IceCube Upgrade Earned Value Management System (EVMS)

Catherine Vakhnina, Project Controls Manager
WBS 1.1 Project Office

NSF Site Visit Review
March 17, 2020

IceCube Upgrade

Outline

- Project Management Control System (PMCS) Overview
- Earned Value Management L2 Role as a Control Account Manager
- Earned Value Management System (EVMS) Data Flow
- Earned Value Analysis Inputs and Sample Report
- Summary

Project Management Control System (PMCS) Overview

The PMCS is comprised of both software tools for development of the project databases and the processes and procedures needed to organize and manage the project.

The PMCS helps project stakeholders to:

- determine project status
- make a comparison of project status to the baseline plan
- manage the change process
- track Earned Value

PMCS Components

The Major Components of a PMCS are:

- Technical Document Database
- Detailed Cost Estimate Database
- Project Cost/Schedule Management Database
- Qualified Accounting System
- Change Control Board (CCB) Process

IceCube Upgrade Project Controls Overview*

*Many thanks Marek!

IceCube Upgrade Project Controls Overview*

Scope Management (Smartsheet.com)

- WBS Structure maintenance. (smartsheet.com => Upgrade Project Schedule Year 2)
- Cost Breakdown Structure (CBS) maintenance. (smartsheet.com => Cost Workbook Y2)

Cost Management tools

(smartsheet, excel, python etc)

- **Cost estimation** (smartsheet.com => Cost Workbook Y2, excel => in-house developed spreadsheets)
- **Cost Risk Estimation**. (excel and python-based Monte Carlo simulators and other in-house developed tools)
- **Cost Control** using **EVMS** system built in excel and used for reporting and diagnostics.

Schedule

- Schedule Updating (annual re-planning), Maintenance & Reporting, smartsheet.com => Upgrade Project Schedule Year 2, data fed into EVMS system and live dashboard (in smartsheet.com for L2 Managers).

Change Management

- Assistance in Change Assessment
- Schedule Change Assessment & Implementation
- Cost Change Assessment and Implementation

*Many thanks Marek!

Earned Value Management System - Roles

US Collaborators' Accounting

UW Accounting

Project Controls Manager

Scheduler

Project Stakeholders (PM, NSF, L2's)

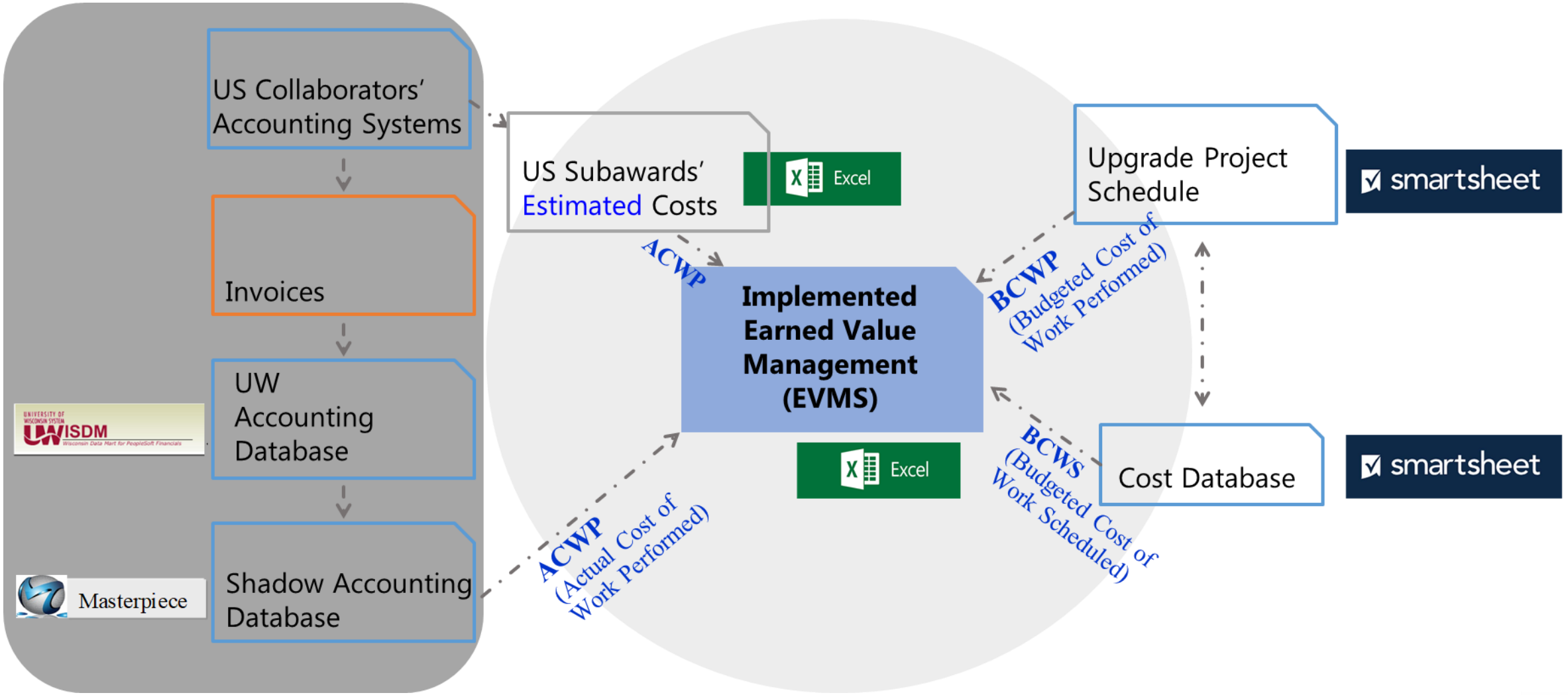
Earned Value Management (EVM)
L2 Role as a Control Account Manager (CAM)

- The L2 plays a critical role in an earned value management system
- L2 can manage multiple accounts
- L2 maintains responsibility for each individual control account (CA) that represents the work assigned to one responsible organizational entity (or integrated work team) for a single program WBS element
- L2 is responsible for the planning, coordination and achievement of all work within a CA and provides a single authority for all scope, technical and cost issues for the CA

Earned Value Management (EVM)
L2 Role as a Control Account Manager (CAM)

- Am I on schedule?
- How do I provide schedule status and changes to the project schedule?
- How are the budget and the schedule linked?
- What is my budget?
- How much have I spent to date and how does it compare to my baseline plan?
- What happens if I do not spend all my budget?
- When is a change request needed and how are change requests processed?

EVMS Data Flow



MS Excel

Used for:

- Actual cost information
- Performance and cost reporting
- Forecasting
- Primary EVM data reporting
- Earned value management
- Variance analysis and reporting

Not used for:

- Project scheduling

Accounting Database (Masterpiece)

Used for:

- Actual cost data
  - Actual Cost split by WBS and cost categories
  - Actual Hours split by WBS
  - Encumbrances (open work orders expected but not yet invoiced)

Not used for:

- Earned value management

Cost and Performance Reporting

Internal Reports
↓
Project Management

- Performance is reviewed monthly at the weekly WBS Level 2 Manager / Change Control Board teleconference meetings.

External Reports
↓
NSF

- Performance reports including progress as measured by earned value are provided monthly.
- Annual summary reports with extrapolated (one-month) cost, schedule and earned value information.

Earned Value Management System

EVMS:

- Is used to track NSF-funded activities only
- Provides early performance problem identification
- Improves financial reporting
- Management tool
- Communication tool

EVMS Does Not:

- Recognize Critical Paths
- Take management action

Planned Value (PV) or Budgeted Cost of Work Scheduled (BCWS)

The project is loaded with resources which results in an allocated spend plan – planned value (PV):

WBS	NAME	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	PY3	PY4	PY5
1.1	PROJECT MANAGEMENT	$ 101,973	$ 106,869	$ 126,346	$ 111,765	$ 101,973	$ 138,280	$ 101,973	$ 143,895	$ 111,765	$ 119,415	$ 101,973	$ 101,973	$ 1,307,190	$ 1,373,187	$ 1,359,715
1.2	ICECUBE UPGRADE DRILL	$ 158,849	$ 422,742	$ 294,648	$ 202,549	$ 158,726	$ 137,430	$ 394,489	$ 261,248	$ 363,258	$ 427,061	$ 1,102,032	$ 289,461	$ 1,872,423	$ 1,683,306	$ 1,618,314
1.3	DEEP ICE SENSOR MODULES	$ 39,336	$ 50,127	$ 29,082	$ 25,773	$ 10,204	$ 19,925	$ 47,300	$ 74,252	$ 47,866	$ 49,271	$ 37,520	$ 14,362	$ 159,811	$ 42,978	$ -
1.4	COMMS, POWER, AND TIMING (CPT) DISTRIBUTION SYSTEM	$ 138,423	$ 44,885	$ 41,461	$ 39,646	$ 35,990	$ 64,597	$ 61,312	$ 68,526	$ 51,103	$ 44,822	$ 39,930	$ 27,544	$ 658,543	$ 49,397	$ 28,572
1.5	CHARACTERIZATION AND CALIBRATION SYSTEM	$ 5,327	$ 559	$ 10,759	$ 2,242	$ 559	$ 559	$ 559	$ 559	$ 5,417	$ 10,185	$ -	$ -	$ 30,162	$ 125,437	$ 130,412
1.6	M&O DATA SYSTEMS INTEGRATION	$ 31,349	$ 27,830	$ 27,830	$ 27,830	$ 27,830	$ 38,900	$ 33,392	$ 27,830	$ 27,830	$ 27,830	$ 37,830	$ 27,830	$ 148,390	$ 211,327	$ 94,562
	Total Budgeted Cost	**475,256**	**653,012**	**530,126**	**409,806**	**335,282**	**399,691**	**639,025**	**576,309**	**607,239**	**678,583**	**1,319,286**	**461,170**	**4,176,519**	**3,485,633**	**3,231,575**

Actual Cost (AC) or Actual Cost of Work Performed (ACWP)

Actual cost is entered and includes open commitments such as unpaid invoices for materials and equipment:

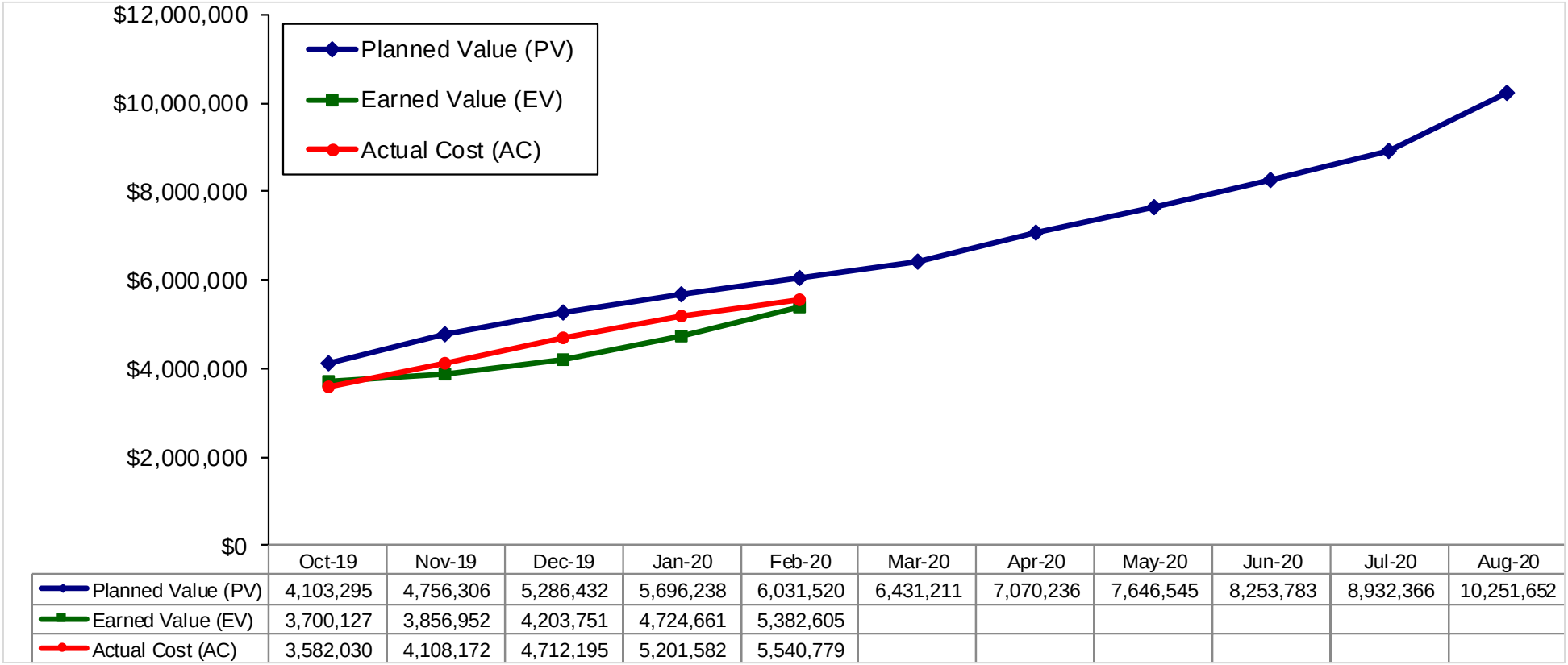
Actual Cost (AC) of Work Performed		PY2												
WBS	WBS Name	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Total
1.1	PROJECT MANAGEMENT	153,026	138,707	125,048	129,953	60,866								1,483,705
1.2	ICECUBE UPGRADE DRILL	280,874	264,872	380,949	250,436	169,428								2,926,515
1.3	DEEP ICE SENSOR MODULES	40,605	36,319	29,747	37,759	38,803								345,292
1.4	COMMS, POWER, AND TIMING (CPT) DISTRIBU	36,503	43,214	33,428	36,067	41,500								482,129
1.5	CHARACTERIZATION AND CALIBRATION SYSTE	11,598	5,897	9,192	7,194	6,061								77,467
1.6	M&O DATA SYSTEMS INTEGRATION	67,539	37,134	25,659	27,978	22,539								225,672
Insert new rows above this one														5,540,779
	Total Actual Cost	590,144	526,143	604,023	489,386	339,197								
	Cumulative Actual Cost (AC)	3,582,030	4,108,172	4,712,195	5,201,582	5,540,779								

Earned Value (EV) or Budgeted Cost of Work Performed (BCWP)

Progress is reported by L2 managers at the lowest level for each of the scheduled activities and then rolled up to WBS L2:

Cumulative Earned Value (EV)		PY2											
WBS	WBS Name	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20
1.1	PROJECT MANAGEMENT	21.05%	17.91%	19.51%	21.57%	23.59%							
1.2	ICECUBE UPGRADE DRILL	13.76%	16.30%	18.04%	20.95%	24.01%							
1.3	DEEP ICE SENSOR MODULES	31.20%	32.28%	32.78%	35.02%	40.11%							
1.4	COMMS, POWER, AND TIMING (CPT) DIS	17.47%	19.46%	21.27%	22.90%	28.70%							
1.5	CHARACTERIZATION AND CALIBRATION	10.41%	10.41%	11.05%	11.69%	14.33%							
1.6	M&O DATA SYSTEMS INTEGRATION	14.39%	16.17%	17.71%	19.28%	21.11%							
		3,700,127	3,856,952	4,203,751	4,724,661	5,382,605							
		148,383	156,825	346,799	520,910	657,944							

Earned Value Analysis Sample Report
as of February 29, 2020



	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20
Planned Value (PV)	4,103,295	4,756,306	5,286,432	5,696,238	6,031,520	6,431,211	7,070,236	7,646,545	8,253,783	8,932,366	10,251,652
Earned Value (EV)	3,700,127	3,856,952	4,203,751	4,724,661	5,382,605						
Actual Cost (AC)	3,582,030	4,108,172	4,712,195	5,201,582	5,540,779						

Earned Value Variance Report by WBS L1 / L2
as of February 29, 2020

	WBS Earned Value Variance Report as of February 29, 2020												
	CURRENT PERIOD					CUMULATIVE TO DATE					AT COMPLETION		
WBS L1/L2	PLANNED	EARNED	ACTUAL	SV	CV	PLANNED	EARNED	ACTUAL	SV	CV	BAC	EAC	VAC
1.0	335,282	657,944	339,197	322,662	318,747	6,031,520	5,382,605	5,540,779	-648,915	-158,174	21,606,549	22,241,482	-634,934
1.1	101,973	122,800	60,866	20,826	61,934	1,219,828	1,434,082	1,483,705	214,254	-49,622	6,079,196	6,289,549	-210,352
1.2	158,726	332,631	169,428	173,905	163,203	2,721,268	2,609,957	2,926,515	-111,311	-316,558	10,870,291	12,188,734	-1,318,443
1.3	10,204	64,151	38,803	53,946	25,347	767,043	505,518	345,292	-261,526	160,226	1,260,329	860,862	399,467
1.4	35,990	107,110	41,500	71,120	65,610	752,380	530,010	482,129	-222,369	47,881	1,846,725	1,679,894	166,832
1.5	559	9,411	6,061	8,852	3,349	53,185	51,083	77,467	-2,102	-26,384	356,473	540,590	-184,117
1.6	27,830	21,842	22,539	-5,988	-697	517,816	251,955	225,672	-265,861	26,283	1,193,534	1,069,028	124,506

Earned Value Management Reporting Aids Management Decisions

The project office reviews the following items on a monthly basis:

- CPI/SPI trends
- Variances and variance analysis and corrective actions
- Estimates at completion
- Project personnel and staffing
- Project baseline change actions
- Risk strategies

Summary

- EVMS tools and approach tailored to project scale and complexity
- Project Management and Controls Systems (PMCS) is adapted to meet project needs
- Bottom-up baseline cost and schedule were developed and fully support the project scope of work
- Monthly reporting presents up-to-date Cost and Performance

Presenter's Background

- IceCube Upgrade Project Controls Manager
- IceCube Maintenance and Operations Resource Coordinator
- 9+ years with IceCube Collaboration (2010-present)
- CMB PolarBear Project Control & Systems Manager (2015-2016)
- 12+ years of financial & project management experience in academia and private industry
- Master of Business Administration (MBA) degree (2008)
- Project Management Professional (PMP), license No. 1820230 (2015)
- Member of Project Management Institute, PMI (2014–present)

Supplemental Material

Additional Earned Value Management related materials for reference

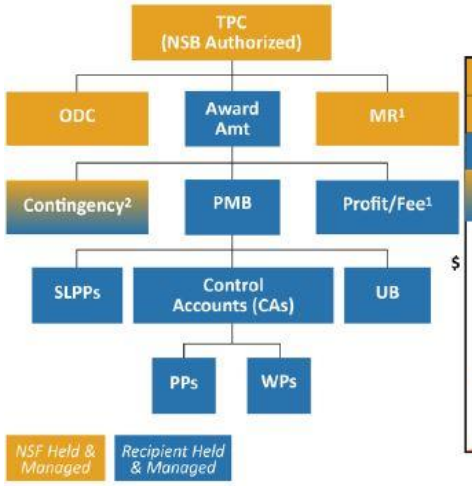
Earned Value Tracking

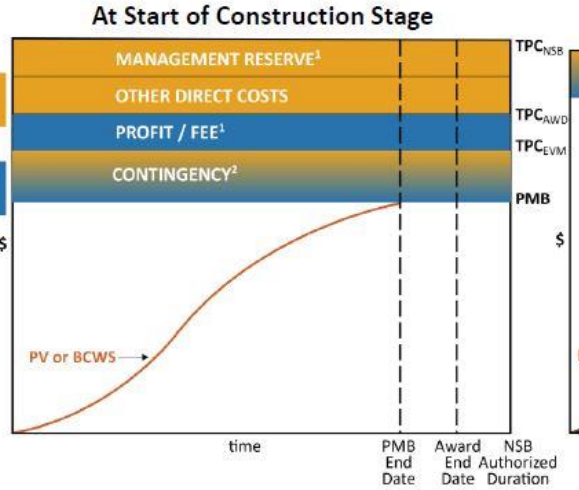
Earned Value (EV) based performance measurement systems
“Link Expenditures to accomplishments”

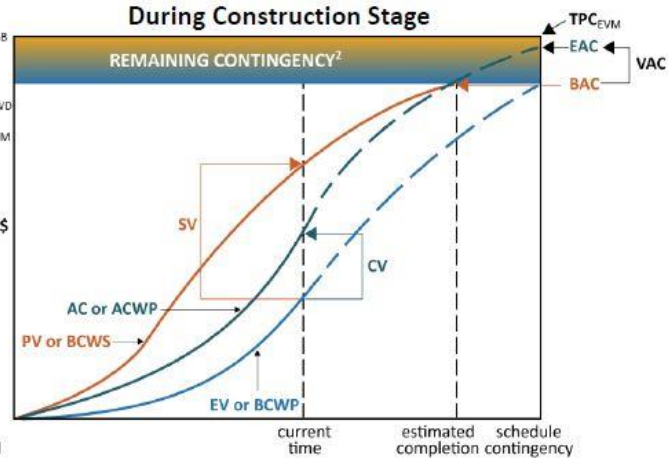
Earned Value Management System

Initiating	Planning	Executing	Monitoring & Controlling	Closing
				
	• Planning when and howto use EVM • Determine acceptable variance to schedule and budget baselines • Baselines approved	• Communicate schedule and budget status to stakeholders • Distribute reports	• Perform EVM • Analyze data and variances • Forecast • Change requests • Re-estimate	

NSF Major Facilities Earned Value Management Gold Card







COMPONENTS

CA	=	Control Account = WPs + PPs
MR	=	Management Reserve is held by NSF
ODC	=	Other Direct Costs
PMB	=	Performance Measurement Baseline = CAs + UB + SLPPs = BAC
PP	=	Planning Package (far-term activities within a CA)
SLPP	=	Summary Level Planning Package
TPC_{NSB}	=	Total Project Cost (NSB authorized)
TPC_{AWD}	=	Award Amount to Recipient (PMB + contingency + profit/fee)
TPC_{EVM}	=	Total Project Cost managed by Recipient (PMB + contingency)
UB	=	Undistributed Budget (activities not yet distributed to CA)
WP	=	Work Package (near-term, detail-planned activities within a CA)

EVMS BASIC COMPONENTS

AC	=	Actual Cost	= ACWP	= Actual Cost of Work Performed
EV	=	Earned Value	= BCWP	= Budgeted Cost for Work Performed
PV	=	Planned Value	= BCWS	= Budgeted Cost for Work Scheduled
BAC	=	Budget at Completion	= $\sum$BCWS	= Sum of Budgeted Cost for Work Scheduled
EAC	=	Estimate at Completion	= ACWP + ETC	
ETC	=	Estimated cost of remaining work (WR)		

VARIANCES

CV[3]	=	EV – AC	=	BCWP – ACWP	= Cost Variance
SV[3]	=	EV – PV	=	BCWP – BCWS	= Schedule Variance
CV%	=	(EV – AC) / EV	=	(BCWP– ACWP) / BCWP	= Cost Variance %
SV%	=	(EV – PV) / PV	=	(BCWP– BCWS) / BCWS	= Schedule Variance %
VAC	=	BAC – EAC			= Variance at Completion

OVERALL STATUS

% scheduled	=	PV_{cum}/BAC	= $BCWS_{cum}/BAC$
% complete	=	EV_{cum}/BAC	= $BCWP_{cum}/BAC$
% budget spent	=	AC_{cum}/BAC	= $ACWP_{cum}/BAC$
Work Remaining (WR)	=	$BAC – EV_{cum}$	= $BAC – BCWP_{cum}$

PERFORMANCE INDICES *(Favorable is >1.0, unfavorable is <1.0)*

CPI	=	EV / AC	= BCWP / ACWP	= Cost Performance Index
SPI	=	EV / PV	= BCWP / BCWS	= Schedule Performance Index
$TCPI_{EAC}$	=	$WR / (EAC – AC_{cum})$	= EAC-based To Complete Performance Index	

ESTIMATE AT COMPLETION FORMULAE

EAC	=	BAC / CPI_{cum}	= Estimate at Completion (general)
EAC_{CPIcum}	=	$AC_{cum} + WR/CPI_{cum}$	= Estimate at Completion (CPI)
$EAC_{composite}$	=	$AC_{cum} + WR/(CPI_{cum} * SPI_{cum})$	= Estimate at Completion (composite)

Notes:
[1] If authorized as part of TPC.
[2] During execution, contingency moves into the PMB per change control process.
[3] Favorable > 0, Unfavorable < 0

NSF Major Facilities Earned Value Management Gold Card

EVMS Measurement Terminology

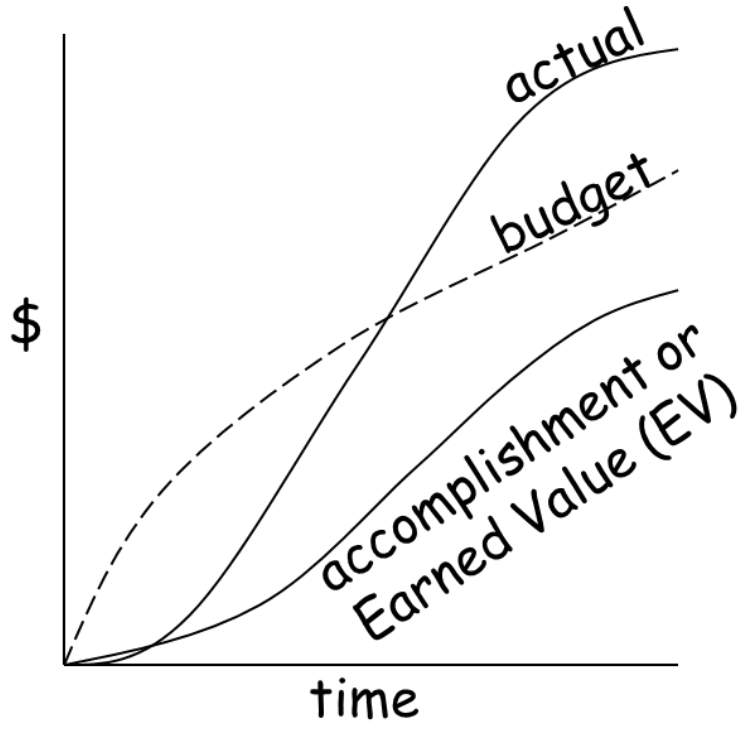
- **Budget at Completion (BAC)**
  - The sum of the total budget for a work package, major task, or project.
- **Planned Value (PV)**
  - The scheduled cost based on the allocation cost items such as resources and material during the timeline of an activity
  - Also called *Budgeted Cost for Work Scheduled (BCWS)*
- **Earned Value (EV)**
  - The value of the work performed to-date using any reasonably accurate, mutually acceptable methodology for determining value (i.e.; 0/100%, 50/50%, 30/40/40, ratio of units completed versus total units, manager estimate, level of effort, being some examples).
  - Also called *Budgeted Cost for Work Performed (BCWP)*
- **Actual Cost (AC)**
  - Total incurred costs charged to a work package by the organization's accounting system, which can include labor costs, direct costs (overhead), and indirect costs (material, travel, and etc.)
  - Also called *Actual Cost for Work Performed (ACWP)*

These values are used to calculate performance.

EVMS Performance Terminology

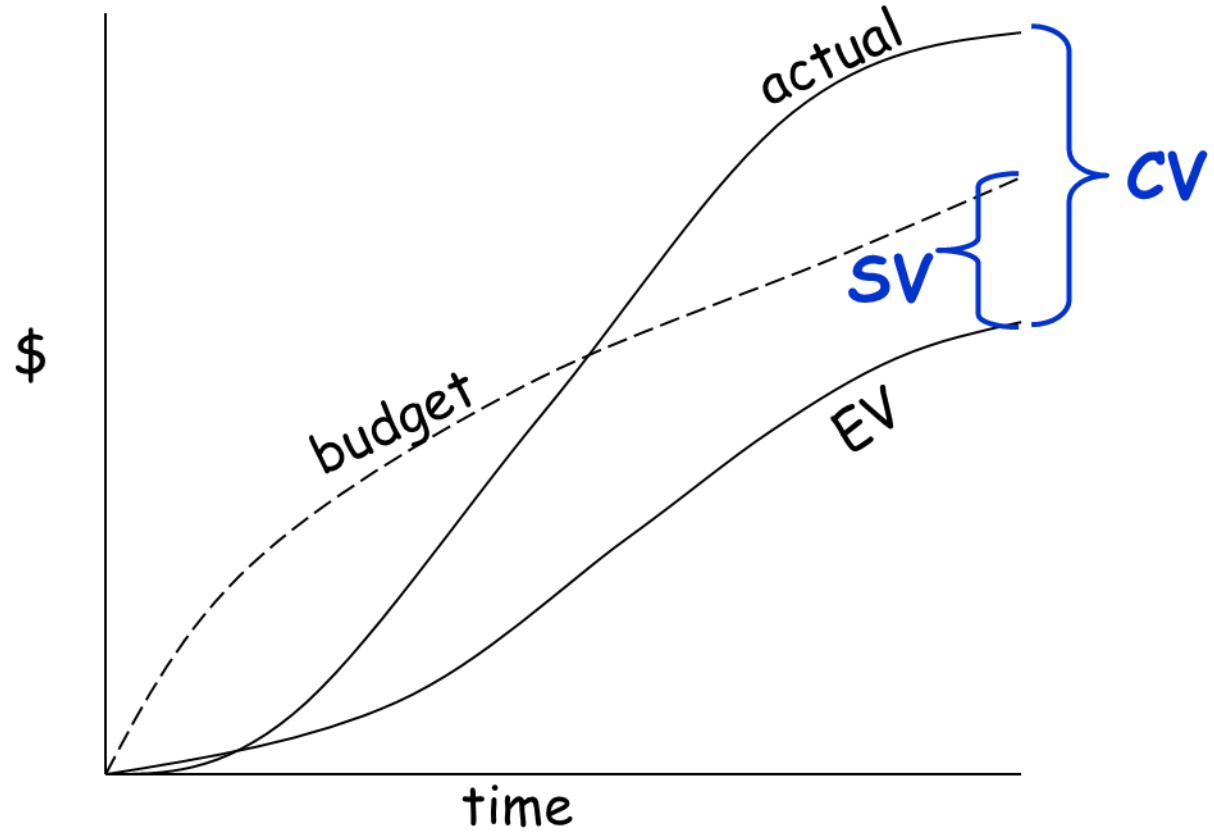
- **Cost Variance (CV)**
  - CV = EV – AV = BCWP – ACWP
- **Cost Performance Index (CPI)**
  - The cost efficiency ratio of earned value to actual costs (CPI = EV/AV)
  - In PMPlan, the CPI is used to calculate **Estimate at Completion (EAC)** (EAC = BAC/CPI)
- **Schedule Variance (SV)**
  - SV = EV – PV = BCWP – BCWS
- **Schedule Performance Index (SPI)**
  - The schedule efficiency ratio of earned value accomplished against planned value (SPI = EV/PV). The SPI describes what portion of the planned schedule was actually accomplished.
- **Variance at Completion (VAC)**
  - The predicted magnitude of possible underrun or overrun at completion of work package, major task, or project (VAC = BAC – EAC)

Earned Value Management System (EVMS)



- Plan all project work
- Objectively assess progress at the performance level
- Accomplished work is from planned tasks progressed
- The budgeted cost of the work quantifies the amount of accomplishment
- Summarize data for progressively higher levels of project management
- Analyze significant deviations form the baseline plan
- Forecast impacts on cost and schedule
- Maintain the baseline

Earned Value Management System (EVMS)



- Cost Variance (CV)

  CV=EV-Actual

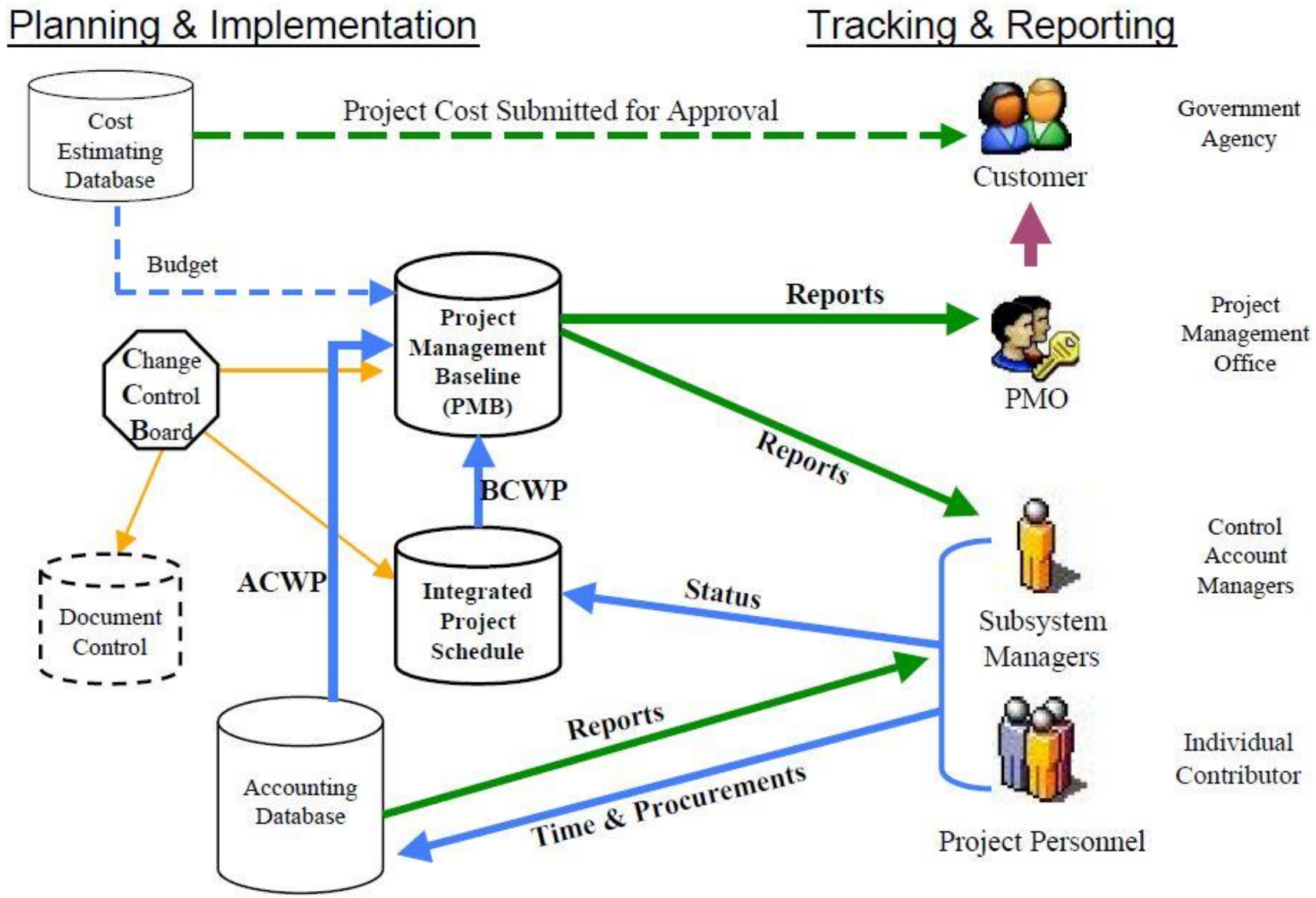
- Favorable or unfavorable

- Schedule Variance (SV)

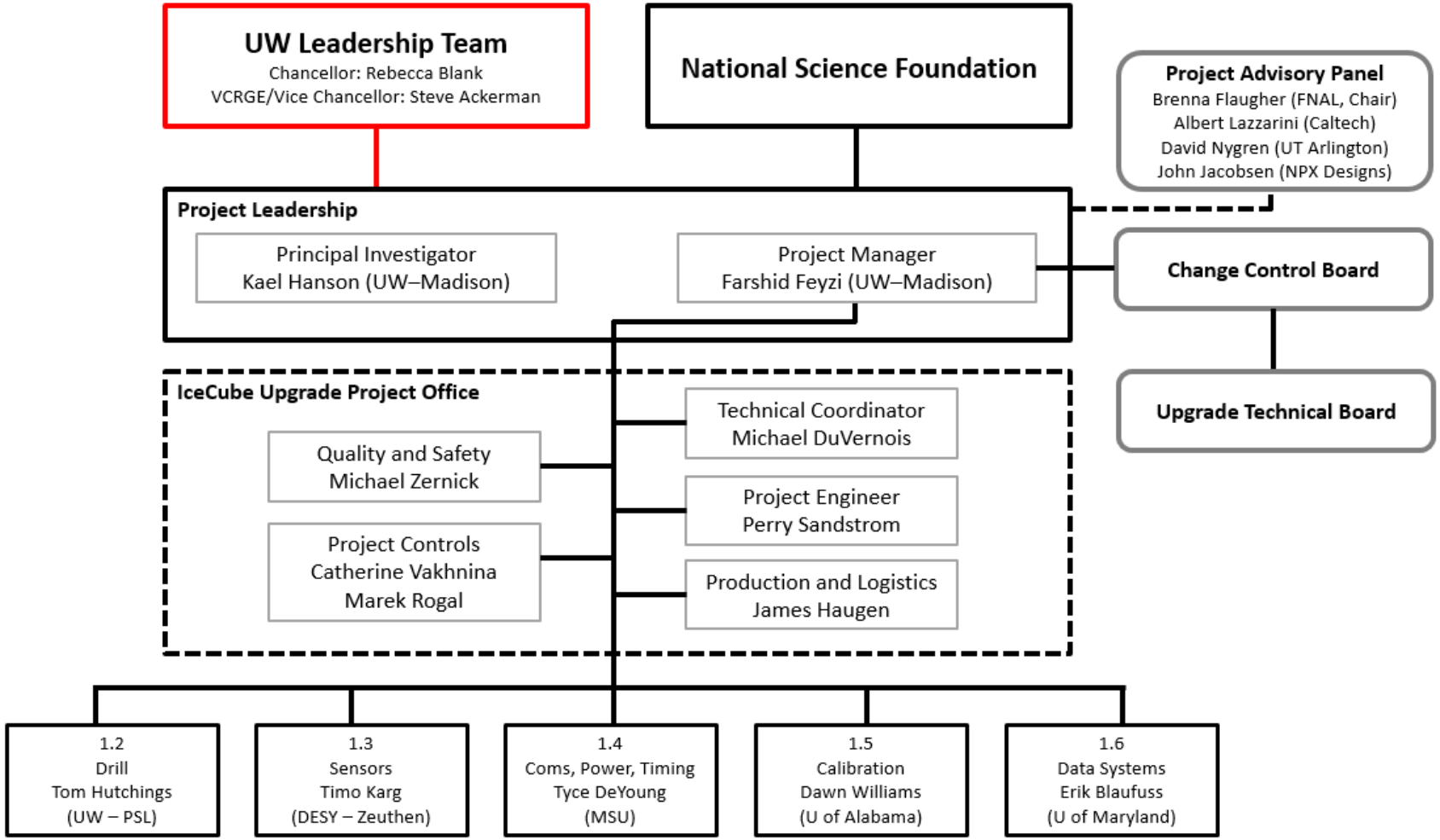
  SV = EV – Budget (Planned)

- Ahead or behind

IceCube Gen-1 PMCS Overview



Project Office and Level 2 Organization



Level 3 Organization