2023 Research Infrastructure WORKSHOP

June 27-30, 2023 – Washington, D.C.

Performance Measurement & Management (Part 2): Progress Tracking & Reporting

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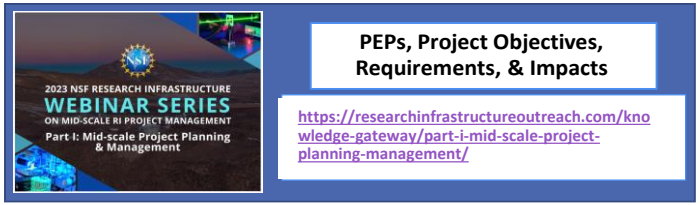
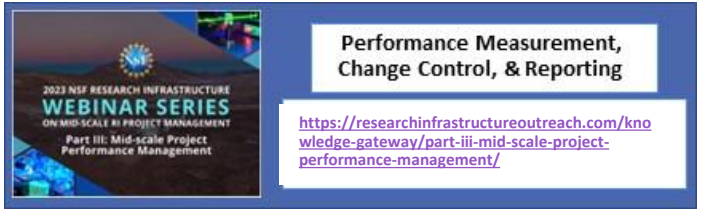
Talk Overview

Takeaway: Learn how to use tailored PMM tools and methods to manage and control mid-scale Projects during execution.

- Progress Tracking and Reporting components of Performance Measurement and Management (PMM)
- NSF Requirements for Mid-scale PMM
  - Scaled EVM
  - Guidelines and References
  - EVM Basics
- PMM/EVM Steps used during Execution, using examples of tailoring to project characteristics
  - Collecting Data on Project Status
  - Comparison of Status to Target Plan and Analysis
  - Management and Reporting
- Summary





Helpful background on Project Management terms and topics found in these NSF Webinars

Performance Measurement/Management Defined

Takeaway: Track progress and manage based on comparison of current status to target baseline.

Completed Before Execution

1. **Build a "target" baseline plan**
   - Scope and quality
   - Budget and schedule
   - Risk exposure and contingency

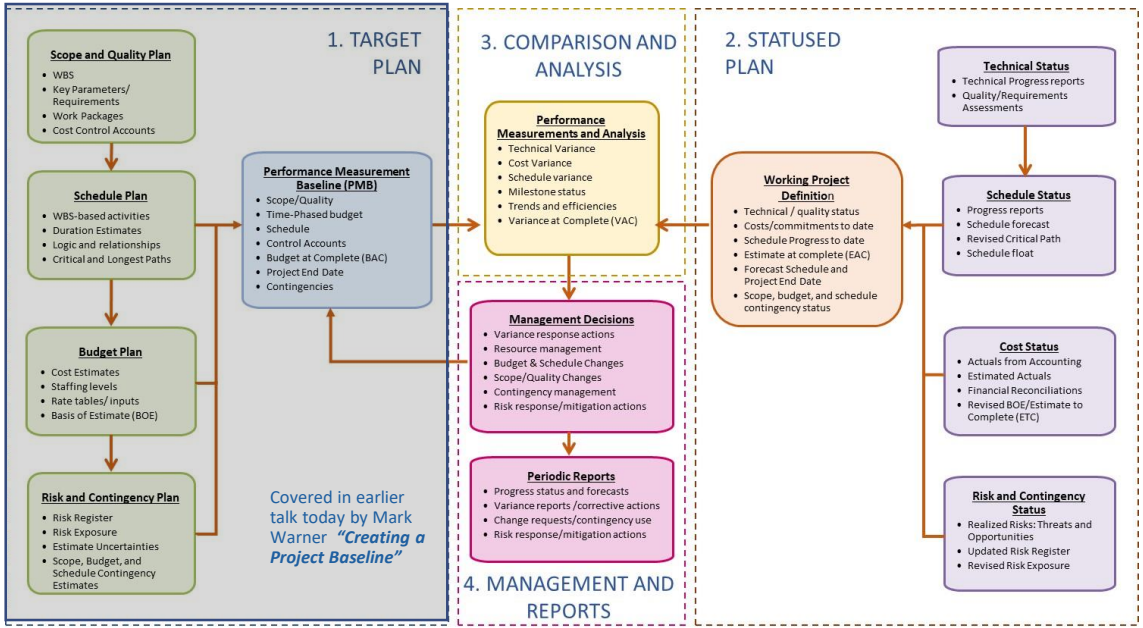
Tracking and Reporting during Execution

2. **Collect "status" in a working project definition**
   - Technical accomplishments
   - Schedule progress and actual costs to date
   - Forecast of schedule and cost estimate for remaining work
   - Risk re-evaluation

3. **Compare "status" plan against "target" plan and analyze differences**
   - Technical status
   - Cost and schedule variances
   - Estimate at complete (EAC) and end date

4. **Manage based on analysis and Report Status**
   - Manage resources
   - Use contingencies
   - Change the target PMB as needed
   - Create periodic reports

Established process to compare "status" at a certain date to "target" plan and analyze the results.
Use the information to successfully manage the project



Four Steps of Performance Measurement and Management

NSF Guidelines for Scaled EVM/PMM

Performance Measurement, Change Control, & Reporting

https://researchinfrastructureoutreach.com/knowledge-gateway/part-iii-mid-scale-project-performance-management/

projectperformancemanagement/

Takeaway: NSF Guidelines support, but don't require, scaled EVM methods for mid-scale projects.

Industry Standard For Performance Measurement is Earned Value Measurement (EVM)

- EVM provides an objective assessment of project status using defined metrics
- Works best on projects characterized by a linear progression of work assigned to discrete work packages

Industry Standards for Scaled EVM introduced for mid-scale projects

- Reduced number of guidelines and formality, with tailoring to fit project characteristics
- Reduces administrative burden on mid-scale projects
- With modifications, can be applied to projects that do not normally fit EVM structure characteristics

NSF requires responsible PMM, but does not require EVM for midscale projects

- NSF encourages Scaled EVM as the preferred project management methodology for NSF midscale projects

EVM Scaling at NSF

References:

1. NSF Research Infrastructure (RIG) Section 6.8 (Building and using scaled EVM)
2. NDIA Earned Value Management System: Guideline Scalability Guide (useful scaled examples)
3. Earned Value Management Systems EIA-748-D Intent Guide (Full EVMS with 32 guidelines)

EVM Principles and steps are the same regardless of amount of scaling

- Number and complexity of tools, processes, and report elements vary

Low Risk/Complexity Projects	Moderately Complex Projects	High Risk, Complex Projects
Mostly staffing costs; few procurements; simple WBS and schedule; low risk	Staffing, procurements, construction; more and lower WBS; schedule dependencies; moderate risk	High detail WBS; complicated BOE; many tasks, constraints, and interdependencies; high risk
Simple Spreadsheet Tools • Block schedule and time phased budget • Progress milestones lists • Single homemade spreadsheet for baseline and comparison • Simple risk register; low risk exposure • Report CV, SV, EAC, % complete, milestones	**Fancier Tools, including commercial SW** • Budget Spreadsheets • Commercial Scheduling software • Schedule critical path • Commercial or homemade EV report tools • Risk register; Simple MC for risk exposure • Report EV, CV, SV, SPI, CPI, EAC, % complete, milestones/critical path	**Enterprise level tools** • Budget / BOE Spreadsheets or Software • Commercial Scheduling software with resource loading and critical path analysis • Commercial or homemade EV report tools • Risk register and Monte Carlo risk analysis • Full EVM Report for EV, CV, SV, SPI, CPI, EAC, % complete, milestones, s-curves, etc.

Determine which category describes the project and then scale PMM/EVM processes and tools

NSF Scaled Earned Value Management (EVM)
Guidelines Reference Slide

Takeaway: Look for scaled EVM guidance in NSF and NDIA documents and for alternative PPM guidance in online documents.

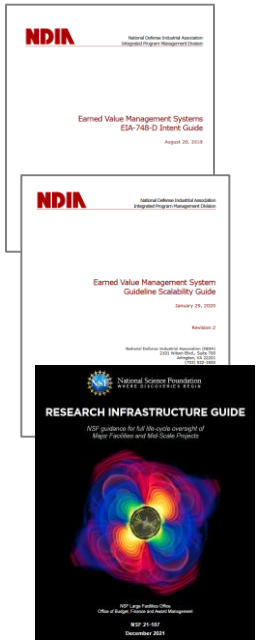
NSF Midscale Guidelines for PMM in the RIG based on NDIA Scaled EVM Guidelines

- All 7 principles but only 18 of the 32 guidelines for the industry standard EIA-748.

RIG does not address PMM for projects not easily compatible with EVM

- Compelling alternative methodology is allowed if the project (or a significant part) is not EVM compatible
- A few places to get guidance:
  - NDIA Earned Value Management System: Guideline Scalability Guide
  - PMI: EVM on service projects-- an optimized paradigm
  - PMI: Beyond backlogs and burndowns--complementing "agile" methods with EVM for improved project performance
  - An Alternative to EVM: The Zone Method

Performance Measurement Major Steps	Seven Principles of EVM	Scaled NDIA and NSF EVM Guidelines
1. Build a "target" baseline plan - Scope and quality - Budget and schedule - Risk exposure and contingency	1. **Plan all project's work scope** (create WBS).	1, 2, 5
	2. **Break work scope into finite pieces** with responsible owners over objectives	
	3. **Create a performance measurement baseline (PMB)** for scope, schedule, cost, and contingency. Control changes to the baseline.	6, 7, 8, 9, 13, 14
2. Periodically **collect "status" in a working project definition** - Technical accomplishments - Schedule progress and actual costs to date - Forecast of schedule and cost estimate for remaining work - Risk re-evaluation	4. **Use actual costs incurred** and recorded in accomplishing the work performed.	17, 18, 22, 23, 26
	5. Objectively **assess accomplishments/ progress** at the work performance level.	
3. Compare "status" plan against "target" plan and analyze differences - Technical status - Cost and schedule variances - Estimate at complete (EAC) and end date	6. **Analyze significant variances** from the plan, **forecast impacts**, develop corrective actions, and prepare an estimate at completion based on performance to date and the remaining work to be performed.	
4. Manage based on analysis and Report - Manage resources - Use contingencies - Change the target PMB as needed - Create periodic reports	7. **Use the EVMS information** in the project's management processes.	17, 18, 22, 23, 26 25, 27, 28, 32



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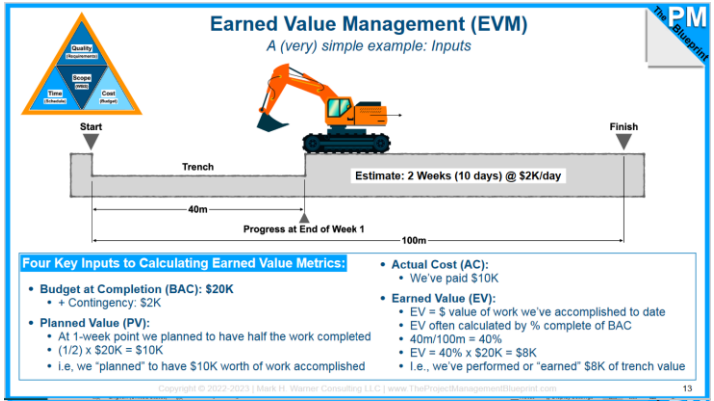
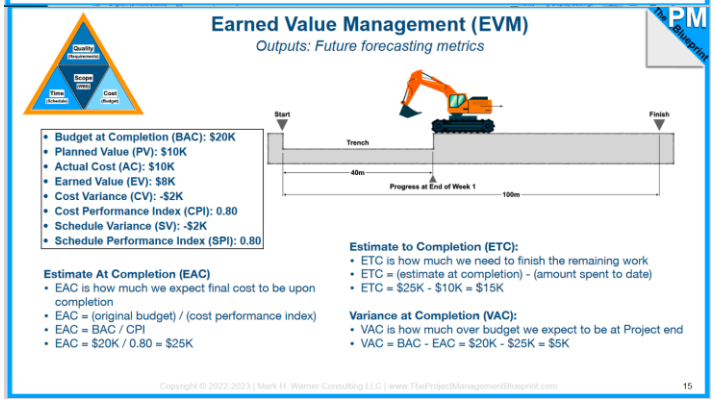
Note talk on Earned Value Management (EVM) in Agile Development
10:50 AM Wednesday June 28

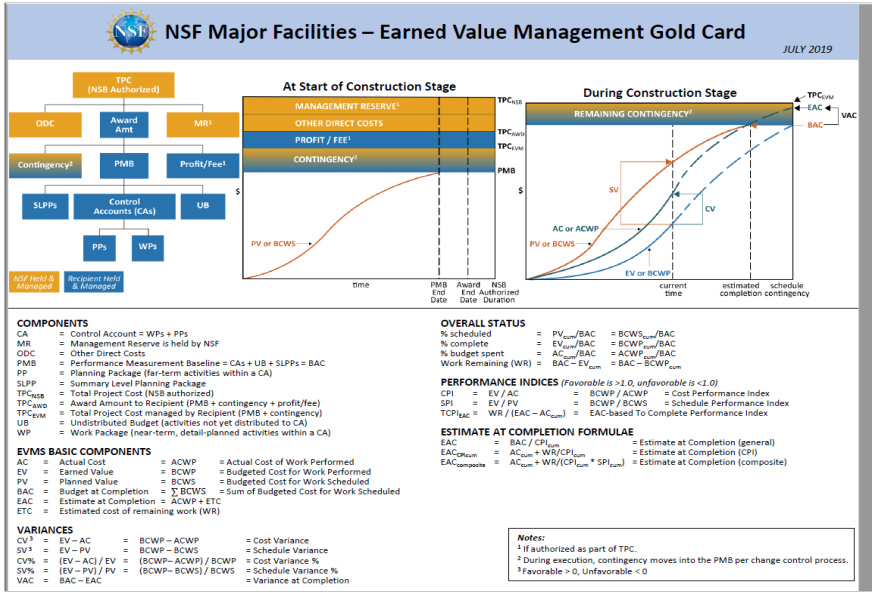
EVM Basics Example

Takeaway: Take time to learn/understand the EVM basics.





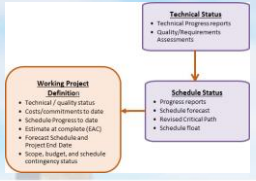
Example taken from NSF midscale Webinar Series



Link to NSF EVM Gold Card

PMM Step 2. Statusing Technical and Schedule Progress

Takeaway: Collect technical and schedule progress data and document in the schedule and MS tables.



Determine what you have done each reporting cycle:

The schedule establishes and maintains the relationship between technical achievement and progress statusing

- Collect Qualitative inputs
  - Control Account Managers (CAMs) and technical leads discuss status and issues in project meetings
  - PI, PM, and Leads "walk their spaces"
- Collect Quantitative inputs
  - Written reports from Leads on Technical accomplishments (work done, quality, risks)
  - Schedule Progress Input from Leads, either by fillable forms or live input: actual start, actual finish, and % complete*
  - Forecast Input from leads: revised start dates, finish dates, durations
- Update the working version of the schedule and the Milestones Table in scheduling tool

*Some Examples of % complete Techniques for EV, established before execution

EV Technique	Assigning % complete
0/100	Nothing until 100% complete
50/50	50% at start; 100% at finish
Units completed	% of total units completed
Weighted milestone	% based on apportioned resources/budget
Level of Effort	% complete based on elasped time percent
Physical % complete	Estimate of % complete (SME judgement)

Project Update May 31 2023 and 3 Month Look-Ahead

WBS Code	Name	% Comp	Duration	Planned Start	Planned Finish	Schedule Updates: % Comp	Duration	Planned Start	Planned Finish	Actual Start	Actual Finish
1	Reference Antenna 12m	91%	668d	11-Jan-21	11-Aug-23					11-Jan-21	
1.1	System Review & Inspections Reference Antenna 12m	90%	603d	11-Jan-21	12-May-23					11-Jan-21	
1.1.5	Procurement & Equipment Purchase Reference Antenna 12m	84%	265d	2-May-22	12-May-23					2-May-22	
1.1.5.1	Labor: Procurement & Equipment Purchase Reference Antenn	55%	265d	2-May-22	12-May-23					2-May-22	
1.1.5.3	Procurement: Spare Parts for Antenna 12m	60%	29.6w	17-Oct-22	12-May-23					17-Oct-22	
1.4	Development & Integration Wideband Antenna 12m	89%	653d	1-Feb-21	11-Aug-23					1-Feb-21	
1.4.1	Development Wideband Antenna 12m	91%	586d	1-Feb-21	10-May-23					1-Feb-21	
1.4.1.1	Labor: Development & Integration Wideband Antenna 12m	70%	328d	28-Jan-22	10-May-23					28-Jan-22	
1.4.2	Wideband 12m Instrumentation Fabrication	89%	330d	25-Mar-22	7-Jul-23					25-Mar-22	
1.4.2.11	Phase 2.9: Field Deployment and on Antenna Testing	90%	35.4w	16-Nov-22	12-May-23					16-Nov-22	
					w	15-May-23	26-May-23				
					d	26-May-23	26-May-23				
					w	29-May-23	23-Jun-23				
					0d	29-May-23	7-Jul-23				
					0d	29-May-23	7-Jul-23				
					w	26-Jun-23	7-Jul-23				
					d	7-Jul-23	7-Jul-23				
					d	7-Jul-23	7-Jul-23				
					9d	15-Jun-22	5-May-23			15-Jun-22	
					8w	31-Jan-23	5-May-23			31-Jan-23	
					d	5-May-23	5-May-23				
					0d	25-Mar-22	10-May-23				

RF Team Lead Monthly Report Feb 28, 2023

P08 Radio Frequency Interference Evaluation and Support

The project is 45% complete as of February 28, 2023, 2023, and its expected completion date is August 3, 2023.

- Project work pace has slowed significantly due to project lead and other resources prioritizing P12. Although procurements are under way, actual work is expected to pick up in March/April.

P12 Reference Antenna (12m) Repairs

The project is 83% complete as of February 28, 2023, and current completion date is August 9, 2023.

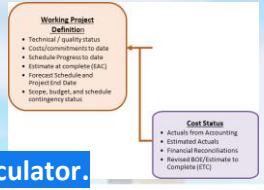
- Dewar's cryogenic performance/longevity checks perform
- Built and validated Radome's dry air system.
- Validated UDC.
- Will revise monitoring architecture to include helium line
- Will add supporting structure to 12-meter antenna to rel
- Will complete filter bank assembly with new filters and va performance.

Example: Arecibo 12m Telescope Repair Subproject

Project WBS	Milestone Name	Baseline Date	Forecast Date	Actual Date	Variance (days)
P00 - 1.6.4	Final Project Execution Plan Submitted	7-Jun-22	7-Jun-22	07-Jun-22	0
P00 - 1.8	Completion of All Subprojects (MS)	31-Mar-23	31-Mar-23		
P00 - 1.8.1	Completion of All Sub- Projects (MS)	31-Mar-23	31-Mar-23		
P00 - 1.9.2	AOR Project Closeout Complete (MS)	3-Jul-23	3-Jul-23		
P08 - 1.1.10	RFI Site & Laboratory Surveys Complete (MS)	27-Dec-22	27-Dec-22		
P08 - 1.1.3	Start RFI Monitoring Site and Laboratory Surveys (MS)	12-Apr-22	12-Apr-22	12-Apr-22	0
P08 - 1.1.6	Procurement RFI Survey Test Equipment & Materials Complete (MS)	4-Aug-22	30-Sep-22		-57
P08 - 1.2.1.5	RFI Station Design & Development complete (MS)	8-Jun-22	8-Jun-22	08-Jun-22	
P08 - 1.2.2.5	Procurement RFI Station instrumentation Complete (MS)	18-Aug-22	23-Nov-22		-97
P08 - 1.2.2.9	RFI Station Fabrication & Procurement Complete (MS)	14-Nov-22	23-Nov-22		-9
P08 - 1.2.3.6	RFI Station Installation Complete (MS)	27-Dec-22	29-Dec-22		-2
P09 - 2.1.1.12	HF Loads Procurement Complete (MS)	10-Aug-22	1-Sep-22		-22
P09 - 2.1.1.2	Start HF Loads Selection and Procurement (MS)	21-Mar-22	21-Mar-22	21-Mar-22	0
P09 - 2.1.1.6	HF Dummy Loads Design Complete (MS)	23-May-22	23-May-22	23-May-22	0
P09 - 2.1.1.8	Descope Decision: Drop Procurement of Spare Dummy Load (MS)	3-Aug-22	3-Aug-22	3-Aug-22	0
P09 - 2.1.2.3	Descope Decision: Drop Installation of 2 Dummy Loads (MS)	31-Aug-22	22-Sep-22		-22

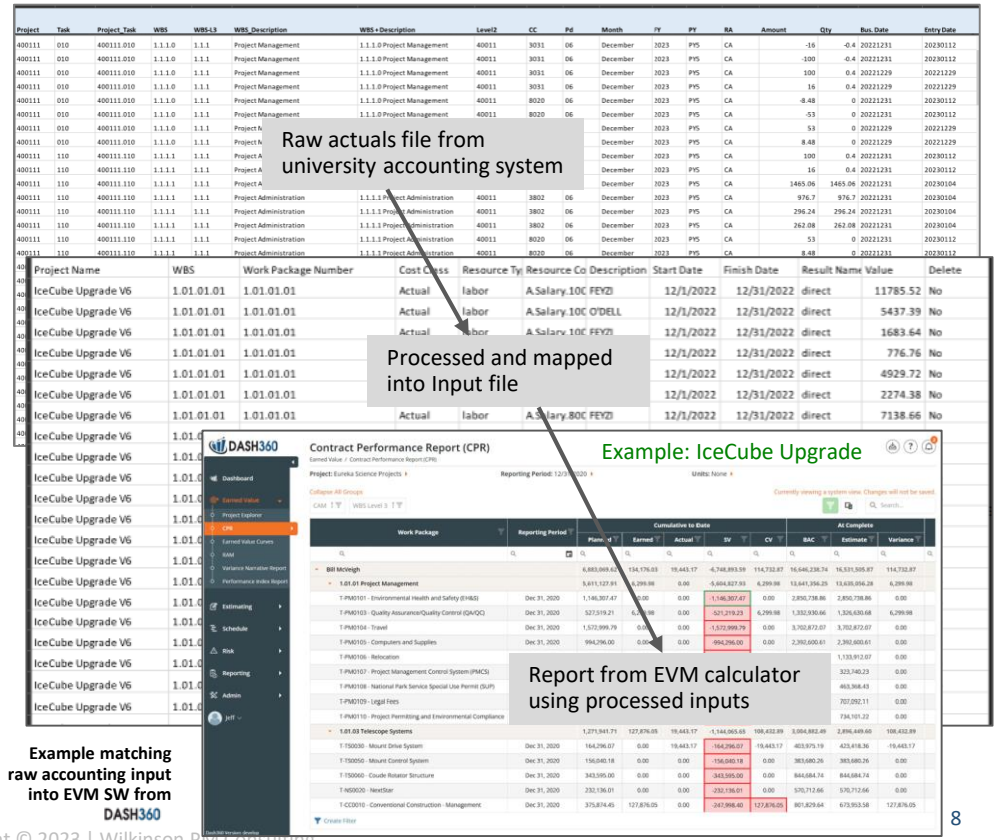
Arecibo Hurricane Repair Project: ~$12M; Management tool is "Celoxis" for resource-loaded Gantt schedule and EVM. Celoxis reports were modified to accommodate fully loaded budgets/costs. PM & Project Controls staff authorized to work in master schedule; Leads can work in "sandboxes".

PMM Step 2. Statusing: Actual Costs and EAC Forecast



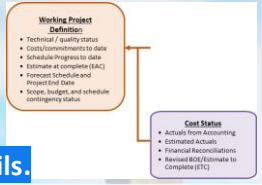
Takeaway: Raw Actual cost data are collected from accounting and processed for input to EVM calculator.

- **Collect Quantitative Data from all Partners**
  - Import actual costs from host institution accounting reports into a processing sheet
- **Process data into format compatible with EVM tools**
  - Map actuals to Control Accounts, resource codes, or other tracking codes/tags established with accounting systems
  - Clean up file formats and data fields to match EVM calculator input requirements
  - Import file into EVM calculator
- **Periodically update Cost of Work Remaining**
  - Collect any new knowledge about cost changes (market, added work, risk impacts)
  - Create bottom-up re-estimates of the Estimate to Complete (ETC)
  - Update Estimate at Complete (EAC)



Example matching raw accounting input into EVM SW from DASH360

PMM Step 2. Statusing: Missing Actual Costs



Takeaway: Establish methods to deal with the reality of late invoicing and lack of cost details.

When actuals are not available, EVM data may be less accurate/useful.

- Some institutions report actuals only once a semester or submit invoices long after delivery or completion of work
- Most don't do time keeping (collect hours spent on different tasks)

Follow EVM as much as possible.

- Two common methods of dealing with issue
- Less common method: "Reverse Estimation" for Service-type projects:
  PMI: EVM on service projects-- an optimized paradigm

Accruals ("Estimated Actuals")

- Materials and trackable effort: estimate the cost to date in the period and reconcile later when invoiced
- Labor: Create a time keeping system - require institutional leads and/or CAMs to collect or guesstimate hours or % FTE
- Alternatively: Treat partner sub-awards as fixed price contracts and track progress with cost-weighted milestones

Pros:
- Allows application of EVM for entire project
- Prevents large variances

Cons:
- Only as good as estimates
- Estimating creates work
- Reconciliation required later

Mixed EVM Application ("In-time and Assigned Actuals")

- Materials: Input actuals only when invoices arrive and explain variances in reports
- Labor and Services: Actuals are assigned to best known values and reconciled after invoicing

Pros:
- Does not try to force EVM where not applicable
- Less project effort and coordination in reporting actuals

Cons:
- EVM cost analysis less useful
- Variance reporting creates work for CAMs and Leads
- Schedule progress must be carefully tracked

NICHE PEP Revision #3 March 1, 2023 Set Actuals = Planned: AC=PV

10.2 Progress Reporting Plan (EVMS)

….

On a monthly basis it is expected that the schedule EVM information will represent the timeliest data and be best the indicator of project status. This is because the actuals that will be reported each month are equal to the "planned" level of effort and are not reconciled to the actual costs until the completion of the semester, which occurs three times a year. This fact results in the cost variances associated with labor only providing meaningful insight a few times a year.

PMM Step 2. Statusing:
Risk and Contingency Evaluation

Baselines, Risk, & Contingency

https://researchinfrastructureoutreach.com/knowledge-gateway/part-ii-mid-scale-project-development-definition-and-risk/

Takeaway: Re-evaluate status of risks, both new and old, and document contingency usage and status.

Re-evaluate status of risks each month

- Follow processes in your Risk Management Plan (RMP) in the Project Execution Plan (PEP)
- Discuss risks (threats and opportunities) in project meetings; frequency depends upon number of risks and impacts
  - Check for near-term/imminent risks and decision milestones. Has the risk passed, and can it be retired?
  - Has a risk been realized? If so, what are the consequences if you do nothing? What response actions can be taken?

Periodically update list of risks and re-estimate risk exposure

- Risks and risk exposure are not static
- Has a risk changed in any way? Any new risks to add?

Track Contingency Usage

- Document all 'puts' and takes ' in a Contingency Log for cost, schedule, and scope/quality contingency during the reporting period

Risk Mgt Process Cycle from
RIG 6.2 *RISK MANAGEMENT GUIDELINES FOR CONSTRUCTION STAGE*

		Risk Identification and Tracking		Major Risk Flag	Post-Mitigated Qualitative Risk Evaluation					
					Probability and Impacts				Risk	
Risk ID	Associated WBS	Risk Description	High Estimate		Risk Probability [%]	Impact on schedule [weeks]	Impact on cost [$]	Impact on technical performance	Schedule Risk Score [weeks]	Cost Risk Score [$]	Technical Performance Risk Score
TECH 1	1.2.4	Unable to complete controls system work on-schedule due to cargo front-loading and/or staffing limitations.	8		20%	6	$103,500.00	Low	1.2	$ 20,700.00	Low
TECH 2	1.2.4	Unable to make critical controls hardware procurements (motor drives, DGH's servers, sensors, etc) on-schedule due to vendor shortages and transportation delays.	12		40%	10	$103,500.00	Low	4	$ 41,400.00	Moderate
TECH 3	1.2.4	Delay in development of user interfaces, control algorithms, and hands-on integration and test activities due to Test Bed limitations.	12		25%	8	$101,750.00	Low	2	$ 25,437.50	Low
TECH 4	1.2	Loss of key drilling expertise/personnel	20		30%	12	$103,500.00	Moderate	3.6	$ 31,050.00	Moderate
TECH 5	1.2	Novel string installation - Final down-hole cable design requires the development of new equipment and processes for installation (i.e. New rope reel with coordinated load sharing)	40		50%	24	$120,000.00	Low	12	$ 60,000.00	Moderate
TECH 53	1.2	Because design and testing of the load sharing technique is critical and cannot delay the off-ice drill schedule, additional effor may be needed to validate / test load sharing for the drill head / drill hose.	0		20%	0	$207,000.00	Low	0	$ 41,400.00	Low

Example: IceCube risk register and Monte Carlo Risk Exposure Estimate

Example: IceCube Contingency Log

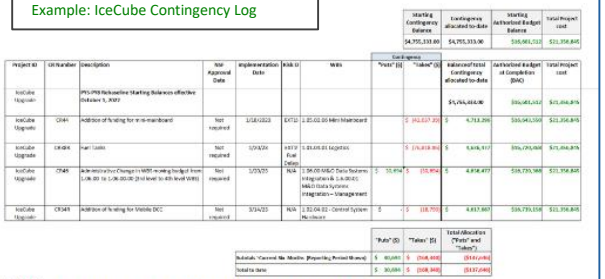
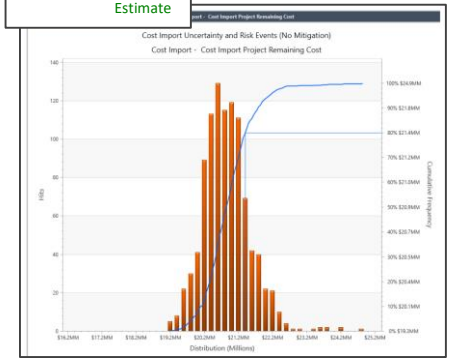


Table 7 "Puts" and "Takes" table for Change Requests processed for the rebaselined project.

3.2 Contingency Allocations during this Reporting Period (IceCube)
Table 7 shows the "puts" and "takes" table for the rebaselined project. During March, one CR was processed (CR34R), a revision of the cost for the Mobile Drill Control Center, with a draw on contingency of $18,790.



Step 3. EVM Comparison

Takeaway: There are many readily available EVM calculators that can be used as is or adapted.

Performance Measurements and Analysis
- Technical Variance
- Cost Variance
- Schedule variance
- Milestone status
- Trends and efficiencies
- Variance at Complete (VAC)

Step 1 (PMB) and Step 2 (Status) Inputs

- **PV** for the period and **BAC** from PMB
- **% complete** from Working Schedule (or EV)
- **AC** (actual + accruals) from accounting

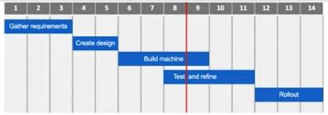
Step 3: Comparison in EVM Calculator (Spreadsheets or SW)

- Free spreadsheets: DIY, PMI, Pueo, etc.
- Deltek Cobra or OpenPlan, DASH360, ProjectManager, etc.
- MS project, Smartsheets, Celoxis, OmniPlan, Vertex42, Primavera, etc. do both scheduling and EVM

Step 3 Outputs: Needed Metrics/Reports

- Calculator should provide standard Tables
- Create more graphs, tables, (DIY or in SW)
- Standard NSF report elements

MS Example EVM sheets for simple project, using EVM at top project level



Planned Values

#	Activity	Days	Cost per Day	Planned cost
1	Gather requirements	3	800	2,400
2	Create design	2	600	1,200
3	Build machine	4	900	3,600
4	Test and refine	4	700	2,800
5	Rollout	3	500	1,500
			Total budget:	11,500

Actual Values Per End of Day 8

#	Activity	Incurred Cost	Actual % Complete
1	Gather requirements	2,400	100%
2	Create design		
3	Build machine		
4	Test and refine		
5	Rollout		

EVA Metrics

#	Activity	AC (ACWP)	EV (BCWP)	PV (BCWS)	CPI (EV/AC)	CV (EV - AC)	SPI (EV/PV)	SV (EV-PV)
1	Gather requirements							
2	Create design							
3	Build product							
4	Test and refine							
5	Rollout							
		0	0	0	0.00	0	0.00	

2:31 / 11:44 • Earned Value Analysis >

Project Management Institute.

Free PMI EVM Calculator sheet for simple project, can be adapted for EVM at lower WBS levels and rolled up

Earned Value Management (EVM) Calculator <---link **Override date:**

Task ID	Task	Planned Start	Planned Finish	Planned Cost (Total)	% Complete	AC	PV	EV	SV	SPI	CV	CPI	EAC1	EAC2	ETC
1	Design	1/1/14	3/31/14	$100,000	100%	$80,000	$100,000	$100,000	$0	1.00	$20,000	1.25	N/A	N/A	N/A
2	Build	4/1/14	6/30/14	$250,000	60%	$175,000	$250,000	$150,000	-$100,000	0.60	-$25,000	0.86	$275,000	$291,667	$75,000
3	Test	7/1/14	8/31/14	$75,000	0%	$0	$75,000	$0	-$75,000	0.00	$0	0.00	$75,000	$75,000	$75,000
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
							$0	$0	$0	0.00	$0	0.00	$0	$0	$0
				Totals	$425,000		$255,000	$425,000	$250,000	-$175,000	0.59	-$5,000	0.98	$350,000	$366,667	$150,000

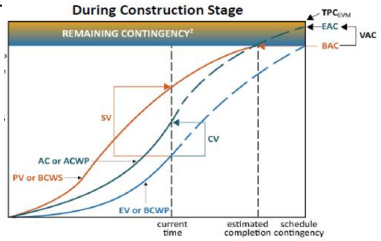
Note: Many free EVM Calculators online

PMM Step 3. Comparison and Analysis
EVM Analysis: Cost and Schedule

Performance Measurements and Analysis
- Technical Variance
- Cost Variance
- Schedule variance
- Milestone status
- Trends and efficiencies
- Variance at Complete (VAC)

Takeaway: Understanding the causes for variances and indices gives insights into corrective actions.

Build the story (cause) behind the cost and schedule metrics that lead to decision making. Look at variances and performance indices at control account and overall project level



Basic Variance Formulas

CV	= EV – AC	Cost variance
SV	= EV – PV	Schedule variance
VAC	= BAC - EAC	Variance at Complete

- **Create variance reports at control account, with causes and corrective actions.**
  Example: Behind schedule in installing equipment; Work is more complicated than expected; Add workers a) from non-critical path task with no change in project cost or b) use contingency to pay current workers to work overtime.
- **Track SV and CV at project level to evaluate overall project status**

Performance Index Formulas (trending inefficiencies)

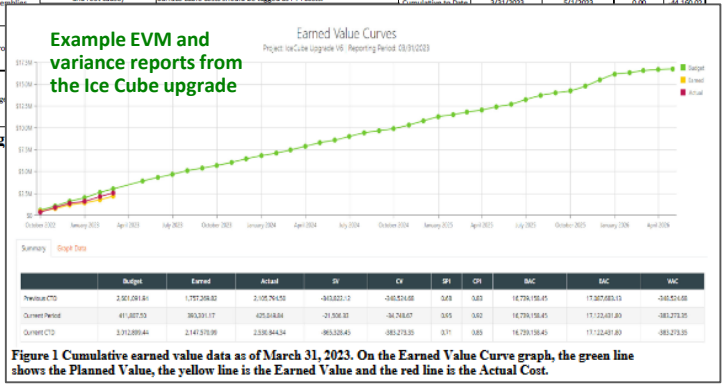
CPI	= EV /AC	Cost Performance Index
SPI	= EV/PV	Schedule Performance Index

- Use SPI and CPI to find trends, where values less than 1 indicate poor performance and inefficiencies. If not corrected, variances will continue to grow
  Example: Project started falling behind schedule, which also resulted in being under budget. Corrections took several months to accomplish.

WBS	Name	Field Name	Value	Period Type	Reporting Period	LastUpdatedDate	Sum of SV	Sum of C
1.03.01.01	mDOM DAQ Electronics	Explanation (Provide description and root cause)	The actuals for the Subaward should be in 1.6.1.6.	Cumulative to Date	3/31/2023	5/1/2023	0.00	-13,092.99
		Corrective Action	Per Timo, these actuals should be moved to 1.6.1.6 OM Firmware. The difference between 17,953.93 - 9,214.34 = $8,739.59 for the A.Subawards.3802.					
1.03.02.09	D-Egg Production and Testing	Explanation (Provide description and root cause)	There were five trips that were taken and not budgeted. Additionally, there are small materials and supplies charges (~1K).	Cumulative to Date	3/31/2023	5/1/2023	0.00	-17,412.68
		Corrective Action	Create a change request to cover the cost of the travel and M&S charges.					
1.03.03.03	IceCube DOM Refurbishment	Explanation (Provide description and root cause)	PDOM work is delayed due to priorization of the D-Egg activities (the PDOM Mainboard is derived from the D-Egg mainboard) and due to electronic parts supply chain issues.	Cumulative to Date	3/31/2023	4/28/2023	-79,841.82	424.14
		Corrective Action	The PDOM work is being replanned with a Final Design Review scheduled for August 2023 and subsequent refurbishment of the Gen1 DOMs. These activities are not on or near the critical path.					
1.04.01.05	Cable Emulators	Explanation (Provide description and root cause)	Per Mike, this work was all associated with PY4 and actuals should be tagged as PY4.	Cumulative to Date	3/31/2023	5/1/2023	0.00	-2,967.06
		Corrective Action	Mike and Lucas to coordinate with Barb and Laura to tag as PY4 and make an adjusting entry in PY5 to back the actuals out.					
1.04.02.01	Surface Cable Assemblies	Explanation (Provide description and root cause)	Surface cable costs should be tagged as PY4 costs.	Cumulative to Date	3/31/2023	5/1/2023	0.00	-44,160.03
1.04.03.01	FieldHub Electro							
1.05.04.01	Calibration Manage							

Table 4 Variance log

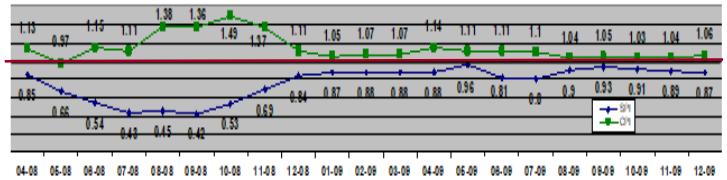
Example EVM and variance reports from the Ice Cube upgrade



	Budget	Earned	Actual	SV	CV	SPI	CPI	BAC	EAC	VAC
Previous CTD	2,501,091.61	1,757,268.82	2,101,764.50	-343,822.12	-343,524.68	0.63	0.83	16,739,158.45	17,307,683.13	-343,524.68
Current Period	611,807.53	360,191.17	425,614.04	-21,506.33	-34,749.67	0.65	0.92	16,739,158.45	17,122,431.80	-383,273.35
Current CTD	3,312,899.44	2,147,570.99	2,536,944.54	-865,328.45	-383,273.35	0.71	0.85	16,739,158.45	17,122,431.80	-383,273.35

Figure 1 Cumulative earned value data as of March 31, 2023. On the Earned Value Curve graph, the green line shows the Planned Value, the yellow line is the Earned Value and the red line is the Actual Cost.

Figure 1: SPI and CPI History: Advanced LIGO



CPI & SPI	SPI <1.0	SPI = 1.0	SPI >1.0
CPI < 1.0	Over Budget Behind Schedule	Over Budget On Schedule	Over Budget Ahead of Schedule
CPI = 1.0	On Budget Behind Schedule	On Budget On Schedule	On Budget Ahead of Schedule
CPI > 1.0	Under Budget Behind Schedule	Under Budget On Schedule	Under Budget Ahead of Schedule

PMM Step 3. Comparison and Analysis

Critical Path, Float, and Milestones

Takeaway: Critical path and float comparisons provide information to explain variance causes.

Performance Measurements and Analysis
- Technical Variance
- Cost Variance
- Schedule variance
- Milestone status
- Trends and efficiencies
- Variance at Complete (VAC)

Tracking schedule through critical path and float puts variance into days rather than dollars and indicates seriousness of SVs

Scheduling tools illustrate project longest, or critical, path

- Driving relationships and Schedule float should also be indicated
- Helpful for tracing back through schedule to find driving activity

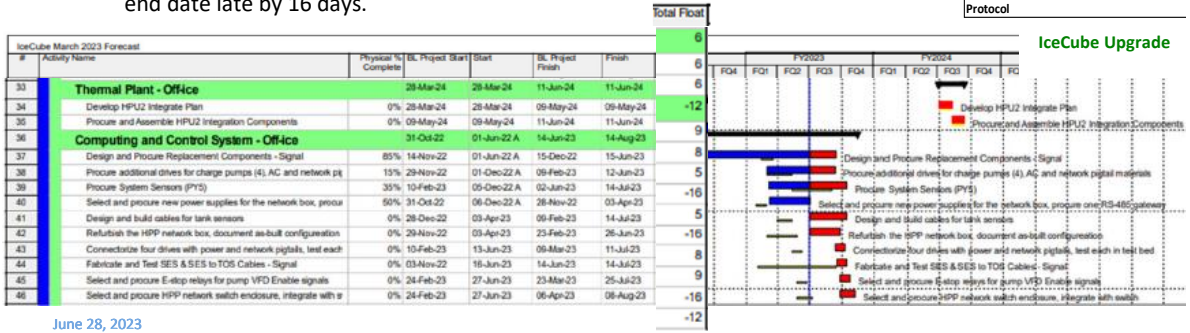
Milestone charts helps in analyzing potential scheduling problems

- From scheduling tool: Baseline dates, Current Forecast dates in the working schedule, Actual dates, Schedule Variance, and remaining Total Float
- Investigate slippage cause and determine whether an action is warranted

  Example 1: Slip of -4 weeks, but still have 31 days of float. So, could just accept the variance …. unless the slippage is going to continue and eventually threaten project end date.

  Example 2: No variance. But the planned and forecast dates will push the project end date late by 16 days.

Milestone /Activity Description (Brief Text) NICHE	WBS/Subsystem (Number)	Milestone Level	Planned Date (mm/dd/yyyy)	Actual Date/Forecasted Date (mm/dd/yyyy)	Variance (wks/mnths)	Total Float (days)
Final Design of WOPDT Complete	1.3.2.1	1	05/11/23	06/20/23 1	- 4 weeks	31 days
WOPDT Commissioning Complete	1.3.2.3	1	06/19/24	07/18/24	- 4 weeks	-20 days
NICHE Project Package Complete	1.8.1.2	1	10/30/25	11/14/25	- 2 weeks	-20 days
Preliminary Cost Estimate for NICHE Submitted	1.8.1.2	1	10/06/23	11/21/23	- 6 weeks	28 days
Science/Technical reqs for NICHE Complete	1.8.3.1	1	10/01/25	10/01/25 2	-	-16 days
Pre-FDR Ready Design of NICHE Complete	1.8.4.1	1	06/13/25	06/13/25	-	21 days
Preliminary machine design concept reviewed	1.8.4.1	2	07/03/23	07/03/23	-	281 days
OSU Upgrade Commissioned	1.3.3.2	2	08/09/23	10/11/23	- 9 weeks	189 days
NICHE WBS Complete	1.8.2.1	2	01/18/24	03/01/24	- 6 weeks	322 days
FIU Make-ready Complete	1.3.2.2	2	02/16/24	02/16/24	-	-20 days
WOPDT Installation complete	1.3.2.3	2	05/20/24	05/20/24	-	-20 days
CRC Requirements for NICHE Complete	1.5.1.1	2	10/23/24	12/20/24	-8 weeks	178 days
NICHE Site Selection Complete	1.8.1.1	2	09/24/24	09/24/24	-	168 days
SE plan for NICHE Complete	1.7.2.2	2	03/19/25	03/19/25	-	120 days
PDT Scale CFD Results Complete	1.4.8.2	2	03/25/25	03/31/25	- 1 week	53 days
Workforce Development Plan for NICHE Cc						
Descope #1 - Decision regarding Reduction Experiment						
Descope #2 - Decision regarding Reduction Simulations						
Descope #3 - Decision regarding Hybrid Sin Protocol						



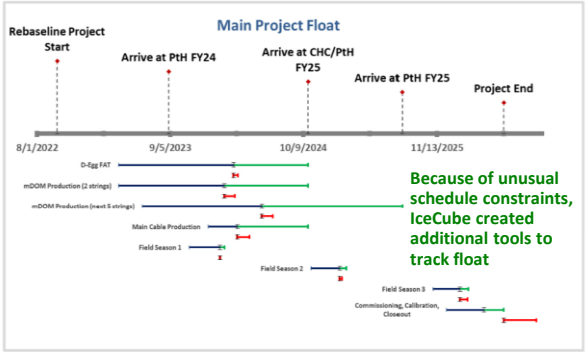


Figure 1 Critical Path dashboard for the IceCube Upgrade Project. Major efforts leading to the completion of the project are shown in the figure. Black lines represent the baseline schedule, red lines represent the additional time needed predicted by the schedule risk Monte Carlo at an 80% confidence level, and green lines represent the baseline float. The final milestone (commissioning, calibration, and closeout) determines the end of the project, and is therefore the critical path by definition.

PMM Step 3. Comparison and Analysis
Impacts on Contingency

Performance Measurements and Analysis
- Technical Variance
- Cost Variance
- Schedule variance
- Milestone status
- Trends and efficiencies
- Variance at Complete (VAC)

Takeaway: Track contingency usage against risk exposure and plan actions if contingency is inadequate.

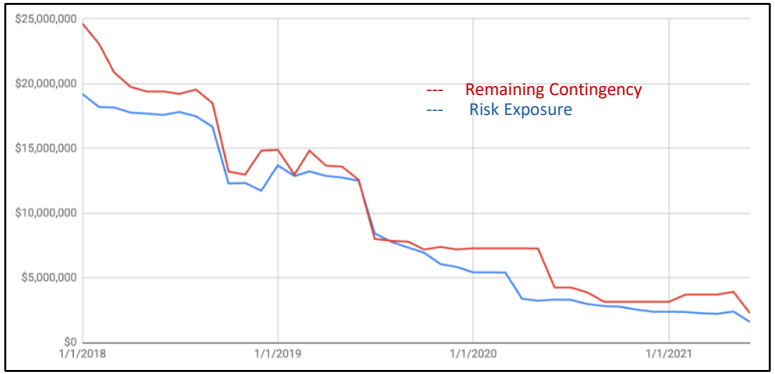
NSF allows/expects projects to use Contingencies to control risks, including mitigation activities and recovery from variances

- **Risk Exposure is used to set/validate Budget and Schedule contingency amounts**
  - Budget and Schedule Contingencies in the Total Project Cost and Schedule
    - Part of Total Project Cost and Duration but separate from baseline cost and schedule
    - Based on quantitative analysis of known risks and estimate uncertainties (Risk Exposure)
  - Scope Contingency can provide additional budget and schedule contingency
    - De-scoping of deliverables in the baseline frees up resources, budget, and schedule
    - Removal of scope entails some level of negative impact on project deliverables

Note: NSF does not allow Management Reserve, i.e., money or time included as part of the Total Project Cost to address unforeseen events or uncertainties that are beyond the control of the Recipient or agency.

- **Analyze Adequacy of Remaining Contingency Amounts**
  - Compare Remaining Cost Risk Exposure to statused Remaining Contingency
    - Burn down charts are a good way to do this
    - Risk Exposure should always be less than or equal to remaining contingency amounts
  - Check forecasted Project End Date against Baseline End Date plus schedule contingency or float
  - Check Budget Variance at Complete (VAC) against remaining budget contingency
  - Plan remedial actions to eliminate cost and schedule variances or to increase contingency amounts if any contingency is deficient

DKIST Cost Risk Burn Down Chart



Research Infrastructure Guide 4.2.5.8 Reporting Requirements
Projects are expected to periodically compute the estimate to complete (ETC) and estimate at completion (EAC) and compare the EAC to the Budget at Completion (BAC). At least annually, the project should update the remaining risk exposure to establish a risk-adjusted estimate at completion (RAEAC) for comparison to the TPC. The updated remaining risk exposure should be based on the quantitative risk analysis with current risks and uncertainties. NSF will monitor the financial information provided and compare the available contingency to the estimated remaining risk exposure. NSF may request a recovery plan if the contingency budget appears inadequate to manage remaining risk.

PMM Step 4. Management Deciding on Actions

Takeaway: Use EVM analysis to decide on corrective actions, including controlled changes to the Baseline .

Management Decisions
- Variance response actions
- Resource management
- Budget & Schedule Changes
- Scope/Quality Changes
- Contingency management
- Risk response/mitigation actions

Regardless of project size, effective project management requires executing corrective action plans to mitigate issues as soon as they are identified and tracking their resolutions to closure.

- **If action is required, determine responsibility**

  Technical leads and CAMs may be authorized to act for small variances. PM is responsible for cross work package actions and project level variances.

- **Consider the cause and consequences to determine whether to act or to accept the variances or risk impacts (i.e., do nothing)**
  - No-Action Example 1: Accept a variance

    A work package component cost $800 more than expected but is on schedule. The variance is only 1% of total work package cost. The CAM accepts the variance, assuming that on average, all components will come in on budget. The CAM will take future action if there is a trend for all components to be higher cost.
  - No-Action Example 2: Accept a temporary variance

    A vendor product has been delivered 3 weeks late. Monthly report shows a significant under budget cost variance. Investigations shows delay in receiving and paying invoice. Since project does not do accruals and item is not critical path, CAM accepts variances with expectation cost variance will resolve when invoice is paid.

- **Evaluate options and select best action that conserves resources**
  - Action Example 1: Manage resources

    A work package on the critical path shows a slip of one month, with investigation showing that slippage will continue. Amount of work was underestimated, and a key worker is on long term sick leave. Options to recover schedule include 1) asking existing team to work overtime, 2) hiring temporary workers, or 3) moving workers from a non-critical task in another work package. All involve some cost increase. PM decides to move workers from the other task, accepting its schedule variance. CAM is asked to reduce costs elsewhere in work package to cover cost.

These examples do not entail changes to the baseline = no change requests

- **Contingency usage and changes in scope involve Baseline changes**
  - Action Example 2: Cost and Schedule Contingency draw

    A risk has been realized: testing reveals a major component does not meet critical specs. The fix requires a significant cost increase, a delay of 3 months to achieve, and a delay of 2 months to the overall project end date. CAM submits a change request for review and approval to use $25K and 2 months of contingency. PM approves the change.
  - Action Example 2: Descoping with NSF Approval

    All work packages are slightly behind schedule and overbudget halfway through the project, resulting in unfavorable cumulative overall project variances, SPI, and CPI. Remaining contingency is just under the remaining risk exposure. The PM decides to execute an identified descope option, choosing one that recovers most of the cost and schedule and has the smallest impact on project goals. The PM writes a change request to execute the descope and use savings and some contingency draws to cover all major overruns. NSF approval is required for the change.
  - Action Example 3: Replenish contingencies

    Cost contingency drops significantly below risk exposure and schedule contingency is inadequate. PM takes steps to increase contingency back to acceptable levels. PM writes a change request to retrieve cost underruns from several work packages. Technical Leads and CAMs are asked to find ways to reduce costs by 5% in their work packages through value engineering or increased efficiencies and ways to reduce critical path by one month. A descope option is chosen, dropped from the baseline, and moved into upscope options. Cost and schedule savings are moved into contingencies.

Note: Examples above entail changes to the Baseline Plan and must follow Change Control Plan and Contingency Management Plan

PMM Step 4. Management
Change Control

Performance Measurement, Change Control, & Reporting

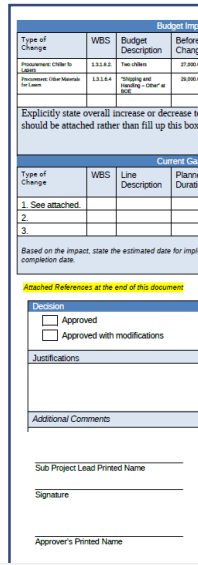
https://researchinfrastructureoutreach.com/knowledge-gateway/part-iii-mid-scale-project-performance-management/

Takeaway: Tailor change control documentation to project needs.

Management Decisions that change cost or schedule beyond set threshold limits, significant scope changes, and contingency usage all require documented and authorized change control.

Change Documentation requirements are negotiated by NSF at time of award

- The project Change Control Board (CCB) reviews and approves or rejects requests; NSF reviews and approves above thresholds (PM can be the authorizer in tailoring)
- NSF requires a Summary Change Log at a minimum for all projects (Can double as a simple Change Request Form for projects with few and uncomplicated changes)
  - Change control action title, document reference number, approval date,
  - Change amounts in budget, scope, and/or schedule, for each affected WBS element,
  - Any adjustments to contingency amounts,
  - WBS elements affected by the changes
  - Associated Risk Register ID number and description for the risk being addressed, and
  - NSF approval signature and date if required.
- Change Request Forms may be needed when NSF approval is required, and/or the complexity of the changes entail more involved explanations



Budget Impact: Yes No

Type of Change	WBS	Budget Description	Before Change	After Changes	Delta	Effort Hours	Additional Comments
Procurement: Chiller fo Lasers	1.3.1.6.1	Two chillers	27,000.00	30,277.53	3,277.53	0	8-10 weeks lead time + 2 procurement lasts
Procurement: Other Materials for Lasers	1.3.1.6.4	"Shipping and Handling – Other" at BOE	29,000.00	25,722.47	-3,277.53	0	

Explicitly state overall increase or decrease to sub-project budget. Long complicated BOEs and quotes should be attached rather than fill up this box.

Current Gantt Detail Change

Type of Change	WBS	Line Description	Planned Duration	Panned Baseline Start Date	Panned Baseline Finish Date	Effort Hours	Additional Comments
1. See attached.							
2.							
3.							

Based on the impact, state the estimated date for implementing the requested completion date.

Attached References at the end of this document

Decision
Approved
Approved with modifications
Justifications
Additional Comments
Sub Project Lead Printed Name
Date
Signature
Approver's Printed Name
Date

Change Request Form — Arecibo Change Request

BCR#AOR_P13.3_001_Rev3
BCR Title: AOR P13.3 Chillers Cost & Schedule Changes

Project Name	Lidar Lab Instrumentation	Date	09/08/2022
Project Number	AOR P13.3	Requestor	Luis Quintero
Project Manager	Luis Quintero	Project Owner	Luis Quintero

Summary Description: Include Technical, Budget and Schedule Impact)

Our engineering team initially selected the ThermoFlex 3500 water-cooled chiller with P2 pump. The purchase request was submitted, but the distributor (TEquipment) replied with very long lead times (delivery by March 2023).

After reviewing the chiller selection, we submitted a new quote request for an air-cooled unit with P1 pump, based on the Powerlite DLS 9000 series laser series datasheet (3kW cooling capacity & 1-2 GPM @ 10-40PSI pressure drop). Currently, we don't have a quote for the new selection.

The laser manufacturer recently recommended PolyScience as a chiller manufacturer and new requirements for the DLS 9050 laser (8kW cooling capacity & 2-3 GPM @ 10-40PSI pressure drop). We selected and received the quote for two Polyscience DCA3040I that satisfy the minimum requirements (10.5kW cooling capacity, 1.5 HP Bronze Turbine Pump). The lead time is 8-10 weeks and could be reduced once the order is placed.

Describe the Reason for the Request and Include any Risk

We estimated $27,000.00 for the two chillers, and the quote is for $27,154.73, including shipping. Sales tax is not included (11.5% for Puerto Rico). The new estimated total is $30,277.53 approximately. We are requesting a budget increase of $3,277.53.
We included $7k for Shipping and Handling – Other in line AOR-P13 3.1.5:MATE, task 1.3.1.6.4. Procurement: Other Materials for Lasers.

Technical Impact: [x] Yes [ ] No (Include a modification, performance impacts and new QA, etc)

The new selection will increase the cooling capability, originally estimated at 3.5kW per unit to 10.5kW per unit.

Schedule Impact: Yes No

Schedule Description with Before & After Changes	Finish Dates	Float for Sub-Projects	Impact on Milestones or on other Sub-Projects
1. See attached document. New planned finish 10Jan2023. Final reports starting 14Dec2022.			
2.			
3.			

Based on the impact, state the estimated date for implementing the requested change. State the new estimated project completion date.

Change Request Form 1

RIG References

2.4.1 Construction Award Management and Oversight
4.2.5-1 Sample of a Change Control Request Form, with instructions for filling out the various sections
6.2.11.2 Change Control for Contingencies
6.2.11.6 Documentation and Reporting of Contingency Use

Advanced LIGO Project - Change Control Log ($K)

ACR No	DCC No	Change Title	Originator	Impacted Subsystems	NSF Approval Required/ Obtained	Disposition	Cost Impact	Schedule Impact	Contingency Balance	Approved Budget	Total Project Cost	Change Description
090011	M0900160	DAQ Timing System	R. Bork	DAQ	N/A	Approved 6/12/09	$0	None to critical path	$37,208	$167,912	$205,120	A management decision has been made to have the Timing System work be performed by a contractor rather than CIT Labor, as originally planned. A small portion of the CIT labor was retained to provide support and guidance. This change documents that decision.
090012	M0900169	Staff Additions to DAQ, SUS & SYS	D. Coyne	DAQ, SUS, PM (SYS)	N/A	Approved 6/22/09	$605	None to critical path	$36,603	$168,517	$205,120	It has been determined that additional staffing is required by the DAQ, SUS and SYS subsystems in order to meet schedule commitments. This change request is for budget from reserve to pay for the additional staff.

PMM Step 4. Reporting

Takeaway: Include status, EVM analysis data, and actions taken in the monthly reports to NSF.

Periodic Reports
- Progress status and forecasts
- Variance reports /corrective actions
- Change requests/contingency use
- Risk response/mitigation actions

Contents and format of periodic reports will be negotiated between NSF and the Project post-award and be scaled to the project

- **Use the reports to communicate with sponsors – tell it like it is – no surprises**
- **After NSF makes an award, it wants a project to succeed – collaborates to make project successful**

Many of the reports, tables, and graphics generated during the EVM process will be used in the reports

(concentrating on EVM data here – see References for more detail)

Periodic Reports (monthly is typical)

Project management
- Project performance to date and for the reporting period, w.r.t. planned scope, budget, and schedule
- Milestone status report
- Risks/Issues of concern: threats, opportunities, and actions
- Charge requests and contingency usage/status
- Performance Measures (tailored EVM) report
- Variance reports and recovery plans
- Financials report: actuals, obligations, remaining budget, remaining contingency

Standard, well-defined reporting elements common to all projects: reported every period

Technical Progress
- Accomplishments per WBS L2 for the period
- Program Officer may specify content and format
- Always include photos for the PO to show and tell

Non-Standard reporting that varies over time and depends upon the specific project details

2.4 Top Level EVM Data Table and S Curves

EVM Status Report		$M	Description
EVM Reporting Date		Mar-23	
Total Project Cost (TPC)		21.38	Performance Baseline + Contingency
NSF Funding To-Date		3.83	Cumulative funding received to date
Budget at Completion (BAC)		16.74	Approved Budget
Planned Value ($M)		3.01	
Earned Value ($M)		2.15	
Actual Costs ($M)		2.53	
% Complete (Planned)		18.0%	PV/BAC*100%
% Complete (Actual)		12.8%	EV/BAC*100%
% Complete (Spent)		15.1%	AC/BAC*100%
Cost Variance (CV)		-0.38	EV-AC
Cost Performance Index (CPI)		0.85	EV/AC
Schedule Variance (SV)		-0.87	EV-PV
Schedule Performance Index (SPI)		0.71	EV/PV
Forecasts			
Estimate at Completion (EAC)	EAC$_t$	17.12	AC+(BAC-EV)
	EAC$_c$	26.71	AC+(BAC-EV)/(CPI*SPI)
Date of last EAC update		Mar-23	Date of last EAC update
Unencumbered Funds		4.64	TPC-BAC
Liens		N/A	Known costs, variances not in BAC
Budget Contingency		0.01	Unencumbered Funds - Liens
Estimate to Complete (ETC)		14.59	EAC$_t$-AC
		24.18	EAC$_c$-AC
% Budget Contingency of ETC		0.1%	(BC/ETC$_t$)*100%
		0.0%	(BC/ETC$_c$)*100%
Risk Exposure			
Risk Confidence Level		80%	
Critical Milestone Planned Date		2-Jun-2026	Planned Project end date
Critical Milestone Forecast Date		2-Jun-2026	Forecast Project End Date
Schedule Contingency		2 months	Based on (original) late finish date of MC (30-Jul-2026)

Table 3 Top level EVM data table.

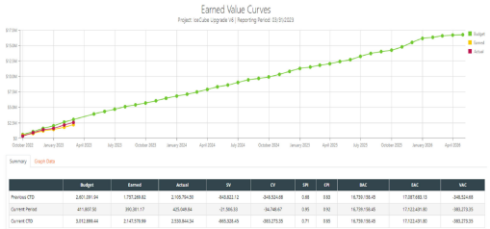


Figure 1 Cumulative earned value data as of March 31, 2023. On the Earned Value Curve graph, the green line shows the Planned Value, the yellow line is the Earned Value and the red line is the Actual Cost.

Detailed Format used for EVM reporting for IceCube

V.A. Table with Detailed EVM Data

<<Specify data reporting period, "Month ending, Month Day" and report all values in $K.>>

WBS L2/L3 Subsystem Description	Cumulative Planned Value	Cumulative Earned Value	Cumulative Actual Cost	CPI	SPI	BAC	EAC
<<X.X Insert Description Here>>							
<<X.X Insert Description Here>>							
Contingency							
Risk Adjusted Total Project Cost							

WBS L2/L3 Subsystem Description	Budgeted Cost ($X.XXM)	Cumulative Actual cost ($X.XXM)	Work % complete
<<X.X Insert Description Here>>			
<<X.X Insert Description Here>>			
<<X.X Insert Description Here>>			
<<X.X Insert Description Here>>			

Simple Format used for EVM reporting for NICHE

References

1. **NSF Midscale Webinar Series #3**

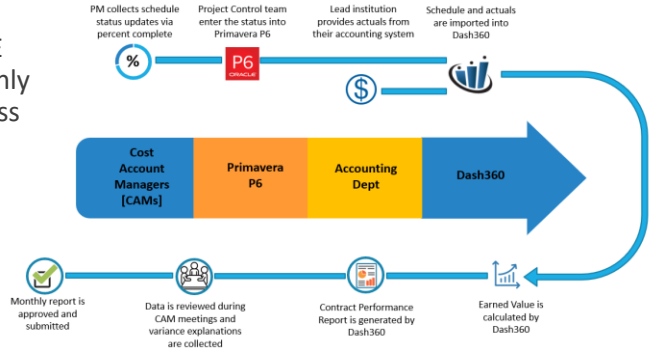
2. **RIG 4.2.5.8 *Reporting Requirements*** and **RIG 4.6.2 *Recipient Reporting Requirements*** for more details

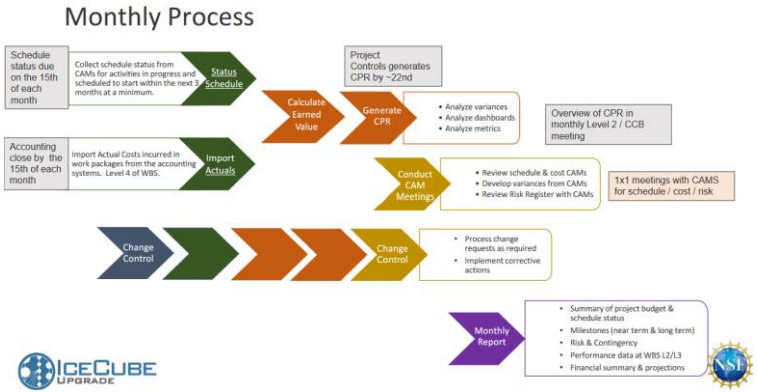
Summary

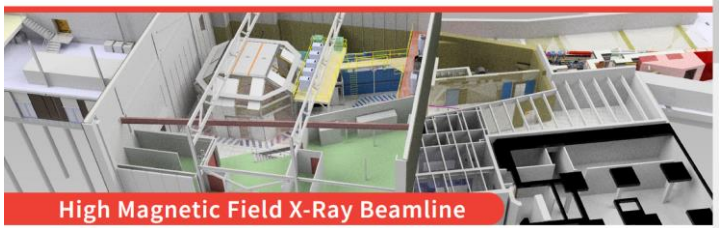
Takeaway: Tailor the PMM processes and tracking tools to be meaningful to the project team.

- **Defined Progress Tracking and Reporting techniques in PMM**
  - Necessary and beneficial for control and management of Midscale projects
  - You can't manage what you can't measure
- **Defined NSF PMM requirements and Scaled EVM**
  - EVM not required by NSF as PMM but scaled EVM strongly encouraged
- **Demonstrated the 3 steps** used to perform EVM during execution through examples
- **Key Take-aways**
  - Plan to implement scaled EVM if possible, modifying processes or substituting others when necessary
  - Match (scale) processes and tools to characteristics of project, institutions, and needs
  - Project Baseline must be set up to support selected EVM/PMM processes and tools
  - Example tools and methods used by current midscale projects can be adopted or adapted
  - Negotiate/collaborate with NSF on PMM processes and reports

NICHE Monthly Process







For those interested in an in-depth look at tools used in a mid-scale project, consider attending the next talk.

The High Magnetic Field (HMF) Project Execution Plan (PEP) as a Structured Document Built on a Platform of MS Project/ Excel/Word

Ernie Fontes, Technical Director, High Magnetic Field (HMF) X-ray Beamline Project, Cornell High Energy Synchrotron Source (CHESS)

Questions?

Note: Project managers from NICHE (Kerry Gonzales), IceCube (Vivian Odell), Arecibo Hurricane Repair (Carol Wilkinson), and ngGONG (Mark Warner) are here at RIW