-planning of construction projects, changes in key personnel, and major changes in research technical design, direction, or scope. These reviews should determine the extent to which the facility is meeting the goals of their Annual Plan as well as the overall goals for the award, discuss any upcoming challenges and highlight best practices that could be applied to other large NSF facilities. Whenever possible, the review should be conducted at the facility itself by an external panel with expertise in the construction and operations of large scientific facilities.<sup>1</sup> The panel should produce a formal written report. The review is organized and conducted by the PO in consultation with the LFO Liaison. Both the review committee membership and the charge to the committee require concurrence from the PO and LFO Liaison. Invitees to the review shall include the PO, the cognizant Business Officer, and staff from the Large Facilities Office. Following the review, the LFO Liaison will produce an independent assessment of the review for the HLFO. The Operations or Performance Review is not meant to compete with other reviews listed in Section 4.5.3., such as the Business Systems Review (BSR), which looks at business processes.

Careful consideration should be given to the selection of independent reviewers, and in all cases the skill sets of the reviewers should be matched to the type and kind of review to be conducted. Broad programmatic review panels charged with reviewing all aspects of a project will generally have representation from the academic and broader national/international

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<sup>1</sup> Consult with the NSF Program Officer for guidance and best practices with respect to planning and executing External Reviews of NSF's Large Facilities.



research community, as well as experts in administrative aspects of facilities/project management. A review panel focusing on specific administrative or technical aspects of a project would have a different set of skills.

The PO will typically use a standard review “template.”<sup>1</sup> These well-defined review formats provide a broad outline against which the project can be compared and checklists that can be used to assess the status of the project. These reviews can be particularly helpful in the pre-award phase in ensuring that the project is ready to be implemented. Exceptional circumstances may arise that necessitate some alternate format. In this case, the PO consults with the LFO Liaison to constitute a review charge and format tailored to meet the specific requirements of the review.

#### **4.5.3.3 Business Systems Reviews (BSR)**

The BSR is one of NSF’s advanced monitoring activities that assist with oversight and provide assurance of the suite of business systems that support the administrative management of a large facility. These reviews are designed to provide reasonable assurance that the business systems (people, processes, and technologies) of NSF Recipients are effective in meeting administrative responsibilities as well as satisfying other federal requirements. Specifically, a BSR verifies that administrative and financial policies and procedures are written; determines if these policies and procedures conform to OMB requirements, NSF expectations, and other applicable federal regulations; and if they are used to administratively manage the large facility in each of the core functional areas. BSRs are also intended to provide an opportunity for cross-fertilization of ideas through the identification of best practices, and serve to refocus recipients on the importance of administrative quality.

The LFO has the lead role in coordinating the assessment of these systems by using desk reviews and site visits to determine if the administrative business systems used in managing the facility meet NSF expectations and are in compliance with federal regulations.

BSRs are generally conducted on a five-year cycle for all facilities. For new MREFC projects, the BSR is ideally conducted prior to the construction award. The LFO uses an internal risk assessment process to decide which facilities will have a BSR conducted in any given year. Risk factors include:

- When the last BSR on the facility was conducted;
- New MREFC project being proposed;
- Other identified risks such as audit finding, significant changes in funding levels, management, scope, operational performance or mission of the large facility;

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<sup>1</sup> Please contact the cognizant NSF PO for details and a description of best practices and/or preferred templates.



Further information and various details of the BSR process are provided in the BSR guide,<sup>1</sup> which defines and establishes the procedures for the planning, execution and follow-up activities associated with conducting BSRs. The Guide also defines the roles and responsibilities of NSF staff assigned to BSR activities and identifies core and targeted review areas.

#### **4.5.3.4 Cost Incurred Audits**

NSF conducts a cost incurred audit for large facility awards above \$100M at the end of the award and potentially during execution of the award based on an annual large facility risk assessment conducted by the Large Facilities Office and the Cooperative Support Branch at NSF. Recipients should be prepared for such an audit at any time based on 2 CFR 200.205-7 of the Uniform Administrative Requirements, Cost Principles and Audit Requirements for Federal Awards and as stated in the terms and conditions in the Cooperative Agreement.

Recipients must maintain adequate internal controls, policies and procedures, and reliable accounting systems. The purpose of the Cost Incurred Audit is to provide prudent oversight for those responsible for the effectiveness, efficiency, and economy of the recipients' operations and the use of Federal funds. The Incurred Cost Audit is performed to assure the existence of adequate controls which will prevent or avoid waste, fraud, and abuse and inefficient practices.

In preparation for a cost incurred audit, recipients are required to submit financial expenditures (incurred cost) data to NSF on a frequency to be determined by the Grants and Agreements Officer and the Cooperative Agreement's Terms and Conditions. It will be no less frequently than annually. The Large Facilities Financial Data Collection Tool, created by NSF to assist recipients in preparing and recording financial expenditure information for its cooperative agreements for large facilities, is required for submission of the financial expenditures data. The Large Facilities Financial Data Collection Tool is a macro-enabled Excel workbook that provides recipients a single, standardized method for submitting direct and indirect expenditure data with minimal effort and help to ensure data quality and accuracy. It will enable NSF and independent auditors to more easily and consistently collect the financial data required to maintain proper oversight and stewardship over funds and facilitate recipient compliance in meeting its reporting requirements.

To complete the data collection, recipients will need to collect expenditure information for all active Cooperative Agreements during the awards performance period. Suggested sources from which to collect this data include the recipient's Chart of Accounts, General Ledger, Project Cost Ledger, NSF Award budget, and the award organization's Negotiated Indirect Cost Rate Agreement. To submit expenditure data, recipients can download the Large Facilities Financial Data Collection Tool file from NSF at: [http://www.nsf.gov/bfa/lfo/lfo\\_documents.jsp](http://www.nsf.gov/bfa/lfo/lfo_documents.jsp)

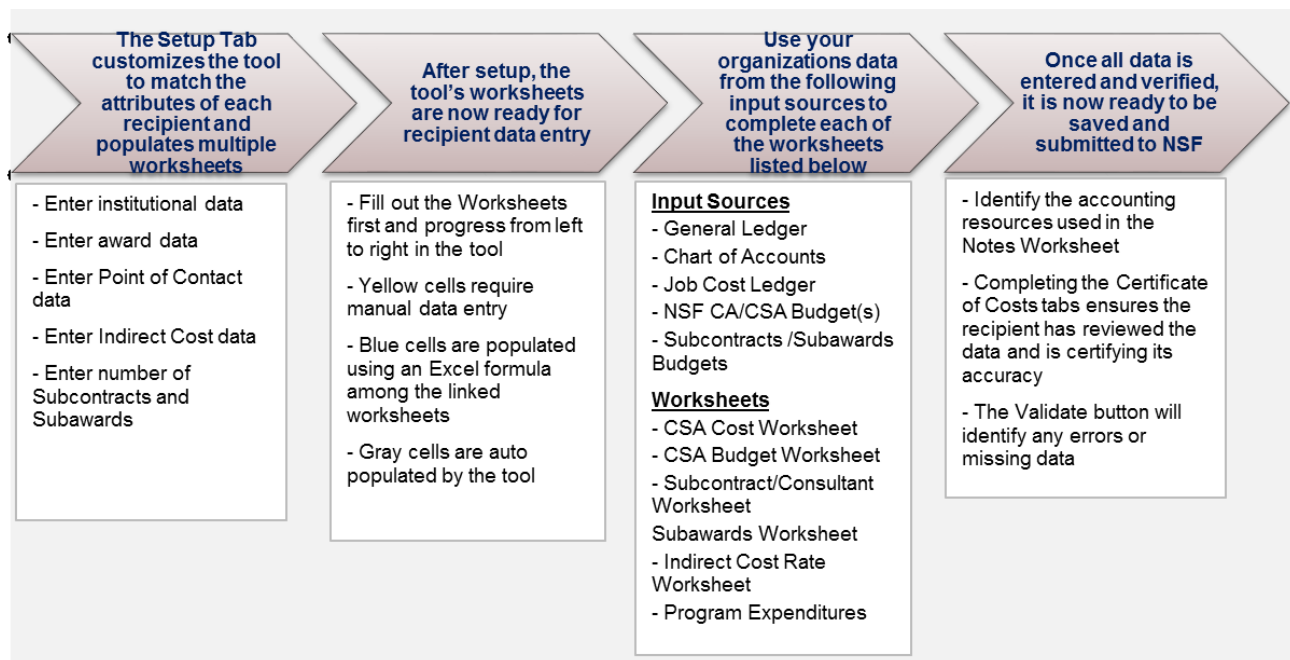
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<sup>1</sup> See "Business Systems Review (BSR) Guide."



Once downloaded, recipients should save the file and then begin to enter data following the guidance provided in the tool. See Figure 4.5.3-1 for a flow diagram for data entry. Recipients are instructed to submit this data collection annually to NSF as well at the end of your project or based on the Terms and Conditions of the award. When completed, this Large Facilities Financial Data Collection Tool will allow submission financial data electronically to the NSF Grants and Agreements Officer or an independent auditor. Questions regarding this collection should also be directed to the responsible NSF Grants and Agreements Officer.

Figure 4.5.3-1 Large Facility Financial Data Collection Tool Process Flow Diagram, identifying the core data sources recipients should utilize to complete the worksheets to accurately capture the data. Progressing through the tool's worksheets from left to right will streamline the data capture and submission process.



#### 4.5.3.5 Earned Value Management Validation

*(This section reserved for future content)*





#### 4.5.4 NSF Performance Metric for Construction

In accordance with the GPRA Modernization Act of 2010 (P.L.111-352); *Empowering the Nation Through Discovery and Innovation: NSF Strategic Plan for Fiscal Years (FY) 2011-2016*; and OMB requirements, NSF developed goals to measure construction/upgrade performance based on EVM systems used to monitor project cost and schedule. **For MREFC facilities<sup>1</sup> that are under construction and that are more than 10 percent complete, the NSF performance metric goal is that total project EVM cost and schedule progress variances against the performance baseline will be kept at, or less than, negative 10 percent.** (Projects that are less than 10 percent complete are not held to this goal because EVM data is less meaningful statistically in the very early stages of a project.)

Negative total project variances exceeding 10 percent should be reported to NSF and be accompanied by an explanation and a proposed plan and timeline for recovery or accommodation of the cost and schedule shortfalls (e.g., use of contingency, de-scope).<sup>2</sup>

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<sup>1</sup> This includes facilities whose construction is partially supported by funds or in-kind contributions from outside agencies. In such cases, the variance for the total project and the variance for the MREFC-funded portion should be reported separately. For example, if the total project variance is -7% and the MREFC portion is -12%, then the -12% would be reported, accompanied by a recovery plan. Alternatively, if the total project variance is -15% and the MREFC variance is -11%, then both variances would be reported with appropriate recovery plans with timelines.

<sup>2</sup> See section 4.5.2 for requirements on variance reporting at lower WBS levels for monthly progress reports.



### 4.5.5 Re-Baselining

If maintaining the original performance baseline (scope, total project cost, or end date) is no longer possible, the Recipient will consult with the PO to determine whether re-baselining the project is warranted. When deciding which course of action to pursue, the PO will need to balance the effect of failing to achieve the project's performance goals against the impact on the research and education proposed for the completed facility.

The PO should consult with the NSF Integrated Project Team and the Directorate/Division Leadership, prior to authorizing re-baselining a project. Variances may result from many factors – for example, inadequate project planning or management, or factors not within the Project Director's (or manager's) control. Examples of the latter include failure to identify the complexity in particular tasks (such as integration), failure to budget for adequate labor, materials or time versus unexpected increases in the cost of labor and/or materials, unavailability of labor and/or materials, unusually severe weather, etc.

For construction projects, uncertainties are normally managed through re-planning<sup>1</sup> and the use of contingency, per Section 4.2.5. Re-baselining for construction projects occurs for variances that result in:

1. Increases in the NSB-approved Total Project Cost (TPC),
2. A change in the approved project end date, and/or
3. Major changes in scope.

The LFO, the MREFC Panel, and the Director should be kept informed of any pending re-baselining discussions. NSF approvals are required per Section 2.4.1 of this manual. If only the schedule is extended without an increase in TPC, the terms and conditions of the award instrument apply (i.e. NSF policy on No-Cost Extension for CAs). Once a re-baselined Project Definition has been approved, the re-baselined requirements replace the Baseline Project Definition as the standard against which progress is measured. Consequently, costs exceeding budgeted amounts in the initial Baseline Project Definition are not referred to as "overruns" once a new project baseline has been implemented by the project management and accepted by NSF.

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<sup>1</sup> See Section 2.4.1 for the definitions of "re-baselining" and "re-planning".



## 4.6 PARTNERSHIPS

### 4.6.1 Partnerships Overview

For both MREFC and smaller projects, partnerships are an essential consideration – beginning at project inception. Partnerships may take many forms, but typically include coordinated funding from states or state institutions, other federal agencies,<sup>1</sup> non-governmental entities, and foreign funding agencies. International partnerships are generally the most complex.

Key issues in these partnerships, whether international or the result of interagency or state collaboration, present several important challenges that the recipient and PO need to consider carefully.

The first is “culture shock.” The science or engineering cultures in different countries will generally exhibit great variations in procedures when it comes to funding, managing and overseeing, constructing and operating a facility. Differences often include lack of mutual understanding or considerably different contexts for defining the role and function of project management. It is typically very challenging for each nation to manage its part of the project unless there is a means for integrated management and oversight by the central Project Manager.

The Project Director or Manager should be in place before funds are released and, to be most effective, should be given budget authority (or authority over in-kind resources) and should not simply act as a coordinator. In terms of oversight, reviews of project status by U.S. agencies are not universally accepted. U.S. agencies use reviews heavily, but not all countries do. In some countries, reviews that uncover problems may be received without a sense of urgency and may not be acted upon quickly. U.S. partner agencies may be able to insist upon resolution of issues when playing a majority role in funding; if not, other steps should be taken. Full project transparency is essential to success.

A second important issue is early negotiation with international partners. There is a need to start with a clear understanding by all partners as to how the construction project is to be managed and the facility is to be operated. It is also important to know how agencies in different countries view the project in terms of shared goals, the science or engineering case for the project, and its priority. If participating partner countries all rate the priority of a project at the highest level, then commitments carry more weight.


Funding risks associated with international partnerships should be assessed and contingency plans developed regarding potential changes in commitment. Finally, early negotiation also

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<sup>1</sup> See “Best Practices for Federal Research and Development Facility Partnerships,” IDA Science & Technology Policy Institute, IDA Paper P-5148 Log: H 14-000676, for guidance or models on forming interagency federal partnerships.



provides a means to establish and maintain regular agency-to-agency contacts, providing an early understanding of funding pressures and other emerging pressures in each country.

The NSF Office of International and Integrative Activities (OIIA)  should be advised of potential international partnerships early in the process and kept apprised of significant developments. That Office can facilitate coordination with the Department of State and the White House Office of Science and Technology Policy on foreign policy and geopolitical issues, advise on interactions between NSF and counterpart funding organizations in other countries, and provide information/contacts on matters such as visa issues for project participants and cost issues related to assessment of import duties on internationally shipped items.



## 4.6.2 Partnership Funding

Funding of projects involving partnerships is obviously a central consideration. International partner agencies need to understand the funding processes in the different countries involved. The complexity of the NSF process can lead to misunderstandings regarding the schedule of funding and project approvals. Because of the great variation among countries as to how labor costs are counted, it is good practice to adopt standard costing techniques for equipment, labor, commissioning and operations. MOUs need to be developed, detailing the foreign contributions. In some cases, these contributions may be in cash or in-kind level of effort; but deliverables should be clearly specified and the contributions should be valued in U.S. equivalent terms (including all labor costs) for projects in which NSF is the lead agency. To aid project management and eventual close-out, it should also be made clear what scope NSF and the other partner are either paying for or contributing (by WBS element) and proper segregation of funding rules employed as appropriate.

As with all such projects, contingency funds (or their equivalent) need to be identified by all partners. There is great variation in practice among countries, again because labor costs may or may not be included in contributions to the project. This can have a great impact. For example, in a cost-overrun situation it may become expeditious to simply stretch the project out. This may work for one country, resulting in less focus on schedule issues; but it generally does not work for U.S. projects where “standing army” costs are directly allocated to the total cost for construction of a facility.

In addition, when partner funding is in cash, variations in exchange rate can have a large effect on the ability of a given country to meet its commitment on deliverables. Therefore, scope contingencies need to be explored. When international partners do not include adequate contingency, and the U.S. does, funding “caps” (agreed upon in advance) are an appropriate policy. Although caps may enforce discipline, they may have other effects. For example, when there are schedule slips and “standing army” costs rise, caps can limit the deliverables that may be provided. Strict adherence to caps may therefore compromise the overall performance goals.

Finally, a facility’s project management and operations plans should be well understood by all partners. When different countries have responsibilities for separate subsystems, strong system integration and comprehensive interface documents become very important. The change-control process needs to be clearly understood. Change control is made very complex because performers in one country may be ill equipped to handle or adapt to required changes. It is also very important to establish a sound schedule baseline and adhere to it.



For partnerships with organizations or agencies in the United States, the following activities are advised:

- Evaluate NSF's role (NSF's authority and responsibility vary depending on its status as executive agent or as a majority, equal or minority partner). Assess risks and develop a plan to address them, e.g., implementation of controls that limit NSF's exposure to overruns (see Section 5.2, Risk Management Guidelines).
- Ensure that all partners understand the review and approval processes of the other partners.
- Prior to entering into a partnership, develop and execute an MOU.



### 4.6.3 Memorandum of Understanding (MOU)

MOUs are broad, general agreements between NSF and other parties to pursue activities of mutual interest and benefit; cooperate in areas where science and engineering interests coincide; and provide a framework for cooperation. A typical MOU includes:

- The purpose of the Understanding; authority of the parties to enter into an Understanding;
- Scope of the Understanding, including a project description and the respective responsibilities of each party for funding, management and oversight (including procedures for resolving conflicts and dealing with defaults);
- Rights of each party with respect to access, ownership and intellectual property (Chapter VII of the PAM); means for resolving disputes; and
- A termination clause.

MOUs are developed by the PO and cleared according to procedures outlined in Chapter VIII of the *Proposal and Award Manual* (PAM).



## 5 SPECIAL TOPICS AND SUPPLEMENTARY MATERIALS

### 5.1 INTRODUCTION

This section contains extensive supplementary information on special topics having to do with the National Science Foundation (NSF) role in planning, oversight, and assurance of large facility projects. The materials are presented in a tutorial format to be of particular benefit to individuals newly involved with large facility projects. They are based primarily on current standards and best practices for project management.





## 5.2 RISK MANAGEMENT GUIDELINES

### 5.2.1 Introduction

Project risk management is a process which increases the probability of a successful project by identifying threats to the project, assessing the nature of those threats, and identifying actions that can be taken to either reduce the probability of those threats occurring or reduce the impact of the threats to the project. Even on a simple project, things seldom go as planned. With the highly-technical, scientifically ground breaking, and long duration projects undertaken by the NSF there will be many changes required to the baseline plan as a project matures. Successful projects anticipate problems, work to avoid those problems, and limit the impact those problems will have on a project.

Risk management serves two purposes; one is to forecast impacts of possible events on the project's cost and schedule, the other is to prioritize and inform project decisions on alternate strategies to mitigate the cost or schedule impact of a possible event or increase the technical performance margin of a system or subsystem. The former (quantitative risk analysis) creates a framework for quantifying the risks to the project goals in terms of cost in dollars, schedule in days, and performance for the purpose of forecasting the final cost, schedule, and performance of the complete project. The latter (qualitative risk analysis) helps the team sort through the hundreds and perhaps thousands of risk to identify and address the ones that are most likely to have the most significant impact on the project.

Qualitative risk analysis practices have remained relatively unchanged recently while quantitative risk analyses have been evolving rapidly as the software tools and their integration with scheduling software packages have evolved. While quantitative risk analysis has become easier and more sophisticated, it is unlikely to fully replace qualitative risk analysis because the quantitative analysis requires validated inputs that are more labor intensive to produce. Most projects utilize the qualitative risk analysis practices for their month-to-month risk management and implement quantitative risk analysis only when they need to re-forecast the estimate at complete cost and completion date of the project.

Risk management involves all project personnel. With an effective risk management project every project team member should be able to state the top project risks as well as the top risks to their subsystem. Risk management has an inherent Malmquist (completeness) bias – there will always be more risks to a project than are reflected in the risk register. To minimize this effect every project team member from every perspective in the program should be contributing threats, opportunities, and mitigation ideas to the risk board. The team also needs to be well aware of the risks associated with their subsystems so they recognize how a mistake in their area would impact the overall project (an aspect of human error prevention and project safety).



Some projects refer to risk management as risk and opportunity management, to emphasize to the team that they should also be thinking about opportunities for changes in the baseline plan that could save cost, save schedule, or improve performance. This section follows the Hulett definition of risk that is in the Project Management Body of Knowledge (PMBOK) that includes opportunities in the definition of risk. Project teams should remind each other to keep thinking about new opportunities as well as threats to the project.

Risk and opportunity management feeds into the key decisions that make a project successful. It is a core activity for project managers, systems engineers, subsystem leads, program officers, and review panels.

NSF requires large facility recipients to develop and follow formalized Risk Management during the design and construction stages of sponsored Major Research Equipment and Facilities Construction (MREFC) projects.

Successful Risk Management entails early recognition, proactive planning, and aggressive execution of all risk management processes. Ideally Risk Management begins as early as the initiation stage of the project life cycle. This guide provides detailed information on the Risk Management<sup>1</sup> methodologies and strategies commonly applied during project planning and execution.

There are three key products of Risk Management as applied to NSF construction projects:

- A Risk Management Plan that sets out how risks will be identified and managed by the project following standard risk management processes and practices,
- A Risk Register, or tracking tool, that documents identified risks, and
- A determination of Risk Exposure and the related amount of Contingency needed to control risks, based on quantitative risk analysis.

The Risk Management Plan (RMP) is a required element of the Project Execution Plan (PEP) described in Section 3 of this manual (often as a separate document). A RMP should be included in the project planning and proposals no later than the start of the conceptual design phase. The Plan should identify the responsibilities for risk management and describe the Risk Management process that will be followed— including roles and responsibilities, procedures, criteria, tools, and techniques to be used to identify, analyze, respond to, and track project risks. The level of detail in the plan, and the scope, timing, and level of risk analysis should be commensurate with the maturity and complexity of the project and may evolve and change over time. An example of an acceptable RMP outline is shown in Table 5.2.5-1.

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<sup>1</sup> The NSF Program Officer, as part of oversight responsibilities, identifies project-related agency risks to NSF, formulates mitigation strategies, and documents them in an Internal Management Plan (IMP), accessible only to NSF staff.



The Risk Register – typically a spreadsheet or data base – is a tracking tool that includes a description of all risks that are deemed to be important to achieving project success, along with an assessment of those risks that allows them to be prioritized for effective management. The Risk Register also includes the risk handling strategy, the person to whom each risk has been assigned for accountability purposes, the current status of the risk handling strategy, and comments. An example of a commonly used style for a Risk Register is given in Table 5.2.5-1. It should be noted that appropriate tracking tools will vary among projects because the types of information and indicators being monitored vary from project to project. The selection and definition of a tracking system to be used in a project should be commensurate with the size and complexity of the project and should be defined in the project’s RMP.

Risk Management strategy involves the estimation of overall risk exposure and the determination of an adequate amount of contingency – a quantity of money, scheduled time, or reductions in scope intended to recover project objectives if uncertainties and risks occur with negative impacts. The values for cost and schedule contingencies are taken from distributions generated by Monte Carlo simulations with probability and impact ranges for uncertainty and risks for activities defined in the baseline. The confidence levels for meeting a chosen project end date and total cost should lie between 70% and 90%. Scope contingency involves identifying lower priority tasks that can be delayed or dropped from the project without a crippling impact to project objectives. De-scoping may be used if the project forecast indicates that cost or schedule overruns are likely. For NSF MREFC projects, these contingencies are held separately from the project Performance Measurement Baseline (PMB) cost, schedule, and scope. Strategies for using contingency are detailed in the project Risk Management Plan. Contingency is controlled and managed through the project Configuration/Change Control Process (CCP). The use of contingency is subject to approval by project leadership, and by NSF, if amounts are above certain thresholds, as defined in the cooperative agreement (CA).

While the text of this section tends to refer to projects in construction, good risk management practices can be useful throughout a project’s life cycle, including during operations. “The best laid schemes of mice and men / Often go awry.” Implementing preventative mitigations and pre-planning alternative strategies will reduce the likelihood and impact of these events. The following subsections provide guidelines for planning the Risk Management processes, developing the RMP, creating a Risk Register, and calculating a quantized measure of risk exposure that leads to the establishment of contingencies. Examples of accepted or good practices are included as guidelines.



## 5.2.2 Definition of Project Risk and Risk Exposure

**Risks** are defined many ways. One of the most inclusive definitions, and the one used in these guidelines, is; "... an uncertain event or condition that, if it occurs, has a positive or negative effect on at least one project objective."<sup>1</sup>

Most international standards agree that risk is made up of both threats and opportunities. Capturing and capitalizing on opportunities to reduce costs, save time, and improve technical performance may improve the possibility of finishing on time, budget, scope and quality by offsetting the negative impact of threats to those objectives. The tools and methods employed in managing threats are also used to identify and take advantage of these opportunities for reducing project cost or schedule or improving technical performance. NSF requires Opportunity Management as a necessary component of risk management.

Project **Risk Exposure** is the quantized result on project objectives of various risks and uncertainties occurring. Project risk exposure is usually expressed as an amount of budget or time that is the output of a Quantitative Risk Analysis that combines probability of occurrence with consequence. Project risk exposure diminishes over time as risks are realized or avoided and should always be less than or equal to remaining contingency amounts.

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<sup>1</sup> This definition is used in the *Guide to the Project Management Body of Knowledge*, (PMBOK® Guide), Project Management Institute, 5<sup>th</sup> Edition, 2013, Chapter 11.



### 5.2.3 Definition of Allowable Contingencies

Contingencies are a necessary component of risk management for NSF projects – they provide the wherewithal and flexibility to control risks and realize opportunities. Contingency allocations are for in-scope deliverables and are to be used to mitigate identified risks and uncertainties that may impact a projects ability to achieve approved project objectives.

#### 5.2.3.1 Allowable Contingency

Most risk management guides define two general types of budget and schedule contingency:

**Contingency:** *“a planned amount of money or time which is added to a baseline estimate to address specific, identified risks.”<sup>1</sup>*

**Management reserve:** *“a planned amount of money or time which is added to a baseline estimate to address unforeseeable events.”<sup>2</sup>*

NSF does not carry management reserves as defined above. For NSF projects, only the first type, **Contingency**, is allowed. This means that the estimation of contingency amounts must be tied to risks identified at the time the total budget and duration are set, and that such contingency can only be used to mitigate those pre-identified risks. Use of contingency to cover unforeseen events is not allowed. See Section 5.2.7 for using proper quantitative estimating methodologies for determining risk based contingencies.

In addition to budget and schedule contingency planning, NSF requires projects to assess possible use of scope contingency and to develop a plan to make effective use of scope contingency options, if necessary, during construction. This provides the project with an additional tool to manage the overall project given the lack of Management Reserve within NSF. Use of all contingency is managed through formal change control processes, as described in Section 4.2.5.

#### 5.2.3.2 Contingency Definitions

Contingency for NSF projects includes cost, schedule, and scope amounts, as defined below:

**Budget Contingency:** *An amount added to a baseline budget estimate to allow for identified items, conditions, or events for which the state, occurrence, or effect is uncertain and that*

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<sup>1</sup> Identified risks are often referred to as “known unknowns” in the literature. In other words, a risk that can be identified during planning is “known,” but the probability of occurrence and the extent of its impact cannot be determined with accuracy and are therefore “unknown.”

<sup>2</sup> Unforeseeable events are those that are not or cannot be identified during planning and are typically referred to as “unknown unknowns” in the literature. They may also include low probability, extreme events that are beyond project control, such as the effects of terrorism and war, natural disasters with impacts beyond expected historical ranges, or global economic crises.



*experience shows will likely result, in aggregate, in additional costs. Typically estimated using statistical analysis or judgment based on past asset or project experience.*

For MREFC construction projects, the amount of budget contingency is determined by performing a probabilistic risk analysis on the baseline cost and schedule and selecting a Total Project Cost with an acceptable confidence level (typically between 70%-90%). See Section 4.2.5 for details on Total Project Cost requirements and caps. Thus Total Project Cost is the sum of the baseline budget and selected contingency amount. Budget contingency is held separately from the PMB and allocations of budget contingency to and from the PMB are managed through formal change control.

**Schedule contingency:** *An amount added to a baseline schedule estimate to allow for identified delays, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional project duration. Typically estimated using statistical analysis or judgment based on past asset or project experience.*

For MREFC construction projects, the amount of schedule contingency is determined by performing a probabilistic risk analysis on the baseline schedule of activities and selecting a commitment finish date with a confidence level between 70%-90%. The overall project duration is the sum of the baseline duration and the selected contingency amount. Schedule contingency is held separately from the PMB and allocations of schedule contingency to and from the PMB are managed through formal change control.

**Scope contingency:** *Scope included in the project baseline definition that can be removed without affecting the overall project's objectives, but that may still have undesirable effects on facility performance. Identified scope contingency should have a value equal to at least 10% of the baseline budget.*

Scope contingency can be retained or deleted, depending on project risk performance and available contingency, in order to stay within the Total Project Cost. A scope contingency plan includes a time-phased estimate of available budget and or time from de-scoping options, based on key decision points. See Section 4.2.5 for details on requirements. Implementation of scope contingency options is managed through formal change control.



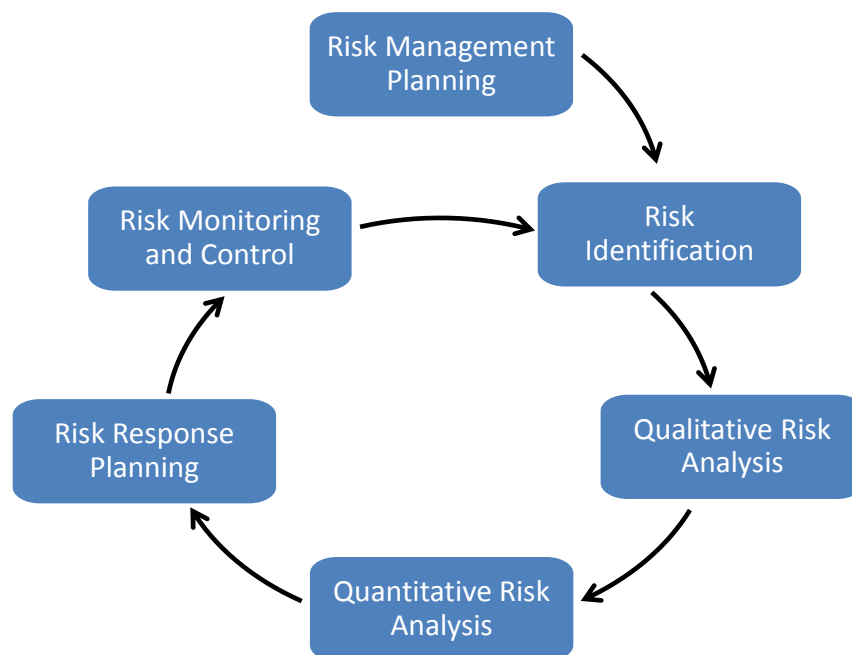
## 5.2.4 Risk Management Steps and Methodology

The steps involved in the Risk Management process have been defined variously by different practitioners. For the purposes of these guidelines, the Risk Management process is defined as comprising the following steps:<sup>1</sup>

- Risk Management Planning
- Risk Identification
- Qualitative Risk Analysis
- Quantitative Risk Analysis
- Risk Response Planning
- Risk Monitoring and Control

The relationship between these steps is shown in Figure 5.2.4-1.

Figure 5.2.4-1 Picture of Six Risk Management Processes (According to PMI)<sup>2</sup>



The Risk Management steps outlined above are iterative and continuous and any one step, or all of the steps, could be active at any given time. Risk analysis is performed continuously

<sup>1</sup> The six steps are the same as the processes described in the PMBOK® Guide Chapter 11.

<sup>2</sup> Risk Handling and the Project Management Institute's Risk Response Planning process are somewhat equivalent. Risk Handling includes implementing the risk mitigation and other responses, whereas Risk Response Planning envisions that these actions will be included in the Project Execution Plan and implemented as part of the PEP.



throughout the project life cycle. For example, a conceptual risk analysis may be conducted to facilitate selection between alternative options, to determine the level of project management required, to identify where the challenges lie, and to determine the level of technical information and development activity necessary to achieve project success. That risk analysis is then updated during each of the life cycle phases of the project. Performing risk analysis is particularly necessary in preparing for key project decisions. Periodic reviews of the risks at appropriate intervals should be performed to identify new risks, to evaluate progress in risk handling strategies, as well as to evaluate changes during the project development and implementation cycles. Risk Management Planning, and the RMP, may also need to be re-addressed at times of significant change, such as transitions from one project life cycle to another or during a re-baselining with significant modifications to the project baseline.





## 5.2.5 Risk Management Planning

Planning begins by developing and documenting a Risk Management strategy. Early efforts establish the purpose and objectives, assign responsibilities for specific areas, identify additional technical expertise needed, describe the assessment process and areas to consider, delineate considerations for mitigation planning, define a rating scheme, dictate the reporting and documentation needs, and establish report requirements. The strategy to manage root causes provides the program team with direction and a basis for planning. The output of risk management planning is a written document – the Risk Management Plan (RMP) – containing the details of how risk will be managed through application of tools and processes defined in the plan. See the next subsection for a description of requirements for the RMP.

One key strategic decision that should be made early in the Risk Management planning is the selection and assignment of personnel with appropriate capability in Risk Management to lead and/or guide the planning and analyses. As will be seen from the topics presented in the analysis portion of the section, the art and science of risk management can be extremely complicated for complex, high risk projects. While project managers, scientists and engineers may have expert knowledge and judgment for identifying, estimating impacts from, and defining mitigation for individual risks, they are usually not expert in estimating the overall or aggregate risk exposure to the project from the combined impact of many individual risks. Finding qualified resources to meet the risk management requirements of the project, particularly for establishing the amount of contingency, should be a high priority for early planning in order to ensure that methodologies and programming tools can be selected and implemented in a timely manner. Options include sending existing staff for specialized training in risk management and tool usage, directly hiring risk management experts, contracting with industry, or some combination of the above.

A second early key decision is the determination of what risk assessment methodologies and tools will be used, from first estimates through construction. The sophistication of the appropriate risk assessment tools typically increases with advancing planning detail and maturity, as well as with increasing project complexity. A project that includes a high number of procurements and in-house tasks typically requires software applications and methods that use a fully resource loaded schedule for risk assessment and contingency estimation, while a project entailing management of a single large contract may be adequately served by tools and methods that use cost spreadsheets and summary level schedules. Choosing the appropriate tools and methods at the outset can avoid the need and the burden of changing to different systems as the project planning matures.

Risk Management planning is iterative. Normally, the risk management methodology and procedures are defined as part of the risk management process planning early in the design stage, but they may be extended or modified during design and execution as long as the efforts remain within approved scope.



### 5.2.5.1 Risk Management Plan (RMP)

The Risk Management Plan (RMP) describes how risk management will be applied on the project. It is an integral part of the PEP, as outlined in Section 3.4 of this manual. The level of detail in the plan and the scope, timing, and level of risk analysis should be commensurate with the complexity and maturity of the project as it advances through design and construction stages. The plan is a living document used throughout design and implementation and should therefore be under configuration management. The Risk Management Plan should include the following elements:

- Risk Management Strategy and Approach
- Roles and Responsibilities
- Processes used to apply the Risk Management process
- Baseline definition for Calculating Risk Exposure and Contingency needs
- Contingency Estimating and Management
- Resources assigned to and schedule, cost, and timing of risk management activities

The Recipient should periodically review the RMP and revise it, if necessary. Some events may drive the need to update an existing RMP, such as: (1) the baselining of a project, (2) preparation for a major decision point, (3) technical audits and reviews, (4) an update of other project plans, and (5) a change in major project assumptions. A sample format with the expected content for a Risk Management Plan (RMP) is outlined in Table 5.2.5-1.

Table 5.2.5-1 Sample Format for a Risk Management Plan

Section	Description
<b>1. Introduction</b>	This section should address the purpose and objective of the plan, and provide a brief summary of the project, to include the approach being used to manage the project, and the acquisition strategy.
<b>2. Definitions</b>	Definitions used by the Recipient should be consistent with NSF definitions for ease of understanding and consistency. However, the NSF definitions allow program officers flexibility in constructing their risk management programs. Therefore, each Recipient's RMP may include definitions that expand the NSF definitions to fit its particular needs. For example, each plan should include, among other things, definitions for the ratings used for technical, schedule, and cost risk in qualitative risk analysis.
<b>3. Risk Management Strategy and Approach</b>	Provide an overview of the risk management approach, to include the status of the risk management effort to date, and a description of the project risk management strategy.
<b>4. Organization</b>	Describe the risk management organization of the Recipient and list the roles and responsibilities of each of the risk management participants.



Section	Description
<b>5. Resources Implications of the Plan</b>	The resources to be used in managing risk on the project should include the time of management and project team members as well as risk specialists and contractors if appropriate, to manage effectively the risks on the project. These risk management costs should appear specifically in the project budget.
<b>6. Schedule Implications of the Plan</b>	The time periods in the project schedule when risk management activities are planned to occur. Activities providing sufficient time to perform the tasks and milestones to record their completion should be inserted in the project schedule and statused along with the schedule statusing plan.
<b>7. Risk Management Process and Procedures</b>	Describe the project risk management process to be employed, i.e., risk planning, qualitative and quantitative risk assessment, handling, monitoring and documentation, and a basic explanation of these components. Also provide application guidance for each of the risk management functions in the process. If possible, the guidance should be as general as possible to allow the project's risk management organization flexibility in managing the project risk, yet specific enough to ensure a common and coordinated approach to risk management. It should address how the information associated with each element of the risk management process will be documented and communicated to all participants in the process, and how risks will be tracked to include the identification of specific metrics if possible.
<b>8. Risk Planning</b>	This section describes the relationship between continuous risk planning and this RMP. Guidance on updates of the RMP and the approval process to be followed should be included.
<b>9. Risk Identification</b>	This section of the plan describes the identification process. It includes procedures to be used for examining the critical risk areas and processes to identify and document the associated risks.
<b>10. Risk Register Analysis and Ranking</b>	This section summarizes the analyses process for developing a qualitative or quantitative risk rating and populating the Risk Register. This rating is a reflection of the potential probability of each risk and the impact of each risk on the project schedule, cost, scope and quality. It also describes how the risk analysis data will be collected and maintained throughout the project's life cycle.
<b>11. Probabilistic Risk Analysis and Contingency</b>	This section describes the way the project will analyze the implications of identified and quantified risks on the total project schedule and cost objectives or major milestones. Typically a Monte Carlo simulation is used based on the project resource-loaded schedule or on the cost estimate if a schedule is not available. This section also describes the use of the risk analysis results for setting contingency amounts and prioritizing risks for risk mitigation.
<b>12. Risk Handling</b>	This section describes the risk handling options, and identifies tools that can assist in implementing the risk handling process. It also provides guidance on the use of the various handling options for specific risks.
<b>13. Risk Monitoring</b>	This section describes the process and procedures that will be followed to monitor the status of the various risk events identified including the frequency and organizational level of risk review. It provides for identification and calibration of new risks should they arise. It should provide criteria for the selection of risks and risk mitigations to be reported on, and the frequency of reporting. Guidance on the selection of metrics should also be included.



Section	Description
<b>14. Risk Management Information System, Documentation and Reports</b>	This section describes the management information system structure, rules, and procedures that will be used to document the results of the risk management process. It also identifies the risk management documentation and reports that will be prepared; specifies the format and frequency of the reports; and assigns responsibility for their preparation and dissemination.
<b>15. Risk Exposure and Contingency Management</b>	This section describes the specific process and procedures used to determine construction project risk exposures and the concomitant contingencies for scope, cost, and schedule. It describes contingency management plans and processes and ensures that contingency use is linked to both an identified risk and an appropriate Work Breakdown Structure (WBS) element within project scope.

**5.2.5.2 Roles and Responsibilities**

Typically, the Project Manager or a designated Risk Manager (RM) is responsible for leading the identification and analysis of project risks. All stakeholders (e.g., users, designers, and sponsors) involved in the project are asked to provide input on what they deem to be the risks for the project, possible risk mitigations, and ways to capture potential opportunities. The RM consolidates the information collected and creates the list of risks with accompanying attributes, and manages the response to the risks. An example of a Roles and Responsibilities table for key stakeholders and project staff that meets requirements is shown below in Table 5.2.5-2.

Table 5.2.5-2 Example of a Risk Management Roles and Responsibilities Table

Roles	Responsibilities
<b>Organization Management</b>	<ul style="list-style-type: none"> <li>• Support the risk management process. Encourage all levels of the project organization to participate fully and openly in the process.</li> <li>• Make project decisions based in part on the results of risk analysis.</li> <li>• Provide the culture that supports risk management and welcomes honest and realistic results.</li> </ul>
<b>Risk Manager</b>	<ul style="list-style-type: none"> <li>• Oversee the Identification and documentation of new risks (threats and opportunities) in the risk register</li> <li>• Oversee the analysis of risks by the project team and work with them to develop risk response plans (mitigate, avoid, accept, and transfer).</li> <li>• Oversee reporting and tracking of risk activities during project status meetings</li> <li>• Document and communicate risk activities frequently with stakeholders</li> <li>• Review risks as they are concluded, and identify lessons learned</li> <li>• Recommend and champion mitigation strategies to the Change control Board (CCB) on behalf of the risk management team.</li> </ul>

5.2.5 Risk Management Planning

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)



Roles	Responsibilities
<p><b>Project Team Members</b></p>	<ul style="list-style-type: none"> <li>• Assist the RM with the risk identification, qualitative and quantitative risk analysis and development of risk response plans (mitigate, avoid, accept, and transfer). Participate in risk workshops and interviews to provide risk data.</li> <li>• Submit new threats, opportunities, and mitigations into the risk system as they arise.</li> <li>• Assist the RM with the development and execution of risk response plans</li> <li>• Attend project risk status meetings, as needed, and assist RM with the reporting and tracking of risk activities</li> <li>• Assist the RM with documenting and communicating the risk (threats and opportunities) activities frequently with stakeholders</li> <li>• Review risks as they are concluded, and identify lessons learned</li> </ul>
<p><b>Risk Owner</b></p>	<ul style="list-style-type: none"> <li>• Assist the risk originator (PM, RM, project team member, etc.) with development of the risk descriptions</li> <li>• Assist the RM and project team with the analysis development of risk response plans (mitigate, avoid, accept, and transfer) contingency plans</li> <li>• Update the risk register with modifications to risks</li> <li>• Monitor the risk triggers and update the risk register</li> <li>• Attend project status meetings, as needed, and assist the PM with reporting and tracking risk activities</li> <li>• Assist the RM and project team with documenting and communicating risk activities with stakeholders</li> <li>• Capture risk closure notes in the risk register and lessons learned</li> </ul>

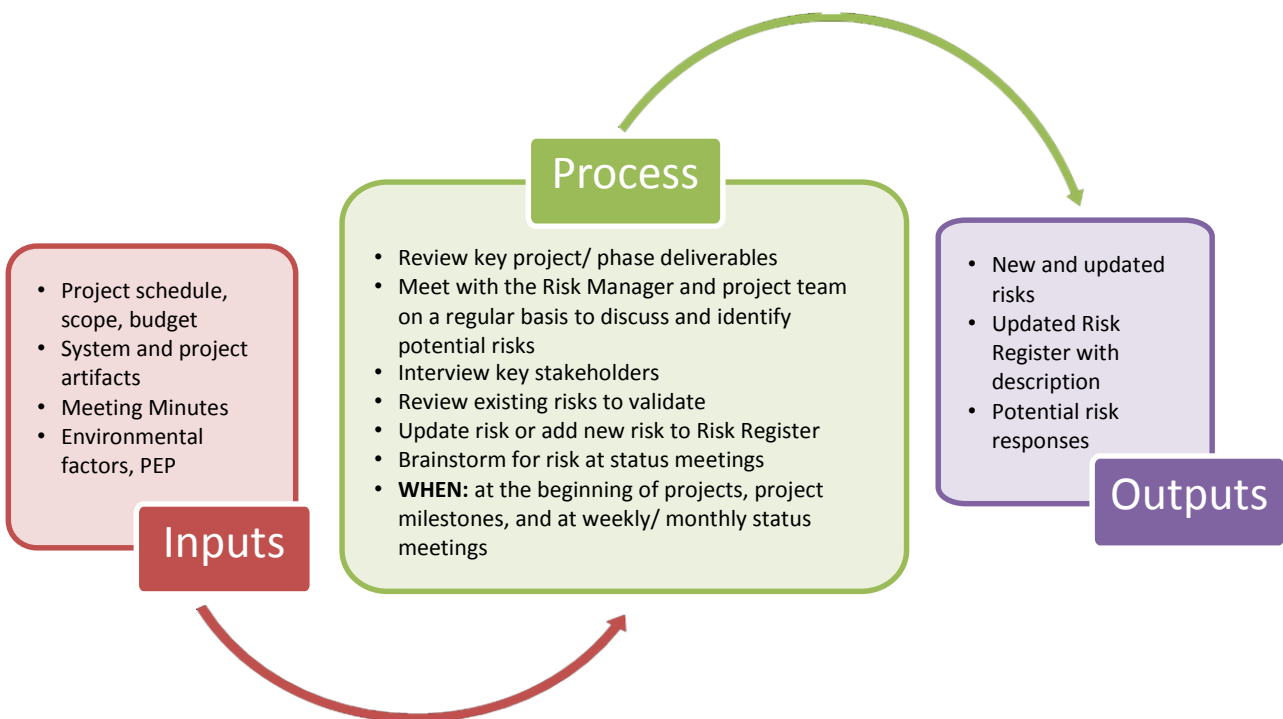


## 5.2.6 Risk Identification

### 5.2.6.1 Risk Identification Process

Risk identification is an organized approach for determining, listing, and describing events that might impact a project’s objectives (for example, time, cost, scope, and performance). It is an iterative process that is conducted throughout the entire project life cycle. The risks are described with a basis as to why this event is considered a risk. Identification relies on the skill, experience, and insight of project personnel and subject matter experts (SMEs), as well as the Recipient’s project manager, the NSF Program Officer, and the NSF Grants and Agreements Officer. The objective of risk identification is to describe all the relevant risks so that the group can focus on uncovering the probability and impact of the risks on project objectives (used in qualitative risk analysis) or activities / costs affected (used in quantitative risk analysis). The process for performing Risk Identification, along with inputs and outputs, is given in Figure 5.2.6-1.

Figure 5.2.6-1 Risk Identification Process



Techniques used in identifying risks include leveraging existing project artifacts and guidance documents, as well as proactively searching and gathering information to assist in that identification. The quality and completeness of risk identification is primarily dependent upon the knowledge and experience of the project team and its commitment to risk management processes. For example, the following basic methods can be used to assist in the identification of risks:



- Brainstorming
- Diagramming
- Interviewing
- Analysis of existing project artifacts
- Comparison to historical information

Formal risk identification is performed in the early part of the project life cycle and as part of a continuous effort during the project life cycle. Any person associated with the project should be encouraged to continually identify potential project risks. Risk Identification, whether in workshops or in interviews, should include at least the following participants:

- Project managers
- Project team leaders
- Project team members
- Business stakeholders
- SMEs
- Contractors
- SMEs outside the project team, for unbiased perspective
- Project partners (e.g., foreign agencies, organizations with diverse objectives)

One immediate outcome of risk identification is the populating of the Risk Register, or tracking tool, with the identified risks. The priorities based on impacts to project objectives and plans for handling and reducing impacts will be added after analysis and risk handling planning, as described in later sections. The Risk Register provides a means of tracking and reporting status as risks occur and migration strategies are implemented, and is an important tool for Risk Management implementation.

#### **5.2.6.2 Risk Identification and the Risk Register**

The Risk Register includes a description of all risks that are deemed to be important to achieving project success (from the Risk Identification process) along with an assessment of those risks (using Qualitative Risk Analysis) that allows risks to be prioritized for effective risk management. The results of identification, qualitative analysis, and risk handling – the major components in the Risk Register – can lead to further analysis (Quantitative Risk Analysis, for example).

Each risk should be assigned a unique identification number or code. Once a risk is entered in to the Register, it is never deleted. Its state may be changed to inactive (for example, retired, closed, or merged with another risk), but it should never be deleted from the register. Risk IDs are never reused.

The Register should be accessible (read-access) to all project members – the primary objective of the Register is to keep the project team thinking pro-actively about how to avoid or mitigate threats and take advantage of opportunities. It can be a spreadsheet, data base, or a specialized



risk management software tool. Changes to the Register should be managed through the risk process, which often may restrict ability to make changes (write-access) to a small team or to the Risk Manager. The mechanism for all project members to read, comment on, and submit new risks and mitigations should be established in the RMP.

The examples shown here and in Section 5.2.7, Qualitative Risk Analysis, lead to a Risk Register containing a ranked subset or summarized set of risks based on individual, qualitative impact analysis. Note that numeric impacts determined by the qualitative method for individual risks may not be summed or combined to give a value for overall project risk exposure.

Further discussion of Risk Register content is given in Section 5.2.7, Qualitative Risk Analysis, with a sample Risk Register shown in Figure 5.2.7-6.

### 5.2.6.3 Risk Description

The risk description serves as a key point in the Risk Register, and will be generated and updated as needed. If there is a trigger event that causes the risk or foretells the risk's occurring it should be described since it will specify what condition(s) would launch the risk and maybe activate a contingency plan.

Risks (both threats and opportunities) are typically identified and tracked using the following sentence structure for the Risk Description:

*"Because of (some cause) a (risk) may occur, and (consequences) will happen."*

Example:

*"Because foreign exchange rates may change, the cost of components in WBS 3.1 and 2.6 may increase or decrease, causing cost variances which affect contingency use."*

Using this format helps to distinguish the uncertainty or risk from its cause and its consequence, a distinction which is important for mitigation planning. For instance, a statement that "we have 5 schedule risks" is focused on an objective (schedule) that is impacted, not the root cause of the risk or uncertainty. Alternatively, a statement that "the risk is that the technology is really hard" does not lend itself to mitigation efforts. Difficulty of technology is a fact or a "cause" in this format, which cannot be changed. The risk may be that "we do not have the right skills on the project to handle the complexity" or "we may have to rely on third parties to gain control of this technology." That is a risk that can perhaps be mitigated. A possible risk description for this scenario may be:

*Because the technology for the major components in WBS 2.7 is very advanced, we may have to rely on third parties for design, with the consequence that we have less control over cost and schedule and an added burden of increased communication efforts.*





Risks should be identified that are both internal, perhaps under project control, and external, likely to be beyond project control. Risks for which there are no plans for mitigation should also be included in the register.<sup>1</sup> However, note that NSF does not allow the use of contingency for risks that are commonly referred to as “unknown unknowns”<sup>2</sup> such as exceptional events or major changes in scope. These exceptional events may not be included in quantitative risk analyses used in determining contingency amounts.

#### 5.2.6.4 Risk Identification Concerns

Efforts should be made to identify all risks to the project as early as possible, employing all stakeholders identified in and using the techniques listed in Section 5.2.6.1, Risk Identification Process. At the time of the risk analysis there are likely to be risks that are currently unknown but may be revealed at a later date. When they become apparent, they can be then analyzed and a “corrective action” can be specified and implemented. The objective of the Risk Management program is to minimize the number of unanticipated issues and to address them when possible and prudent.

Some people believe that project risk is often underestimated in both cost and schedule, leading to well-known, sometimes notorious, overruns.<sup>3,4</sup> Historical experience suggests that mega-projects suffer from such problems systematically.<sup>5</sup> Strategic or overarching risks are often missed in the risk identification process since the participants do not think globally, only locally. Systemic or overarching risks are often not discussed or even considered during risk identification. There may be cultural bias that leads to optimistic thinking in which threats are systematically underestimated, outcomes are assumed to be achievable with less than realistic effort and the potential for set-backs and rework is ignored. Any tool or technique that will encourage people to “think outside of the box” when identifying project risk will help identify the possibility of large overruns – when caught early, these risks may be manageable.

One common issue in identifying and collecting project risks is that people’s response and participation in the identification process may be “stove-piped.” That means that people will ordinarily discuss threats and opportunities that have to do with their own area of

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<sup>1</sup> The fact that “we cannot do anything about it” or “we choose to accept the risk” does not disqualify it as a risk to the project. One can argue that these risks must be in the Risk Register and certainly in the Quantitative Risk Analysis.

<sup>2</sup> In many Risk Management guides, a portion of contingency is designated as management reserve for “unknown unknowns.” NSF does not allow what is normally referred to as management reserve. The current NSF budget cap policy and scope decrease plans of 10% of the Project Management Baseline replaces reserve.

<sup>3</sup> See Bent Flyvbjerg, Nils Bruzelius, and Werner Rothengatter, *Megaprojects and Risk: An Anatomy of Ambition*, 2003 Cambridge University Press, and Glenn Butts and Kent Linton, “NASA the Joint Confidence Level Paradox – a History of Denial,” NASA Cost Symposium, April 28, 2009.

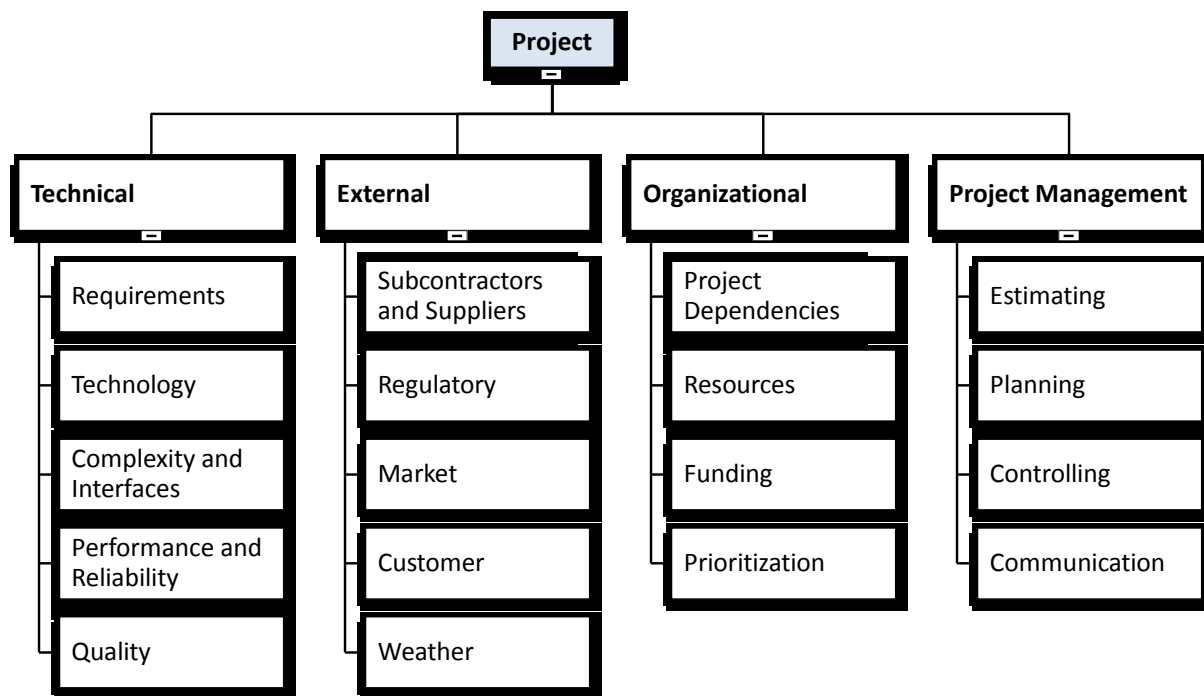
<sup>4</sup> Challenges to Meeting cost, Schedule, and Performance Goals, NASA IG-12-21

<sup>5</sup> Edward W. Merrow, *Industrial Megaprojects*, 2011, Wiley.



concentration. In practice the project teams and other SMEs have experience and knowledge outside these narrow areas, so the data collection method used should encourage them to think broadly and strategically when identifying risks. Reminding risk identification participants of external, organizational and project management source-areas of risks can help elucidate strategic risks that they know about but that are outside their narrow area of technical expertise or their work assignment. Often the use of a standard Risk Breakdown Structure shown in Figure 5.2.6-2 will encourage risk identification participants to think more broadly about risks to the project.

Figure 5.2.6-2 Typical Risk Breakdown Structure (RBS)<sup>1</sup>



Different approaches to Risk Management may subdivide risks into various categories for analysis. For illustrative purposes, this guide will use cost, schedule, and technical or performance risk as the categories used in examples. Other risk categories commonly in use are programmatic, business or economic, design requirements, software, and technology risks. Alternatively, the OMB Risk Categories shown in Figure 5.2.6-3 could be used as guidelines for identifying the various types of risk that apply to the project (refer to “OMB Risk Categories” document in Critical Infrastructure Protection (CIP) for detailed descriptions and examples of these categories). See the Government Accountability Office (GAO) Cost Estimating and Assessment Guide, GAO-09-3SP, Chapter 14, for more examples. Some projects may also decide to differentiate between internal and external risks. In many cases, it may be advisable to use

<sup>1</sup> This RBS was the initial model for the RBS in the PMBOK® Guide, Chapter 11 of the Project Management Institute



different categories for various parts of a project. For instance, categories of risk may be different for software development than for hardware procurement. Each project should decide which categories are most appropriate for its use while establishing the Risk Management Plan and processes.

Figure 5.2.6-3 OMB Risk Categories: to be used as a starting point for projects to select their own categories

1) Schedule	11) Overall Risk of Project Failure
2) Initial Costs	12) Organizational and Change Management
3) Life Cycle Costs	13) Business
4) Technical Obsolescence	14) Data/Info
5) Feasibility	15) Technology
6) Reliability of Systems	16) Strategic
7) Dependencies and Interoperability	17) Security
8) Surety (Asset Protection)	18) Privacy
9) Risk of Creating a Monopoly	19) Project Resources
10) Capability of Agency to Manage the Investment	

Another related social or cultural issue in identifying project risks is that people are often uneasy about (or even afraid to be) discussing risks that can be embarrassing or harmful to the project. This unease is often experienced during risk workshops or in other group settings. Social pressures to conform (“groupthink”) – to suppress dissenting opinions clearly unpopular to the group, including management, to agree with others against personal opinion just to move the workshop along, and to defer to people perceived to have greater expertise even when in disagreement – often make it difficult for some people to speak out.<sup>1</sup> A possible solution to the impacts of social pressure is to conduct one-on-one, in-depth interviews with SMEs in which the interviewee is promised confidentiality. Such interviews often yield honest opinions about what might affect the project’s success. Usually some or most of the risks revealed and discussed in these sessions are not on the organization’s risk register and would not be analyzed in qualitative or quantitative risk analysis in the absence of the interviews. For these reasons it is important to provide a safe environment for project team members and others to identify and discuss project risks.

Risk identifiers may have concerns about including risks that are 100% likely to happen (sometimes these are called “uncertainties or issues”) in the Risk Register. If the risks are 100% likely to happen and their impacts are known, they should be included in the PMB. Often, however, a risk that is certain to occur will have an impact that is not already included in the project execution plan and that needs to be handled somewhere else, such as in the risk

<sup>1</sup> These phenomena are discussed in Understanding and Managing Risk Attitude, David Hillson and Ruth Murray-Webster, Gower, 2005.



analysis. Or the risk may have an uncertain impact on project objectives. These situations call for the risk to be identified, even if it is already happening or certainly will happen, so the risk can be included in the Risk Register and the subsequent quantitative risk analysis. The objective of risk identification is to describe all the relevant risks so that the group can focus on uncovering the probability and impact of the risks on project objectives (used in qualitative risk analysis) or activities / costs affected (used in quantitative risk analysis). Once a risk that is certain to occur has been included in the PMB it can be removed from the Risk Register.

Care must be taken to provide the same thoroughness of identification for events far in the future as well as for the near term for projects that have an execution period of several years. Project team members usually find that it is easier to identify and discuss the risks that are current or on the near horizon than those that may occur much later in the project. Adding to the difficulty is the fact that future events may not be well defined at the time of risk analysis. The risk identification exercise should take special care to encourage the participants to look into the future, maybe with the help of lessons learned documents or their own experiences on prior projects, to see what risks are far down the project life cycle. Another useful technique is to “walk through” the activities planned for later execution. Examples of unidentified risks may include unexpected legal changes, technical performance issues, resource losses, etc. Other sources of future risks might include the reliance on unproven or even just conceptualized technology or on doing business with an organization or in a country unknown to the sponsors. The risk identification should include thinking about risks that have happened on other similar projects or might occur in later phases of this project. If the team spends some time discussing these down-stream risks they can perhaps remember other projects or conceptualize the existence of risks that would otherwise go unreported.

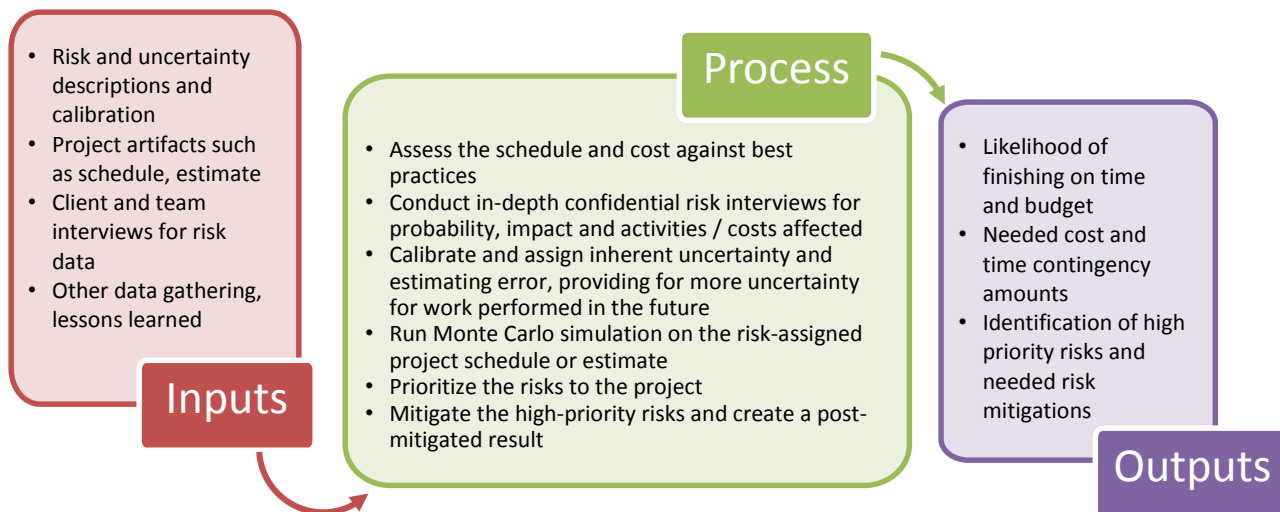


## 5.2.7 Qualitative Risk Analysis – Risk Register Ranking

### 5.2.7.1 Purpose of Qualitative Risk Analysis

Qualitative risk analysis involves determining the probability of the occurrence of a risk, assessing the consequences of this risk on specific project objectives (time, cost, scope and quality) if it occurs, and using the two dimensions of a risk (probability and consequence) to identify a rank or “risk level.” This risk level represents a judgment as to the relative risk to the project objectives and the project as a whole and is categorized as *Low*, *Moderate*, or *High*. Based on the risk level, risks can be prioritized for mitigation to responses. The results of Risk Identification, Qualitative Risk Analysis, and Risk Response Planning comprise the main elements of the Risk Register. The process for performing Qualitative Risk Analysis, along with inputs and outputs, is given in Figure 5.2.7-1 below.

Figure 5.2.7-1 Qualitative Risk Analysis Process



Achieving risk reduction is an integral part of setting priorities, sequencing project work, and responding to the most serious risks first. Thus, the identified risks must be prioritized. Note that Qualitative Risk Analysis is applied only to individual risks and is not used in estimating overall project risk exposure or in determining contingency amounts. The analysis of impact or consequence, however, may serve as input to Quantitative Analysis used to estimate overall risk exposure.

### 5.2.7.2 Considerations When Performing Qualitative Risk Analysis

A number of factors complicate qualitative risk analysis, including:

- Risk data, like data about the future contained in cost estimates or project schedules, have a significant content based on subjective, expert judgment. The evaluation of risks



to cost and schedule therefore generate approximate rather than precise results. “There are no facts about the future.”<sup>1</sup>

- The term “risk” includes both “threats” and “opportunities” for NSF purposes. Project risk team members should look for uncertainties that could help improve the project’s results or offset threats. Both threats and opportunities should be examined for total project impact, since opportunities for one project participant may be considered threats by another, and vice versa.
- The probability that a risk may occur and the impact if the risk were to occur should be evaluated separately before combining the two parameters in a risk matrix. The idea that “the risk is unlikely so its impact must be low” confuses the two parameters of probability and impact. SMEs should be asked to estimate the impacts as if the risk has occurred. Probability and impact will be considered together in the combined risk matrix approach.
- It is good practice to assess risks’ impact on separate objectives such as time, cost, scope or quality/performance Impact ranges rather than creating a single, overall risk level for the risk. Thus, ranking levels are defined for each of these objectives. For instance, a risk can be judged to have a high impact on time but a moderate impact on cost and a low impact on scope.
- The definitions of impact on each project objective (very low, low, moderate, high and very high) are set by the Risk Manager and documented in the RMP.
- The definitions of combined risk level for probability and impact taken together (low, moderate or high; or green, yellow or red) in the Risk Matrix are set by the Risk Manager and documented in the RMP.
- The impact of an individual risk may be modest and still be considered a high or very high priority for mitigation. This is because the combined or aggregate risk of many moderate risks may be high. The project may want to mitigate some low or moderate risk in order to reduce the combined threat from many risks.
- The risk register should include only root cause risks. Risks as defined in the plan may not be mutually exclusive, that is, they may have the same root cause risk. Put another way, if two or more risks are not mutually exclusive as written, their common root cause risk should be identified and used instead.

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<sup>1</sup> Lincoln E. Moses, Administrator of the Energy Information Administration, Administrator’s Message to the [Annual Report To Congress, 1977](#), Volume Three.



### 5.2.7.3 Limitations of Qualitative Analysis

There are some limitations to the practice of qualitative risk analysis. Recognizing these will help the organization appreciate and use the results correctly:

- Qualitative Risk Analysis addresses the impact of individual risks on project objectives one at a time. As such it is dedicated to prioritizing individual risks based on subjective estimates of probability and subjective estimates of the impact to the project objectives. It is not equipped to forecast or estimate overall project results such as the finish date or total cost.
- Qualitative Risk Analysis is unlikely to yield valid quantitative results since it usually does not include all possible correlations and outcomes for impacted activities from a single risk. SMEs must consider the risk with its probability of occurring and all the activities in the schedule it would affect if it occurred, whether or not those activities are on the risk critical path (the risk equivalent to the critical path in CPM scheduling). They must also evaluate whether other risks might keep that risk from creating much improvement if it were mitigated. All of this analysis is being done in the individual SME's head. Such complex calculations are best handled by the Quantitative Risk Analysis simulation method described in Section 5.2.7.
- The estimation of the impact of a risk on cost must consider the impact of that risk directly on cost plus the impact indirectly on the cost of time-dependent resources if the risk also affects time. This is another calculation that individuals are not well-equipped to make without a computer but is handled well by Quantitative Risk Analysis.
- Judging whether a risk has a high-priority for the project would involve reviewing the conclusions on each objective and asking the risk manager to prioritize the objectives. Some projects are time sensitive and some are budget driven, others have a fixed scope or could be de-scoped. These factors would need to be considered to determine whether the risk is low, moderate or high priority for the project as a whole. Some software packages that perform qualitative risk analysis assume that if a risk is "high" for any objective it should be judged to be "high" for the entire project. There is no real basis for doing so, since the risk may be judged to be high for an objective that is not the most important for the specific project under consideration.

### 5.2.7.4 Qualitative Risk Analysis – Probability and Impact Assessment

Risk level determination can be done using a variety of techniques. The method given here begins by assigning qualitative values for event probability and impact/consequence(s) to each objective separately. These will then be used to determine a qualitative risk level. A key feature of this method is that it requires independent assessment of the probability and consequence of a risk.



The probability of a risk occurring is usually given to a range of possible probabilities of occurring. Similarly, consequences are usually expressed in levels that represent ranges of impacts judged by the risk manager to be of very low, low, moderate, high or very high impact as the result of one risk among many. The ranking of a risk as it is applied to a particular objective (e.g., time) is determined by the combination of probability and impact ranges, where the project manager or some other stakeholder (e.g., the customer) determines which combinations would indicate that the risk is high, moderate or low priority for further study, quantitative risk analysis or handling.

The following steps provide the details of this Qualitative Analysis method:

1. Address each risk statement from the Risk Identification process individually.
2. Determine the qualitative probability of occurrence value (P) range that best describes the probability for each risk with appropriate basis and justification. Discuss the probability that the risk might occur on the project with some noticeable effect on the objective being discussed. Estimate the probability for the risk without regard to which objective(s) the risk affects if it occurs. The probability of occurrence is for the duration of all project phases. Table 5.2.7-1 provides an example of typical criteria for establishing probability values.
3. Determine the qualitative consequence or impact of occurrence value I range that best describes the impact for the objective such as time, cost, scope or performance for each risk with appropriate basis and justification. In the evaluation, assume that the risk has occurred and determine the recovery time, the cost of recovery, and the impact on scope or quality. The consequence of occurrence is for the duration of all project phases and for the objective being assessed. Table 5.2.7-2 provides typical criteria for establishing consequence values. This table illustrates the different definitions that are applied to the implications for time, cost, scope and quality. Of course these definitions should be tailored to the project by the project manager or some other stakeholder (e.g., the owner or customer).





Table 5.2.7-1 Sample Risk Probabilities Table

Each project should determine the appropriate number of levels and their definitions that match that project’s circumstances.

Probability of Occurrence Descriptor	Probability of Occurrence	
	Numerical Ranges equivalent levels <sup>1</sup>	Criteria in Words
Very Low	<0.1	Will not likely occur anytime in life cycle of the facilities; or the probability of occurrence is less than equal to 10%.
Low	>0.1 but <0.4	Will not very likely occur in the life cycle of the project or its facilities; or the probability of occurrence is greater than 10% but less than or equal to 40%.
Moderate	>0.4 but <0.6	Will likely with middling probability (e.g., a coin flip) to occur sometime during the life cycle of the project or its facilities; or the probability of occurrence is greater than 40% but less than 60%.
High	>.6 but <.8	Likely to occur with more than 60 percent chance during the project, or the probability of occurrence is between 60% and 80%
Very High	>0.8	Will likely occur sometime during the life cycle of the project; or the probability of occurrence is greater than or equal to 80%.

Table 5.2.7-2 Sample Risk Consequences<sup>2</sup> Table

The descriptors for the objectives of cost and time are explicitly given as numbers while those for scope and quality are expressed in narrative descriptions.

Defined Conditions for Impact Scales of a Risk on Major Project Objectives, e.g., Time Definition for Threats Only					
Project Objective	Very Low	Low	Moderate	High	Very High
Cost	Insignificant Cost Increase	<5% Cost Increase	<5 - 10% Cost Increase	<0 - 20% Cost Increase	>20% Cost Increase
Time	Insignificant Time Increase	<5% Time Increase	<5 - 10 % Time Increase	<0 - 20 % Time Increase	>20% Time Increase
Scope	Scope Decreases are Barely Noticeable	Minor Areas of Scope Affected	Major Areas of Scope Affected	Scope Reduction Unacceptable to Sponsor	Project End Item is Effectively Useless
Quality	Quality Degradation Barely Noticeable	Only Very Demanding Applications are Affected	Quality Reduction Requires Sponsor Approval	Quality Reduction Unacceptable to Sponsor	Project End Item is Effectively Useless

<sup>1</sup> The scales still must be calibrated per the discussion and reference in Section 5.2.9.

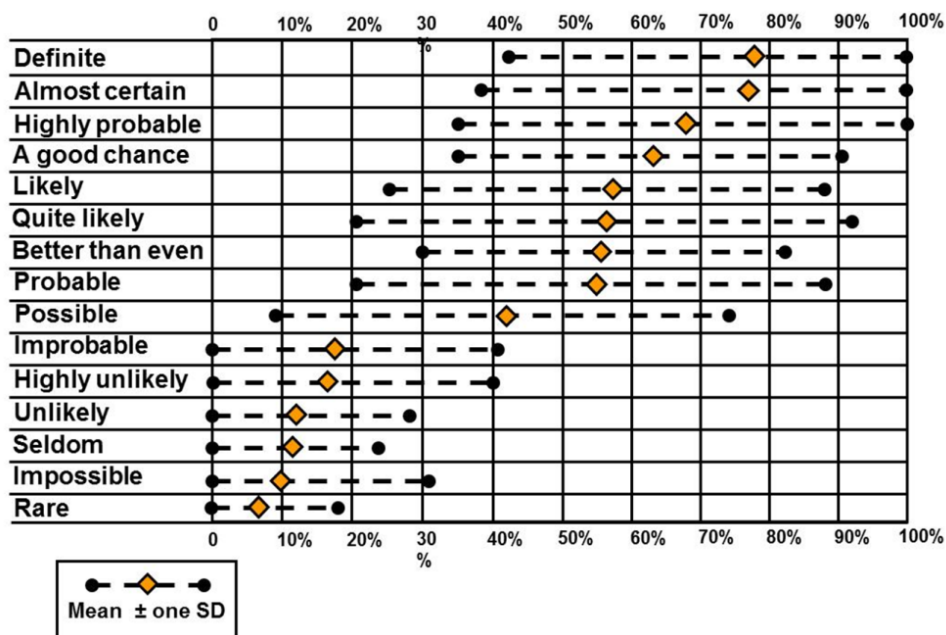
<sup>2</sup> An earlier version of this table was used in the PMBOK® Guide. The percentage ranges should be adjusted by the project manager for the project and translated into days and dollars for ease of use.



Notice that the definitions for time and cost can be quantitative but that those for scope and quality are generally descriptive. Sometimes a project’s scopes can be quantified, though it may have several dimensions. Quality or performance might be measurable in terms of failure rates or number of “fixes” that would be needed. The more the impact levels can be quantified the more the responses by different people will be comparable. The project manager can calibrate the numerical ranges for the specific project. The consequence definitions of very low, low, moderate, high or very high (or *Negligible, Marginal, Significant, Critical, and Crisis*) may vary considerably from a small to a large project. These tables should be provided as part of the RMP.

It is preferable to refer to the numerical levels when gathering qualitative risk data since definitions in words are often misleading. For instance, two people may use the term “Likely” but mean different values. Or, one may say the risk is “likely” to occur and another may say “unlikely” but mean the same numerical value, or at least in the same “bucket” or range of values. Research has shown that the overlap in probability values with common word definitions is severe.<sup>1</sup> (See Figure 5.2.7-2.)

Figure 5.2.7-2 Overlap in Risk Probability of Occurring When Descriptors Are Used



Expert judgment is required in risk analysis, just as it is for project scheduling and project cost estimating. That is why several or many people need to be involved in providing their opinions and experiences when assessing project risks. With multiple people assessing the probability and impact of each risk against each objective, such as in the recommended in-depth

<sup>1</sup> Private research conducted by Dr. David Hillson in 2004 and presented at a PMI EMEA conference.



confidential interviews, there will be differences of opinion between them. The risk analyst has to consolidate the data from different sources into one set of parameters for each risk and objective from the dissimilar responses. This process uses expert judgment.

**5.2.7.5 Alternative Approach to Qualitative Risk Impact Analysis – Maxwell**

An alternative approach is that proposed by F. D. Maxwell for projects such as those supported by the Aerospace Corporation or the Space & Missile Systems Center of the US Air Force in Los Angeles. See Table 5.2.7-3. The “risk driver category” is not the same as the project objectives, but rather describes where the risks might be originating. This was not used by Maxwell in conjunction with the probability before 1990, but it does illustrate definitions of impact that were used on many aerospace and scientific projects. Maxwell stated that:

*Special attention must be given to first-of-a-kind risks because they are often associated with project failure. First-of-a-kind risks should receive a critical or crisis consequence estimate unless there is a compelling argument for a lesser consequence value determination.*

Table 5.2.7-3 Maxwell Risk Driver Assessment Framework<sup>1</sup>

		Risk Levels				
Risk Driver Category	Very Low	Low	Medium	High	Very High	
1 Required Technical Advancement	Nothing New	Minor Modifications Only	Major Modifications	State of the Art	Beyond State of the Art	
2 Technology Status	Currently in Use	Prototype Exists	Under Development	In Design	Concept State	
3 Complexity	Simple	Somewhat Complex	Moderately Complex	Highly Complex	Highly Complex with Uncertainties	
4 Interaction/Dependencies	Independent of Other Risk Drivers	Dependent on One Additional Risk Driver	Dependent on Two Additional Risk Drivers	Dependent on Three Additional Risk Drivers	Dependent on more than Three Additional Risk Drivers	
5 Producibility	Established	Demonstrated	Feasible	Known Difficulties	Infeasible	
6 Process Controls	Statistical Process Controls (SPC)	Documented Controls (No SPC)	Limited Controls	Adequate Controls	No Known Controls	
7 Manufacturing Precision	High	Adequate	Limited Margins	Known but Inadequate	Unknown	

<sup>1</sup> Developed by F. D. Maxwell at the Aerospace Corporation. Included in “Estimating Cost Uncertainty when only Baseline Cost is Available,” quoting R.L. Abramson and S. A. Book, “A Quantification Structure for Assessing Risk-Impact Drivers,” Laserlight Networks, briefing presented to the 24th Annual DOD Cost Symposium (Leesburg, VA, September 5-7, 1990).



Risk Driver Category	Very Low	Low	Medium	High	Very High
8 Reliability	Historically High	Average	Known Limited Problems	Serious Problems of Unknown Scope	Infeasible
9 Criticality to Mission	Nonessential	Minimum Impact	Known Alternatives Available	Possible Alternatives Exist	“Show Stopper”
10 Cost	Established	Known History or Close Analogies	Predicted by Calibrated Model	Out of Range of Experience	Unknown or Unsupported Estimate
11 Schedule	Demonstrated	Historical Similarity	Validated Analysis	Inadequate Analysis	Unknown or Unsupported Estimate

**5.2.7.6 Qualitative Risk Analysis – Risk Level Matrix**

Once the probability and impact level of each identified risk is agreed to, the risk’s position is determined on the probability and impact matrix shown in the following figures. The vertical matrix axis labels in the figures correspond to the definitions for probability levels given in Table 5.2.7-1, and the horizontal axis labels correspond to the values for impact defined in Table 5.2.7-2. Combinations of probability and impact for a risk are shaded as red, yellow and green for high, medium, and low risk level. The risk manager, project manager, or other stakeholder should set these regions for each risk level, based on an understanding of the definitions of the axes, which would cause the risk to rise to the appropriate level of attention.

Figure 5.2.7-3 shows a risk probability and impact matrix for one objective that is symmetrical. Figure 5.2.7-4 shows a risk probability and impact matrix for an objective that emphasizes the impact of the risk on its red-yellow-green status. This asymmetrical risk matrix indicates that any risk that has a very high impact will achieve “high risk” or “red risk” status without regard to the probability that the risk will occur on the project. Of course the definitions of risk impact and probability buckets defined in the RMP will determine the relative score that the risk achieves.



Figure 5.2.7-3 Symmetrical Risk Level Matrix

Probability and Impact Matrix for a Specific Objective (Time, Cost, Scope or Quality)					
Probability	Symmetrical				
Very High	Mod	Mod	High	High	High
High	Low	Mod	High	High	High
Mod	Low	Mod	Mod	High	High
Low	Low	Low	Mod	Mod	Mod
Very Low	Low	Low	Low	Low	Mod
	Very Low	Low	Moderate	High	Very High
	Impact				

Figure 5.2.7-4 Asymmetrical Risk Level Matrix

Probability and Impact Matrix for an Objective (Time, Cost, Scope)					
Probability	Impact Averse				
Very High	Low	Mod	High	High	High
High	Low	Mod	Mod	High	High
Mod	Low	Low	Mod	High	High
Low	Low	Low	Mod	Mod	High
Very Low	Low	Low	Low	Mod	High
	Very Low	Low	Moderate	High	Very High
	Impact				

The Risk Level for each objective for a defined risk depends upon where it falls in the Risk Level Matrix according to the axes definitions. For example, a cost risk with an estimated probability of 70% of occurrence and an estimated impact of \$280K, or cost increase of 9% for the item at risk, would fall into the High probability range and the Moderate cost impact range, according to Table 5.2.7-1 and Table 5.2.7-2. Thus the Risk Level for cost for this particular risk occurring falls into the High, or “red” range in Figure 5.2.7-3.

It is important to scale probability and impact so that the risks can be distinguished. On the one hand, if the lower bound for an impact score of very high is easy to reach there will be many risks with the same “red” assessment and the method will not distinguish risks for priority Risk Handling. On the other hand, definitions of high or very high impacts that are very difficult to reach will lead to very few or no “red” risks. While that may be true for some projects it would be unusual for an NSF project with a high scientific impact.



The objective of the matrix is to communicate the choice of priorities for monitoring and response, which may best be done with the 2-D diagrams (5x5) shown herein. Depending upon the activity and the ability to differentiate the risk levels, other matrices may be chosen by the risk analysis team. For example, a 5x5x4 risk level (the fourth level represents the 4 objectives) matrix would then have five values for probability, five for consequence and four for objectives.

Recall that Risk Management entails the identification and ranking of opportunities as well as threats.<sup>1</sup> Opportunities that are assessed to be in the “High” category are viewed as “low-hanging fruit” that can be easily claimed for the project if sought. For instance, if people are coming off another similar project where they have had a good result, our project will benefit if we can encourage or otherwise get them to join our project team. However, if such an opportunity is not recognized in a timely manner, those productive people will go to other projects. Another example is a potential cost saving if older but acceptable technologies can be used in place of cutting edge solutions without impacting performance or quality. This type of cost savings is common in data acquisition and storage systems, for instance.

The butterfly or mirror risk probability and impact matrix below shows scoring threats and opportunities in similar ways. The red-yellow-green ranges for threats have been discussed. The red risks for opportunities are those that have a high likelihood of occurring and if they occur they help the project achieve its objectives, if only by offsetting threats. Risk Response of opportunities needs to be proactive in order to secure these opportunities for the project.

Figure 5.2.7-5 Probability and Impact Matrix including Threats and Opportunities

Mirror or Butterfly Probability and Impact Matrix for Threats and Opportunities											
Project Objective (e.g., time, cost, scope, quality)											
Prob.	Threats					Opportunities					Prob.
VH	L	M	M	H	H	H	H	M	M	L	V
H	L	L	M	H	H	H	H	M	L	L	H
M	L	L	M	H	H	H	H	M	L	L	M
L	L	L	L	M	H	H	M	L	L	L	L
VL	L	L	L	L	M	M	L	L	L	L	VL
	VL	L	M	H	VH	VH	H	M	L	VL	
	Impact (threats)					Impact (opportunities)					

<sup>1</sup> An early discussion of the use of opportunities in project management can be found in: Effective Opportunity Management for Projects: Exploiting Positive Risk, David Hillson, Marcel Dekker, 2004.



### **5.2.7.7 Risk Level Input to the Risk Register**

The Risk Levels per each objective for all identified risks are entered into the Risk Register. See the sample Risk Register in Figure 5.2.7-6. It is common practice to also include a column in the matrix for the probability descriptor for ease of reference. As mentioned before, it is good practice to list the Risk Level for each project objective separately and not combine them into a single risk level for the stated risk. Projects may choose, however, to designate a flag to identify some risks as “Major” or “Top” risks. These Top Risks are judged by the project management to call for more aggressive management and more frequent monitoring than other risks.

Communicating and tracking the status of the top project risks is a key element of project management. The Risk Management Plan should address the frequency with which these significant risks are tracked. Top risks should be reviewed and evaluated during standard sub-system team meetings and reviews as well as at project status meetings.

Projects should also include a status report for the top risks in the various required reports to NSF, including the monthly report, as well as for reviews. One simple method for communicating the summary status of top risks to various stakeholders is shown in the sample Top Risk Matrix shown in Figure 5.2.7-6, which shows risk level and trend data for selected risks.



Figure 5.2.7-6 Sample Risk Register with Risk ID Number, Associated WBS Identification, Qualitative Probability and Impact for Initial and Post-mitigation States, and Mitigation Actions

Risk ID	Risk Description	Associated WBS	Pre-Mitigated Scores							Post-Mitigated Scores										
			Probability and Impacts				Resulting Risk Score			Risk Action				Probability and Impacts				Resulting Risk Score		
			Prob. Risk Occurs	On Sched.	On Cost	On Scope/Quality/Performance	Risk on Sched.	Risk on Cost	Risk on Scope/Quality/Performance	Risk Owner	Risk Mitigation Actions	Trigger or Watch date	Major Risk Flag	Prob. Risk Occurs	On Schedule	On Cost	On Scope/Quality/Performance	Risk on Sched.	Risk on Cost	Risk on Scope/Quality/Performance
PM1	If ..., then ...	2.2	H	VH	H	M	H	H	M					M	M	M	L	M	M	M
TECH1	If ..., then ...	3.2.5	H	VH	H	H	H	H	H					M	H	M	L	H	M	M
EXT8	If ..., then ...	3.1.3	M	VH	H	M	H	H	M					L	H	M	L	M	M	L
ORG4	If ..., then ...	1.2	M	H	M	M	H	M	M					L	M	M	M	M	M	M
PM4	If ..., then ...	2.4.1	M	H	H	M	H	H	M					L	L	L	L	L	L	L
TECH5	If ..., then ...	3.3.1	M	VH	H	M	H	M	M					VL	M	M	M	L	M	L
TECH6			L	H	M	M	M	M	M					VL	L	L	M	L	L	M
EXT6			L	H	H	L	M	M	L					VL	M	L	L	M	L	L
PM2			M	L	H	L	M	H	M					L	L	H	VL	L	M	L
TECH9			VL	VH	VH	L	M	H	L					VL	H	VH	L	M	H	L
TECH10			VL	VH	M	VL	M	L	L					VL	M	L	VL	L	L	L

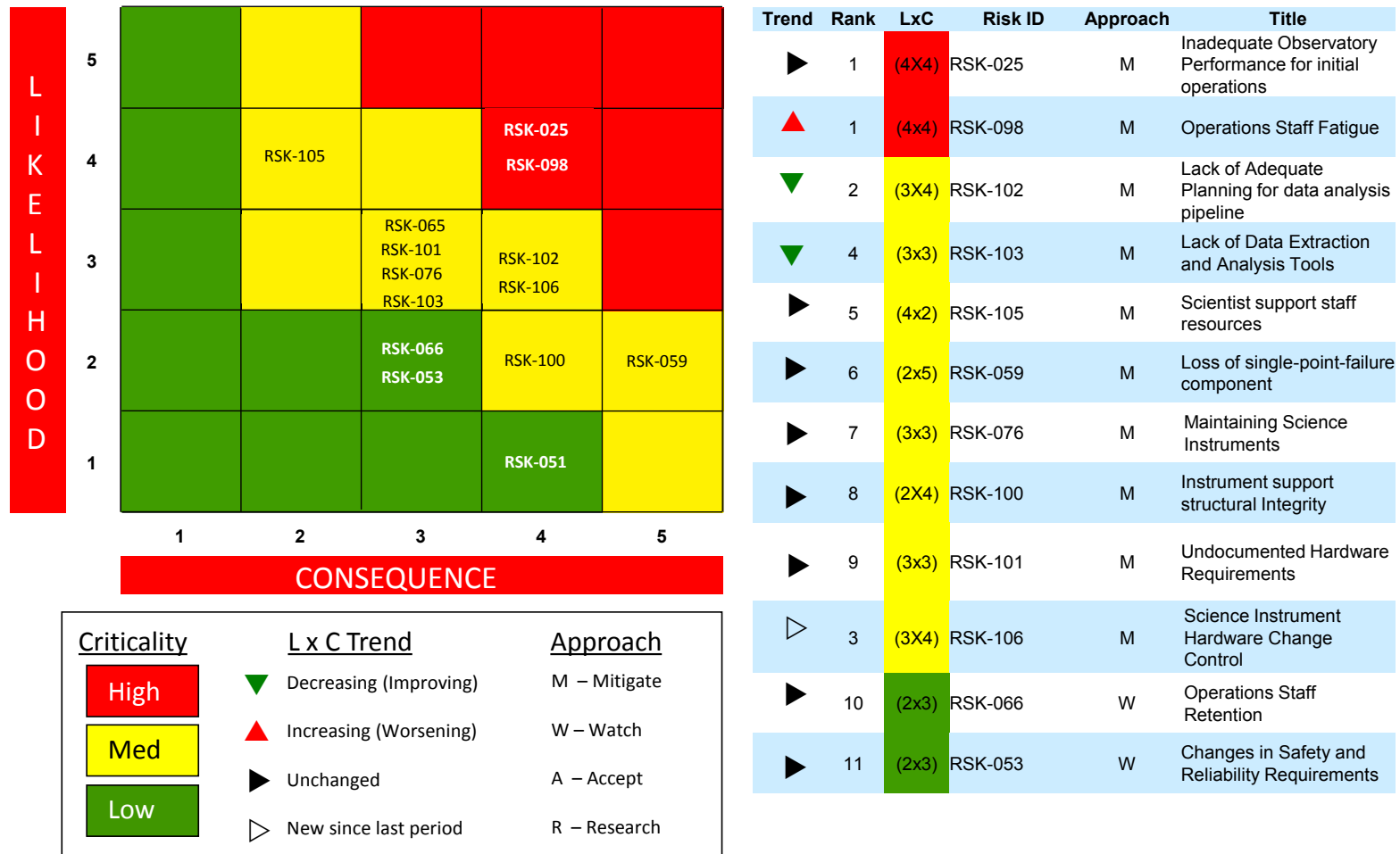




Figure 5.2.7-7 Sample Top Risk Matrix and Status Report, showing list of project risks selected as most significant to monitor on a frequent basis, with ranking and trend data

Note that top risks include some with Low and Medium criticality (or ranking), as well as those evaluated as High criticality.

### Project Top Risk Matrix





### 5.2.7.8 Other Qualitative Risk Analysis Methods

Expected monetary value, simulation, Bayesian probability theory, reliability, and the use of decision trees or its inverse, failure mode effects and criticality analysis (FMECA) are other risk analysis methods that are used in project management. They are not described in detail here but may be researched using the given references.

Expected monetary value is the product of the risk event probability multiplied by the value of the gain or loss that will be incurred. Schedule impacts and intangibles (i.e., a loss may put the organization out of business) must be considered when using this approach. This method for scaling contingency amounts does not take advantage of information about the range of possible impacts or probabilities. It can only provide a mean value of the contingency, not some other target level of confidence. It is not good for time risks or cost risks that have time risk components.<sup>1</sup>

Any schedule of a real project can easily be handled using Monte Carlo simulation techniques,<sup>2</sup> discussed in the next section on Quantitative Risk Analysis. Simulation uses a model of a system such as the project schedule to simulate a project using Monte Carlo analysis. Monte Carlo “performs” the project many times so as to provide a statistical distribution of calculated results under many different scenarios, since in each scenario different risks may occur with different combinations of impact. The use of Monte Carlo analysis to estimate the risk schedule or cost distribution by statistically combining risk costs is illustrated in the next section.

A decision tree is a diagram depicting key interactions between decisions and associated events and uncertainties as understood by the decision-maker.<sup>3</sup> A FMECA is a bottoms-up version of a decision tree, building up from the elements to the decisions. Either approach helps the analyst to divide a problem into a series of smaller, simpler, and more manageable events that more accurately represent reality to simplify decision-making.

Bayesian probability theory treats probability as a degree of belief or uncertainty in a given statement. More information may be found in Foundations of Risk Analysis.<sup>4</sup>

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<sup>1</sup> Integrated cost-schedule risk analysis is presented in Section 5.2.8, Quantitative Risk Analysis.

<sup>2</sup> For schedule impact the organization should not use the Program Evaluation and Review Technique (PERT or the Method of Moments) to represent project risk in schedules. This method underestimates risk for the type of projects addressed herein. Refer to “Project Schedule Risk Analysis: Monte Carlo Simulation or PERT?” David T. Hulett, PM Network published by the Project Management Institute, February 2000, pp. 43 ff

<sup>3</sup> See Recommended Practice 85R-14, Use of Decision Trees in Decision Making, Association for the Advancement of Cost Engineering International (AACEI), 2014, David T. Hulett principal author. Also, “Use Decision Trees to Make Important Project Decisions,” David T. Hulett, Cost Engineering (published by AACEI, July / August 2014).

<sup>4</sup> Pages 62 and 64 of Foundations of Risk Analysis by Aven.



## 5.2.8 Quantitative Risk Analysis – Estimating Contingency

### 5.2.8.1 The Purpose of Quantitative Risk Analysis

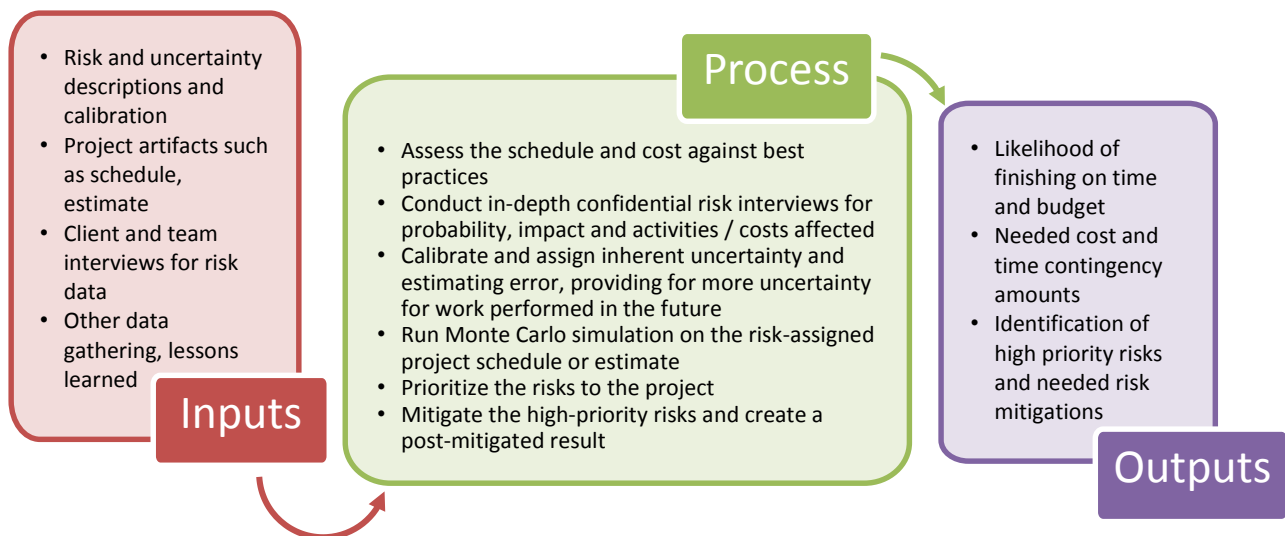
Quantitative risk analysis can analyze the impact of all of the risks and uncertainties on the project objectives of overall time and cost. Hence quantitative risk analysis can derive results that qualitative risk analysis cannot provide, i.e. the likely finish date and project cost when all risks are considered within a model of the entire project.

Quantitative risk analysis allows the risk analyst to estimate:

- How likely is the project to meet its schedule and cost goals?
- How much schedule and cost contingency is needed to achieve the project’s desired level of certainty?
- Which risks are causing any potential overrun and are thus high priority for risk mitigation?

Quantitative risk analysis allows the analyst to estimate the finish date and cost of the project based on a probability distribution created by applying Monte Carlo simulation to a project plan such as the schedule, cost estimate or cost-loaded schedule. The inputs are uncertainty and discrete risk events, although there may also be probabilistic branches, weather / calendar effects and even conditional branches. The process for performing Quantitative Risk Analysis is shown in Figure 5.2.8-1 below. Outputs are the estimated total cost and finish date and associated contingency amounts above the baseline input cost and finish date.

Figure 5.2.8-1 Quantitative Risk Analysis Process



A quantitative risk analysis requires an accurate, up-to-date schedule as well as up-to-date risk data to be useful. The schedule used for analysis is often not the detailed Integrated Master Schedule (IMS), but is a summary schedule that can be resource loaded.



While software tools have made it relatively simple to run a Quantitative Analysis, the preparation work for a simulation run can take significant time and effort. Often, projects use Qualitative Analysis for month-to-month risk management and use Quantitative Analysis for establishing a new baseline or calculating an updated Estimate at Complete (EAC).

There are several commercial packages available that provide tools and programs for performing Quantitative Analysis using cost estimates and/or resource loaded schedules. While NSF strongly recommends probabilistic analysis methods for estimating total project risks and contingency amounts, it does not endorse or recommend any particular program or product.

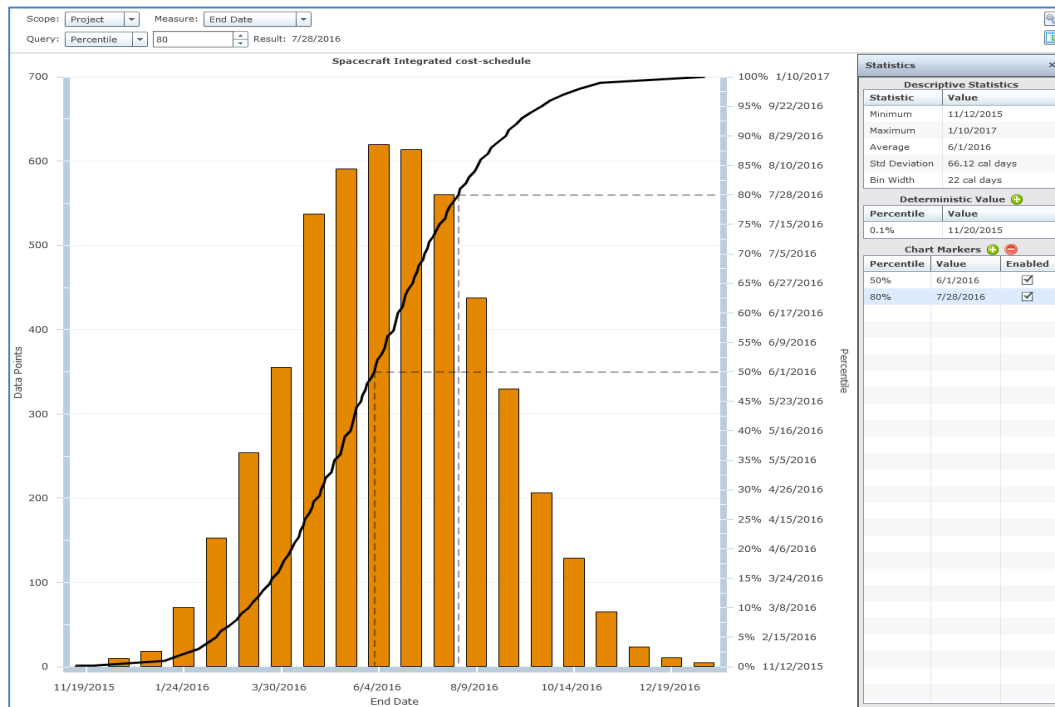
A typical result of a quantitative schedule risk analysis using one such commercial tool, in this case a schedule risk analysis histogram of possible end dates, is shown in Figure 5.2.8-2. The estimated ranges of impact of risks and uncertainties on the duration of scheduled activities were fed into a Monte Carlo simulation program that generated a distribution of possible end dates based on a resource loaded schedule. For the histogram below, the horizontal axis shows the possible end dates. The right vertical axis shows the end dates for the confidence level curve.<sup>1</sup> The dotted lines on the plot represent the end dates for which the confidence level for completion by that date is 50% and 80% respectively. For this example, the PMB end date is 11/20/2015. If the project elects to use the 80% confidence level, then the chosen project finish date is 7/28/2016, indicating that the project needs to mitigate or provide contingency for an additional 8.3 months of project duration beyond the baseline date.

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<sup>1</sup> NSF sets a required range for the confidence level unless an exception is requested and approved by NSF. See Section 4.2.5 for details.



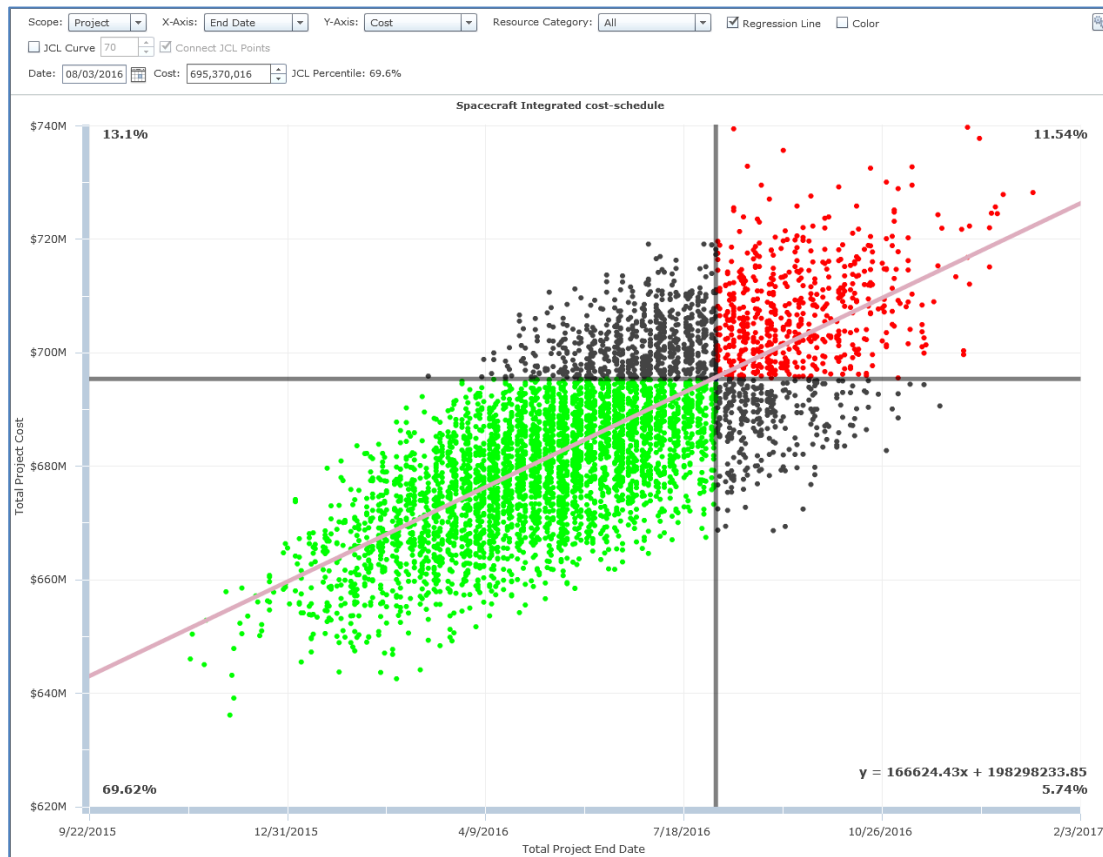
Figure 5.2.8-2 Typical Result of a Quantitative Schedule Risk Analysis



Another typical output, from quantitative analysis of a resource-loaded schedule, is a time-cost scatter diagram. Figure 5.2.8-3 plots cost on the y-axis against end date on the x-axis. A line is drawn through the slope of the distribution. The plot illustrates the important fact that time and cost are related. In this case, longer schedule activities with labor-type resources generate higher cost.



Figure 5.2.8-3 Time-Cost Scatter Diagram: Each data point represents one realization of the simulation



**5.2.8.2 Key Elements in Quantitative Risk Analysis**

The platform for quantitative risk analysis is the project cost estimate or project schedule. Since most cost estimates are developed in a spreadsheet, a risk analysis of the project’s cost estimate alone is often conducted using a software package that simulates a spreadsheet model.<sup>1</sup> Schedule risk analyses simulate a project schedule, so software that is able to simulate schedules developed in the organization’s preferred scheduling package must be used.<sup>2</sup> Integrated cost-schedule risk analyses involve a good-quality PMB schedule (i.e., without cost or schedule contingency) with loaded resources representing the cost estimate attached to the activities they support.

<sup>1</sup> Two commonly-used packages are @RISK from Palisade Corporation and Crystal Ball from Oracle. (NSF does not endorse or recommend any particular package.)

<sup>2</sup> There are several schedule simulation packages available. Two of the schedule simulation packages with the most capabilities are Polaris from Booz Allen Hamilton and Primavera Risk Analysis from Oracle. Others include Acumen RISK from Deltek, Risky Project from Intaver Institute, @RISK for Project from Palisades, JACS from Tecolote and Full Monte from Barbecana. (NSF does not endorse or recommend any particular package.)



The elements of risk that may affect the cost, duration, or both cost and duration of a project include uncertainty, identified discrete risk events, and possible discontinuous events.

- Uncertainty represents inherent variability in predicting the outcome of future events. The uncertainty may be from people and organizations' inability to do the same thing the same way reliably or from the fact that future events cannot be predicted with complete accuracy. Uncertainty has a probability of 100% (since it is always present) and an estimated range for duration or cost. The range often has a positive tail (opportunity) and a negative tail (threat) such as -5% and +10%. These ranges represent the confidence in the estimates of activity duration or cost element actually occurring as estimated. The uncertainty ranges are often specified as a 3-point estimate with low, most likely and high values for a specified distribution shape, often a triangular distribution. For every iteration in a simulation, the software pulls a random impact multiplier for each duration and/or each cost item from within the chosen distributions. That value, say 1.07, is then multiplied by the activity duration or element cost in the model to get the value to be used for that iteration.
  - There may be asymmetry in the range of uncertainty since it is often easier to overrun than underrun an estimated value. Hence the optimistic tail of the distribution may not have as much probability as the pessimistic tail has. Also, the most likely value may not be the assigned value in the schedule or estimate. Hence a fairly typical uncertainty range could be .95, 1.05, and 1.15 – the middle value implies that the duration or cost is most likely 5% higher than in the baseline model.
  - The range of uncertainty can also be used to cover potential, but as yet unidentified, discrete risks that may surface later in the project than at the time of analysis. The inability to identify discrete risks is common for events that occur significantly later in the project or for activities that cannot yet be well defined. Most often these uncertain risks can be addressed by allocating a wider range of uncertainty to these durations or costs than to those assigned to better understood activities occurring in the early years of the project. In this way the generally higher level of uncertainty for durations and costs in the later years of the project can be included in the risk analysis leading to the size of the contingency reserve.
  - Some types of activities have more inherent uncertainty than others. It may be more difficult to make estimates of duration and cost for testing than for design, whereas fabrication may be somewhere in between. Therefore, some categories of activities may have wider uncertainty ranges than others. These activity-type specific uncertainty bands are sometimes termed reference ranges.
- Discrete Risk Events include those already identified and quantified in the Risk Register as well as any that may be discovered when interviewing for risk data to use in the



quantitative risk analysis. Discrete risks are specified by their probability and range of impact if they happen to activity durations or cost elements.

- The probability determines the fraction of the Monte Carlo iterations that they appear in.
  - The impact range is related to the duration of the individual activities or size of cost line items that they are assigned to. Hence the concept of impact range for quantitative analysis is not the same as that used for qualitative risk analysis, which is impact on the final date or total cost for the entire project.
  - A risk can affect many activities or cost elements. Activities or cost elements can be affected by more than one, sometimes many, discrete risks.
  - Discrete risks can be represented by adding a risk to a cost element or schedule activity or by specifying a multiplicative factor to apply to the estimated cost (risk register method) or activity duration (risk driver method).
- Discontinuous Risk Events are discrete events that can have consequences beyond adding duration to existing activities or cost to an existing budget element. Technically challenging projects such as NSF facilities typically have numerous discontinuous risks. Capturing a complete list of these risks is critical to effective RM and project success. For example, failing a qualifying test (or other discontinuous event) may require adding new activities and cost to the schedule in order to recover from the event. These activities and cost elements are almost certain not to be in the baseline schedule or cost estimate since those artifacts are usually based upon success of the baseline plan.

### 5.2.8.3 Platforms for a Project Quantitative Risk Analysis

A project schedule risk analysis starts with a good-quality Critical Path Method (CPM) schedule:

- The schedule can be a summary or roll-up of the detailed schedule of the project and should not have any padding or contingency for risk. Estimated project end date and schedule contingency duration are outputs of the risk analysis. The detailed project schedule is not always a good candidate for risk analysis input since it usually has several thousand activities and may be difficult to debug. That is, the detailed project schedule, perhaps a contractor's schedule, may not conform to scheduling best practices.<sup>1</sup> Hence, and in recognition that a schedule risk analysis is a strategic analysis of the project, summary or “analytical” schedules may be used instead of the detailed schedule. This analytical schedule needs to represent all the work of the project (including contractor and other participants such as the customer) and be validated against best CPM best practices. It is recommended that the summary or analytical schedule format adheres to the project WBS to facilitate reporting of contingency usage.

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<sup>1</sup> One source of complete scheduling best practices is the Government Accountability Office (GAO) Schedule Assessment Guide, 2015.





Characteristics of a schedule used for Quantitative Risk Analysis are:

- 1) It represents all the work of the project,
- 2) All logic links are established,
- 3) All constraints are appropriate, and
- 4) It is resource loaded.

Since the schedule validation process can require significant effort by project leaders, some references<sup>1</sup> recommend creating a 300-1000 line summary schedule from the project IMS and resource loading it with a minimal number of summary resources. (Some multi-billion dollar projects have been known to use as few as eight summary resources.) That methodology is followed in the exercise demonstrated in the following case study.

A cost risk analysis starts with a complete, PMB cost estimate:

- The PMB cost estimate is complete for all in-scope work but does not include any built-in “padding” or contingency for risk. The estimated cost contingency amount is an output of the risk analysis. The cost estimate is usually specified in spreadsheet format and may be simple or detailed. It is recommended that the summary or analytical schedule format adheres to the project WBS to facilitate reporting of contingency usage.

An integrated cost-schedule risk analysis starts with a resource loaded schedule for a PMB with cost and schedule estimates:

- A schedule, either analysis or detailed level, that is loaded with resources. For the purpose of a risk analysis the resources do not have to be detailed at the same level as the Cost Book, but they do have to distinguish between time-dependent (e.g., labor, rented equipment) resources that will cost more if their activities are longer and time-independent (e.g., materials, purchased equipment) resources that may have variable cost but not because of uncertainty in duration. Again, it is recommended that the summary or analytical schedule format adheres to the project WBS to facilitate reporting of contingency usage.

All quantitative risk analyses require:

- Good quality risk data collected in the Risk Register but usually enhanced using good interview techniques. Note that SMEs are often more willing to talk freely about extreme good and bad possible risk results in confidential interviews.

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<sup>1</sup> David T. Hulett, principal author, Recommended Practice 57R-09, Integrated Cost and Schedule Risk Analysis Using Monte Carlo Simulation of a CPM Model, AACEI, 2011.

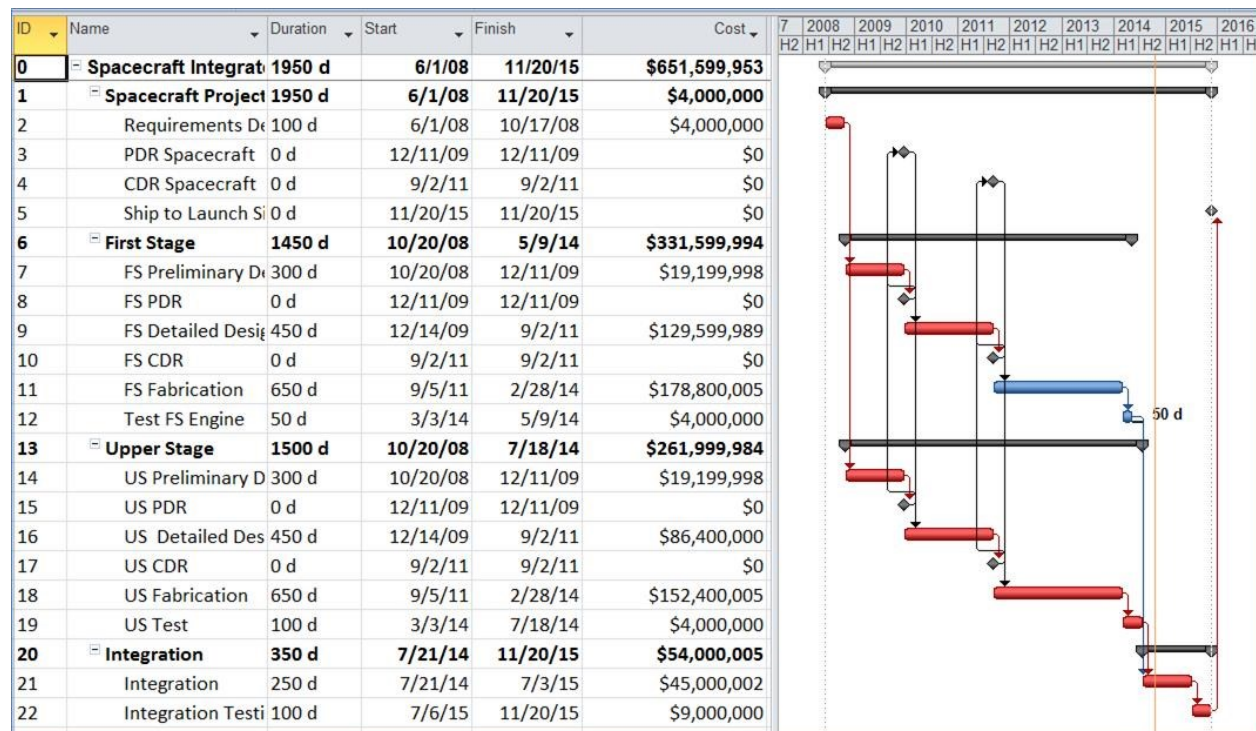


- A professional schedule risk simulation package<sup>1</sup> that can perform a Monte Carlo risk analysis simulation on a risk-loaded schedule.
- An organizational culture that is committed to conducting an unbiased and realistic risk analysis and to use its output, such as total risk to objectives or prioritized risk events to be mitigated in order to improve the prospects of the project.

**5.2.8.4 Case Study: Quantitative Risk Analysis<sup>2</sup> Exercise**

These steps will be illustrated with a simple case study of an integrated cost-schedule risk analysis of design and fabrication of a space vehicle, as shown in the resource-loaded Gantt chart schedule shown in Figure 5.2.8-4.

Figure 5.2.8-4 Resource Loaded Schedule Used for a Simple Case Study of an Integrated Cost-Schedule Risk Analysis for Design, Fabrication, Testing, and Delivery of a Space Vehicle



<sup>1</sup> There are several different software packages that can do this analysis. The package used for these charts and tables is Polaris® from Booz Allen Hamilton.

<sup>2</sup> David T. Hulett, principal author, Recommended Practice 57R-09, Integrated Cost and Schedule Risk Analysis Using Monte Carlo Simulation of a CPM Model, AACEI, 2011.



This is a project starting June 1, 2008, with a ship to launch site end date of November 20, 2015. The project cost is estimated at \$651.6 million.<sup>1</sup> Resources are shown on the bar chart and include mostly labor, with some equipment in the First Stage and Upper Stage Fabrication activities.

In this case study the resources, as shown in Table 5.2.8-1, are few and summary.

Table 5.2.8-1 Resources for Quantitative Risk Analysis Example

Resource Name	Type
Preliminary Designers	Work
Detail Engineers	Work
Fabrication	Material
Integrators	Work
Integration Testers	Work
Specification Writers	Work
Unit Testers	Work
Fabricators	Work

### 5.2.8.5 Schedule Risk Analysis – Uncertainty

The schedule risk analysis starts with uncertainty reference ranges, estimated by the project SMEs. Recall that the probability for uncertainty occurring is 100%, and thus occurs for all simulation iterations for all assigned durations. The ranges shown in Table 5.2.8-2 are the SMEs’ estimates of uncertainty in the task durations. Note that three of these imply that the SME interviewees assess the “Most Likely” value to be greater than the durations in the schedule. This may be because they view the schedule as being built with optimistic durations or that more has been learned about activity durations, leading to a higher estimate of the “most likely” durations. Although not shown here, their evaluation could also have resulted in lower, mostly durations. The use of Risk Drivers allows these distributions to have both threat and opportunity tails.

<sup>1</sup> This schedule has been developed in Microsoft Project. Another popular scheduling package is Primavera P6 from Oracle. Most schedule simulation packages can import projects from these two scheduling packages.



Table 5.2.8-2 Schedule Duration Risk Reference Ranges

Activity Category	Low	Most Likely	High
Designers	0.90	1.00	1.20
Fabricators	0.95	1.05	1.20
Integrators	0.95	1.05	1.20
Requirement Writers	0.90	1.00	1.15
Testers	0.85	1.10	1.25

Notice that these are fairly narrow ranges that represent inherent variability, for instance, but do not represent the impact of discrete risks on the activity durations. These ranges are applied to the activities in the named categories by a triangular distribution, in this case, from which the computer pulls at random a multiplicative factor that is applied to the schedule duration. The example exercise demonstrated here uses 5,000 iterations because the software is fast, but 3,000 iterations would generally be enough.

Uncertainty ranges should be wider the further out into the future the work is being planned and estimated. This is because it is harder to estimate durations or costs several years into the future, since the work has not been contracted yet and may not actually be detailed with any specificity. Also, there will be risks in the future that cannot be identified today as discrete risks but should be provided for with wider uncertainty ranges.

The analysis is performed using the reference ranges. If the analysis stopped at this point with just uncertainties, the schedule results would look like the histogram shown in Figure 5.2.8-5 below. The 80<sup>th</sup> percentile has been chosen as the target level of confidence for this example. The target confidence level for actual projects is chosen by the project or the customer.<sup>1</sup> The related cost risk histogram shown in Figure 5.2.8-6 represents the effect of duration uncertainty alone on the costs for time-dependent resource.

<sup>1</sup> To show these results one software package, Polaris, was chosen. However these results can be achieved using Primavera Risk Analysis, JACS, Risky Project and others.



Figure 5.2.8-5 End Date Results for Schedule Duration Uncertainties

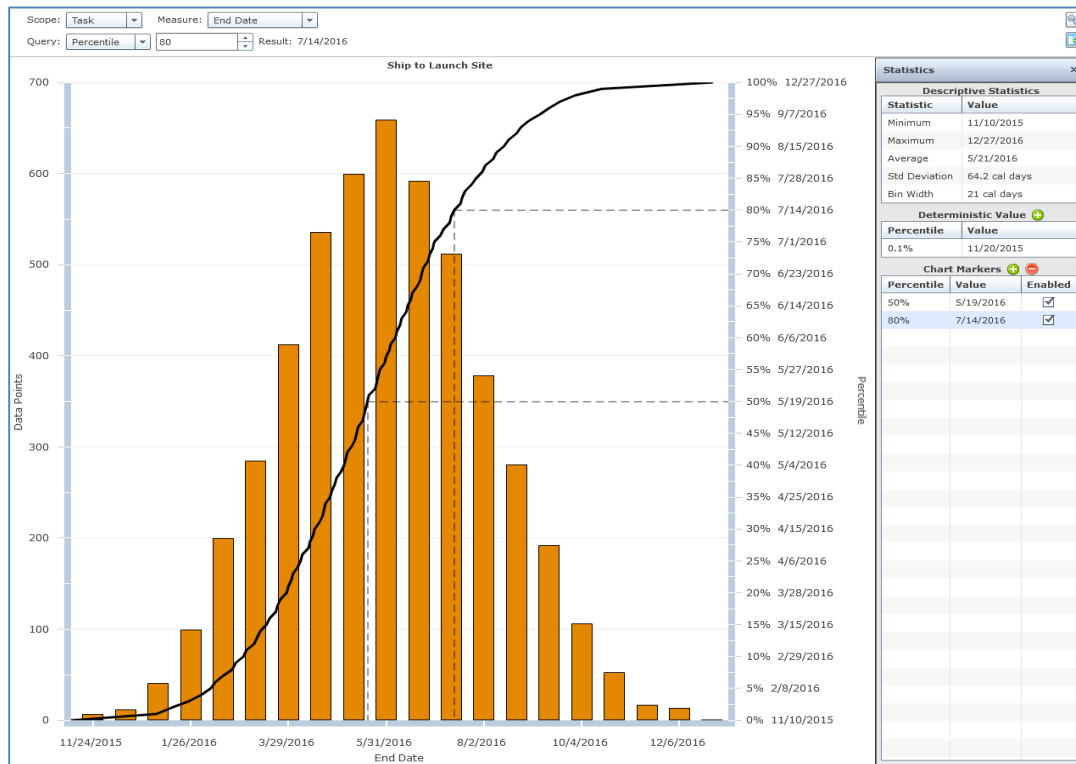
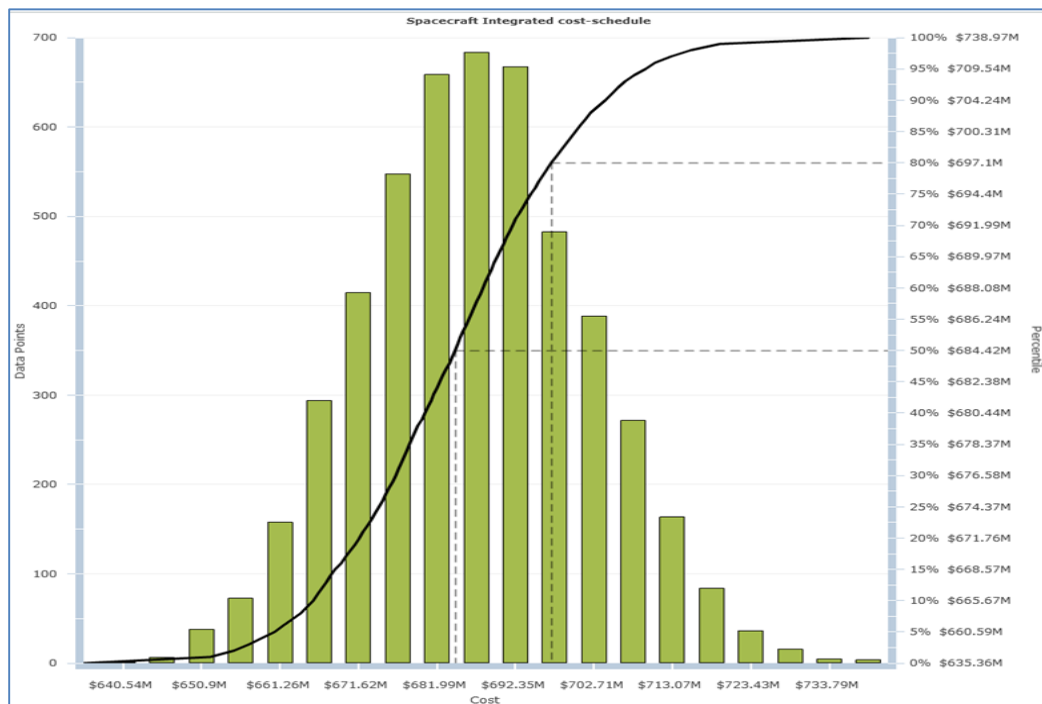


Figure 5.2.8-6 Cost Result for Schedule Duration Uncertainties





The results can also be shown in tabular form, with the 5% and 95% values included to determine if the total range is believable. For uncertainties alone, the results in Table 5.2.8-3 are believable.

Table 5.2.8-3 Results with Schedule Uncertainties Assigned

Schedule	Baseline	5%	50%	80%	95%
Dates	20-Nov-15	8-Feb-16	19-May-16	14-Jul-16	7-Sep-16
Months from Base		2.6	6.0	7.8	9.6

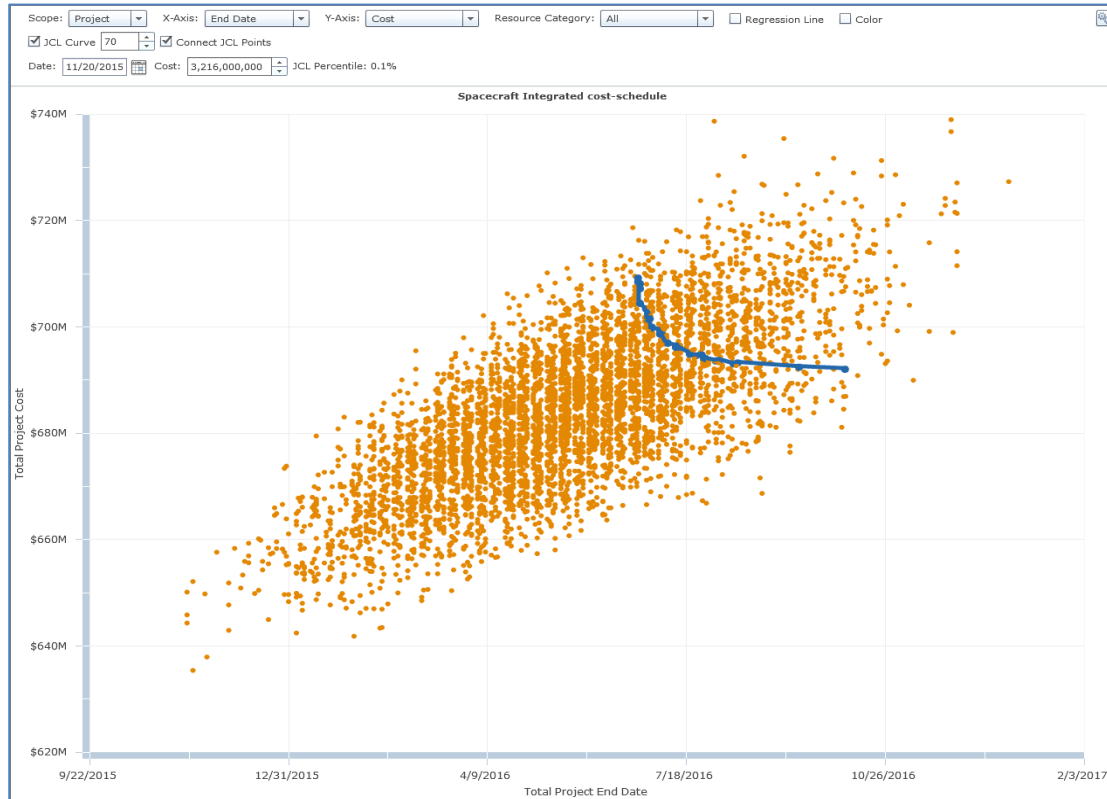
Cost	Baseline	5%	50%	80%	95%
Dollars (millions)	651.6	660.6	684.4	697.1	709.5
% above Base		1%	5%	7%	9%

Because this is an integrated cost-schedule risk analysis there is interest in the relationship between time and cost. This is shown in a finish date – total cost scatter diagram shown in Figure 5.2.8-7. The scatter plot has a dot for each of all 5,000 iterations. The scatter slope indicates the positive relationship between time on the horizontal axis and cost on the vertical axis. The curved line toward the top right of the scatter represents those combinations of cost and schedule results that exhibit a 70% probability of meeting both objectives, given the uncertainties applied to the cost-loaded schedule. The target of 70% confidence level for budgeting and scheduling was chosen in this case since it is often used by several government funded agencies, such as NASA.<sup>1</sup>

<sup>1</sup> See: “Understanding the Joint Confidence Level (JCL) at NASA,” NASA Office of Evaluation at 9/4/14.



Figure 5.2.8-7 Total Cost and End Date Scatterplot for Schedule Uncertainties



Note that the schedule uncertainty data in this example are assumed to be not correlated. If they were correlated (i.e. if one is high in its range then the others would also be high in their ranges), the extremes in cost and time would be greater and the correlation between time and cost would be tighter than shown above. The analyst should explore whether the uncertainty distributions should exhibit correlation or not. If so, then the analyst will want to exploit the capabilities of the chosen analysis package to handle correlations.

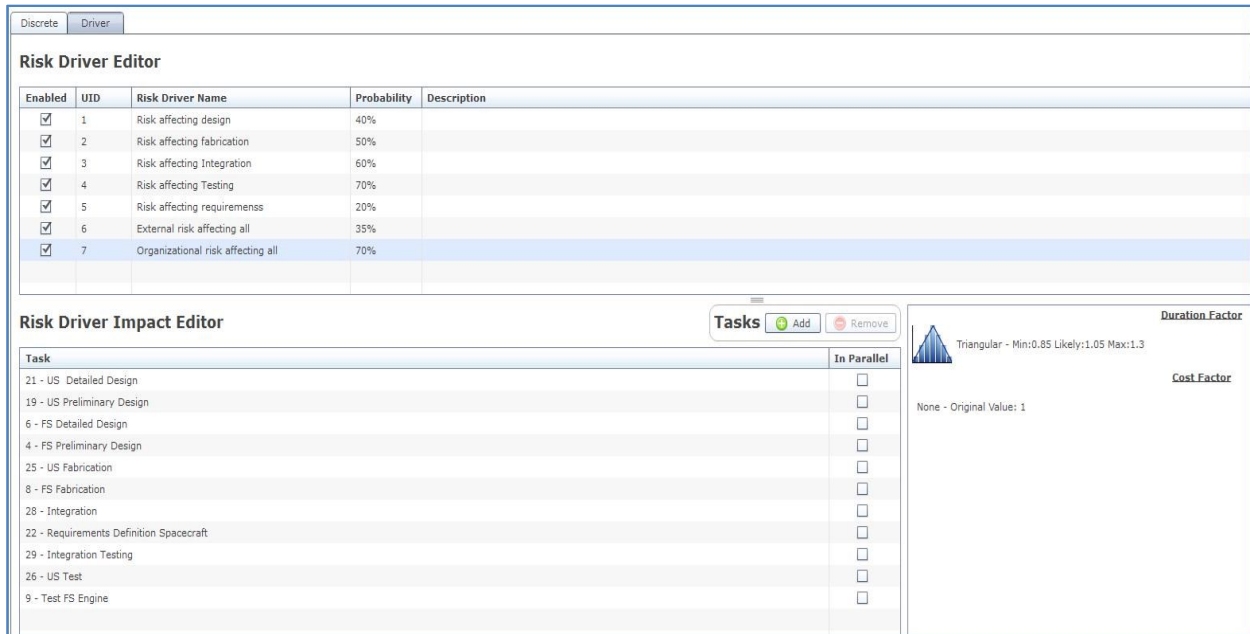
**5.2.8.6 Schedule Risk Analysis – Discrete Risks Added as Drivers**

The second step is to identify, calibrate and assign discrete risks to the project schedule. The risks used in this example are applied to the categories of activities, including design, fabrication, integration, testing and requirements. For this exercise the risks are given generic names, but in an actual analysis the risks would be taken from the Risk Register and augmented by risks discussed in the confidential risk interviews. The generic risks for this exercise, with their probabilities are shown in the top section in Figure 5.2.8-8. One risk, “Organizational risk affecting all,” has been selected to show its assigned impact range next to the triangle symbol on the right: Min 0.85, mode 1.05, Max 1.3. The Organizational risk has a probability of 70% and is assigned to all tasks since its impact is felt on everything. Although the description has not been filled in for this exercise, the organizational risk could stem from “lack of ready access to



key decision makers that can increase durations” or to “organizational red tape that could slow decision making,” for example.

Figure 5.2.8-8 Schedule Risk Drivers – Organizational Risk



When these risk drivers are assigned to multiple tasks or activities, those activities’ durations become correlated since (1) if the risk occurs it occurs for all activities to which it is assigned, and (2) the multiplicative factor chosen for that iteration is applied to all of those activities. If only one risk is involved the activities become 100% correlated. If other risks are also assigned the correlation between activity durations is reduced. In this way the risk driver method models how correlation occurs so SMEs do not have to guess at the correlation matrix. With the addition of discrete risks to the analysis, the schedule impacts are more pronounced and the results show a later start (by 15.4 months) and higher cost (by \$100 million) than with just the uncertainties for the 80% confidence level. See Table 5.2.8-4 below. Note that the cost increase is due to schedule duration risk drivers alone, and not to any cost uncertainty or risk.

The scatterplot in Figure 5.2.8-9 shows greater correlation of time and cost risk than the previous plot showing uncertainties only, since the Organizational risk driver was assigned to all activities.





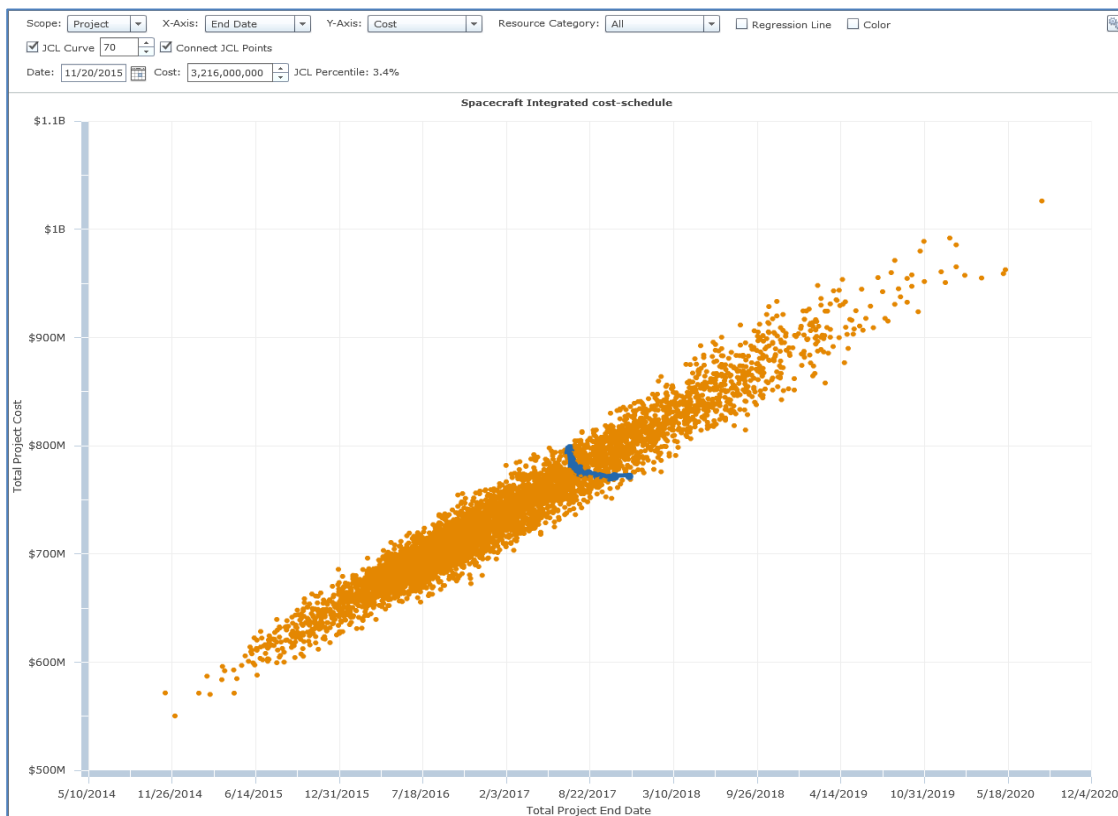
Table 5.2.8-4 Results with Schedule Uncertainties and Discrete Risks Assigned

Schedule	Baseline	5%	50%	80%	95%
Dates	20-Nov-15	5-Jan-16	28-Dec-16	26-Oct-17	16-Aug-18
Months from Base		1.5	13.3	23.2	32.9

Cost	Baseline	5%	50%	80%	95%
Dollars (millions)	651.6	650.7	730.6	797.6	865
% above Base		0%	12%	22%	33%

Figure 5.2.8-9 Total Cost and End Date Scatterplot Showing Greater Correlation of Time and Cost Risk



**5.2.8.7 Cost Risk Analysis – Uncertainty and Discrete Risk Drivers**

The last consideration in this simple example is whether there are uncertainties and discrete risks for cost which would cause cost variations that are independent of schedule.

Examples of uncertainty could be errors in the time independent cost of fabrication, variances in the time-dependent activities’ daily “burn rate” due to uncertainty in the number of hours/workers needed per day, and/or uncertainty in the estimated salaries. These risks, if they



occur, are in addition to the cost impact from schedule duration risks already discussed in the previous material. The cost estimating error on the burn rate of labor or total cost of equipment can be entered by resource as uncertainties, with probability of 100% and a range of impact. Example uncertainty reference ranges for cost uncertainty as applied to different resources for this exercise are shown in Figure 5.2.8-10.

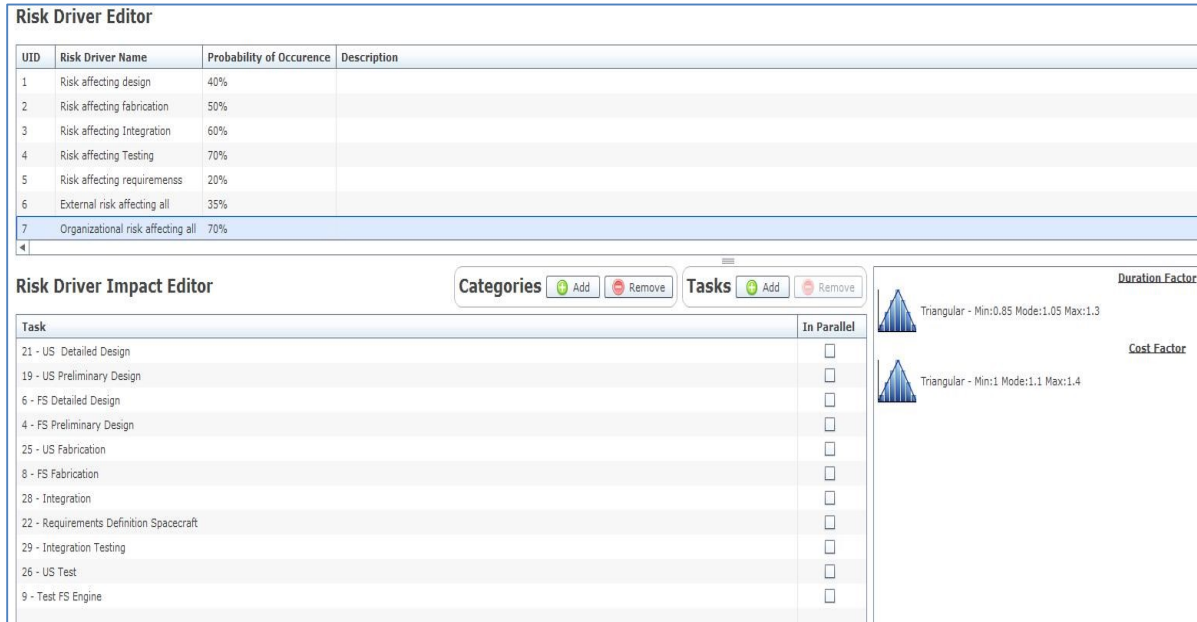
Figure 5.2.8-10 Uncertainty in the Burn Rate and Total Cost

Resources and Their Utilization Uncertainty				
UID	Resource	Type	Planned Units per Unit or Day	Rate Per Unit or Day Min - Most Likely - Max
1	Preliminary Engineers	Time Dependent	640	600 - 650 - 700
2	Detail Engineers	Time Dependent	960	900 - 960 - 1,020
3	Fabrication	Time Independent	1	0.9 - 1.05 - 1.15
4	Integrators	Time Dependent	1,200	1,100 - 1,250 - 1,500
5	Integration Testers	Time Dependent	1,200	1,150 - 1,250 - 1,550
6	Specification Writers	Time Dependent	800	750 - 800 - 850
7	Unit Testers	Time Dependent	800	700 - 825 - 950
8	Fabricators	Time Dependent	720	680 - 720 - 760

Discrete Risk drivers affecting cost can also be included to the analysis, in addition to the uncertainty factors. These cost factors can be entered as the implication of identified risk drivers, just as in the previous exercise for schedule drivers. If both cost and schedule risks occur, the burn rate, cost estimate, and duration will vary, and each driver will cost to vary. While new risks may be entered that just affect the burn rate or total cost of equipment, the existing risks with schedule drivers already included can have those impacts as well. For example, a cost factor has been added to the Risk Driver Editor for the previously identified Organizational risk affecting all tasks, as shown in the Figure 5.2.8-11.



Figure 5.2.8-11 Screenshot of Risk Driver Editor



After running the program with the addition of cost uncertainties to resources and allowing risk drivers to affect costs directly rather than only through schedule risk, there is a direct impact on cost, as can be seen in Table 5.2.8-5 below. The schedule table is not shown, since the cost drivers included in the exercise do not by themselves impact duration. Note that some risks will have just schedule duration uncertainties and risk drivers, some will have just cost uncertainties and drivers, and some will have both. Cost will be affected in all cases, but schedule is affected only for those risks with duration uncertainties and drivers.

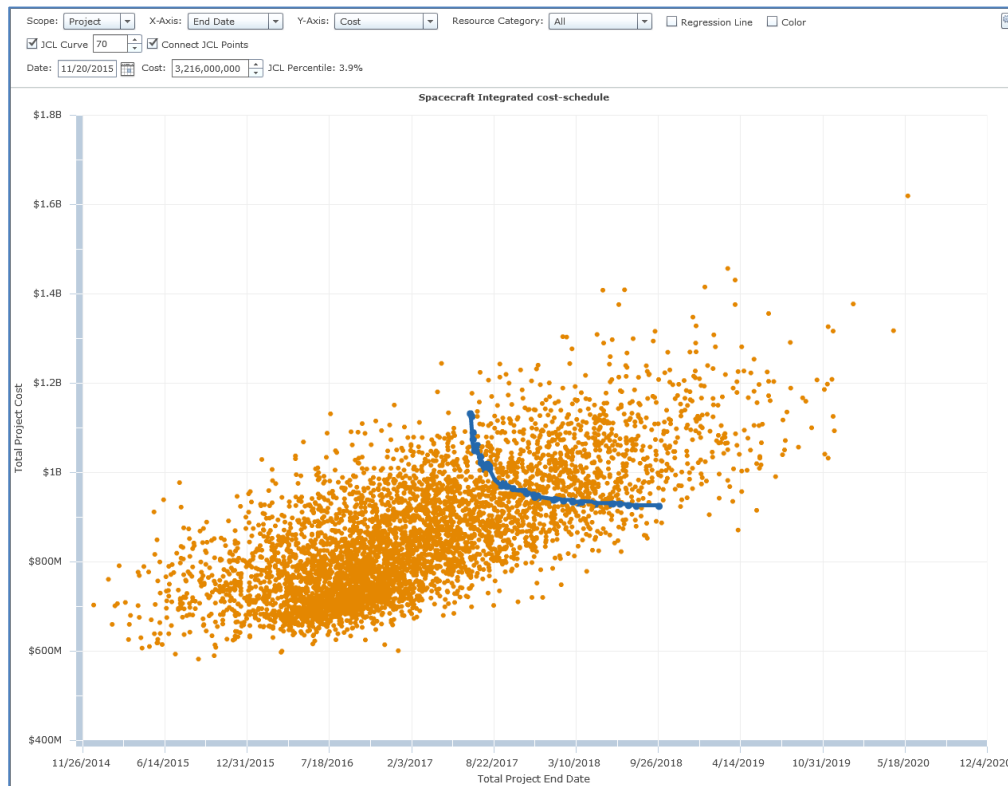
Table 5.2.8-5 Results with Uncertainties and Cost Risks Assigned

Cost	Baseline	5%	50%	80%	95%
Dollars (millions)	651.6	679	838.6	975	1100
% above Base		4%	29%	50%	69%

Adding the uncertainty and risks affecting the costs independently of time to the simulations results in a time-cost scatterplot shows less connection between time and cost, as shown in Figure 5.2.8-12.



Figure 5.2.8-12 Scatterplot Showing Less Connection between Time and Cost



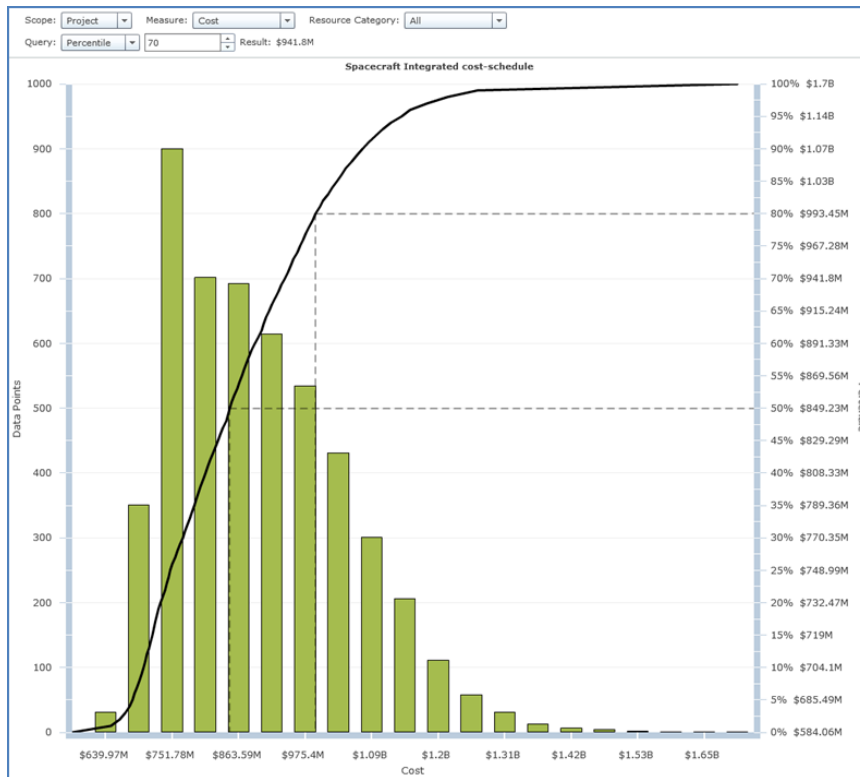
**5.2.8.8 Handling Inflation**

Inflation is a part of the NSF budgeting and project planning. The program should select an acceptable source for the future inflation rate and use it in the baseline and the risk analysis of that baseline. For the case study in this exercise, the baseline cost is projected at \$651.6 million in base year dollars, that is, without inflation. With risks but no inflation the risk analysis simulation shows a cost in base year dollars of \$975 million at the 80<sup>th</sup> percentile of certainty.

The analysis program can be used to factor in inflation if the cost estimating has been performed in base year dollars. Adding the factor of cost inflation and setting it at the rate of 3% causes the risked cost at the P-80 level to increase to \$993 million in then-year dollars as shown below in Figure 5.2.8-13:



Figure 5.2.8-13 Scatterplot with Addition of Cost Inflation Factor



The value of 3% inflation may be a most likely number, but the software used in this exercise does not support an uncertain inflation level in simulation. A suggestion is to perform two scenarios where the inflation rate is either lower or higher than 3%.

- At 2% inflation the cost is estimated at \$987 million
- At 4% inflation the cost is estimated at \$1 billion.

These scenarios can help understand the total “then dollar” cost of the project that is risk adjusted, and the impact of the inflation assumption on that number.

### 5.2.8.9 Prioritizing the Discrete Risks – Risk Mitigation Workshop

The organization is encouraged to use these results to help improve the prospects of the project by mitigating the important risks. To do this the risks are prioritized. See Table 2.1.6-1 for sample prioritization from this exercise. This prioritization method uses the Monte Carlo simulation, a 60-year old method, and the schedule which the project team is using to manage or at least summarize the project. It is thought that this prioritization of risks is more realistic than that using qualitative methods resulting in the risk register, in part because it recognizes the structure of the schedule and handles correlations.



Table 5.2.8-6 Savings and Days Saved

ID	Name	Cost Savings	Days Saved
7	Organizational risk affecting all	\$196.15M	207
7	Uncertainty	\$48.03M	152
6	External risk affecting all	\$34.97M	41
2	Risk affecting fabrication	\$23.8M	31
4	Risk affecting testing	\$4.28M	34
3	Risk affecting Integration	\$10.86M	32
1	Risk affecting design	\$5.35M	10
5	Risk affecting requirements	\$0	0

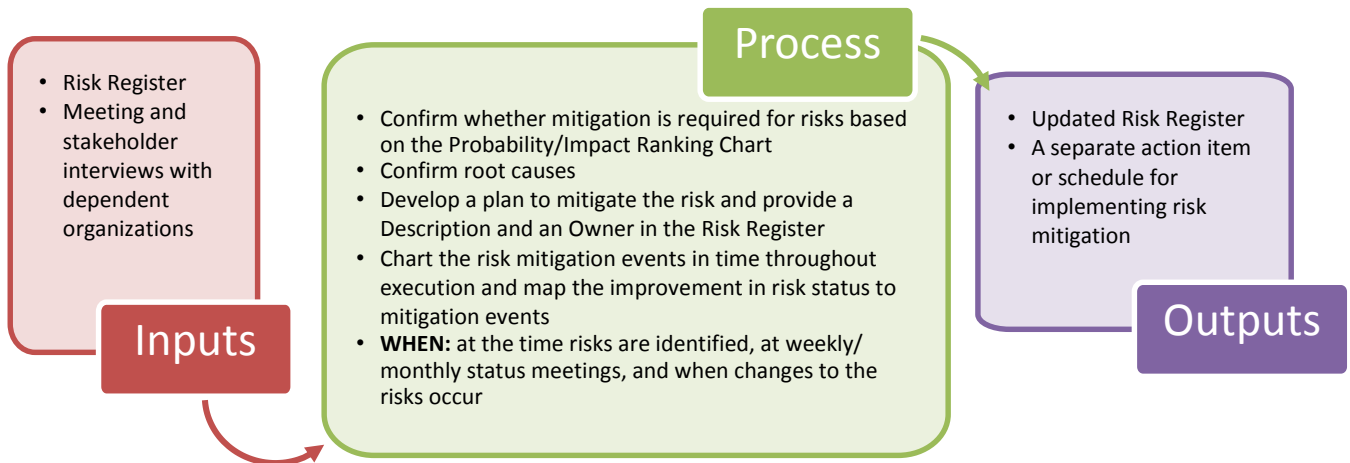
The risk mitigation exercise must be done in a workshop setting since many people have to contribute and commit to the mitigations.

- This workshop includes the PM, DPM, team leads and others involved in mitigation of risk.
- Given the prioritized list of risks for a project that may overrun cost and schedule targets, the project team can develop risk mitigation actions. The mitigation workshop estimates the improvement in the probability and impact parameters is expected to result from the various mitigations planned for each identified risk (uncertainty cannot be mitigated in concept).
- For the mitigation actions to “count” against the project risk management must commit to them as evidenced by their post-mitigation budget, schedule and assignment of people to monitor the risks and their mitigations. These risks should be added to the risk register as well so they are reviewed frequently.
- Each risk mitigation action accepted is modeled and the post-mitigation amount of risk to time and cost is recorded, along with the cost of the risk mitigation. A post-mitigation simulation will determine how much benefit is expected from the mitigations.
- The final report includes post-risk mitigation results and the overall project cost and schedule risk if those risk mitigation actions are taken and mitigate the risks. Note that the original cost and schedule target will generally not be met since that would require complete mitigation of the risks that caused the estimate of overrun in the risk analysis itself.



## 5.2.9 Risk Response Planning

Figure 5.2.9-1 Risk Response Planning Process



A known risk (often referred to as a “known unknown”) is a risk that has been identified and can be calibrated (probability and impact) and analyzed. Examples of known risks may include strategic or overriding aspects of the project environment such as poor project management practices, lack of resources, multiple projects, external dependencies, relationships between project participants, technical complexity etc. Identified risks need to be proactively managed throughout the project life cycle by identifying who owns the management of that risk and by outlining risk symptoms, triggers, and contingency plans that would prevent the risk from occurring or that would lessen the project impact should it occur.

The Risk Response Planning step includes considerations related to risk mitigation and response planning. This includes the assignment of one or more persons to take responsibility for each identified risk and the development of measures and action plans to respond to the risk should it become an issue. PMI PMBOK® Guide defines Risk Response Planning as the process of developing options and actions to enhance opportunities and to reduce threats to project objectives.

Risk response actions for threats are generally categorized as:<sup>1</sup>

- **Avoid** – This strategy involves changing the project to eliminate the threat from identified risk
- **Mitigate** – This strategy involves taking early action to reduce the likelihood and/or impact of risk
- **Transfer** – This strategy involves shifting the responsibility and ownership of the risk to another party. Although this strategy is seldom used for NSF projects, it typically

<sup>1</sup> This listing and these descriptions are described in the PMBOK® Guide, 5<sup>th</sup> Edition, 2013 PMI



involves purchasing insurance against the type of risk or requiring vendors to assume more risk.

- **Accept** – This strategy involves acknowledging the threat as part of the project and accepting the consequences of its occurrence. An example of this is political or legislative risk that is out of the control of the project team. The consequence of acceptance may mean that contingency resources may need to be applied if the risk is realized.

Risk response actions for opportunities are generally categorized as:

- **Exploit** – This strategy seeks to eliminate the uncertainty associated with this opportunity to ensure it happens. This is similar to Avoid threats.
- **Enhance** – This strategy seeks to increase the probability and / or the positive impacts of the opportunity. This is similar to Mitigate threats.
- **Share** – This strategy seeks to share the benefits of the opportunity with another organization that is in the best position to secure the opportunity for the project. This is similar to Transfer for threats.
- **Accept** – This strategy accepts an opportunity if it arises but does not envision pursuing it, similar to Accept for threats.

For the most part, project risk response planning will consist of defining risk thresholds for action, confirming risk triggers, and then planning a mitigation strategy and/or developing backup plans if risks occur. A risk trigger is an event or events that activate the execution of a backup plan, should the risk become an issue. Triggers should be specified in the Risk Definition in the Risk Register, as well as the date that risk resolution is required for each risk. Mitigation strategies identify actions that may minimize or eliminate project risks before the risk occurs or document decisions to accept the consequences of risks without action. A risk may have several mitigation activities that attempt to balance the reduction in the probability and/or the severity of the risk occurrence with the cost-effectiveness of the mitigation strategy. Mitigation planning requires that the root cause(s) of the risk be identified and that the mitigation strategy and plans be aligned accordingly. Backup plans define actions to be taken in response to identified risk triggers in hopes of reducing potential project impact as a result of a realized risk (often defined in the literature as an "issue").

A tabulated example of the impact of Risk Response evaluation is given below in Table 5.2.9-1.



5.2.9 Risk Response Planning

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)



Table 5.2.9-1 Impact of Risk Handling on Project Cost

Risk Item or Basis	Before Handling				After Handling			
	Risk Level	Worst Case Cost (\$K)	Handling Strategy	Cost Implement Handling	Risk Level	Residual Risk Cost Estimates (\$K)		
						Best Case	Most Likely	Worst Case
Redesign to solve problems identified during reviews	Moderate	3,360	Mitigate	75	Low	0	150	500
Do analyses or design per external comments	Moderate	390	Avoid	0	--	N/A	N/A	N/A
Rework design documents during concept evolution	Moderate	5,720	Mitigate	0	Moderate	0	750	2,500
Redesign for add'l equipment for ops or pretreat interface	Moderate	160	Mitigate	0	Low	0	40	100
Design for sintering equipment	High	500	Mitigate	308	Moderate	0	0	200
Redo design for SNF re-sizing	Moderate	200	Accept	0	Moderate	0	50	200
Redesign; contamination control in process room	Moderate	5,000	Mitigate	361	Moderate	0	300	3,000
Change design basis, due to scale-up impact	Low	50	Accept	0	Low	0	15	50
Redesign, for SC furnace	Low	800	Mitigate	0	Low	0	0	50
Redesign to add gas-trapping system	Low	1,550	Accept	0	Low	0	0	1,550
Rework to add waste streams to design	High	3,000	Mitigate	0	Moderate	0	250	2,300
Rework robotic features design	High	7,440	Mitigate	53	Moderate	0	500	2,000
Redesign for characterization	High	5,000	Mitigate	176	Moderate	0	600	3,000
Redesign to meet canister requirements	Moderate	3,000	Accept	0	Moderate	0	100	3,000
Design for new cables	Moderate	400	Mitigate	0	Low	0	0	50
Redesign for additional MC&A equipment	Moderate	400	Mitigate	0	Low	0	0	50
Redesign, to apply new structural criteria to 105L	Moderate	1,500	Mitigate	300	Low	0	0	700
Redesign, per SGS inputs	Low	500	Accept	0	Low	0	0	500
Redesign for changes, per NRC interface	Moderate	200	Mitigate	0	Low	0	0	150
Additional utility design features	Moderate	500	Accept	0	Moderate	0	300	500
Delays initiating design, awaiting R&D completion	High	5,360	Mitigate	0	Moderate	0	240	720
Delays redesigning for classified process control system	Low	60	Avoid	0	--	N/A	N/A	N/A
Add features to meet IAEA	Moderate	500	Mitigate	0	Low	0	0	50
Uncertainty in obtaining contingency funds	Moderate	2,000	Avoid	0	--	N/A	N/A	N/A
Disposal of bundling tubes	Moderate	100	Avoid	75	--	N/A	N/A	N/A
Decontamination of final-product canister	Moderate	500	Avoid	341	--	N/A	N/A	N/A
Storage location for depleted uranium	Moderate	100	Avoid	75	--	N/A	N/A	N/A
Availability of emergency generator and fuel tank	Moderate	40	Avoid	0	--	N/A	N/A	N/A
Redesign for necessary structural supports	Moderate	300	Avoid	225	--	N/A	N/A	N/A
Arithmetic Sums:		48,630		1,989		0	3,295	21,170



The risks with mitigation plans and risk triggers are all listed in the Risk Register with their Qualitative Risk Assessment status. After Risk Response Planning has been performed the entire entry for the risk includes:

- Its statement or definition
- Analysis and ranking of initial risk
- Assignment to a risk owner
- Risk mitigation actions and backup plans
  - Costs
  - Timing and risk triggers
  - Expected results
- Status of mitigation efforts
- Analysis and ranking of residual risk after mitigation

The last item listed above is the expected residual risk and ranking after mitigation has been applied. This is accomplished by repeating the analysis of probability and ranked impact on project objectives with successful mitigation assumed. Thus, the Risk Register shows “before” and “after” views of the analysis, with risks migrating down from red to yellow to green with the mitigation steps that cause the improvement in risk status and timing of those steps. The sample risk register shown in Figure 5.2.7-6 shows columns with headings for “Pre-Mitigated” and Post-Mitigated” analysis results.

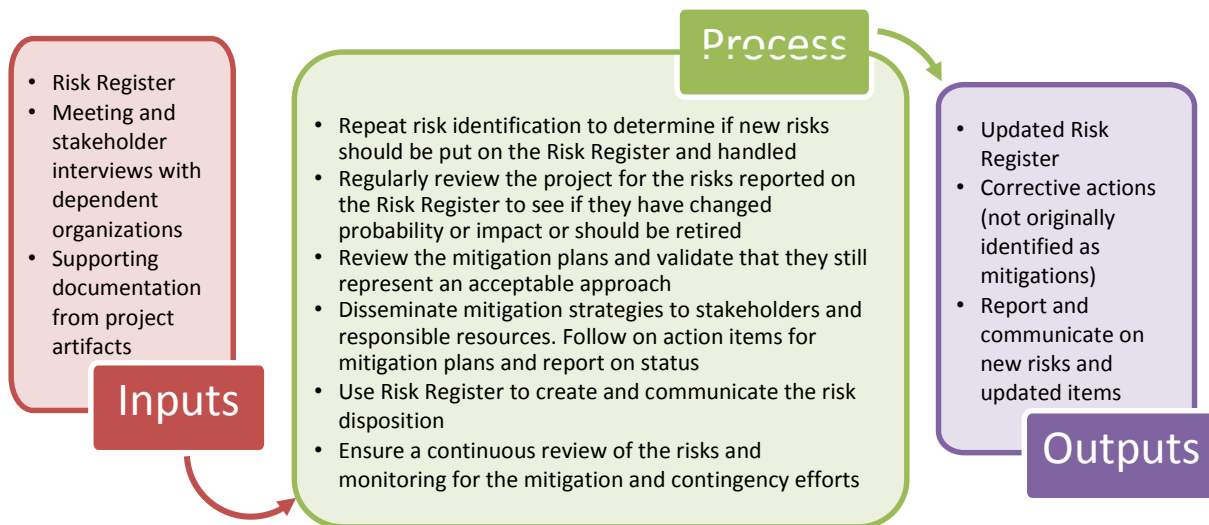


### 5.2.10 Risk Monitoring and Control

Risk Management requires continuous monitoring of project risk and iterative application of the risk identification, analysis, and response processes. Existing risks need to be monitored, controlled, and ultimately retired, while new risks must be identified and added to the Risk Management process. Risk Monitoring and Control is the process of identifying, analyzing, and planning for new risk, keeping track of and re-analyzing identified risks, monitoring risk symptoms and triggers, reviewing the execution of risk responses strategies while evaluating their effectiveness, and reporting status to stakeholders. The Risk Register, as the tool that supports Risk Management and provides a means of communication, must be kept up to date with status and changes. The frequency and process for reviewing project risk is set out in the project Risk Management Plan.

Risk Control includes the process of regularly updating the Risk Register and communicating to stakeholders the latest risk status, with resulting impacts on the project and mitigation plans. Reporting of project and program level risks should be included as part of regularly scheduled status meetings with, and in formal status reports to, internal project members as well as external stakeholders and the NSF. The NSF has emphasized the need to communicate the risks at regularly scheduled status meetings to ensure that continued focus and awareness is placed on risk management.

Figure 5.2.10-1 Risk Monitoring and Control Process



When risks are resolved, they should be retired from the list of active risks. When the project ends, the risk register may be closed. If some risks pose other future threats to the program or future projects, consideration should be given to re-opening a risk with the appropriate operations management, or at the program level as an “ongoing risk.”



## 5.2.11 Contingency Management for Risk Mitigation

### 5.2.11.1 Contingency Budget Timeline

NSF expects the project to refine its WBS budget estimates following the Preliminary Design Review (PDR), adding additional definition to the tasks associated with accomplishing the project's deliverable activities. At Final Design Review (FDR) the PEP budget estimate should be substantially based on externally obtained cost estimates (vendor quotes, bids, historical data, etc.). This added definition is expected to result in an increase to the project's estimated Budget at Completion (BAC) and project schedule, and a concomitant reduction in its budget and schedule contingencies, while TPC and the risk-adjusted, committed schedule finish date remain constant. The quantitative risk analysis should have a component to anticipate this increase in cost and time so that the original contingency amounts are sufficient to provide for this increase.

As a project progresses, the baseline cost estimate and schedule will typically be exceeded and contingency amounts of dollars and time will be used. Periodically the project cost estimate must be revised to reflect all new information, including actual costs and use of contingency funds, adjustments to the risk profile, learning curves for manufactured items, etc. This new estimate of the cost of the remaining work is called the Estimate to Complete (ETC), and the Actual Cost of Work Performed + ETC is equal to the latest revision of the EAC. The EAC should be compared to the sum of BAC plus remaining contingency to ensure that it is less than the TPC. If the sum of BAC plus remaining contingency is greater than the TPC, de-scoping may be necessary. See Section 4.2.5 for details on requirements for budget contingency use.

The project should create and maintain an expected contingency allocation profile. Contingency allocation profiles usually do not track the commitment or spending profiles. For many projects, the highest use of both schedule and budget contingency occurs during procurement and during final commissioning/integration phases. A contingency allocation curve for such a project would be bi-modal, with one peak for procurements activities and another for significant contingency amounts held back until the end of the project, even though the spending curve may be low near the end of the project. Although risk does burn down over time, there may be significant reworking of hardware, for example, needed as a result of knowledge gained during integration and commissioning activities.

### 5.2.11.2 Change Control for Contingency Adjustments

Adjustments to cost, schedule, and scope are documented and approved under the project Change/Configuration Control Process (CCP), developed as a part of the PEP. The Risk Management Plan describes how the project uses the Change/Configuration Control Process (CCP) to assign contingency to specific WBS elements when risks materialize, and how budget contingency is de-allocated from WBS elements and returned to the contingency category when budget underruns occur. The Change Control Process should be initiated when the Total Project Cost is established at the Preliminary Design Review, and followed for the duration of the



project. All change control actions that affect the use of contingency – cost, schedule, or technical performance and scope – must include a link to an identified and documented risk and indicate the affected WBS elements at the first meaningful level of technical differentiation within the project. The CCP must make provision for seeking prior approval from the NSF Program Officer for all actions exceeding thresholds as defined in the CA. All change requests are to be archived by the project, and made available for review by NSF. The Project must keep a log of all change actions such that contingency actions, including puts and takes, can be reported and summarized. See Section 4.2.5 for further details and a sample Change Request form.

Note that use of contingency does not automatically require a change to the baseline. For instance, a change control action can authorize contingency to cover a cost overrun which is tracked as a variance on the baseline Budget at Complete (BAC). In such a case the contingency can be incorporated into either the BAC or the EAC. In the first instance, the BAC is changed. In the second, the variance from the BAC remains and can be used for trending and other information. See Section 4.2.5 for further details on approval levels for use of contingency.

Adjustments to contingency should include taking advantage of opportunities to assign savings and underruns to contingency. Savings should not be left in associated WBS elements if they are above thresholds set out in the Risk Management Plan, nor should they be shifted to other tasks without going through the Change Control Process for return to contingency and subsequent allocation to a different WBS element. Budget and cost underruns should be moved to contingency as risks are retired and WBS elements are closed out and reconciled. Savings realized through the implementation of planned de-scoping options should also be placed into contingency. Returning the savings allows the best use of contingency for overall project priorities.

### **5.2.11.3 Liens List: Forecasting and Opportunity Management**

The Project should maintain a Liens List of planned future adjustments to contingency as a forecasting tool that tracks actions that have not yet been incorporated into the BAC or EAC. The list may document items such as very high probability risks with trigger points for action, deferred scope held as contingency until a decision date, realized risks needing draws on contingency that require more definition for a change control action to be implemented, and anticipated opportunities for returns to contingency. It can also be used to record the need for contingency to cover variances that will not/cannot be mitigated. It does not serve the same purpose as a watch list or major threats list from the Risk Register. It acts as an escrow or staging account for planned or near certain contingency allocations.

The List should include a description of the identified risk and the anticipated action, with estimates of budget and schedule impacts, and anticipated decision date for any CCB action. The affected WBS elements should be identified, at the second level (or the first meaningfully specific level of scope description), where known.



Projected amounts of possible future adjustments to contingency in the Liens List are to be periodically reported to NSF. NSF recommends including this information within the monthly status report as well.

#### **5.2.11.4 Updates of the Estimate at Complete and Risk Exposure**

The project should maintain an estimate of total costs and risk exposure by periodically updating the schedule, the Estimate at Complete (EAC), and the analysis of overall project risk. Estimated contingency amounts should be appropriate for the risk exposure throughout the project life cycle. During concept and early development stages, a qualitative risk analysis and risk register may provide an adequate estimate of risk exposure for both the design and construction planning estimates. As project planning reaches the preliminary design phase, the drawbacks of qualitative analysis – limited subset of risks, ignored correlations, and arithmetic sums of averages – do not allow that method to adequately portray total project risk.<sup>1</sup> Project planners must transition to quantitative risk analysis in order to establish a substantiated Total Project Cost at the time of the PDR.

For the construction stage, initial contingency is a part of project total cost, scope and schedule. As time goes by, risk exposure changes with risk mitigation, new knowledge, and new circumstances. The amount of remaining contingency budget fluctuates over time with assignments to risk mitigation and return of savings. The remaining risk exposure estimate should be compared to the remaining available contingency to determine whether the project has adequate funds to cover anticipated risks. Remaining available contingency (RAC) is defined as the difference between the combination of the EAC plus any liens and The Total Project Cost:

$$\text{RAC} = \text{Total Project Cost (TPC)} - (\text{EAC} + \text{liens})$$

The sum of the (EAC + liens) should include variances (backward looking actuals) and updated estimates (forward looking forecasting) in the current plan, not the target baseline BAC. The EAC should equal the BAC only at project start and after major changes to the baseline from re-planning or re-baselining.

It is good practice to re-estimate EAC and Risk Exposure yearly, unless stated otherwise in the CA. Specific dates may also be appropriate times for re-evaluation, such as at major milestones dates. The Project Manager periodically re-assesses the current risk assessment to identify and address any new risks that arise as the project progresses. This assessment should result in a determination of whether cost and schedule contingency remains sufficient for project risks.

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<sup>1</sup> Projects usually adopt a more conservative certainty target such as the 80<sup>th</sup> percentile.



### **5.2.11.5 Contingency Use and NSF Oversight during Construction**

The NSF Program Officer must concur on all CCB actions exceeding CA-defined thresholds for allocation of budget, schedule, or scope contingency. NSF will negotiate a CA with the recipient institution to fund project construction activity which will specify thresholds above which prior NSF approval<sup>1</sup> is required before allocation of contingency (following formal CCB review) to specific WBS elements. Contingency may only be used to support in-scope work for the approved project baseline. See Section 4.2.5.7 for additional details.

### **5.2.11.6 Documentation and Reporting of Contingency Use**

Risk management actions involving Change Control actions fall under the following documentation and reporting requirements, as stated in more detail in Section 4.2.5:

- All Change Control Requests, irrespective of amount or whether they increase or decrease the BAC, are to be reported directly to NSF Program Officer
- The recipient will keep an archive of all Change Control Requests
- The recipient will keep a summary log of all Change Control Requests
- Projected amounts of possible future adjustments to contingency (“liens”) are to be periodically reported to NSF.

NSF recommends including this information within the monthly status report. Note that National Science Board (NSB) approvals<sup>2</sup> are required when Change Control actions exceed the even higher thresholds defined by NSB policy.

The required summary log of all Change Control actions should include the following:

- Change control action title,
- Change control document reference number,
- Change control approval date,
- Amounts of change in budget, scope, and/or schedule, for each affected and identified WBS element,
- Any adjustments to contingency amounts,
- WBS elements affected by the changes (at WBS Level II or at the first meaningful level of technical differentiation within the project)
- Risk Register ID number and description for the risk being addressed, and
- NSF approval date if required.

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<sup>1</sup> Thresholds are necessary to allow the project to respond in a timely way to small, immediate needs for use of contingency, such as field changes during construction. This avoids potential cost escalation that could result from delay.

<sup>2</sup> See Section 2.4, Construction Stage, for details on NSF policy on how and when NSB approval is required.



Monthly reports must also include the status of contingency as part of the Earned Value Management (EVM) reports. See Section 4.2.5.8 for details on reporting.





## **5.2.12 Partnership Considerations for Contingency Management**

NSF may partner with other entities to plan and construct a major facility. The guidelines within Section 4.2.5.9 of this document are applicable when NSF funds a particular scope of work within a larger overall project. Risk assessment, contingency development processes and contingency status reporting are to be applied to those WBS elements to be funded by NSF.

NSF encourages the development of unified management for project planning and execution of the entire project scope wherever practical.



### **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.



#### 5.4 GUIDELINES FOR PLANNING AND EXECUTING EXTERNAL REVIEWS OF NSF'S LARGE FACILITIES

This document, which is in preparation, will describe the process for evaluation and review of all NSF large facility projects proposed for construction, under construction or currently in operation. It will provide assistance to the Program Officer (PO) in preparing and planning a review of the *non-research related aspect* of the project's management, budgets, schedule and related activities. The information contained will offer guidance for three situations: reviews of facilities in planning; reviews of construction activity; and operational reviews of ongoing facilities. A description of the overall process of planning and carrying out an external review of a large facility project is provided as an aid to the PO or associated staff who may be unfamiliar with these processes or need a reference source on best practices.

The evaluation and reviews covered in the document include assessment of management, schedules and budgets, as well as other matters relevant to a large facility project, such as scrutiny of the project baseline for construction activity. It does not address the intellectual merit or the broader impact criteria used to select the project for support, but rather focuses on evaluation of the Recipient's planning and implementation activities.



## 5.5 ENVIRONMENTAL CONSIDERATIONS IN LARGE FACILITY PLANNING

NSF's funding for the construction or modification of facilities constitutes a Federal Action that triggers compliance with several statutes designed to protect the Nation's environmental, cultural and historic resources. Awareness of, and strict adherence to, all relevant environmental regulations are extremely important considerations in the planning, construction and operation of facilities.

These statutes include, but are not limited to the National Environmental Policy Act (NEPA), the National Historic Preservation Act (NHPA), and the Endangered Species Act. Furthermore, there are international agreements and treaties that deal with environmental impacts. For further information, see the *Proposal and Award Policies Procedures Guide* Chapter II.C.2.j.

NSF regulations governing compliance with the National Environmental Policy Act (NEPA) are found at 45 CFR §640. NSF regulations supplement the Council on Environmental Quality's (CEQ) regulations, published at 40 CFR §§1500-1508. Program Officers, as required by NSF regulations, are responsible for evaluating the environmental impacts that may result from the implementation of a Foundation award and determining into which category incoming proposals fall (i.e., CATEX, EA, or EIS). Compliance with NEPA also includes providing opportunities for public input on issues such as potential environmental impacts and ways to avoid, minimize, and/or mitigate adverse impacts. Determining the required level of compliance activities – including what documentation, consultation and/or permits may be required – is a complex task. The Program Officer (PO) should not attempt to determine the extent of compliance requirements without consulting the Environmental Compliance Team within NSF's Office of the General Counsel. NEPA compliance may require the preparation of an Environmental Assessment (EA) in cases where no significant environmental impacts are expected or the more extensive documentation of an Environmental Impact Statement (EIS) where adverse effects are anticipated. Failure to take necessary steps can cause undue delays in a project's schedule, significant cost escalation and potential federal litigation.

Additionally, in conjunction with or independent of its NEPA compliance, NSF may be required to initiate consultations with Native Americans and other interested parties pursuant to the NHPA and/or initiate informal or formal consultation with the U.S. Fish and Wildlife Service under the Endangered Species Act. These compliance requirements can introduce significant schedule and cost risk into the project which should be considered and addressed. Furthermore, there is no special source of funding within NSF to pay for the environmental compliance process; the cost is normally borne by the program using Research and Related Activities (R&RA) funds.

Given the above considerations, the following guidance is offered:



1. It is imperative that the PO contact the Environmental Compliance Team within NSF's Office of the General Counsel early in the conceptual design stage to seek guidance on specific requirements for compliance.
2. It is extremely important that the PO and the project get cost estimates for the compliance process and factor these into the project's scope, schedule and budget early in the design process.

The cost drivers associated with these activities (their impact on the project construction cost) need to be well understood by PDR since the PDR budget and risk assessment provide the basis for the construction funding request.



## **5.6 GUIDELINES FOR PROPERTY MANGEMENT**

*(Reserved for future content)*



## **5.7 GUIDELINES FOR FINANCIAL MANAGEMENT**

*(Reserved for future content)*



## **5.8 GUIDELINES FOR EARNED VALUE MANAGEMENT SYSTEMS**

*(Reserved for future content)*





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## 7 LIST OF ACRONYMS

AD	Assistant Director
AMBAP	Award Monitoring and Business Assistance Program
BAC	Budget at Complete
BFA	Office of Budget, Finance, and Award Management
BOE	Basis of Estimate
BOT	Business Oversight Team (Replaced by Integrated Project Team [IPT])
CA	Cooperative Agreement
CAAR	Cost Analysis and Audit Resolution
CATEX	Categorical Exclusion (NEPA)
CCB	Change Control Board
CCP	Change/Configuration Control Process
CDR	Conceptual Design Review
CEP	Cost Estimating Plan
CO	Contracts Officer
CPM	Critical Path Method
CPRD	Cost Proposal Review Document
CSB	Cooperative Support Branch
DACS	Division of Acquisition and Cooperative Support
DD	Division Director
DDLFP	Deputy Director for Large Facility Projects
DGA	Division of Grants and Agreements
DIAS	Division of Institution and Award Support
DRB	Director's Review Board
EA	Environmental Assessment
EAC	Estimate at Complete
EHR	Education and Human Resources
EIS	Environmental Impact Statement
ES&H	environmental safety and health
ETC	Estimate to Complete (for Cost)
EVM	Earned Value Management
EVMS	Earned Value Management System
FAR	Federal Acquisition Regulations
FDR	Final Design Review
FFRDC	Federally Funded Research and Development Center
FY	Fiscal Years
GAO	Government Accountability Office
G/AO	Grants and Agreements Officer
GPRA	Government Performance and Results Act
HLFO	Head, Large Facilities Office
ICA	Independent Cost Assessment
ICE	Independent Cost Estimate



IMP	Internal Management Plan
IMS	Integrated Master Schedule
IPT	Integrated Project Team (replaces the BOT and the PAT)
IT	Information Technology
LFM	Large Facilities Manual
LFO	Large Facilities Office at NSF
LFWG	Large Facilities Working Group
MOU	Memorandum of Understanding
MREFC	Major Research Equipment and Facilities Construction
NCE	No-Cost Extension
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NICRA	Negotiated Indirect Cost Rate Agreement
NRC	National Research Council
NSB	National Science Board
NSF	National Science Foundation
O&M	Operations and Maintenance
OD	Office of the Director
OGC	Office of the General Counsel
OMB	Office of Management and Budget
ORR	Operations Readiness Review
PAM	Proposal and Award Manual
PAT	Project Advisory Team (replaced by the Integrated Project Team [IPT])
PDP	Project Development Plan
PDR	Preliminary Design Review
PEP	Project Execution Plan
PI	Principal Investigator
PMB	Performance Measurement Baseline
PMBOK	Project Management Body of Knowledge
PO	Program Officer
R&D	Research and Development
R&RA	Research and Related Activities
RAC	Remaining Available Contingency
RBS	Risk Breakdown Structure
RET	Research Experiences for Teachers
REU	Research Experiences for Undergraduates
RFP	Request for Proposals
RI	Research Infrastructure
RM	Risk Manager
RMP	Risk Management Plan
S&E	Science and Engineering
SOG	Standard Operating Guidance
SME	Subject Matter Expert



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SPC	Statistical Process Control
TPC	Total Project Cost
WBS	Work Breakdown Structure



## 8 LEXICON

### 8.1 LEXICON PREFACE

This Lexicon contains definitions of project and program management terms used in this Manual, as applied to NSF large facilities. It is a combination of specialized terms defined by NSF and used in the management of its large facilities, and terms and definitions commonly used in professional project and program management. A subset of common project management terms compatible with NSF usage were selected from a standard source, the *PMI Lexicon*,<sup>1</sup> for inclusion in this lexicon.

The Lexicon provides a common set of standard terms and definitions that should facilitate communication and understanding between stakeholders when used in documents and correspondence related to large facility management.

The terms and definitions included in this lexicon are in development and are subject to modifications in future versions.

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## 8.2 TERMS AND DEFINITIONS

**Acceptance Criteria.** *A set of conditions that is required to be met before deliverables are accepted.*

**Activity.** *A distinct, scheduled portion of work performed during the course of a project.*

**Actual Cost.** *The realized cost incurred for the work performed on an activity during a specific time period.*

**Analogous Estimating.** *A technique for estimating the duration or cost of an activity or a project, using historical data from a similar activity or project.*

**Apportioned Effort.** *An activity where effort is allotted proportionately across certain discrete efforts and not divisible into discrete efforts. (Note: Apportioned effort is one of three earned value management [EVM] types of activities used to measure work performance.)*

**Approval.** The act of officially accepting an idea, action, or plan.

**Assistance.** The act of giving support or help; making it easier for someone to do something or for something to happen.

**Assumption.** *A factor in the planning process that is considered to be true, real, or certain, without proof or demonstration.*

**Assurance.** To give a strong and/or definite statement that something will happen or that something is true; to give confidence to.

**Backward Pass.** *A critical path method technique for calculating the late start and late finish dates by working backward through the schedule model from the project end date.*

**Baseline.** *The approved version of a work product that can be changed only through formal change control procedures and is used as a basis for comparison.*

**Baseline Definition.** The description of the approved scope of work and resources for a construction project, including a hierarchical, product-oriented Work Breakdown Structure (WBS) and associated WBS dictionary; the cost and schedule Performance Measurement Baselines (PMB); and any contingency amounts.

**Basis of Estimate.** *Supporting documentation outlining the details used in establishing project estimates such as assumptions, constraints, level of detail, ranges, and confidence levels.*

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**Budget Contingency.** An amount added to a baseline budget estimate to allow for identified items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs. Typically estimated using statistical analysis or judgment based on past asset or project experience. Budget contingency is allowed on MREFC awards.

***Bottom-up Estimating.*** A method of estimating project duration or cost by aggregating the estimates of the lower-level components of the work breakdown structure (WBS).

***\*Budget at Completion.*** The sum of all budgets established for the work to be performed. (For NSF projects, contingency amounts are not included in the ETC, EAC, BAC, or PMB due to the NSF requirement that contingency is held and managed separately from the baseline.)

***Change Control.*** A process whereby modifications to documents, deliverables, or baselines associated with the project are identified, documented, approved, or rejected.

***Change Control Board.*** A formally chartered group responsible for reviewing, evaluating, approving, delaying, or rejecting changes to the project, and for recording and communicating such decisions.

***Change Control System.*** A set of procedures that describes how modifications to the project deliverables and documentation are managed and controlled.

***Change Request.*** A formal proposal to modify any document, deliverable, or baseline.

***Code of Accounts.*** A numbering system used to uniquely identify each component of the work breakdown structure.

**Conceptual Design Phase.** The first phase of the Design Stage, after passing the gate from the Development Stage, that advances the definition of the scope and requirements, determines feasibility, and produces updated drafts of most elements of the Project Execution Plan, including parametric cost and schedule range estimates and a preliminary risk analysis.

**Contingency.** A planned amount of scope, budget, or time added to an estimate to allow for items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs. Typically estimated using statistical analysis or judgment based on past asset or project experience.

**Contingency Report Table.** A table containing a list of change control actions and allocations, with ties to associated WBS elements and identified risk events, for all Performance Measurement Baseline (PMB) changes that impact the use of contingency.

***Constraint.*** A limiting factor that affects the execution of a project, program, portfolio, or process.

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**Construction Stage.** The period of time in which funds are obligated for acquisition and/or construction of a facility that fulfills the terms and conditions set forth in an award instrument between NSF and the recipient(s). This stage ends with the start of the Operations Stage

**Control Account.** *A management control point where scope, budget, actual cost, and schedule are integrated and compared to earned value for performance measurement.*

**Corrective Action.** An intentional activity that realigns the performance of the project work with the project management plan.

**Cost Book Report.** A compilation of Cost Book Sheets, typically used to present total project cost, but may be used to present rolled-up costs for smaller elements or sub-elements.

**Cost Book Sheet.** A compilation of related information from the Cost Model Data Set, used to define and present the cost estimate for a particular element or sub-element of a deliverable-based work breakdown structure for construction or a functional (i.e., deliverable or activity oriented) based work breakdown structure for operations.

**Cost Estimating Plan.** A plan describing how the cost estimating guidance in this manual will be implemented, how the cost estimate will evolve over time, and how the “Cost Model Data Set” will meet the various needs of the project. The CEP should typically include a narrative and sufficient detail explaining the ground rules and assumptions, practices, systems, and calculations used to develop the cost estimate.

**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.

**Cost Performance Index.** *A measure of the cost efficiency of budgeted resources expressed as the ratio of earned value to actual cost.*

**Cost Variance.** *The amount of budget deficit or surplus at a given point in time, expressed as the difference between the earned value and the actual cost.*

**Crashing.** *A technique used to shorten the schedule duration for the least incremental cost by adding resources.*

**Critical Chain Method.** *A schedule method that allows the project team to place buffers on any project schedule path to account for limited resources and project uncertainties.*

**Critical Path.** *The sequence of activities that represents the longest path through a project, which determines the shortest possible duration.*

**Critical Path Activity.** *Any activity on the critical path in a project schedule.*

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**Critical Path Method.** *A method used to estimate the minimum project duration and determine the amount of scheduling flexibility on the logical network paths within the schedule model.*

**Current Plan.** The project cost and schedule plan reflecting the status of progress to date and updated estimates for completing remaining work that is compared to the approved Performance Measurement Baseline (PMB), as part of Earned Value Management.

**Data Date.** *A point in time when the status of the project is recorded.*

**Decision Tree Analysis.** *A diagramming and calculation technique for evaluating the implications of a chain of multiple options in the presence of uncertainty.*

**Decomposition.** *A technique used for dividing and subdividing the project scope and project deliverables into smaller, more manageable parts.*

**Defect Repair.** *An intentional activity to modify a nonconforming product or product component.*

**Deliverable.** *Any unique and verifiable product, result, or capability to perform a service that is required to be produced to complete a process, phase, or project.*

**De-Scoping Options (Plan).** See Scope Contingency Plan.

**Design Stage.** The life cycle stage for detailed planning for projects approved by the NSF Director at the end of the Development Stage and funded under the formal MREFC planning process. It is divided into the Conceptual, Preliminary, and Final Design Phases; with a formal and rigorous review gate at the end of each phase to show readiness for advancement to a higher level of refinement with regard to scope, cost, and schedule.

**Development Stage.** The Facility Life Cycle stage in which initial high level ideas are developed and a consensus built for the potential long-term need, priorities, and general requirements for a large research facility of interest to NSF and the broader research community.

**Discrete Effort.** *An activity that can be planned and measured and that yields a specific output. (Note. Discrete effort is one of three earned value management [EVM] types of activities used to measure work performance.)*

**Early Finish Date.** *In the critical path method, the earliest possible point in time when the uncompleted portions of a schedule activity can finish based on the schedule network logic, the data date, and any schedule constraints.*

**Early Start Date.** *In the critical path method, the earliest possible point in time when the uncompleted portions of a schedule activity can start based on the schedule network logic, the data date, and any schedule constraints.*

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**Earned Value.** *The measure of work performed expressed in terms of the budget authorized for that work.*

**Earned Value Management.** *A methodology that combines scope, schedule, and resource measurements to assess project performance and progress.*

**Effort.** *The number of labor units required to complete a schedule activity or work breakdown structure component, often expressed in hours, days, or weeks.*

**Enterprise Environmental Factors.** *Conditions, not under the immediate control of the team, that influence, constrain, or direct the project, program, or portfolio.*

**\*Estimate at Completion.** *The expected total cost of completing all work expressed as the sum of the actual cost to date and the estimate to complete. (For NSF projects, contingency amounts are not included in the ETC, EAC, BAC, or PMB due to the NSF requirement that contingency is held and managed separately from the baseline.)*

**\*Estimate to Complete.** *The expected cost to finish all the remaining project work. (For NSF projects, contingency amounts are not included in the ETC, EAC, BAC, or PMB due to the NSF requirement that contingency is held and managed separately from the baseline.)*

**Facility.** Shared-use infrastructure, equipment, or instrument - or an integrated network and/or collection of the same – that is either acquired or constructed to collect, analyze, and provide necessary data and information in support of research having a major impact on a broad segment of a scientific or engineering discipline.

**Facility Life Cycle.** The sequence of steps or stages that characterize the lifetime of a facility from beginning to end. For NSF, the stages are Development, Design, Construction, Operations, and Divestment.

**Fast Tracking.** *A schedule compression technique in which activities or phases normally done in sequence are performed in parallel for at least a portion of their duration.*

**Final Design Phase.** The third and last phase of the Design Stage, after a successful Preliminary Design Phase, that further refines the project Baseline Definition and the Project Execution Plan and demonstrates that project planning and management meet requirements for readiness to receive funding. The Final Design phase ends in a potential NSF approval to obligate construction funds.

**Finish-to-Finish.** *A logical relationship in which a successor activity cannot finish until a predecessor activity has finished.*

**Finish-to-Start.** *A logical relationship in which a successor activity cannot start until a predecessor activity has finished.*

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**Forward Pass.** *A critical path method technique for calculating the early start and early finish dates by working forward through the schedule model from the project start date or a given point in time.*

**Free Float.** *The amount of time that a schedule activity can be delayed without delaying the early start date of any successor or violating a schedule constraint.*

**Gantt Chart.** *A bar chart of schedule information where activities are listed on the vertical axis, dates are shown on the horizontal axis, and activity durations are shown as horizontal bars placed according to start and finish dates.*

**Internal Management Plan.** The internal document that defines NSF strategy for conducting project oversight and assurance, managing NSF risk, and providing project funding.

**Lag.** *The amount of time whereby a successor activity is required to be delayed with respect to a predecessor activity.*

**Late Finish Date.** *In the critical path method, the latest possible point in time when the uncompleted portions of a schedule activity can finish based on the schedule network logic, the project completion date, and any schedule constraints.*

**Late Start Date.** *In the critical path method, the latest possible point in time when the uncompleted portions of a schedule activity can start based on the schedule network logic, the project completion date, and any schedule constraints.*

**Large Facility.** A facility for which the construction cost is more than a specified percentage of the sponsoring NSF organization's budget plan, and which is paid for out of MREFC funds. Construction costs for large facilities typically range between \$100M and \$800M.

**Lead.** *The amount of time whereby a successor activity can be advanced with respect to a predecessor activity.*

**Lessons Learned.** *The knowledge gained during a project which shows how project events were addressed or should be addressed in the future for the purpose of improving future performance.*

**Level of Effort.** *An activity that does not produce definitive end products and is measured by the passage of time. (Note. Level of effort is one of three earned value management [EVM] types of activities used to measure work performance.)*

**Liens List.** A list of expected adjustments to project scope, budget, and schedule contingency amounts that are waiting for implementation, including formal change control actions for planned baseline modifications, scope contingency options held for decision, and coverage of variances.

**Logical Relationship.** *A dependency between two activities or between an activity and a milestone.*

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**Management.** The act of controlling and making decisions about an operation, organization or project; the act or process of deciding how to use something; the judicious use of means to accomplish an end.

**Management Reserve.** A planned amount of money or time added to a baseline estimate to address unforeseeable events (often referred to as “unknown unknowns”). Management reserves are not allowable on NSF awards.

**Milestone.** *A significant point or event in a project, program, or portfolio.*

**Most Likely Duration.** *An estimate of the most probable activity duration that takes into account all of the known variables that could affect performance.*

**“No Cost Overrun” Policy.** NSF policy requiring that a Total Project Cost estimate established at the Preliminary Design Stage have adequate contingency to cover all foreseeable risks, and that any cost increases not covered by contingency be accommodated by reductions in scope.

**Operations Stage.** The Life Cycle Stage that succeeds Construction and includes the day-to-day work to operate and maintain the facility and to perform research. Operations may also include activities to transition from construction to operations, replacement or upgrade activities, technology research and development, and activities that support planning and staging for the Divestment Stage.

**Opportunity.** *A risk that would have a positive effect on one or more project objectives.*

**Optimistic Duration.** *An estimate of the shortest activity duration that takes into account all of the known variables that could affect performance.*

**Organizational Breakdown Structure.** *A hierarchical representation of the project organization, which illustrates the relationship between project activities and the organizational units that will perform those activities.*

**Organizational Project Management Maturity.** *The level of an organization's ability to deliver the desired strategic outcomes in a predictable, controllable, and reliable manner.*

**Oversight.** Watchful and responsible care of something or some activity; regulatory supervision.

**Parametric Estimating.** *An estimating technique in which an algorithm is used to calculate cost or duration based on historical data and project parameters.*

**Path Convergence.** *A relationship in which a schedule activity has more than one predecessor.*

**Path Divergence.** *A relationship in which a schedule activity has more than one successor.*

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***Percent Complete.*** An estimate expressed as a percent of the amount of work that has been completed on an activity or a work breakdown structure component.

**Performance Measurement Baseline.** (Aka target baseline or performance baseline) The approved cost and schedule plan for accomplishing project work scope that can be changed only through formal change control process and that is used as a basis of comparison for Earned Value Management. (For NSF projects, contingency amounts are not included in the Earned Value tracking amounts due to the NSF requirement that contingency is held and managed separately from the baseline.)

***Pessimistic Duration.*** An estimate of the longest activity duration, which takes into account all of the known variables that could affect performance.

***Phase Gate.*** A review at the end of a phase in which a decision is made to continue to the next phase, to continue with modification, or to end a project or program.

***Planned Value.*** The authorized budget assigned to scheduled work.

***Portfolio.*** Projects, programs, subportfolios, and operations managed as a group to achieve strategic objectives.

***Portfolio Management.*** The centralized management of one or more portfolios to achieve strategic objectives.

***Precedence Diagramming Method.*** A technique used for constructing a schedule model in which activities are represented by nodes and are graphically linked by one or more logical relationships to show the sequence in which the activities are to be performed.

***Predecessor Activity.*** An activity that logically comes before a dependent activity in a schedule.

**Preliminary Design Phase.** The second phase of the Design Stage, after the Conceptual Design Phase, that further advances the project definition and the Project Execution Plan. It produces a bottom-up scope, cost, schedule, and risk analysis of sufficient maturity to allow determination of the Project Total Cost and Duration for a stated future start date and to establish the MREFC budget request.

***Preventive Action.*** An intentional activity that ensures the future performance of the project work is aligned with the project management plan.

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**Probabilistic Risk Assessment.** A quantitative risk analysis that uses probability distributions to represent the uncertainty usually present in the cost of a deliverable or the duration of a scheduled activity, in order to obtain a range of outcomes for overall project cost and finish dates that support selection of contingency amounts as part of risk management. Many commercial probabilistic risk analysis applications employ Monte Carlo simulations of project cost and schedule.

***Probability and Impact Matrix.*** A grid for mapping the probability of each risk occurrence and its impact on project objectives if that risk occurs.

***Procurement Management Plan.*** A component of the project or program management plan that describes how a team will acquire goods and services from outside of the performing organization.

***Program.*** A group of related projects, subprograms, and program activities that are managed in a coordinated way to obtain benefits not available from managing them individually.

***Program Management.*** The application of knowledge, skills, tools, and techniques to a program to meet the program requirements and to obtain benefits and control not available by managing projects individually.

***Progressive Elaboration.*** The iterative process of increasing the level of detail in a project management plan as greater amounts of information and more accurate estimates become available.

***Project Calendar.*** A calendar that identifies working days and shifts that are available for scheduled activities.

**Project End Date.** The projected date for the completion of all the project baseline schedule activities plus use of all schedule contingency. (Note that this date may be earlier than, but no later than, the end date of the award instrument.)

***\*Project Execution Plan.*** The document that describes how the project will be executed, monitored, and controlled.

***Project Life Cycle.*** The series of phases that a project passes through from its initiation to its closure.

***Project Management.*** The application of knowledge, skills, tools, and techniques to project activities to meet the project requirements.

***Project Management Office.*** A management structure that standardizes the project-related governance processes and facilitates the sharing of resources, methodologies, tools, and techniques.

***Project Manager.*** The person assigned by the performing organization to lead the team that is responsible for achieving the project objectives.

***Project Phase.*** A collection of logically related project activities that culminates in the completion of one or more deliverables.

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**Project Schedule.** *An output of a schedule model that presents linked activities with planned dates, durations, milestones, and resources.*

**Project Scope.** *The work performed to deliver a product, service, or result with the specified features and functions.*

**Project Scope Statement.** *The description of the project scope, major deliverables, assumptions, and constraints.*

**Quality Management Plan.** *A component of the project or program management plan that describes how an organization's quality policies will be implemented.*

**Re-Baselining.** Project re-planning that results in a change that is outside the terms set forth in the award instrument for any of the following: 1) Total Project Cost (TPC); 2) overall project duration or end date; or 3) project scope, except for approved options in the scope contingency plan. Re-baselining actions require special review and approval by NSF beyond those of the typical change control approval process for re-planning actions.

**Re-Planning.** A normal project management process to modify or re-organize the Performance Measurement Baseline cost and/or schedule plans for future work without impacting total project cost, project end date, or overall scope objectives; or the implementation of approved de-scoping options. Formal change control processes are followed for all baseline changes. Retroactive changes to past performance should not be included in re-planning.

**Requirement.** *A condition or capability that is required to be present in a product, service, or result to satisfy a contract or other formally imposed specification.*

**Resource Breakdown Structure.** *A hierarchical representation of resources by category and type.*

**Resource Calendar.** *A calendar that identifies the working days and shifts upon which each specific resource is available.*

**Resource Leveling.** *A technique in which start and finish dates are adjusted based on resource constraints with the goal of balancing demand for resources with the available supply.*

**Responsibility Assignment Matrix.** *A grid that shows the project resources assigned to each work package.*

**Review and Recommend.** The act of carefully looking at or examining the quality or condition of something AND then suggesting that someone taken action or do something.

**Risk.** *An uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives.*

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***Risk Acceptance.*** A risk response strategy whereby the project team decides to acknowledge the risk and not take any action unless the risk occurs.

***Risk Avoidance.*** A risk response strategy whereby the project team acts to eliminate the threat or protect the project from its impact.

***Risk Breakdown Structure.*** A hierarchical representation of risks that is organized according to risk categories.

***Risk Category.*** A group of potential causes of risk.

**Risk Exposure.** Quantitative impact of risk for a single event, quoted in currency or time, and typically estimated from probability of occurrence and a likely impact or consequence. Overall project risk exposure results from an accumulation of individual risk impacts for the work to be completed, typically determined by applying probabilistic analysis to the set of individual risks.

***Risk Management Plan.*** A component of the project, program, or portfolio management plan that describes how risk management activities will be structured and performed.

***Risk Mitigation.*** A risk response strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk.

***Risk Register.*** A document in which the results of risk analysis and risk response planning are recorded.

***Risk Transference.*** A risk response strategy whereby the project team shifts the impact of a threat to a third party, together with ownership of the response.

***Rolling Wave Planning.*** An iterative planning technique in which the work to be accomplished in the near term is planned in detail, while the work in the future is planned at a higher level.

***Schedule Compression.*** A technique used to shorten the schedule duration without reducing the project scope.

**Schedule Contingency.** An amount added to a baseline schedule estimate to allow for identified delays, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional project duration. Typically estimated using statistical analysis or judgment based on past asset or project experience.

***Schedule Management Plan.*** A component of the project or program management plan that establishes the criteria and the activities for developing, monitoring, and controlling the schedule.

***Schedule Model.*** A representation of the plan for executing the project's activities, including durations, dependencies, and other planning information, used to produce a project schedule along with other scheduling artifacts.

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**Schedule Performance Index.** *A measure of schedule efficiency expressed as the ratio of earned value to planned value.*

**Schedule Variance.** *A measure of schedule performance expressed as the difference between the earned value and the planned value.*

**Scope Baseline.** *The approved version of a scope statement, work breakdown structure (WBS) and its associated WBS dictionary, which can be changed only through formal change control procedures and is used as a basis for comparison.*

**Scope Contingency.** Scope included in the project baseline definition that can be removed without affecting the overall project's objectives, but that may still have undesirable effects on facility performance. Identified scope contingency should have a value equal to at least 10% of the baseline budget.

**Scope Contingency Plan.** A component document of the Project Execution Plan that describes how scope contingency is determined, monitored, and controlled over the project lifetime.

**Scope Creep.** *The uncontrolled expansion to product or project scope without adjustments to time, cost, and resources.*

**Scope Management Plan.** *A component of the project or program management plan that describes how the scope will be defined, developed, monitored, controlled, and validated.*

**S-Curve Analysis.** *An earned value management technique used to indicate performance trends by using a graph that displays cumulative costs over a specific time period.*

**Secondary Risk.** *A risk that arises as a direct result of implementing a risk response.*

**Sponsor.** *A person or group that provides resources and support for the project, program, or portfolio, and is accountable for enabling success.*

**Staffing Management Plan.** *A component of the human resource plan that describes when and how team members will be acquired and how long they will be needed.*

**Stakeholder.** *An individual, group, or organization that may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project, program, or portfolio.*

**Start-to-Finish.** *A logical relationship in which a successor activity cannot finish until a predecessor activity has started.*

**Start-to-Start.** *A logical relationship in which a successor activity cannot start until a predecessor activity has started.*

**Successor Activity.** *A dependent activity that logically comes after another activity in a schedule.*

**Summary Activity.** *A group of related schedule activities aggregated and displayed as a single activity.*

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**Divestment Stage.** The stage in the facility life cycle encompasses divestment of the facility to control by another entity or decommissioning, including dismantling/demolition, starting after of the NSF Operations Stage ends and funding for divestment begins.

***Threat.*** A risk that would have a negative effect on one or more project objectives.

***Three-Point Estimate.*** A technique used to estimate cost or duration by applying an average or weighted average of optimistic, pessimistic, and most likely estimates when there is uncertainty with the individual activity estimates.

***To-Complete Performance Index.*** A measure of the cost performance that is required to be achieved with the remaining resources in order to meet a specified management goal, expressed as the ratio of the cost to finish the outstanding work to the remaining budget.

***Total Float.*** The amount of time that a schedule activity can be delayed or extended from its early start date without delaying the project finish date or violating a schedule constraint.

**Total Project Cost.** The sum of the Performance Measurement Baseline budget and the budget contingency.

**Total Project Duration.** The sum of the Performance Measurement Baseline schedule duration and the schedule contingency.

***Trigger Condition.*** An event or situation that indicates that a risk is about to occur.

***Variance Analysis.*** A technique for determining the cause and degree of difference between the baseline and actual performance.

***Variance at Completion.*** A projection of the amount of budget deficit or surplus, expressed as the difference between the budget at completion and the estimate at completion.

***WBS Dictionary.*** A document that provides detailed deliverable, activity, and scheduling information about each component in the work breakdown structure.

***What-If Scenario Analysis.*** The process of evaluating scenarios in order to predict their effect on project objectives.

***Work Breakdown Structure.*** A hierarchical decomposition of the total scope of work to be carried out by the project team to accomplish the project objectives and create the required deliverables.

***Work Package.*** The work defined at the lowest level of the work breakdown structure for which cost and duration can be estimated and managed.

***Workaround.*** A response to a threat that has occurred, for which a prior response had not been planned or was not effective.

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## 9 APPENDICES

### Appendix A. Ranking Criteria for Prioritizing MREFC Projects

#### First Ranking: Scientific and Technical Criteria Assessed by Researchers in a Field or Interdisciplinary Area (e.g., at the NSF Division level)

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

#### Second Ranking: Agency Strategic Criteria Assessed across Related Fields (e.g., at the NSF Directorate level)

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

#### Third Ranking: National Criteria Assessed across All Fields (e.g., at the overall NSF level)

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



## Appendix B. Memoranda Requesting NSB Approval of MREFC Project

### For MREFC Projects requesting NSB approval (for inclusion in a future budget request)

In addition to the NSF Form 10 (for clearance) and the Assistant Director/Office Head endorsement(s), two items should be prepared and clearly marked as “pre-decisional – Do Not Distribute.”

(1) A Director's Memorandum to Members of the NSB, briefly summarizing the project, the need for the project and the Total Project Cost (TPC) Estimate and estimated duration. The Director's Memorandum should include the following statement:

“With the Board’s concurrence that this project is meritorious and that its planning is sufficiently advanced, the Director will take appropriate action in preparation of a budget request. Board approval of this project for planning purposes does not imply NSB approval of project implementation. Any such approval will be requested from the NSB at the appropriate time.”

The Director's Memorandum should conclude with the following resolution:

“RESOLVED, that the National Science Board concurs that planning for the <project title> is sufficiently advanced, and the intellectual value of the project sufficiently well demonstrated, to justify consideration by the Director and the Board for funding in the FY 20XX or a future NSF budget request.”

(2) A project report (usually six to eight pages) providing an update of the documentation provided to the MREFC Panel.

### For NSB approval of MREFC project implementation

Before project construction can be initiated, project implementation approval should be granted by the National Science Board (NSB). First, the Director should prepare a *Memorandum for NSB Action*.<sup>1</sup> The Director's memorandum to the NSB should summarize information and issues related to the proposed implementation of the project, potential policy issues/implications, precedents involved, prior NSB discussion and any other factors that could be considered non-routine.

It should normally contain: a brief science/engineering overview; a description of connections to any national and international programs; a description of the project; a summary of the review process and a short statement of response to any major concerns raised by reviewers; a schedule with contingency; TPC which includes the performance baseline and contingency; the impact that technological advances would have on the project during construction; the

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<sup>1</sup> See *Proposal and Award Manual (PAM)* VI.H.3.b.



percentage of program or division budgets that the proposed award represents and out-year implications; and a description of plans for project management.

The Memorandum should also include a statement regarding plans for the end of the award period, consistent with the policies set forth in [NSB-08-16](#), “NSB Statement on Competition, Recompetition and Renewal of NSF Awards” and the accompanying Resolution passed by the NSB at its meeting of February 7, 2008.



**From:** [Graff, Ivan](#)  
**To:** [Wilkinson, Carol](#)  
**Subject:** LFM, minor addition: Section 3.4.1-10.2  
**Date:** Monday, May 16, 2016 1:15:54 PM

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Greetings,

While meeting with Battelle two weeks ago it became apparent that brief description in LFM Section 3.4.1, 10.2 EVMS, may or may not cover a description what ANSI/EIA 748C describes in Section 3.7 as the “Earned Value Methodology” but others may describe as “progressing rules.” Although one might argue that the word “processes” covers this, adding “progressing rules” to the description may better highlight an area where the sponsor and recipient need to come to some agreement. Please let me know if you think you could address this in the LFM this time around if this requires wider discussion. Thanks!

Take care,

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# NSF and LFO Improvement Suggestions

June 23, 2016

*Note: Terms “facility,” “project,” “applicant,” “recipient,” “awardee,” and the like pertain solely to cooperative agreements issued by NSF funding the acquisition, operation, or maintenance of property.*

## I. Acquisition

### A. Broadening Interest in Large Facilities

1. Require a solicitation, even for noncompetitive acquisitions, to provide a public record of NSF requirements. For example questions that such a solicitation might answer, see the historical "Guidelines for Development of Internal Management Plans for Large Facilities" (c. 2006).
2. Develop a self-study review course on the LFM and compile job aids.
3. Prepare an information sheet identifying NSF community and funding opportunities and resources for maturing a research infrastructure concept to a completed facility.

### B. Recipient Selection

1. Require relevant prior experience and prioritize qualified applicant entities based on the nature of their past successes related to the scope they propose to accomplish.
  - a. Recipients awarded funds for development need experience developing design and construction planning documents.
  - b. Recipients awarded funds for design need experience preparing similar designs and specifications.
  - c. Recipients awarded funds for construction need experience constructing similar facilities.
  - d. Recipients awarded funds for operations need experience operating similar facilities.
  - e. Recipients awarded funds for divestment need experience completing similar cleanup, closure, and disposal actions.
2. Never assume that just one entity, especially an entity that submitted an unsolicited proposal, has the capability and capacity to complete a scope of work until market research (e.g., a request for letters of intent) shows otherwise.

### C. Ensuring Coordination

1. Require that an office of sponsored research or its equivalent review applications and documents provided to external panelists, and indicate the outcome of the review, prior to submission to NSF. NSF currently has such controls in place for grants, but not yet for cooperative agreements.

### D. Strategy

1. Discourage funding combinations of research and development, operations and maintenance, and upgrades on the same awards to better track the kinds of investments made and avoid reprioritizations without NSF input.

### E. Evolving Policy

1. If NSF continues its current policy of holding recipients accountable to the current version of the Large Facilities Manual (LFM), address in the LFM how projects should request and document the need for equitable adjustments due to NSF changes. Disallow management reserves from absorbing these costs as NSF does not have an independent mechanism for estimating the financial burden of its policy changes.

## II. Information

### A. Project Documentation

1. LFM Section 4.4 lists some documents that projects share with NSF. Provide a comprehensive listing and specify a flat organizational structure for filing the documents to encourage each project to make retrieval as intuitive and efficient as possible.

### B. Software

1. Leverage Web 2.0 services endorsed by GSA to manage contacts (e.g., panelist and consultant inventory) and host discussion forums (e.g., communities of practice).
2. Obtain a site license (or about 30 individual licenses) for software that will allow for reading and modest analysis of schedules prepared in Oracle Primavera 6.

### C. Information Collections

1. Customize application and reporting forms and templates to meet the information needs of large cooperative agreements. Funding for large

cooperative agreements comprise about 15% of NSF annual appropriations so logically a commensurate portion of the content forms collect should serve this subset of recipients.

2. LFO will need to work with DIAS Policy, IT services, and BFA and DAS decision making bodies to facilitate this shift.

#### D. Financial Codes (Segment Values)

1. Add additional segments or options in existing segments to label funding releases for contingency, management fee, and perhaps in the future management reserve. NSF has struggled with tracking the amount of funding released to a project earmarked for these two purposes.

### III. Policy

#### A. Large Facilities Manual

1. Reorganize for the primary audience
  - a. Recognize that recipients comprise the primary audience for the LFM. Reorganize into mandatory and optional sections. Clearly distinguish between requirements and commentary.
  - b. Remove content intended for NSF employees and relocate in standing operating guidance (SOG). This includes references to documents inaccessible outside of NSF such as the Proposal and Award Manual (PAM).
  - c. Add an appendix listing in chronological order all instances where the text directs recipients to obtain more complete direction from a program officer.
2. Complete the Lifecycle
  - a. Require the submission of designs and specifications at each of the three design phases. Describe the kinds of views and details that the plans and specifications need to include.
  - b. Add a loop in the lifecycle process for a project to return to preliminary design following delays in appropriations extending past a year to allow the project to escalate and revalidate its cost estimate.
  - c. Introduce technical readiness levels for experimental systems and equipment. Require documentation of increasing levels of maturity at scales closer to the planned finished product through successive design

reviews. The Construction Industry Institute offers an example of this in its Project Development Rating Index (PDRI).

- d. Discuss circumstances warranting, and procedures and requirements for, rebaselining. Address the need, if any, to complete a change request.
- e. Add definitions for commissioning and transition to operations (T2O). Add discussion comparing commissioning to transitioning to operations.
  - i. Commissioning: Base the definition on ASHRAE Standard 202.
  - ii. T2O: Adopt the five step test used for NEON –
    - Completion of construction
    - Demonstration of functionality
    - Appropriately staffed
    - Budget allocated
    - Segregation of funds controls in place
- f. Require that operations awards specify performance measures and that awardees report against them in annual reports.
- g. Add stage gate reviews to enter and exit the divestment stage.
- h. Reinforce the sequential nature of the stages and the independent aspects of each stage.

### 3. Project Execution Plan (LFM Section 3.4.1)

- a. Reorder the sections to follow a typical progression of project planning and documentation preparation. Section 4 should begin with the scope, then detail the schedule, and finish with documents that contribute to and comprise the budget.
- b. Add adequacy criteria for each section of the project execution plan (PEP) organized by design phase and stage.
- c. Add a section to the PEP for a communications plan that emphasizes communications between NSF and the project. This plan would detail a process and standards for issuing and resolving request for information.
- d. In Section 2.5, strike "outreach" since it appears earlier in Section 1.4.

- e. In Section 10.2, address "earned value methodology" [ANSI/EIA 748, section 3.7]. For each WBS element, identify the ANSI/EIA option most closely aligning with the described methodology: discrete effort, apportioned effort, or level of effort.
- f. Expand Section 11.1 to address existing conditions encountered by upgrade projects since tying into or replacing existing systems poses challenges similar to the constraints of a site or environmental protections.
- g. This section currently provides a brief description of each section. Address each section more fully in dedicated subsequent chapters, perhaps in the optional part of the LFM.

#### 4. Costs

- a. Address by reference (i.e., 2 CFR §200 and PAPPG) and by example allowable and unallowable expenses.
- b. Address spare supplies, material, and equipment including the permissible –
  - i. Source(s) of funds for their acquisition;
  - ii. Classes or kinds; and,
  - iii. Quantities or volumes.
- c. Provide on the public LFO Website templates for documenting and tabulating cost estimates.

#### 5. Panel Reviews

- a. Describe the similarities and differences between all external panel reviews convened during a facility's life cycle with an emphasis on the responsibilities of, and impacts to, the recipient.
- b. Add lists of documents (1) the recipient must supply and (2) the panel must receive for each phase and stage review.
- c. Give panelists access to past deliverables, monthly and annual reports from the project, and relevant portions of bi-monthly reports to the Director where available to better contextualize the project.
- d. Ensure the project sets up and maintains systems scrutinized in a business systems review (BSR).

- e. Require the program officer (PO) to issue direction to the project based on the comments and recommendations of a review panel, rather than pass along the report with an expectation that the project will effectively prioritize and implement it. Note that the review panel SOG(s) will explain that the PO has separate relationships with the panel and the project while the panel and the project have not entered into an agreement.

## 6. Oversight

- a. Execution of the project must include implementing accountability practices, procedures, and systems that a BSR will confirm. To help projects comply with the BSR Guide, repeat the table appearing in Section 3.4.1 (PEP), delete the description column, and add a column for the "organization process assets" (PMI term), i.e., the components of a BSR, on which the activities comprising that portion of the PEP depend.
- b. Require a successful BSR prior to administratively closing out a construction cooperative agreement.

## 7. Reporting

- a. Detail requirements for preparing monthly and annual reports, especially during the design and construction stages.
- b. Have the program officer send a response to monthly reports to the project:
  - i. Prepare a template that would replace or supplement section 6 of the monthly report that would indicate:
    - Errors and omissions;
    - Positive and negative impressions;
    - Corrective expectations for the next month or later; and,
    - An overall confidence level for the future of the project.
  - ii. Inform this feedback with input from members of the integrated project team (IPT).
  - iii. LFO would use the whole or portions of the section 6 feedback verbatim in its bimonthly report to the Director.
- c. Introduce an annual report format for facilities in operations.

## 8. Guidance Chapters

- a. Add a chapter for work breakdown structures (WBS) and the WBS dictionary.
  - i. Differentiate through example project deliverables or products from process activities or administrative requirements.
  - ii. Differentiate between conventional and experimental facilities
  - iii. Include an element in the WBS for each unique item of significant property.
- b. Reference environmental reviews and compliance in conjunction with development and conceptual design. In the course of doing so:
  - i. Revise content to convey that other kinds of environmental reviews besides those currently described may have to occur;
  - ii. Strike references to internal guidance; and,
  - iii. Clarify that environmental compliance remains the responsibility of NSF while the project must obtain permits and licenses.

## B. Internal Procedures

1. Assign the responsibility of writing and managing financial policy to an office within BFA and provide it with the resources (staff, budget, and authority) it needs.
2. Management Reserves
  - a. Future MREFC appropriations requests may include more than the total project cost (TPC). The TPC includes the performance management baseline, management fee, and contingency, but does not include funding to cover NSF risks.
  - b. Allow management reserves for:
    - i. Scope contingency detailed by the project, desired by NSF, but at risk of getting descoped due to draws on contingency; or,
    - ii. Work packages executed by NSF in support of the cooperative agreement such as environmental impact statements.



- c. NSF must base its request for management reserves on sound, verifiable cost estimates obtained prior to entry into final design.
  - d. Do not use management reserves to augment a TPC to compensate for deficiencies in a proposal from the project or other set of project documents. Instead, encourage the project to resolve the deficiencies and then proceed for a review of updated documents.
3. Revise and restructure the approach LFO uses for writing and revising policy.
- a. Select an LFO analyst who will write and revise the SOG and bear the responsibility for addressing all comments received, regardless of their source.
  - b. Develop a comment tracking template to serve as a record of the evolution of a SOG.
  - c. Notify the LFWG membership of the scope of the SOG or SOG revision and compile feedback.
  - d. The analyst will facilitate a series of review sessions scheduled for one week following when invited attendees' will receive a review draft.
  - e. Hold the following series of reviews:

Audience	Type of Review	Timeline
LFWG	Notification (email)	Week 1
LFO	Draft #1	Week 4
BFA	Draft #2	Week 6
LFWG (virtual)	Draft #3	Week 8
LFO	Draft #4	Week 10
LFWG (in person)	Draft #5	Week 12
SMaRT (if needed)	Final	Week 14

- f. Only the assigned LFO analyst may delay the progression of drafts. DIAS will issue the SOG or SOG revision by Week 16.
  - g. LFO will commit to review and revise as necessary each SOG at least once every three years.
4. Standing Operating Guidance (SOG)
- a. Ensure that for all instances in the LFM where the text directs recipients to obtain more complete direction from a program officer, a SOG addresses that direction.

b. Consolidate the planned array of SOGs as of May 2016 into as few documents as possible as the current list has grown and the central themes of information collection, reviews, and assurance have emerged. The current array includes:

- i. MREFC Panel
- ii. Environmental Compliance
- iii. Internal Management Plans
- iv. Integrated Project Teams
- v. Cost Reviews
- vi. eJacket
- vii. Monthly Construction Reports
- viii. Contingency
- ix. Design Stage Review
- x. EVM Guide and Validation
- xi. Construction Stage Review
- xii. Property Reporting
- xiii. Annual Planning Process for Business Systems Reviews
- xiv. Scoping Business System Reviews

c. Additional topics that one or more SOGs need to address (suggested additional topics appear in **bold**)

- i. **LFO SOG writing and updating procedures and assignments**
- ii. **Document Organization**
- iii. **Solicitations**
- iv. MREFC Panel
- v. Environmental Compliance
- vi. Internal Management Plans
- vii. Integrated Project Teams
- viii. Cost Reviews
- ix. **Assessing the Adequacy of a Project Execution Plan and its Subsidiary Plans and Documents**
- x. **Cooperative Agreements and Amendments**
- xi. eJacket
- xii. **Funding Releases and Accounting**
- xiii. **Monthly and Annual Design and Construction Reports and Bimonthly Reports to the Director**
- xiv. **Change Request Reviews**
- xv. Contingency
- xvi. **Rebaselining**
- xvii. Design Stage Review
- xviii. EVM Guide and Validation

- xix. Construction Stage Review
- xx. Property Reporting
- xxi. Assessing the Adequacy of an Operations Plan**
- xxii. Annual Planning Process for Business Systems Reviews
- xxiii. Scoping Business System Reviews
- xxiv. Annual Operations Reports**
- xxv. Operations Stage Review**
- xxvi. Divestment**

- d. Include in the design and construction reports SOG language that the program officer will share his or her feedback with the project and that the same feedback will appear in the LFO's bimonthly report to the Director.
- e. Combine all external review related SOGs and all internal review related SOGs into a single external review SOG and a single internal review SOG.

Stay in touch:

<http://www.energy.gov/phonebook/Ivan%20Graff>

**From:** [Hawkins, Matthew J.](#)  
**To:** [Wilkinson, Carol](#)  
**Cc:** [Porter, Kevin](#)  
**Subject:** Re: Contingency for MREFC Fixed Price Contracts  
**Date:** Wednesday, August 10, 2016 10:32:13 AM

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Correct on UG and profit vs non-profit....the recipient being for-profit or non-profit is what Bart said earlier and is covered by the existing footnote.

Contingency is allowed under UG. "Reserve" or "contingency reserve" is not...see SOG 2016-2 where we cover these definitions as well. Perhaps these definitions should also be included in Section 8.2 (Lexicon)?

Matt

Sent from my iPad

On Aug 10, 2016, at 10:20 AM, Wilkinson, Carol <[CWILKINS@nsf.gov](mailto:CWILKINS@nsf.gov)> wrote:

Oops. The OMB circular has been replaced by the uniform guidance, so that covers contracts with non-profits and educational institutions.

So we will have to use both the FAR and the OMB Uniform Guidance for contracts, depending upon the type of institution.

Carol

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**From:** Hawkins, Matthew J.  
**Sent:** Tuesday, August 09, 2016 2:43 PM  
**To:** Wilkinson, Carol <[CWILKINS@nsf.gov](mailto:CWILKINS@nsf.gov)>  
**Cc:** Porter, Kevin <[KPORTER@nsf.gov](mailto:KPORTER@nsf.gov)>  
**Subject:** Re: Contingency for MREFC Fixed Price Contracts

Carol,

I think we need some very simple "applicability" statements in the opening sections of the LFM.

"Unless otherwise noted, the policies and procedures in the manual apply to research infrastructure projects regardless of the award instrument employed. Cooperative agreements are governed by the Uniform Guidance. Contracts are governed by the FAR."

I know how I handled contingency with FFP sub-contracts under CA's.

What does FAR say about budget contingency?

Matt

Sent from my iPad

On Aug 9, 2016, at 2:08 PM, Wilkinson, Carol <[CWILKINS@nsf.gov](mailto:CWILKINS@nsf.gov)> wrote:

Matt,

The LFM is not clear about contingency expectations in the case of contracts. How do we handle the contingency issue with respect to full fixed price contracts instead of CAs— including return of contingency at the end? I also need to know if the EVM reporting for FFPCs has contingency in the baseline for EVM reporting or if it is carried separately as it is for CAs. On funding, I don't think we can hold back 'contingency' for a contract like we do for CAs.

I'm not clear on the differences between contracts and CAs and neither is the LFM, as the AIMS folks have pointed out.

Carol

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**From:** [Graff, Ivan](#)  
**To:** [Wilkinson, Carol](#)  
**Cc:** [Hawkins, Matthew J.](#)  
**Subject:** LFM Errata: Commissioning Plan and "IMP"  
**Date:** Wednesday, May 11, 2016 2:15:40 PM

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Good afternoon,

In case we have an opportunity to correct what seems like a typographical error in the LFM . . .

In LFM (15-89) Section 2.4.2, Commissioning Plan, in the second sentence which reads "The scope of commissioning work is to undertake initial operation of the facility and bring it up to the design level of operation in accordance with the IMP," I suggest striking "IMP" and replacing it with "PEP" or if we have the latitude to revise the entire sentence, replace it with: "Commissioning verifies that the substantially complete facility operates over its full range of capabilities as specified in final design documents."

Take care,

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Comments on Large Facilities Manual – Jean McGovern

Section/Paragraph	Comment
2.1.3-1, last paragraph	Who are the individuals in the following statement? Individuals should discuss any proposed departures with the cognizant Program Officer. Note: If this is an internal document, are individuals from the Awardee permitted to provide input?
2.1.3-1, last paragraph	IMP should be defined prior to this section as the reader does not have context to the paragraph meaning. ( It is defined in the later sections of the document )
General	I think the document could use a description of science planning, academy reports, Advisory Committee comments and how they shape facilities at NSF in the introductory section (pull up language from section 3.3)
Section 2.1.4 Summary of MREFC	Can industry lead facility projects or only non-profits/academic institutions? (This is usually an FAQ, so perhaps addressing it upfront in the summary section would be beneficial)
Figure 2.1.4-1	NEPA and permitting responsibilities (not just environmental impacts) should be articulated in the chart. Does one need the EA or EIS prior to construction funding request? Editorial Note – label Figures on bottom, Tables on top
Figure 2.1.4-1	What does industrialize key technologies mean? (not a modern term)
Figure 2.1.4-1	When is the Conops delivered and reviewed?
Figure 2.1.4-1	Property management/ownership model should be included or in the PEP. This is very important for developing the design. (lease, NSF own, Awardee own, there are a lot of options to trade off and assess)
Figure 2.1.4-1	What is the systems engineering requirement for Large Facility Projects?
Figure 2.1.4-1	What is the output or definition of a developed Project Controls System?
Section 2.1.5	This to be written Section 2.1.5 should include internal competition planning text as part of this section.
Section 2.1.6	The roles and responsibilities section contains a lot of verbs. In many cases the deliverables and sign off associated with these verbs are unclear. For example, what does assurance deliver and how is it delivered? (a report, a letter, email, witness, controlled document, etc) This section would be a lot stronger if the deliverables and location of the filing of these deliverables would be defined. Appendix B only has some of the information.
HLFO Section	The statement “The HLFO develops and implements processes for insuring that all facility award instruments” is unclear. What are the processes, how are they implemented, who delivers and when? Is it a report, email, discussion? This is unclear.
HFLO Section	I think the paragraph below requires definition of the deliverable that describes the assurance or certification of the total project cost of an MREFC or Operations Project. The paragraph below is unclear. Is it a letter to the CFO certifying the TPC? What gets delivered? I think this is the most important authority that HFLO has in the document. Who is responsible for the project independent cost estimate? Is it LFO or the Directorate?

	<p>“Prior to NSF requesting NSB approval to include a proposed project in a future budget request, the HLFO contributes to agency assurance that the project plans are construction ready, and that the construction and operations budgets are satisfactorily justified.<sup>1</sup> This assurance comes through assignment of the LFO Liaison to the IPT and membership (as assigned) on various governance bodies such as the Director’s Review Board and MREFC Panel.”</p>
<p>HFLO Section – monthly report</p>	<p>What are the specific monthly report requirements for the PO? These requirements have changed over time, but are not specified in the manual. In the past, the requirement was to submit the awardee’s submission that met LFO requirements with a summary from the PO. This was not uniformly applied as some POs wrote their own reports based on the Awardee submissions. The report sections for an MREFC project would benefit from standardization as the Awardees could then use the Manual for direction. Some CAs have clauses written to specify reports, so maybe the Manual should direct the Awardee to the award clause.</p>
<p>Section 2.1.6.3 IPT</p>	<p>Minutes of the meeting should be required and communicated to assurance functions.</p>
<p>Section 2.1.6.4 MREFC Panel &amp; DRB</p>	<p>What are the deliverables from the MREFC panel with respect to assurance and prioritization? Is the facilities plan or budget request timeline prioritized by the MREFC panel? Is there a charter for the MREFC panel that describes functioning and quorum voting, etc? I think the information in Appendix B may not suffice.</p>
<p>Section 2.2.2 Approvals</p>	<p>What is the format for the approvals noted in this section? (letter, email, as described by another policy, etc) Appendix B has some information, but not all.</p>
<p>Section 2.3.3.1 Bullet 2, requirements</p>	<p>The Manual really needs a systems engineering description of this bullet and the relationship to Conops, requirements, derivation, acceptance (test, integration, verification, validation, commissioning and Operational Definition. Here is an example of what is needed:</p> <p>The diagram illustrates the systems engineering process, showing the relationship between Lifecycle Processes and Development Processes over a Time Line. The Lifecycle Processes (top) include: Regional Architecture(s), Feasibility Study / Concept Exploration, Concept of Operations, System Requirements, High-Level Design, Detailed Design, Software / Hardware Development, Field Installation, Implementation, System Validation, System Verification &amp; Deployment, Subsystem Verification, Unit/Device Testing, Operations and Maintenance, Changes and Upgrades, and Retirement / Replacement. The Development Processes (bottom) include: System Validation Plan, System Verification Plan (System Acceptance), Subsystem Verification Plan (Subsystem Acceptance), Unit / Device Test Plan, and Document/Approval. Arrows indicate the flow of information and processes between these stages. A diagonal arrow labeled 'Decomposition and Definition' points from the top-left towards the bottom-right. A diagonal arrow labeled 'Integration and Recomposition' points from the bottom-right towards the top-left. A horizontal arrow at the bottom is labeled 'Time Line'.</p>



	<p>The manual should utilize some sort of INCOSE process and break down the process to address the development, construction and transition processes more clearly than “functional requirements”.</p> <p>Given the unique nature of NSF projects, I do agree that in the conceptual stage there needs to be traceability from the science question(s) or science to the infrastructure conceptual design. In some cases, I think NSF should think about getting external technical review on the traceability before starting the investment in projectizing as this is very expensive and can cause a project to develop without the proper scientific input and prioritization. I would also recommend that projects get a technology readiness level assessment at the traceability (pre-concept design review stage) and get scientific input/external review at that point as well. The definitions of “industrialization, non recurring engineering, subsystem development and their relation to technology and engineering readiness need to be included in the Large Facilities Manual more explicitly.</p> <p>I recommend adaptation of INCOSE processes into facility guidance and the Manual. This is a lesson learned at NSF that needs to be incorporated into the Manual from multiple projects.</p>
2.3.1.1	<p>This section should include a concept of operations. The basics of how the facility is envisioned to be operated and the user requirements as well as the system requirements. This is more specific and a necessary addition as it serves to start user/operator requirements that could be different than a “community outreach” section of the PEP. The User requirements are often omitted from the system requirements or science objectives and missed. This is especially important for cyberinfrastructure projects. (basic systems engineering – above)</p>
2.3.2 PDR phase	<p>When do the operations costs or ceilings get defined? How are they developed and iterated?</p>
2.3.2	<p>How does the no cost overrun policy apply to operational costs? If the ops budget changes, what is the process to right size the scope to assure that the facility being built can be operated to cost? This is a lessons learned from past projects. How is an operational budget change communicated to the MREFC panel &amp; DRB post-approval?</p>
2.3.2	<p>The design process does not include text on design/build vs design/bid/build and how this is handled with respect to project readiness.</p>
2.3.2	<p>NEPA -- Is the FNSI needed or just commencement of the process? In some cases permits involve a lot of risk. How should this be addressed in the text?</p>
2.3.2	<p>What are the requirements for operations budget reviews during the construction phase? How does NSF assure that cost growth is managed along with scope and TPC?</p>
2.3.3.2	<p>“Fit up” is not a modern term. Use an INCOSE lexicon for awardees (interfaces, ICDs, ICAs, etc). This is a lessons learned. Again, the terminology</p>

	with respect to systems engineering, requirements, IVT and commissioning is not modern or to generally accepted engineering practices. This is a lesson learned and has been an FAQ at many design reviews.
2.3.3.2 FDR	Quality and Safety Management should be clearly articulated at FDR and integrated into schedule and cost baselines. Change the wording of “plans” to management and staffing policies, procedures and staff. This is a lesson learned.
2.3.3.3	Awardees are responsible for conducting cost analysis and delivering it to NSF for review. At what step in the process is the cost analysis from the Awardee delivered and reviewed? It should be delivered with every cost estimate at every design review. Where is the cost analysis standard for the Awardee provided in the Manual?
2.4.1	I think there should be more language to describe the baseline maintenance process we expect during construction. The replan definition seems to allow Awardees to allocate schedule contingency without tracking variances to original plans. This is also an EVM comment. I think more guidance is needed on this in the Manual.
2.4.1	Is the OMB requirement to report any impact to a science requirement in the monthly report still valid? How is scope management (descoping) included in the baseline maintenance section?
2.4.2	The Commissioning section does not use modern engineering language. I recommend incorporating INCOSE language and aligning the commissioning strategy with the acquisition strategy. The commissioning plan should be as detailed as the Final Design and acquisition strategy allows. If the plan is allowed to float to year 5 of a 6 year project, it will not have the proper upfront time and budget allocation. Lesson learned on many NSF projects. Too often weak definition of upfront IVT/commissioning results in transfer of costs and risk to the O&M phase. The year 1 O&M budget needs to be clearly reviewed based on the IVT/commissioning at FDR. Year 1 ops budgets should be higher than later years as this is a best practice. In some cases Year 1 should be 20-30% higher than Year 2.
2.4.3	Project Close out costs must be part of the TPC. Therefore this section needs to be completed and the requirements of this section should be included as sections in the PDR and FDR sections. Is project close out an MREFC or R&RA cost? This interpretation should be in the policy.
2.5.1	There is standard award language that indicates the Program Officer provides the Awardee with Annual Work Plan and Annual Report Guidance. I think these sections should perhaps reference the Awards as the language provided in these sections provides a perception that the AWP and Annual Report are “lightweight” as compared to the PEP. In some cases, the AWP will have a framework that is similar to the PEP and incorporate more user and science engagement.
2.5.1	Ops Reviews should review the Operations Plan or Manual that the MREFC effort produced. It might also be helpful to review GPRA at the review and additional metrics for facility performance that should be established via a

	IEEE Conops (if systems engineering language is incorporated). This is not burdensome, it is necessary for the management to have a set of deeper metrics than GPRA to self-assess facility operations and conduct prudent management.
2.5.2	The NSB Recompetition statements and policies should be cross referenced in this section. The IMP should be updated at the recompute stage and included in this section.
2.6	Divestment is covered in two places 2.6 and 3.1.1. The discussion on how to manage divestment prior to defining divestment is awkward in the Manual, especially since in section 3.1.1 you state it as undefined. I recommend in this version that you just the TBD in 2.6 as well so that the reader does not have to search ahead for no definition. Since the divestment strategy influences construction strategy, I recommend getting it defined and reviewed up front. For example modularization, segmentation and incremental build might be a necessary construction strategy based on divestment (LIGO I and LIGO II, etc).
3.4.1-1	The Project Development Plan elements should be made more clear as they are foundational to cost estimation. The CEP development must be in the PDP
3.4.1-1	The PDP should include a section on systems engineering and SEMP
3.4.1-1	The PEP or PDP should include the SOP requirements from the NEPA documentation. These are sometimes expensive cost drivers
3.4.1-1	The Community Outreach should include the SOPs created by the environmental documents and a section on media relations. There are standard processes used for large construction efforts across NSF.
3.4.1-1	Sections 7 and 15 are really the same – see the systems engineering “V” above. I recommend leaving Operations in 15 and moving the IVT to Systems Engineering.
3.4.1-1	Section 5 – Staffing – some projects may require an indirect review or Staffing Integration management review. I think it is important to highlight the integration between back and front offices and assure that the proper direct and indirect support are clearly articulated. This goes to a description of what each indirect rate applies at each institution. This will assure that costs assumed as covered by indirect are actually covered and that the project, NSF and reviewers are clear on cost allocations. Sometimes what is in the rate, does not get applied in practice and this should be resolved for projects up front.
3.4.1-1	I recommend that section 13 be named Environment, Safety and Health (ES&H). NEPA is a continuous process and needs to be managed during construction with safety and health. Usually they are in one scope....after siting....
3.4.1-1	16.3 – Conops is part of the PDP and systems engineering effort, not part of project close out.
3.4.1-1	Divestment is a construction requirement and needs to be in the PDP/systems engineering sections (up front, like conops)
3.4.1-1	The PEP should have a section on deliverables. This should include: 1. Technical Data Package (standards, plans, specs, documentation) 2. Manuals for Operations (Operations Manuals) 3. Standard Operating Procedures 4.

	Cybersecurity and COOP 5. Data specifications and data lifecycle management specs/procedures. The deliverable section should also assure the delivery medium (CDs, paper, website) are specified. The MREFC and R&RA acquisition strategy maps to this statement as the TDPs and Ops Manuals will be different for a turn key vs deliver only. This section should form the basis for funding allocation and auditing.
3.4.1-1	Change from divestment to downsizing, decommissioning and/or divestment. Request that appropriate high level plans, design requirements and schedule/cost are attached to the strategy. What happens if NSF needs to cut operations costs and downsize during the construction period? What are the mid-construction off ramps to address this situation?
3.5	Replace IT security with cybersecurity
3.5	Add data management plan in place as an assessment.
3.5	This section is "light" on proposal preparation requirements. If NSF requires that proposals meet GAO cost requirements, then this section needs to encompass the GAO requirements (WBS, set of requirements, etc, etc). At first pass, the Ops Plan would need to have the same requirements as the PEP for MREFC.
3.5	I suggest you change the title of this section to Management & Operations or Operations & Management. This is the conventional term.
3.5.2	Does the recomp guidance map to the NSB guidance provided in November 2015?
General	Provide the location of the internal guidance documents
4.2.2.4 & General	What is the hierarchy of compliance for documentation? Is it the supplemental info in this Manual or the PAPPG? Shouldn't the Awards Specialist be the person who is providing guidance on this matter (maybe via the Program Officer)?
4.2.2.3 Cost report	I recommend having the report signed by the AOR and PI prior to submission. I also recommend that the Awardee Cost Analysis of the construction report be an appendix of the cost report
4.2.3.3	Emphasize that the WBS should be deliverable based. Emphasize activity based estimates versus LOE. To me, it looks like you are encouraging all IVT to be LOE. I think a statement on minimizing all LOE where practicable would be good guidance.
General	Where is the Annual Work Plan guidance for MREFC projects? How does the AWP for MREFC map to the baseline maintenance processes?
4.2.3.3	Define integration, verification, validation and test. Recommend that this get done at subsystem, system and system of systems levels.
4.2.3.4	Is BOE refinement the Awardee Cost Analysis? It seems confusing.
4.2.5-1 Change Control	There should be a from/to table for rebudgeting and this should be encouraged in the Project Controls Implementation section (or designed). The table on the bottom of the sample form may not allow for clear traceability across accounts, only drawdown. The process for indirect allocation and financial officer sign off (prior to NSF sign off) should be included. This is a lesson learned. Indirect allocation from contingency can then get tracked as well (with proper from/to table)

4.2.5.8	I think putting the “second level” WBS requirement may skew the scope delineation. I recommend that the Awardee propose a reporting level and the panels/NSF decide on the proper reporting.
4.2.5.9	What about in-kind contributions? How should these be handled?
4.3	Use INCOSE language to describe systems engineering and a “V” diagram. The SEMP should have an outline or set of criteria. The acceptance in the Quality program or subcontracts and acceptance at the system/subsystem performance should be clear. (acceptance to spec, acceptance to performance requirements with defined levels (user, witness, cert, etc)
4.4	There are many documents that are missing from this section. Go through the PEP, add the Operations Manual and develop a list of what is required to recomplete the facility. This will provide the comprehensive document list NSF needs. Plans, specs, SOPs, workflows, QA/QC, safety, cybersecurity, data management and many more. IF NSF needs to recomplete, what is the acceptable quality level for the documentation and how do the documents get delivered?
4.4.2-1 figure (5)	Reference the definition of Operations Contingency in the figure. In the section, hotlink the Uniform Guidance
General	I think there needs to be information on rebudget authority as a method of management prior to contingency allocation in an operations or MREFC effort. Rebudgeting may be different than descope as it provides the opportunity to continuously assess time phased scope priorities. For operations this is critical and it should be assessed first, prior to any contingency requests. Rebudgeting may require deobligation by the Awardee and assuring that there is an acquisition strategy/contract to support this method is important.
4.4.2-1	Education & Outreach budgets (EHR vs directorates). I recommend putting (if allowable) next to this term
4.4.2-1	This figure seems like it is encouraging LOE for Operations. I think there should be guidance on encouraging activity based estimates where practicable. This is a standard M&O panel recommendation and should be incorporated into the Manual
4.6	Is there a definition for MOA? Sometimes MOUs are between the Awardee and foreign countries, this section indicates only NSF can have MOUs... I think it depends on the ownership model and other factors
General	Where is the guidance for the Awardee Advisory Committees for the project? This is a lesson learned for large subawards/subcontracts.
5.2	Because expert judgement is required for risk assessment, I recommend that the Awardee assure the experts are vetted by their project advisory committee and maybe even NSF prior to conducting the assessment. This should be a recommendation and not a requirement
Environmental	Where are the decision milestones and off ramps defined? Does a PEA need to be completed by PDR and noticed? This is a lesson learned from past projects.

**From:** [Plimpton, Suzanne H.](#)  
**To:** [Wilkinson, Carol](#); [Hawkins, Matthew J.](#); [Whitehurst, Eddie](#)  
**Subject:** FW: "For comment" draft of the Large Facilities Manual (LFM) published in the Federal Register  
**Date:** Friday, July 08, 2016 12:05:31 PM  
**Attachments:** [image001.png](#)

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Here's OIA's comment.

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**From:** Frye, Joan M.  
**Sent:** Thursday, July 07, 2016 9:33 AM  
**To:** Plimpton, Suzanne H. <[splimpto@nsf.gov](mailto:splimpto@nsf.gov)>  
**Cc:** Iacono, Suzanne <[siacono@nsf.gov](mailto:siacono@nsf.gov)>; Frye, Joan M. <[jfrye@nsf.gov](mailto:jfrye@nsf.gov)>  
**Subject:** FW: "For comment" draft of the Large Facilities Manual (LFM) published in the Federal Register

Hi Suzanne,

No comments from OIA.

Thanks,

Joan

Joan M. Frye, PhD  
Acting Deputy Office Head  
Office of Integrative Activities  
National Science Foundation  
4201 Wilson Boulevard, Suite 935  
Arlington, VA 22230

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**From:** "Frye, Joan M." <[jfrye@nsf.gov](mailto:jfrye@nsf.gov)>  
**Date:** Monday, May 16, 2016 at 10:52 AM  
**To:** OIA ALL <[oaiall@nsf.gov](mailto:oaiall@nsf.gov)>  
**Subject:** FW: "For comment" draft of the Large Facilities Manual (LFM) published in the Federal Register

Good morning!

Please provide comments to me by cob July 6th, so that I can compile and send to Suzanne by the deadline.

Thanks,

Joan

Joan M. Frye, PhD  
Senior Staff Associate  
Office of Integrative Activities  
National Science Foundation  
4201 Wilson Boulevard, Suite 935  
Arlington, VA 22230

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**From:** "Hawkins, Matthew J." <[mjhawkin@nsf.gov](mailto:mjhawkin@nsf.gov)>  
**Date:** Monday, May 16, 2016 at 10:20 AM  
**To:** NSF SMART <[smart@nsf.gov](mailto:smart@nsf.gov)>, NSF DADOH <[nsf-deputyad@nsf.gov](mailto:nsf-deputyad@nsf.gov)>, NSF Division Directors <[divdir@nsf.gov](mailto:divdir@nsf.gov)>, NSF Program Officers <[progoff@nsf.gov](mailto:progoff@nsf.gov)>, NSF AMG <[amg@nsf.gov](mailto:amg@nsf.gov)>, NSF AO/OS <[aos@nsf.gov](mailto:aos@nsf.gov)>, NSF Deputy Division Directors <[depdir@nsf.gov](mailto:depdir@nsf.gov)>, BFA ALL <[BFAALL@nsf.gov](mailto:BFAALL@nsf.gov)>, OGC All <[OGC\\_All@nsf.gov](mailto:OGC_All@nsf.gov)>, DIS ALL <[dis-all@nsf.gov](mailto:dis-all@nsf.gov)>, DAS Staff <[dasstaff@nsf.gov](mailto:dasstaff@nsf.gov)>, BFA BPLG <[bfabplg@nsf.gov](mailto:bfabplg@nsf.gov)>  
**Cc:** NSF POLICY <[policy@nsf.gov](mailto:policy@nsf.gov)>, "Hawkins, Matthew J." <[mjhawkin@nsf.gov](mailto:mjhawkin@nsf.gov)>  
**Subject:** "For comment" draft of the Large Facilities Manual (LFM) published in the Federal Register

Dear Colleagues:

On May 9<sup>th</sup>, NSF published a notice in the Federal Register announcing the availability of a "For comment" draft of the *Large Facilities Manual* (LFM). We are soliciting Directorate/Office comments on the draft LFM until COB July 8, 2016. Please note that all comments should be coordinated through the applicable Assistant Director/Office Head's office and sent to Suzanne Plimpton at [splimpto@nsf.gov](mailto:splimpto@nsf.gov).

The following are links to the Federal Register Notice and the draft LFM:

- <https://www.gpo.gov/fdsys/pkg/FR-2016-05-09/pdf/2016-10793.pdf>
- [http://www.nsf.gov/bfa/lfo/lfo\\_documents.jsp](http://www.nsf.gov/bfa/lfo/lfo_documents.jsp)

Any technical questions should be directed to Dr. Carol Wilkinson in the Large Facilities Office at [cwilkins@nsf.gov](mailto:cwilkins@nsf.gov).

Kind Regards,  
Matt Hawkins



**Matthew Hawkins**

**Head, Large Facilities Office**  
**Office of Budget, Finance & Award Management**  
voice: x7407  
email: [mjhawkin@nsf.gov](mailto:mjhawkin@nsf.gov)





National Science Foundation • Office of Inspector General  
4201 Wilson Boulevard, Suite I-1135, Arlington, Virginia 22230

**MEMORANDUM**

**DATE:** JUL 8 - 2016

**TO:** Suzanne Plimpton  
Reports Clearance Officer, OGC

**FROM:**   
Marie A. Maguire  
Assistant Inspector General for Audit (Acting)

**SUBJECT:** Comments on the National Science Foundation's Large Facilities Financial Data Collection Tool

We are submitting the following comments on the National Science Foundation's (NSF) draft Large Facilities Financial Data Collection Tool (reporting tool) for NSF's consideration. We understand that the overall purpose of the reporting tool is to provide for the collection of cost data from each awardee for each large facility, to increase NSF's management and financial oversight of its large research facilities. Collection of this information will provide NSF valuable budget and expenditure information needed for NSF's oversight purposes. However, we note overall that the reporting tool is not the equivalent of an incurred cost submission (which, among other things, reports total recipient direct costs for all of a recipient's awards and calculates and proposes indirect cost rates subject to negotiation). Therefore, in terms of facilitating an incurred cost audit, it seems that the reporting tool, at best, could only facilitate a direct cost audit with a review of the application of indirect cost rates of the award being reported. NSF would have to further coordinate with the awardee for an indirect cost rate audit for an NSF cognizant awardee.

Nevertheless, we are offering comments to help ensure that NSF's policies and procedures will provide reasonable assurance that the controls in place, both during construction and operations, will strengthen NSF's and its awardees' ability to exercise proper stewardship of large facility funds. Our comments are provided below by section. We hope you find them useful.

**Federal Register Notice Vol. 81, No. 89, dated May 9, 2016, Comment Request**

The Comment Request Summary states that NSF will be "requesting OMB clearance of this collection for no longer than 3 years." We suggest that NSF also state its intentions after that time period (in a later version of the reporting tool), especially since the subsequent charge statement is more focused on determining and assessing awardee burden, rather than on emphasizing NSF's need to improve its, and the awardee's, financial management of large facility awards. The instructions should explain that the reporting tool was instituted to ensure that funds for large

facility awards. The instructions should explain that the reporting tool was instituted to ensure that funds for large facilities are properly expended and managed. This message was verbally conveyed during NSF's recent Large Facility Workshop, but was not communicated as well in the written request for comments from the community.

### **Instructions and Instruction Overview:**

Overall, the reporting tool collects budgeted and actual costs for individual Cooperative Agreements (CA)/Cooperative Support Agreements (CSA). However, NSF does not clearly explain that the reporting tool also provides for budget to actual comparison/reconciliation at the total project level, which is the level cumulative proposed budgets are made and National Science Board approval is obtained. Therefore, the instructions should be clarified to explain that NSF intends to fully account for all of the awards made for each NSF large facility that are in total valued at \$100 million or greater and may be comprised of several different CSA and CA awards, funded by multiple NSF appropriations.

Additionally, the reporting tool does not collect "Contingencies" or "Fee" data (either in budget or in expenditures to date). The tool also does not collect drawdown data or cash on hand data that could be reconciling items when comparing budget and actual costs and costs claimed to the general ledger. Without this information it will not be possible to adequately reconcile and compare actual to budgeted costs to determine how funds are being spent in comparison to how they were planned.

In the Overview Section, specific criteria for applicability of the reporting tool should be clarified, i.e. the tool is required for each CSA and CA for a facility or project that has a total awarded amount of \$100 million or more. It should explain that NSF will identify all the awards that comprise each project and modify the award agreements to identify each CSA and CA that require completion of the reporting tool. This section should state that one other purpose of the tool is to provide for a comparison of expenditures to budget amounts for each award and the total of the project's awards, to the maximum extent practicable.

Also, the Instruction Overview states, "Only this NSF-approved tool should be used to submit incurred cost data." This statement should be clarified because it could create confusion if a full incurred cost submission is required from an awardee for which NSF is cognizant for the purposes of negotiating the awardee's indirect cost rate.

**CSA Budget Worksheet, CSA Cost Worksheet, and Program Expenditures Worksheet:** Under major costs elements, the tool does not provide lines for "Contingencies" or "Fee" (either in budget or in expenditures to date), although these may be significant items included in some CAs. Contingencies are required budget information for construction awards specifically listed on Form SF 424C (line 13), which NSF has agreed to use and should be collected by this tool. Fee should also be included in the tool if a recipient proposes fee, since this is also a cost to NSF. Additionally, we note that the tool does not provide for cost drawdowns (ACM\$), which should be collected for comparison to costs claimed.

The instructions for worksheet preparation for the CSA Cost Worksheet state that the Program Charges Worksheet consolidates this data for all CSAs. There is no *Program Charges Worksheet*, so the instructions should be clarified (perhaps the *Program Expenditures Worksheet*).

It appears, based on the color coding legend provided, that the current expenditure information in the CSA Budget Worksheet is linked from other report tabs and the current claimed amount on the CSA Cost Worksheet is auto-calculated. The tool should explain this and caution the awardee to ensure that the calculated expenditure amount agrees with the amounts claimed. Also, the reporting tool should provide for an explanation in the event there is a difference between the General Ledger and Job Cost Ledger on the CSA Cost Worksheet.

It would also be useful if the tool used consistent terms throughout the different worksheets to identify current costs claimed/expenditures and to ensure that the title of the worksheet tab matches the title on the worksheet.

**Subcontracts and Consultants Worksheet:** We note that worksheet does not require a specific classification of subcontracts vs. consultants. This distinction is important and needs to be made for indirect rate application purposes because modified total direct costs (MTDC) include the first \$25,000 of sub grants/Subcontracts, while the remaining portion of Subgrants/Subcontracts over \$25,000 is excluded. Additionally, the worksheet does not request the type of subcontract (CPFF, firm fixed-price, etc.). It appears the worksheet only provides for cost reimbursement subcontracts, but there is no place for profit which should be collected because it is part of total cost. There should also be a place on the worksheet for firm fixed-price subcontracts. Finally, the worksheet should also include a checkbox to document whether the Uniform Guidance required cost/price analyses in excess of the Simplified Acquisition Threshold (currently \$150,000) are maintained in the file and are available upon request.

**Subawards Worksheet:** This worksheet should also include a checkbox to document whether the Uniform Guidance required cost/price analyses in excess of the Simplified Acquisition Threshold (currently \$150,000) are maintained in the file and are available upon request.

**Indirect Cost Rate Worksheet:** We note that worksheet provides “rate applied” and “total expended,” but does not request the type of rate applied (e.g., provisional, predetermined fixed, carry forward, etc.), which should be requested. Also, the worksheet only addresses three types of indirect rates (classified as F&A, G&A and ID other). Some organizations may have additional indirect rates that should be disclosed, so the tool should be modified accordingly.

**Certification of Costs:** Suggest expanding certification to include award terms and conditions, NSF policies and recipient policies.

If you have any questions or wish to discuss our comments, please contact Jannifer Jenkins, at 703-292-4996.



**National Science Foundation • Office of Inspector General**

4201 Wilson Boulevard, Suite I-1135, Arlington, Virginia 22230

**MEMORANDUM**

**DATE:** July 8, 2016

**TO:** Ms. Suzanne H. Plimpton, Reports Clearance Officer

**FROM:**   
Ms. Marie A. Maguire, Assistant Inspector General for Audit (Acting)

**SUBJECT:** Office of Inspector General Comments on the Draft *Large Facility Manual*

On behalf of the National Science Foundation Office of Inspector General (NSF OIG), I am submitting the attached comments on the draft *Large Facility Manual* (LFM) dated May 2016. Overall, we appreciate the increased oversight incorporated into the LFM. However, we note that the LFM is unclear as to which of the new requirements relate to large facilities in operations and suggest NSF clarify this prior to the LFM issuance. We also suggest ensuring that LFM guidance for NSF staff and recipients aligns with NSF internal Standard Operating Guidance (SOGs). As an example, see our comment on section 4.2.4.1, NSF Policy Positions. We hope you find our comments and suggestions useful.

Attachment

Section/Page Number	Language in Manual/Observations	Comments and Suggestions
<b>Summary Timeline for MREFC Projects, 2.1.4-2</b>	N/A	We suggest updating figure 2.1.4-1 to incorporate new requirements, such as the independent cost estimate, incurred cost audits, incurred cost submissions, etc.
<b>4.2.1 Cost Estimating and Analysis Overview, 4.2.1-2</b>	<p>When submitting packages for cost analysis, Recipients must submit the following as a minimum:</p> <ul style="list-style-type: none"> <li>• Cost Estimating Plan per Section 4.2.2.1.</li> <li>• “Cost Model Data Set” per Section 4.2.2.1.</li> <li>• Reports and Proposals per Sections 4.2.2.2 and either 4.2.3.2 or 4.2.4.2.</li> <li>• The Work Breakdown Structure (WBS) and WBS Dictionary per either Sections 4.2.3.3 or 4.2.4.3.</li> <li>• Supporting information forming the Basis of Estimate (BOE) per Sections 4.2.2.4, 4.2.2.5, 4.2.2.6, and either 4.2.3.4 or 4.2.4.4</li> </ul>	Please clarify whether the steps apply to facilities in construction, operations, or both. For example, it was unclear in the operations section whether WBS is required for operations awards or not.
<b>4.2.2 Cost Estimating and Analysis Process, 4.2.2-10</b>	As a term and condition of the award, the recipient will be required to provide information (typically annually) on the actual use(s) of the management fee.	We suggest NSF more definitively outline the frequency of submitting management fee data. We suggest annually instead of “typically annually”.
	The LFM does not require the auditee to submit a written assertion of need that details all sources of revenue, and examine all federal and non-federal sources of revenue for each awardee in determining whether a management fee is necessary and warranted.	We suggest NSF require the auditee’s proposal involve a full disclosure of all financial resources and other sources of income available to cover unallowable expenses.

	<p>The LFM lists appropriate uses of management fee stating, “Examples of potential appropriate needs include....and financial incentives to obtain and retain high caliber staff.”</p>	<p>Our review of management fee uses at large facility awardees highlighted examples of “incentives,” including significant signing bonuses and payment for private school tuition of employees’ children. The use of management fees for these types of expenses may be questionable to taxpayers. We suggest NSF consider giving examples of “appropriate” financial incentives.</p>
	<p>The LFM does not address whether management fee should be captured under a separate line item in proposals.</p>	<p>We suggest NSF require management fees to be submitted as a separate line item in its future NSF proposals, rather than including them under a category of allowable cost.</p>
<p><b>4.2.2.-7 Cost Estimating and Analysis Process, G.6-Other</b></p>	<p>Budget contingency should also be presented as part of the total amount of Other Direct Costs and included in section G.6 on the standard NSF budget form.</p>	<p>The contingency estimates include indirect costs as well as direct costs, so it is not correct to categorize contingency as only “Other Direct Costs.” Contingencies are required budget information for construction awards specifically listed on Form SF 424C (line 13) which NSF has agreed to use. We suggest that budget contingency have its own separate line item on proposed budgets to NSF.</p>
<p><b>4.2.2.1 Cost Estimating Plan, 4.2.2-1 and 4.2..3-2</b></p>	<ul style="list-style-type: none"> <li>• For <i>construction</i> awards, the CEP must explain how the Recipient will follow “The Twelve Steps of a High-Quality Cost Estimating Process” from the GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs (GAO-09-3SP March 2009, or subsequent revision).</li> <li>• Recipients are required to follow the best practices within the GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program</li> </ul>	<p>Please clarify whether the GAO Cost Estimating and Assessment Guide is a <i>requirement</i> for facilities in construction, operations, or both. On pg. 3.5.1-1 in the operations plan section it states “Note that cost estimating should follow the Government Accountability Office (GAO) Cost Estimating Guidelines, per Section 4.2.” However, 4.2 is unclear what applies to construction and what applies to operations. In addition, while the construction section requires a statement from the awardee that they followed the GAO Cost</p>

	<p>Costs (GAO-09-3SP March 2009, or subsequent revision) and GAO Schedule Assessment Guide: Best Practices for Project Schedules (GAO-16-89G December 2015, or subsequent revision), taking into consideration NSF policy and practice as provided in this manual.</p> <ul style="list-style-type: none"> <li>• In the cost estimate section on construction it states, “The additional high level information should typically be provided ... A statement positively affirming recipient compliance with applicable federal regulations and NSF policy, including the LFM and GAO Cost Estimating and Assessment and GAO Schedule Assessment Guides.” This is not required in the operation’s estimates section of the LFM.</li> </ul>	<p>Estimating and Assessment Guide the same requirement is not made for operations.</p>
<p><b>4.2.2.2 Relevant Guidance and Reporting Formats</b></p>	<p>Budget contingency should also be presented as a part of the total amount of Other Direct Costs and included in section G.6 on the standard NSF budget form. Budget contingency budget estimates should be developed in accordance with Sections 4.2.5 and 5.2 of this manual. Budget contingency and allocations of contingency will be called out in the Cooperative Support Agreement by the G/AO under the “Contingency” section, based on information provided in the negotiated budget justification.</p>	<p>Comment: The new Large Facility Manual outlines how NSF awardees should develop contingency in Sections 4.2.5 and 5.2 including development of a risk management plan, tying contingency to WBS elements, use of Monte Carlo simulations etc. We suggest 4.2.2.2 be clear that the proposal budget should include adequate documentation to support that the contingency amounts were developed in accordance with 4.2.5 and 5.2 and are supportable.</p>
<p><b>Cost Estimating and Analysis for Operations Awards, 4.2.4-1 through 4.2.4-4.</b></p>	<p>The language in the construction estimate section includes:</p> <ul style="list-style-type: none"> <li>• “The results of an independent cost estimate review will be factored into the NSF cost analysis. To ensure maximum usefulness of</li> </ul>	<p>The cost estimating and analysis for operations awards section is silent on whether independent cost estimate reviews will be done on operations awards. We suggest NSF require that significant operation awards go through an independent cost estimate review.</p>

	<p>the review, it will generally be done as part of the Preliminary Design Phase.”</p> <ul style="list-style-type: none"> <li>• “There may be one or more years between the PDR and the start of construction, which is predicated on successful completion of the FDR.”</li> </ul>	<p>We suggest NSF should make it clear when the independent cost estimate will be done so awardees can plan accordingly. Currently, the LFM says “will generally be done as part of the Preliminary Design Phase.”</p> <p>If there are significant changes between the PDR and FDR how will NSF assess the new quotes and data? We suggest NSF conduct an independent review of all updated quotes.</p> <p>If the independent cost estimate review indicates significant issues, or significant time has elapsed between the PDR and FDR, how will NSF handle this? We suggest NSF request the recipient to update its estimates with current, accurate and complete cost data and also perform a follow-up review.</p> <p>We suggest that the large facility proposals go through the most stringent of the eight types of GAO independent cost reviews, an independent cost estimate.</p>
<p><b>4.2.4.1 NSF Policy Positions, Point 4</b></p>	<p>In support of NSF’s “No Cost Overrun” policy, projects shall use a confidence level for contingency estimates between 70 and 90 percent (under a probabilistic approach).</p>	<p>We suggest NSF also state its expectation not only in terms of a confidence level, but also the precision of the estimate (so that NSF can say, for example, that it is 80% confident that the point estimate is accurate within a range of plus or minus 20%).</p>
<p><b>4.2.4.1 NSF Policy Positions, Point 5</b></p>	<p>NSF will hold budget contingency through project completion, in an amount up to 100% of the total NSF-approved contingency budget, until it can be justified for obligation. However, the LFM does not outline the procedures related to this new policy; for</p>	<p>We suggest describing the process and procedures related to this new policy of holding budget contingency, including explaining how the amount of contingency to be held by NSF will be determined. Also, indicate that the allocations would be included in the award notice and the CSA</p>



	<p>example, that the allocations would be included in the award notice and the CSA amended. As another example, the new SOG states the project would monitor budget contingency against both the NSF-approved contingency budget and the total allocation to date. This expectation should be made clear in the LFM.</p>	<p>amended. Additionally, the new Contingency SOG (under Monitoring and Reporting of Budget Contingency) requires that the Project monitor budget contingency use against both the NSF-approved contingency budget and the total allocation to date. This expectation should be made clear in the LFM. We suggest the LFM be updated to align with the SOG, i.e., incorporate requirements from the new SOG as it relates to the recipient.</p>
<p><b>4.2.5.4 Contingency Planning and Assessment during Preliminary Design</b></p>	<p>Use of rigorous probabilistic cost estimating methods that estimate confidence levels for the TPC (such as Monte Carlo methods based on probability distributions for risk) are preferred and NSF highly encourages application of these methods where practical.</p>	<p>We suggest NSF make it clear whether probabilistic cost estimating methods are, or are not, a requirement. If probabilistic cost estimating is not used, what are other acceptable methods?</p>
<p><b>4.2.5.5 Development of the Contingency Use Process</b></p>	<p>The CCB change request document, whether forwarded to NSF for approval or not, must have the minimum content requirements necessary to comply with relevant cost principles, as well as to maintain an audit trail. SEE SAMPLE CHANGE CONTROL REQUEST FORM. This form states “Cost control accounts may be included for traceability in the accounting system.”</p>	<p>When use of budget contingency is requested, we suggest that NSF require the recipient to document in the Change Control Request (in Additional Documentation for example) which of its accounts the related charges will be recorded under to provide better traceability in its accounting system.</p>
<p><b>4.2.5.6 Contingency Planning and Assessment during Final Design</b></p>	<p>At the Final Design Review (FDR) the budget estimate should be substantially based on externally obtained cost estimates (vendor quotes, bids, historical data, etc.). This added definition is expected to result in an increase in the project’s estimated Budget at Completion (BAC) and a reduction in its budget contingency,</p>	<p>It would be useful if the contingency section explained whether the independent cost estimate at PDR would cover a review of contingency. Also, if contingency amounts are further refined between PDR and FDR, we suggest stating that NSF will review the revised amounts and specifying what type of review will be performed.</p>

	while TPC remains constant. Also as part of the FDR, NSF assesses the methodology employed by the project to further refine its cost and contingency estimates including schedule and scope adjustments.	
<b>4.2.5.7 Contingency Use and NSF Oversight during Construction</b>	Unexpended contingency funds may not be used to support operations or other out-of-scope activities.	We suggest that NSF clearly define scope and out-of-scope activities to avoid the possibility of subsequent disagreement between NSF and the recipients as to the meaning of these terms.
<b>4.2.5.8 Reporting Requirements</b>	At a minimum, the monthly report will include: ... (4) an updated change log indicating all contingency allocations (“puts and takes”) and a “liens” list of projected amounts of possible future calls on contingency.	We suggest that NSF also request its recipients to provide a comparison of approved budget to actual use of contingency. This comparison could be the recipients’ affirmation that they are using contingency funds as approved by NSF.
<b>4.4 DOCUMENTATION REQUIREMENTS</b>	In addition, access to any pertinent books, documents, papers and records should be made available to the NSF Director and the Comptroller General of the United States or any of their duly authorized representatives to make audits, examinations, excerpts and transcripts in accordance with either the Uniform Guidance or FAR requirements.	We suggest adding NSF OIG to the list of organizations for which the awardee must provide access to documentation.
<b>4.5.3 Recipient Performance Reviews and Audits, 4.5.3.4</b>	NSF conducts a cost incurred audit for large facility awards above \$100M at the end of the award and potentially during execution of the award based on an annual large facility risk assessment conducted by the Large Facilities Office and the Cooperative Support Branch at NSF.	Please clarify whether the cost submission and cost incurred audits apply to facilities in construction, operations, or both. We suggest both.
<b>4.5.3 Recipient Performance Reviews and Audits, 4.5.3.5</b>	EVM section stated “This section reserved for future content.	As we have recommended in the past, we suggest the certification of EVM systems and the validation of EVM data.

<b>4.5.3.2 NSF External Reviews.</b>	Additional ad hoc reviews may be requested by the PO under certain circumstances, such as significant re-planning of construction projects, changes in key personnel, and major changes in research technical design, direction and scope.	We suggest review of updated vendor quotes/bids be added to the circumstances. As also referred to in Section 4.2.5.7, we suggest the NSF clearly define scope, change in scope and major change in scope, to avoid the possibility of subsequent disagreement between NSF and its recipients as to the meaning of these terms.
<b>4.5.5 Re-Baselining</b>	The re-baselining section does not explain what type of reviews NSF will complete in the event of a re-baseline. For example, whether re-baselined proposals will be required to go through an independent cost review.	We suggest clarifying what types of reviews re-baselined proposals will go through.
<b>5.2.3.2 Contingency Definitions</b>	For MREFC construction projects, the amount of budget contingency is determined by performing a probabilistic risk analysis on the baseline cost and schedule and selecting a Total Project Cost with an acceptable confidence level (typically between 70-90%).	As also mentioned in 4.2.5.1, we suggest NSF also state its expectation not only in terms of a confidence level, but also the precision of the estimate (so that NSF can say, for example, that it is 80% confident that the point estimate is accurate within a range of plus or minus 20%).
<b>5.2.6.3 Risk Description</b>	However, note that NSF does not allow the use of contingency for risks that are commonly referred to as “unknown unknowns” such as exceptional events or major changes in scope.	Suggest that NSF provide some examples of exceptional events for which contingency is not allowed to be used. Also, as mentioned in 4.2.5.7 and in 4.5.3.2, we suggest the NSF clearly define scope, change in scope and major change in scope, to avoid the possibility of subsequent disagreement between NSF and its recipients as to the meaning of these terms.
<b>5.2.8.8 Handling Inflation</b>	Inflation is part of the NSF budgeting and project planning.	We suggest that NSF require its recipients to affirm (and also verify in NSF reviews of proposal budgets) that inflation is not double-counted in other estimates, such as in contingency.
<b>5.2.11.1 Contingency Budget Timeline</b>	At the Final Design Review (FDR) the PEP budget estimate should be substantially based on	Consistent with our comments in 4.2.4, we suggest that NSF instruct its recipients that estimates based

	externally obtained cost estimates (vendor quotes, bids, historical data, etc.)	on vendor quotes/bids should be kept current (i.e., preferably less than a year old but no more than 18 months) throughout the project life cycle at least until award.
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**From:** [Hawkins, Matthew J.](#)  
**To:** [Wilkinson, Carol](#); [Yasky, Rebecca Kay](#)  
**Subject:** FW: Comments on the Large Facilities Manual draft and more  
**Date:** Wednesday, August 31, 2016 8:43:19 AM

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Carol and Rebecca,

I believe I sent this earlier for Carol's consideration & incorporation (I think valuable to include OISE's engagement), but re-sending just in case.

Matt

---

**From:** Sharma, Mangala  
**Sent:** Tuesday, August 30, 2016 4:36 PM  
**To:** Hawkins, Matthew J. <mjhawkin@nsf.gov>  
**Subject:** Comments on the Large Facilities Manual draft and more

Hi Matt,

I'm not sure if you got OISE comments (approved by Rebecca Keiser) on the draft LFM. So, I'm (re-)sending this mail. If, on the other hand, you already did receive these, apologies for the duplication!

Please don't hesitate to let me know if you have any questions or need clarification about our comments. If you have any concerns about the recommendation that OISE be included in the IPT and LFWG, I'd be open to suggestion on a more informal role for OISE as well.

Thanks very much!

Mangala

—

Thank you for the opportunity to comment on the 2016 draft of the manual.

Overall, the NSF Office of International Science and Engineering (OISE) appreciates that the LFM makes thoughtful recommendations about international partnerships and engagements. OISE appreciates, especially, inclusion of international considerations in:

Sec. 2.1.6.4 and Appendix A – MREFC panel roles and criteria for prioritizing MREFC projects;

Sec. 2.3 – Design Stage;

Sec. 4.6 – Partnerships;

Sec. 5.5 – Environmental Considerations; etc.

*We do request that the role of OISE in facilitating and coordinating NSF international research infrastructure be explicitly included both (i) in practice i.e., how LF projects are overseen and (ii) in the LF manual – which are of course related. For (ii), we recognize that, for the most part, specific divisions/offices within NSF are not called out in the manual.*

Regarding specific LF projects, ***could we please consider adding an OISE program officer to each LF Integrated Project Team (IPT)?*** This OISE PO could provide country-specific guidance on international partnership for a particular MREFC project, and as necessary, facilitate coordination with international partners during the design-to-execution phases of the project. If such a role for OISE is agreeable to LFO, then, a suggested edit to the LFM is:

**Sec.2.1.6.2 - Integrated Project Team (IPT) - “Comprised of NSF personnel with knowledge and expertise in areas related to the scientific and technical, award management, *international partnership*, and strategic aspects of a particular MREFC project.”**

***We also request nominating to the overall Large Facilities Working Group the OISE program officer who is assigned to be OISE liaison to LFO.*** This is distinct from the OISE participation on specific IPTs (above). As part of the LFWG advisory group, the OISE PO could provide big-picture input regarding international cooperation, US foreign policy, etc., related to NSF Large Facilities.

Other editorial comments on the draft manual:

**Pg. 157 – Please correct the name of the office; “NSF Office of International and Integrative Activities (OIIA)” should be “NSF Office of International Science and Engineering.”**

Pg. 22 - end of para 1 - "(ideally) were partnerships" should be "(ideally) where partnerships"

**From:** [Porter, Kevin](#)  
**To:** [Wilkinson, Carol](#)  
**Subject:** LFM PEP Guidance & Draft Comments?  
**Date:** Monday, August 08, 2016 3:47:37 PM

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Hello Carol,

I had some LFM related questions for you...

Section 3.4.2 refers to an internal NSF guidance document “Guidelines for Development of Project Execution Plans for Large Facilities.” Can you provide me a copy of this? Is this even useful and still worth sharing with Programs internally at NSF? Should this reference be deleted from the LFM and become a SOG?

I haven’t seen any questions/comments on my draft Section 4.2. Do you have any that I should be working on?

I have some other edits and minor additions to 4.2 (e.g., tweaking some definitions, clarify applicability to contracts, referencing AACEI guidance in a few areas, adding expectations for estimate method typically used at each stage) – is there some protocol I need to follow to incorporate these and address the other public comments?

Thanks,  
Kevin



### 2.2.2 Exit from Development to Design Stage

Formal start of the Design Stage for a facility project occurs once a recommendation of the MREFC Panel and approval by the NSF Director is received. This process is initiated by a request from the sponsoring Directorate and/or Division to the Director's Office once a project is determined to be ready for the Conceptual Design Phase and potential construction with MREFC funds. Generally, such a request is made when the sponsoring organization has determined that: (1) the project is a high priority for further development, (2) the project is eligible for MREFC funding (see criteria) and the MREFC funding route is preferred, and (3) the sponsoring organization is committed to begin explicit investment in more detailed design activities in the current or upcoming budget cycle using Directorate or Divisional funding (R&RA).

The MREFC Panel's recommendation will focus on providing the Director with answers to the following questions:

#### Science

- Is there a compelling science case, and are the project's goals well-articulated?
- Does the project fit solidly within the NSF "mission," within the strategic plans of the NSF and that of the sponsoring Directorate or Division, and within the broader NSF facility portfolio?

#### Planning

- Is the sponsor's plan for stewardship of the Conceptual Design Phase consistent with the guidelines set out in the Large Facilities Manual?
- Does the preliminary timeline for development and implementation include programmatic, NSB, budget and any necessary partnering milestones, including explicit project off ramps?
- Are potential opportunities for internal and or external partnering being considered, if not already underway?
- Are there any conflicts of interest or other major challenges regarding this project that the Director needs to be aware of?

Based on the Panel's recommendation and any further examination, the Director then approves (or disapproves) the project entering the Conceptual Design Phase as a "candidate" MREFC project. Note that no NSF commitment is implied beyond support for the development of a Conceptual Design. The MREFC Panel or Director might alternatively advise the sponsoring organization to look further into an issue or issues and then return to the Panel for further consideration.





**From:** [Hawkins, Matthew J.](#)  
**To:** [Wilkinson, Carol](#); [Plimpton, Suzanne H.](#)  
**Subject:** FW: "For comment" draft of the Large Facilities Manual (LFM) published in the Federal Register  
**Date:** Thursday, May 19, 2016 2:57:34 PM  
**Attachments:** [image001.png](#)

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For the record.

Matt

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**From:** Sholhead, John E  
**Sent:** Thursday, May 19, 2016 1:45 PM  
**To:** Hawkins, Matthew J. <mjhawkin@nsf.gov>  
**Cc:** Howe, Michael <MHOWE@nsf.gov>; Carpenter, Kathleen Elizabeth <kcarpent@nsf.gov>  
**Subject:** RE: "For comment" draft of the Large Facilities Manual (LFM) published in the Federal Register

Hi Matt:

Mike H has three comments (below) for the Large Facilities Manual (LFM). Other than these, we think it looks good.

Thanks,  
John

**4.2.2.4 Supplementary Guidance for Construction and Operations Awards:** Recommend adding specific PAPPG and/or Uniform Guidance references to the sub paragraphs. For example 4.2.2.4.E-Travel: could reference the PAPPG section on Travel (Chapter II.C.2.g.(iv)) and/or perhaps 2 CFR § 200.474.

**4.5.3 Recipient Performance Reviews and Audits:** Recommend considering adding Reviews for Payment Testing and for Program income Reporting. This will increase awareness of these monitoring processes and establish expectations for recipient responses to the reviews. We can provide language should this be recommendation be accepted.

**A general observation:** Risk assessment and monitoring, as well as contingency, are addressed in various sections of the manual. While project lifecycle has a major impact on the subjects, it may be more clear to consolidate risk and contingency into a single subject area in order to provide focus.

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**From:** Hawkins, Matthew J.  
**Sent:** Monday, May 16, 2016 10:21 AM  
**To:** NSF SMART <[smart@nsf.gov](mailto:smart@nsf.gov)>; NSF Deputy AD <[nsf-deputyad@nsf.gov](mailto:nsf-deputyad@nsf.gov)>; NSF Division Directors <[divdir@nsf.gov](mailto:divdir@nsf.gov)>; NSF Program Officers <[progoff@nsf.gov](mailto:progoff@nsf.gov)>; NSF AMG <[amg@nsf.gov](mailto:amg@nsf.gov)>; NSF AO/OS <[aos@nsf.gov](mailto:aos@nsf.gov)>; NSF Deputy Division Directors <[depdir@nsf.gov](mailto:depdir@nsf.gov)>; BFA ALL <[BFAALL@nsf.gov](mailto:BFAALL@nsf.gov)>; OGC All <[OGC\\_All@nsf.gov](mailto:OGC_All@nsf.gov)>; DIS ALL <[dis-all@nsf.gov](mailto:dis-all@nsf.gov)>; DAS Staff <[dasstaff@nsf.gov](mailto:dasstaff@nsf.gov)>; BFA BPLG

<[bfabplg@nsf.gov](mailto:bfabplg@nsf.gov)>

**Cc:** NSF POLICY <[policy@nsf.gov](mailto:policy@nsf.gov)>; Hawkins, Matthew J. <[mjhawkin@nsf.gov](mailto:mjhawkin@nsf.gov)>

**Subject:** "For comment" draft of the Large Facilities Manual (LFM) published in the Federal Register

Dear Colleagues:

On May 9<sup>th</sup>, NSF published a notice in the Federal Register announcing the availability of a "For comment" draft of the *Large Facilities Manual* (LFM). We are soliciting Directorate/Office comments on the draft LFM until COB July 8, 2016. Please note that all comments should be coordinated through the applicable Assistant Director/Office Head's office and sent to Suzanne Plimpton at [splimpto@nsf.gov](mailto:splimpto@nsf.gov).

The following are links to the Federal Register Notice and the draft LFM:

- <https://www.gpo.gov/fdsys/pkg/FR-2016-05-09/pdf/2016-10793.pdf>
- [http://www.nsf.gov/bfa/lfo/lfo\\_documents.jsp](http://www.nsf.gov/bfa/lfo/lfo_documents.jsp)

Any technical questions should be directed to Dr. Carol Wilkinson in the Large Facilities Office at [cwilkins@nsf.gov](mailto:cwilkins@nsf.gov).

Kind Regards,  
Matt Hawkins



**Matthew Hawkins**  
**Head, Large Facilities Office**  
**Office of Budget, Finance & Award Management**  
voice: x7407  
email: [mjhawkin@nsf.gov](mailto:mjhawkin@nsf.gov)

**From:** [Whitehurst, Eddie](#)  
**To:** [Hawkins, Matthew J.](#)  
**Cc:** [Wilkinson, Carol](#); [Rabanal, Florence I.](#); [Kinser, William](#); [Lupis, Jeffery Michael](#)  
**Subject:** RE: LFM  
**Date:** Monday, May 16, 2016 9:10:40 AM

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Matt

Thanks glad to know we can make these small changes. Sometimes the word is used in relation to the award or project and closeout is the official word which should be used to denote the end of the award. These sections should be using the word "closeout" the red words should be deleted and the blue added.

#### 2.1.6-5

##### Table 2.1.6-1

Devises and carries out a renewal or termination strategy that implements recompetition of the operating award wherever feasible

#### 2.1.6-7

Devises and carries out a renewal or termination strategy that implements recompetition of the operating award wherever feasible

Defines business practices for renewal, recompetition, or termination of the Award

Advises PO and G/AO on effective operational oversight strategies, renewal and recompetition strategies, and termination

#### 2.1.6-10

Overseeing implementation, operation, and eventual divestment and termination of NSF support for the project.

#### 2.1.6-13

The G/AO confers with the PO and other relevant offices to ensure that the NSF's technical and administrative oversight activities are well coordinated. The G/AO and the PO collaborate on the preparation of solicitations and the proposal and award process. The G/AO has individual responsibility for developing and overseeing the implementation of financial and administrative aspects of the award process, and joint responsibility with the PO for recompetition planning and execution, and award termination and closeout.

#### 2.3.1-3

facility. It also identifies critical issues and risks facing the project (for example: project management issues, completing essential R&D activities, partnership agreements, termination or divestment liabilities) and lays out a strategy for financing these activities.

#### 3.1-1

Guidelines for plans to terminate operations under NSF awards are in development, with Section 3.6 provided as a placeholder. Divestment, and termination of NSF funding and oversight of a facility, may be accomplished through transfer to another agency or funding source or through decommissioning and deconstruction.

### 3.3-1

This document provides guidance to the PO on topics to be included in an Internal Management Plan (IMP), grouped by life-cycle stage. The IMP is the primary document that describes how NSF will oversee development, construction, operation and eventually divestment and **termination of the award support for a major facility**. The requirement to develop an IMP is described in Section 2.3.1 for MREFC and in Section 2.7 for non-MREFC projects. Two primary purposes are served by development of an IMP:

### 4.2.2-1

The CEP should be tailored to address all relevant stages and costs of the facility lifecycle, from Development and Design through Construction, Operation, and **Termination Disinvestment**. For example, the expected level of funding needed for the Operations Stage should be identified at the Conceptual Design Review. Operating costs estimates will be updated throughout the design and construction process as further discussed in the Concept of Operations Plan developed as part of the PEP described in Section 3.4 of this manual.

### 4.2.2-2

For most large facilities projects, funding is derived from the appropriate NSF budget account depending on the Stage: typically the Research and Related Activities (R&RA), Education and Human Resources (EHR) or MREFC account. Barring documented exceptions, the R&RA (and possibly EHR) account will be used to fund the Development, Design, Operations, and **Termination Disinvestment** Stage costs. The MREFC account will be used to fund construction, acquisition and commissioning costs as part of the Construction Stage.

### 4.2.4-1

If anticipated by NSF and as discussed in Section 2.6 of this manual, proposals will be requested to address partial or full **termination disinvestment** of the facility during the award period, including property decommissioning and disposition costs and other costs related to employee separations. It is incumbent upon the Recipient to ensure their operations proposal is complete, appropriate, and reasonable.

### 4.5.1-1

The Recipient is responsible for complying with the reporting requirements contained in the award instrument (e.g., technical and financial reporting), this manual, and in the Proposal and Award Policy and Procedures Guide (PAPPG) – particularly with respect to property management and final reporting and closeout requirements for **termination** of the award. The Recipient is also responsible for providing internal oversight of its own activities.

Eddie Whitehurst  
Deputy Branch Chief  
Cooperative Support Branch  
National Science Foundation  
4201 Wilson Boulevard, Room II-300.27  
Arlington, VA 22230

(703) 292-2292

---

**From:** Hawkins, Matthew J.  
**Sent:** Friday, May 13, 2016 3:30 PM  
**To:** Whitehurst, Eddie <EDDWHITE@nsf.gov>  
**Cc:** Wilkinson, Carol <CWILKINS@nsf.gov>; Rabanal, Florence I. <frabanal@nsf.gov>; Kinser, William <WKINSER@nsf.gov>; Lupis, Jeffery Michael <jlupis@nsf.gov>  
**Subject:** RE: LFM

Eddie,

The last stage in the MREFC process has been changed to “Divestment”. Are you looking at the posted revision?

If so, do you see the term “termination” used elsewhere inappropriately? If so, please point it out.

We have the opportunity to tweak after the public comment period, so no worries!

Matt

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**From:** Whitehurst, Eddie  
**Sent:** Friday, May 13, 2016 9:38 AM  
**To:** Hawkins, Matthew J. <mjhawkin@nsf.gov>  
**Cc:** Wilkinson, Carol <CWILKINS@nsf.gov>; Rabanal, Florence I. <frabanal@nsf.gov>; Kinser, William <WKINSER@nsf.gov>; Lupis, Jeffery Michael <jlupis@nsf.gov>  
**Subject:** LFM

Matt

I know the LFM is out for public comment. Will we get one last chance for a few edits or changes based on comments or further clarification.

I have one item which I forgot to include because my notes where in an email I could not find during the crazy week of adding the Large Facilities Financial Data Tool.

The concern is the use of the word Termination as part of the construction stage. The new 2 CFR 200 which was approved last year standardized all Federal definitions. Agencies cannot be at odds with the use of the guidance. The LFM use of the word Termination is going against what I think it is you want to convey. The last stage of the construction process is the Closeout of the award not a termination.

The use of the word Termination is a negative and means you end the award before the grantee could finish the project. See below the definitions.

**§200.16 Closeout.**

*Closeout* means the process by which the Federal awarding agency or pass-through entity determines that all applicable administrative actions and all required work of the Federal award have been completed and takes actions as described in §200.343 Closeout.

**§200.95 Termination.**

*Termination* means the ending of a Federal award, in whole or in part at any time prior to the planned end of period of performance.

Thanks

Eddie

Eddie Whitehurst

Deputy Branch Chief

Cooperative Support Branch

National Science Foundation

4201 Wilson Boulevard, Room II-300.27

Arlington, VA 22230

(703) 292-2292

**From:** [Hawkins, Matthew J.](#)  
**To:** [Whitehurst, Eddie](#)  
**Cc:** [Wilkinson, Carol](#); [Rabanal, Florence I.](#); [Kinser, William](#); [Lupis, Jeffery Michael](#)  
**Subject:** RE: LFM  
**Date:** Friday, May 13, 2016 3:30:04 PM

---

Eddie,

The last stage in the MREFC process has been changed to “Divestment”. Are you looking at the posted revision?

If so, do you see the term “termination” used elsewhere inappropriately? If so, please point it out.

We have the opportunity to tweak after the public comment period, so no worries!

Matt

---

**From:** Whitehurst, Eddie  
**Sent:** Friday, May 13, 2016 9:38 AM  
**To:** Hawkins, Matthew J. <mjhawkin@nsf.gov>  
**Cc:** Wilkinson, Carol <CWILKINS@nsf.gov>; Rabanal, Florence I. <frabanal@nsf.gov>; Kinser, William <WKINSER@nsf.gov>; Lupis, Jeffery Michael <jlupis@nsf.gov>  
**Subject:** LFM

Matt

I know the LFM is out for public comment. Will we get one last chance for a few edits or changes based on comments or further clarification.

I have one item which I forgot to include because my notes where in an email I could not find during the crazy week of adding the Large Facilities Financial Data Tool.

The concern is the use of the word Termination as part of the construction stage. The new 2 CFR 200 which was approved last year standardized all Federal definitions. Agencies cannot be at odds with the use of the guidance. The LFM use of the word Termination is going against what I think it is you want to convey. The last stage of the construction process is the Closeout of the award not a termination.

The use of the word Termination is a negative and means you end the award before the grantee could finish the project. See below the definitions.

**§200.16 Closeout.**

*Closeout* means the process by which the Federal awarding agency or pass-through entity determines that all applicable administrative actions and all required work of the Federal award have been completed and takes actions as described in §200.343 Closeout.

**§200.95 Termination.**

*Termination* means the ending of a Federal award, in whole or in part at any time prior to the planned end of period of performance.

Thanks  
Eddie

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### 2.1.3 Facility Life Cycle

Prepared by the Large Facilities Office in the Budget, Finance, and Award Management Office (BFA-LFO)

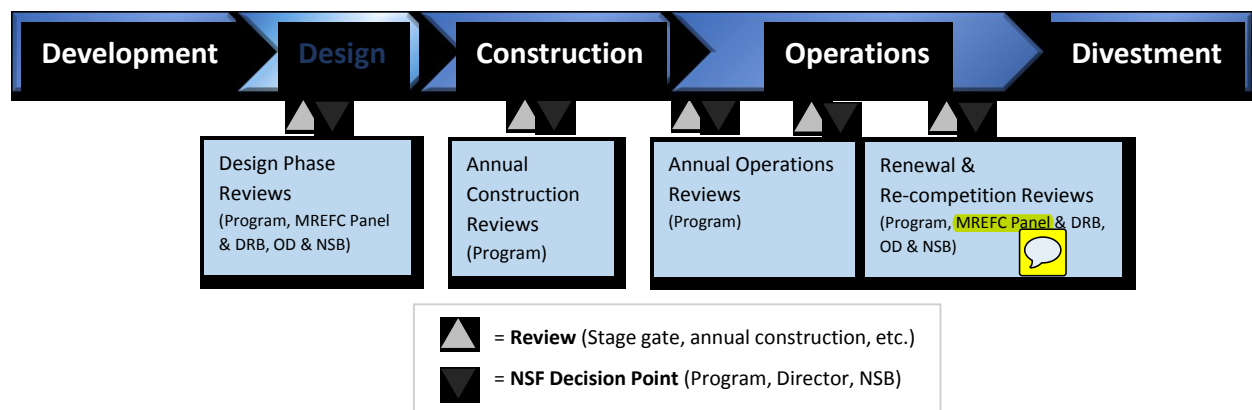
### 2.1.3 Facility Life Cycle

A facility's lifetime is characterized by the following life cycle stages:

1. Development<sup>1</sup>
2. Design
3. Construction
4. Operation
5. Divestment.

Each life cycle stage entails different actions appropriate to the advancement of the project, the review and approval needed to obtain NSF funding, and the creation of NSF budgets to support these activities. Entry and exit from each life cycle stage are clearly defined including required documents and deliverables. A high-level graphic of the progression through the stages is given below in Figure 2.1.3-1.

Figure 2.1.3-1 Progressive Steps in the MREFC Life Cycle, Showing Review and Decision Points for Exit and Entry into Each Stage. The Design Stage is highlighted to indicate that it is further broken down into phases



Points at which there may be departure from the MREFC process outlined here should be identified early in the project development and documented as part of the NSF Internal Management Plan (IMP) Individuals should discuss any proposed departures with the cognizant Program Officer.

The Design Stage is further divided into three phases, each with defined entry and exit points, as shown in Figure 2.1.3-2 below:

1. Conceptual Design
2. Preliminary Design
3. Final Design

<sup>1</sup> A project in the Development Stage may be referred to as a "Horizon" or a Conceptual Development project in earlier NSF documents and references.