



National Aeronautics and
Space Administration

MSFC-HDBK-3684

REVISION A

EFFECTIVE DATE: September 25, 2017

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

CS40

MSFC TECHNICAL STANDARD

**PROJECT PLANNING
AND
CONTROL HANDBOOK**

Approved for Public Release; Distribution Unlimited

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 2 of 230

DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Cancelled)	Document Revision	Effective Date	Description
Baseline		02/26/2013	Baseline Release. Document is authorized through MPDMS.
Revision	A	09/25/2017	<p>Revision A Release. The purpose of this revision is to update outdated references and material.</p> <p>In regards to Configuration/Data Management the word “Change Management” replaced “Configuration Data Management”. Change Management is a better description of the PP&C discipline whereas “Configuration Data Management speaks more of an organization.</p> <p>For the MSFC/NASA Project Life-Cycle discussions the information was updated to align with the latest revision of MPR 7120.1, <i>MSFC Engineering and Program/Project Management Requirements</i>.</p> <p>In the WBS sections the WBS Dictionary discussion was updated to align with the current WBS Data Requirements Description (DRD).</p> <p>In the Cost Estimating sections updates were made to align with the latest versions the NASA Cost Estimating Handbook and NPR 7120.5E, NASA Space Flight Program and Project Management Requirements.</p> <p>In the Contract and Acquisition sections updates were made to align with the current Federal Acquisition Regulations (FAR) such as changing the P-Card value from \$3,000 to \$3,500. Also references to the Source Evaluation Committee (SEC) was deleted to align with the latest version of MWI 5115.2, <i>Procurement Development Team (PDT) & Source Evaluation Board (SEB)</i>.</p> <p>Updated the Accounting sections to capture the current business systems in use such as “BOBJ” and “CGE”.</p> <p>For the EVM discussions the information was updated to reflect the current NASA requirements and Federal Regulations. Also, information was updated to reflect the current Data Requirements Descriptions such as replacing “CPR” with “IPMR”. Analysis tools references were updated such as replacing “wInsight” with “Empower”.</p> <p>Finally, information for Category 3/Class D Flight Projects was added to address a Program/Project Management Advisory Council (PPMAC) action item.</p> <p>Governance sections were updated to reflect current Center Council’s charters and information was added on Agency councils.</p> <p>The PP&C Training section was updated to reflect the current courses being offered.</p>

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MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 3 of 230

TABLE OF CONTENTS

<u>PARAGRAPH</u>	<u>PAGE</u>
1. Introduction	11
1.1 Background and Purpose	11
1.2 Scope	12
1.3 Reference Documents	14
2. Relationship of PP&C to the Project and Mission Support Life-Cycles	15
2.1 The MSFC/NASA Project Life-Cycle	15
2.1.1 Project Formulation.....	15
2.1.2 Pre-Phase A: Concept Studies	15
2.1.3 Phase A: Concept and Technology Development (TD)	16
2.1.4 Phase B: Preliminary Design and Technology Completion.....	17
2.1.5 Approval for Implementation	17
2.1.6 Project Implementation	17
2.1.7 Phase C: Final Design and Fabrication.....	17
2.1.8 Phase D: System Assembly, Integration, Test, Launch, and Checkout	17
2.1.9 Phase E: Operations and Sustainment	18
2.1.10 Phase F: Closeout.....	18
2.2 The MSFC/NASA Mission Support Life-Cycle	18
3. Project Planning & Control (PP&C) Disciplines/Relationships	18
3.1 Project Planning & Control (PP&C) Overview and Description.....	18
3.1.1 Effective Project Planning & Control (PP&C) Functions and Attributes.....	20
3.1.2 Knowledge, Skills, and Abilities	20
3.1.3 Characteristics of Project Planning & Control (PP&C) Team Members.....	21
3.2 The Role of the Project Work Breakdown Structure (WBS) in Planning and Organizing Project and Institutional Work	22
3.2.1 Work Breakdown Structure (WBS)	22
3.2.2 Work Breakdown Structure (WBS) Coding: NASA Structure Management (NSM) System	24
3.2.3 Preparing Work Breakdown Structure (WBS) Element Tree Diagrams	26
3.2.4 Work Breakdown Structure (WBS) Dictionary.....	27
3.2.5 Work Breakdown Structure (WBS) and the Project Life-Cycle.....	29
3.2.6 Integrating the Work Breakdown Structure (WBS), Organization Breakdown Structure (OBS) and Responsibility Assignment Matrix (RAM).....	30
3.2.6.1 Organization Breakdown Structure (OBS)	30
3.2.6.2 Responsibility Assignment Matrix (RAM).....	30
3.2.6.3 Control Account (CA)—Intersection of Work Breakdown Structure (WBS) and Organization Breakdown Structure (OBS)	31

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 4 of 230

3.3	Planning and Scheduling.....	32
3.3.1	Scheduling Methodology	34
3.3.2	Schedule Management Tool Considerations	34
3.3.3	Pre-Schedule Development Activities.....	35
3.3.3.1	Project Scope and the Integrated Master Schedule (IMS).....	35
3.3.4	Schedule Basis of Estimate (BOE)	36
3.3.4.1	The Basis of Estimate (BOE) Process	36
3.3.5	Schedule Levels within the Integrated Master Schedule (IMS).....	39
3.3.5.1	Integrated Master Schedule (IMS) Development.....	39
3.3.5.2	Top Level Project Schedules	39
3.3.5.3	Intermediate Level Project Schedules	40
3.3.5.4	Detailed Level Project Schedules	41
3.3.6	Resource Loading the Integrated Master Schedule (IMS)	42
3.3.7	Status Updates and Schedule Maintenance	45
3.3.7.1	Schedule Update Methodology.....	45
3.3.7.2	Schedule Maintenance	46
3.3.8	Schedule Control.....	47
3.4	Cost Estimating.....	50
3.4.1	Introduction.....	50
3.4.2	Cost Estimating Process	50
3.4.3	Cost Estimating Methods	52
3.4.4	Basis of Estimate (BOE).....	55
3.4.5	Joint Cost Schedule Confidence Level (JCL)	55
3.5	Contract Management Overview.....	56
3.5.1	Contract Considerations.....	57
3.5.2	Acquisition Planning Phase.....	58
3.5.3	Solicitation and Award Phase.....	61
3.5.4	Contract Management Phase	61
3.5.4.1	Integrated Baseline Review (IBR).....	62
3.5.4.2	Earned Value Management System (EVMS) Surveillance	62
3.5.4.3	Contract Closeout/Termination	63
3.6	Work Authorization (WA)/Collaborative Work Plan (CWP)	63
3.6.1	Work Authorization (WA) Process	63
3.6.2	Collaborative Work Plan (CWP) Process	67
3.6.3	Intra-Agency and External Work Agreements.....	69
3.7	Budget Development and Execution	70
3.7.1	Federal Budget	70
3.7.2	Agency Budget.....	72
3.7.3	Planning, Programming, Budgeting & Execution (PPBE)	73
3.7.4	Center Budget.....	75
3.7.5	Program/Project/Mission Support Budget.....	77
3.7.5.1	Initial Project Budget Development	77

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 5 of 230

3.7.5.2	Mission Support Budget Planning	78
3.7.5.3	Budget Formulation and Traceability	78
3.7.5.4	Project Budget Reviews	79
3.7.6	Strategic Workforce Planning (SWP)	80
3.7.7	Project Reserve Management	82
3.7.8	Funds Management	83
3.8	Risk Management.....	85
3.8.1	Risk Management Tools	88
3.8.2	Integrating Earned Value Management (EVM) with Risk Management.....	88
3.8.3	Project Planning & Control (PP&C) Roles and Responsibilities in Risk Management ..	89
3.9	Configuration Management (CM), Data Management (DM) and Change Management	90
3.9.1	Configuration Management (CM) and Data Management (DM).....	90
3.9.2	Project Change Management.....	90
3.9.3	Re-Planning.....	92
3.9.4	Re-Baselining.....	92
3.9.5	Project Planning & Control (PP&C) Roles in Configuration Management (CM) and Change Management:	92
3.10	Earned Value Management (EVM).....	93
3.10.1	Introduction and Requirements.....	93
3.10.1.1	Earned Value Management (EVM) Overview.....	94
3.10.1.2	NASA/MSFC Earned Value Management (EVM) Requirements	96
3.10.2	Earned Value Management (EVM) Implementation on MSFC Contracts	98
3.10.2.1	Project Planning & Control (PP&C) Earned Value Management (EVM) Involvement Prior to Contract Award.....	98
3.10.2.2	Contract Performance Management and Reporting	98
3.10.2.3	Work Breakdown Structure (WBS) and Reporting	99
3.10.2.4	Schedule Management and Reporting.....	100
3.10.2.5	Contractor/NASA Management Reviews	100
3.10.2.6	Project Planning & Control (PP&C) Earned Value Management (EVM) Involvement Post Contract Award	100
3.10.2.7	Contractor Earned Value Management System (EVMS) Validation.....	101
3.10.2.8	Contractor Earned Value Management System (EVMS) Surveillance.....	101
3.10.2.9	Contractor Integrated Baseline Review (IBR)	101
3.10.2.10	Conduct Earned Value Management (EVM) Analysis on Contractor Data	102
3.10.3	Earned Value Management (EVM) Implementation on MSFC In-House Projects.....	103
3.10.3.1	In-House Performance Measurement Baseline (PMB) and Integrated Baseline Review (IBR).....	107
3.10.4	Establishing the Proper Earned Value Management (EVM) Analysis Tools	108
3.10.5	Project Planning & Control (PP&C) Responsibilities in Earned Value Management (EVM):.....	108
3.11	Business Tools.....	109
3.11.1	Business Systems/Tools and Interfaces.....	109

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 6 of 230

3.11.2	Accounting and Indirect Cost Management	111
3.12	Project Planning & Control (PP&C) Analysis and Reporting.....	113
3.12.1	Performance Analysis	115
3.12.1.1	Cost Analysis.....	116
3.12.1.2	Plan vs. Actuals	116
3.12.1.3	Workforce Analysis	118
3.12.1.4	NASA Form (NF) 533 Analysis	119
3.12.2	Establishing Variance Thresholds, Explanations, and Corrective Action Plans.....	121
3.12.3	Schedule Analysis and Reporting	122
3.12.3.1	Schedule Analysis	123
3.12.3.1.1	Schedule Health Check	123
3.12.3.1.2	Critical Path Analysis.....	125
3.12.3.1.3	Schedule Performance Trend Analysis	126
3.12.3.1.4	Baseline vs. Current Forecast Milestone Comparison	128
3.12.3.1.5	Schedule Baseline Analysis	129
3.12.3.1.6	Schedule Risk Analysis (SRA).....	131
3.12.3.2	Schedule Reporting	132
3.12.3.2.1	Program Integrated Master Schedule (PIMS) Report	132
3.12.3.2.2	Project Integrated Master Schedule Report.....	133
3.12.3.2.3	Critical Path Narrative and Analysis Report	133
3.12.3.2.4	Milestone Variance Report	133
3.12.3.2.5	Schedule Margin Metrics Report.....	134
3.12.3.2.6	Schedule Trend Reports	135
3.12.4	Earned Value Management (EVM) Analysis.....	136
3.12.4.1	Integrated Program Management Report (IPMR).....	137
3.12.4.2	Earned Value Management (EVM) Metrics	137
3.12.4.2.1	Cost Variance (CV).....	138
3.12.4.2.2	Schedule Variance (SV).....	138
3.12.4.2.3	Variance at Completion (VAC)	138
3.12.4.2.4	Earned Value Management (EVM) Reports and Trend Analysis	138
3.12.4.2.5	Earned Value Management (EVM) Analysis Charts	140
3.12.5	Estimate at Completion (EAC)	142
3.12.5.1	Estimate at Completion (EAC) Revision	143
3.12.5.2	Comprehensive Estimate at Completion (EAC)	143
3.12.5.3	Routine Estimate at Completion (EAC)	143
3.12.5.4	Developing the new Estimate at Completion (EAC)	143
3.12.5.5	Estimate at Completion (EAC) Analysis without Earned Value Management (EVM) Data.....	144
3.12.5.5.1	NASA Form (NF) 533-Based Estimate at Completion (EAC)	144
3.12.5.5.2	Development of an Integrated Cost/Schedule/Metric System (ICSMS) That Works in a Dynamic Development Environment	144
3.12.5.6	Estimate at Completion (EAC) Analysis Using Earned Value Management (EVM) Data	172
3.12.5.6.1	Estimate at Completion (EAC) Validity.....	172
3.12.6	Performance Reporting at Center Governing Councils and Related Committees	174

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 7 of 230

3.12.6.1	Strategic Planning Council (SPC)	175
3.12.6.2	Center Management Council (CMC)	175
3.12.6.3	Integrated Management Systems Council (IMSC)	176
3.12.6.4	Other Center Reporting	177
3.12.6.4.1	Monthly Performance Reviews (MPRs)	177
3.12.6.4.2	Institutional Performance Review (IPR) Executive Presentation.....	177
3.12.6.4.3	Smartbooks.....	178
3.12.6.5	Agency Governance.....	179
3.12.6.5.1	Executive Council (EC)	180
3.12.6.5.2	Agency Program Management Council (APMC).....	180
3.12.6.5.3	Mission Support Council (MSC).....	180
3.12.6.6	Other Agency Governance Forums	181
3.12.6.6.1	Senior Management Council (SMC).....	181
3.12.6.6.2	Partnership Council (PC)	181
3.12.6.6.3	Directorate Program Management Council (DPMC)	181
3.12.6.6.4	Agency Baseline Performance Review (BPR).....	181
4.	Project Planning & Control (PP&C) Training	182
4.1	Training Overview	182
4.2	Training Courses	182
4.3	Project Planning & Control (PP&C) Training Topics	186
5.	Project Planning & Control (PP&C) Points of Contact	189
5.1	Organizational References	189
5.2	Electronic links to reference materials	190

APPENDICIES

A	Acronyms.....	191
B	Glossary of Terms	196
C	Contract Types and Agreements.....	207
D	Schedule Assessment Checklist.....	214
E	Earned Value Management (EVM) Guidelines.....	215
F	NASA Standard Level 2 Work Breakdown Structure (WBS)	218
G	Project Planning & Control (PP&C) Key Questions.....	223
H	Earned Value Management (EVM) for Small Cat 3 Projects	226

TABLES

I.	Project Control Contract Reporting Requirements Example	62
II.	Training Courses at MSFC	188

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 8 of 230

FIGURES

1.	Business Management Functions at MSFC.....	12
2.	MSFC Project Life-Cycle.....	15
3.	WBS Levels.....	23
4.	NSM – Project Level.....	24
5.	Partial Project WBS Element Tree.....	26
6.	Sample Project WBS Dictionary.....	27
7.	WBS Development and the Project Life-Cycle.....	28
8.	OBS (Partial).....	29
9.	RAM.....	30
10.	WBS/OBS Integration and CAs.....	32
11.	BOE Development Process Flow.....	37
12.	Sample BOE Format.....	38
13.	Top Level Schedule.....	40
14.	Intermediate Level Schedule.....	42
15.	Detail Schedule with Interdependencies.....	44
16.	IMS Resource Pool.....	45
17.	Resource Loading the Schedule.....	46
18.	Managing Resource Allocations through Resource Loading.....	47
19.	CR Form.....	51
20.	Cost Methodology Process.....	53
21.	Parametric Cost Estimating Process.....	56
22.	Development of Engineering Buildup Estimate.....	56
23.	JCL Simulation Calculation.....	58
24.	Project WA Trail.....	67
25.	Project WAD.....	68
26.	CWP Process Flow Diagram.....	71
27.	Federal Budget Process.....	73
28.	NASA Annual PPBE Phases and Steps.....	75
29.	Budget Horizon.....	76
30.	MSFC Budget Process Integrated into PPBE.....	77
31.	Budget Review Process.....	81
32.	Strategic Workforce Portfolio Planning.....	83
33.	SWP Planning Integrated with Yearly PPBE Process Cycle.....	84
34.	Current Workforce Mission Portfolio Approach.....	85
35.	Budget UFE and MR.....	86
36.	Example Risk Classification Chart.....	88
37.	MSFC Mission Support and Project Risk Reporting.....	90
38.	Integrating EVM and Risk Management.....	92
39.	PMB.....	97
40.	Project Performance Insight Using EVM.....	98
41.	MSFC Project Life-Cycle Relationships and EVM Application.....	100
42.	EVM Compliance Thresholds.....	100
43.	Contract WBS Extension Below Level Three.....	103
44.	NASA EVMS Architecture.....	107
45.	CAP.....	109

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 9 of 230

46.	CA and WP Identification within the IMS	110
47.	Business System Interfaces	113
48.	NASA Accounting System.....	115
49.	Types of Analysis Review Data	117
50.	Budget vs. Actual Costs.....	118
51.	Budget vs. Actual Costs vs. Schedule Status.....	119
52.	Obligation Plan	120
53.	Cost Plan.....	121
54.	Workforce Analysis.....	122
55.	NF 533 Monthly Report	123
56.	Sample Variance Analysis Thresholds	124
57.	Example TPM for Mass.....	124
58.	Schedule Health Check.....	128
59.	Schedule Assessment Summary Report – Logic Relationship Types.....	129
60.	Identifying the Schedule’s Critical Path.....	130
61.	Schedule Performance Trend.....	131
62.	Schedule Baseline vs. Actual Finishes Trend.....	132
63.	Project Milestone Status	133
64.	Summary Level Cost / Schedule Correlation	134
65.	BEI.....	135
66.	Probabilistic SRA	136
67.	Milestone Variance Report.....	138
68.	Schedule Margin Tracking Report	139
69.	Work-off Trend Analysis.....	140
70.	EVM Formulas	142
71.	EVM Performance Trends.....	143
72.	CV, SV and VAC	144
73.	6-Month EVM Metrics Summary.....	145
74.	Top Variances in Empower	146
75.	Hardware Tree Selection Process	149
76.	Development Project Template	150
77.	Design & Development Process Major Milestones.....	151
78.	Typical System Hardware Test Article Template	152
79.	Test Article Definitions	153
80.	Tests Conducted During the EM and Qualification Phases	154
81.	Example Ku-band Subsystem Milestone Schedule	155
82.	Example Drawing Releases and Nonstandard Specification Releases.....	156
83.	Cost Plan Overlaid with Schedule/Metrics.....	157
84.	Engineering Expected Cost/Schedule Relationships.....	158
85.	Manufacturing/Purchases Expected Cost/Schedule Relationships.....	159
86.	Functional Costing Plan.....	160
87.	Current Cost/Schedule Plan Versus Baseline Plan.....	161
88.	Actual Work Accomplished per Baseline Plan	161
89.	Determining SPI	162
90.	Determining CPI.....	162
91.	Ku-Band Example	163

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 10 of 230

92.	Drift Charts	164
93.	Mitigation Option: Use of EM for Early Qual Testing	164
94.	Mitigation Option: Early Build of Qual Article	165
95.	Mitigation Option: Early Build and Use of Protoflight Article.....	166
96.	Mitigation Option: Reduce or Eliminate Qual Test.....	166
97.	Impact of Constrained Funding on Fixed and Variable Costs.....	167
98.	Status of Ku-Band Subsystem Cost and Schedule	168
99.	Baseline Cost Plan in Constant Year Dollars	168
100.	Baseline Plan in Fixed and Variable Costs.....	169
101.	Constrained Years' Fixed and Variable Costs.....	170
102.	Computing Schedule Loss	170
103.	Filled in Back End	171
104.	Filled in Middle	171
105.	Conversion to Real Year Dollars.....	172
106.	Schedule Issues with Capped Funding	172
107.	Variations in Full (Loaded) Cost for Different Labor Categories	173
108.	Overhead Rates Vary Between Corporate Divisions	174
109.	Non-critical Subsystem Matrix.....	175
110.	EAC Comparison.....	177
111.	EAC Using EVM Statistical Data	177
112.	Center Governance Framework.....	179
113.	CMC Smartbook Examples	183
114.	IMSC Smartbook Examples	184
115.	MSFC BPR Example.....	185
116.	Business Management Functions Utilized by MSFC Projects	194
117.	Schedule Assessment Checklist.....	219
118.	Space Flight Project Standard WBS	223
119.	Technology Development Project Standard WBS	226
120.	Research and Technology Standard WBS.....	229

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 11 of 230

1. Introduction

1.1 Background and Purpose

The goal of the National Aeronautics and Space Administration (NASA) Marshall Space Flight Center (MSFC) executive management is to achieve the greatest success possible in the execution of MSFC programs and projects. Success is measured as safe project execution, while meeting or exceeding technical quality objectives, within cost and schedule budget commitments. The Program Planning and Control (PP&C) discipline can contribute to project success through detailed programmatic and mission support analysis and the communication of analytical results to the project manager and other stakeholders responsible for making project decisions. Other ways that PP&C analysts can contribute to project success include:

- a. Help those in the management chain to better understand and utilize analytical results to predict future outcomes and influence risk mitigation decisions.
- b. Share data, include and collaborate with all organizations and disciplines supporting the project to ensure optimum communication exchange.
- c. Work with supervisors and other members within the PP&C community to seek ways to learn and share knowledge, with a goal of continuous professional improvement.
- d. Maintain an awareness of daily technical events within the project that might impact cost and schedule baselines, and/or project risk. Help project co-workers to better understand the interrelationships between technical and programmatic events and how this communication and awareness can positively impact project success.

Proper integration and analysis of such programmatic and mission support data may alter decisions that would have been made in the absence of such inputs. The reader of this handbook should look for the data interactions associated within the various discipline discussions and also look for opportunities to question events that occur over time that might have a current or future impact.

This handbook is intended to support the PP&C analyst’s job of being involved in a host of activities, led by various disciplines, and to distill and define information in programmatic and mission support terms. This handbook is also intended to serve as a “how-to” and reference guide for PP&C analysts supporting a project or mission support organization. In addition to published information, this handbook identifies MSFC organizations with resident subject matter expertise that PP&C analysts may contact for additional information and assistance. Finally, this handbook is intended to highlight the programmatic and mission support interfaces, inputs and outputs of the many functions and disciplines that support MSFC programs, projects, and mission support activities, and show how this programmatic data can be used to support quantitative and qualitative analysis.

The ultimate goal of analysis is to provide management with timely information to assess performance and support decision making. A key objective for PP&C analysts is to determine the current technical and quality performance of project or mission support activities relative to cost and schedule, and use performance trends and identified risks to draw conclusions on future performance expectations. This data will help analysts assist the management team in answering key questions such as when the program/project/activity will finish and how much it will cost; and in the case of the projected over-runs, determine the amount of technical content that should be removed from the project, or the amount of reserves that should be utilized, to meet budget, schedule, and minimum success criteria.

Mission support analysis and strategic planning is critical to ensure that MSFC is providing the optimum workforce, facilities, and infrastructure required for current and future Center projects, and to identify and mitigate cross-cutting risks to mission success.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 12 of 230

Managing the development and operations of the Center’s missions with limited resources is one of the most significant challenges facing MSFC today. The result of effective project management and mission support execution is the delivery and successful completion of the program/project/activity within the specified limits of cost, schedule, technical, and risk management. The manager for the given area is responsible for the outcome, and is closely supported by a deputy manager, a Chief Engineer (and possibly a lead systems engineer, etc.), a Chief Safety Officer, and a project business manager (or Project Control manager, PP&C Manager, etc.). These leaders must work very closely together, such that all are aware of any changes in the technical, schedule, or cost baseline; proposed and agreed to project scope changes; proposed or agreed to risks and associated actions; etc. MSFC-HDBK 3173, *Project Management and Systems Engineering Handbook*, was developed to provide guidance and best practices for the project management and systems engineering disciplines. This companion handbook provides PP&C guidance and best practices for the business discipline (including project and mission support). In the context of this handbook, the “PP&C Team” and the “Business Team” are considered one and the same. The term “Mission Support”, as used in this handbook, includes all of MSFC, with the exception of the project directorates, and “Institutional Support” is the subset of Mission Support that is Center Management and Operations (CMO)-funded.

1.2 Scope

Many of the Project Planning & Control (PP&C) principles and practices described in this handbook apply to both programs and projects; however, the emphasis of this handbook is to describe the processes necessary for project and mission support business management.

The MSFC Associate Director is the executive sponsor for the PP&C process. The Office of Strategic Analysis and Communications (OSAC) is the overall PP&C process owner, with discipline expertise residing throughout MSFC (See Figure 1). Additional mission support and project PP&C oversight is provided by the Business Management Committee (BMC) (See MSFC Charter, MC-22, *MSFC Business Management Committee*). Project PP&C oversight is also provided by the MSFC Program/Project Management Advisory Committee (PPMAC) (See MSFC Charter, MC-38, *Program/Project Management Advisory Committee*).

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 13 of 230

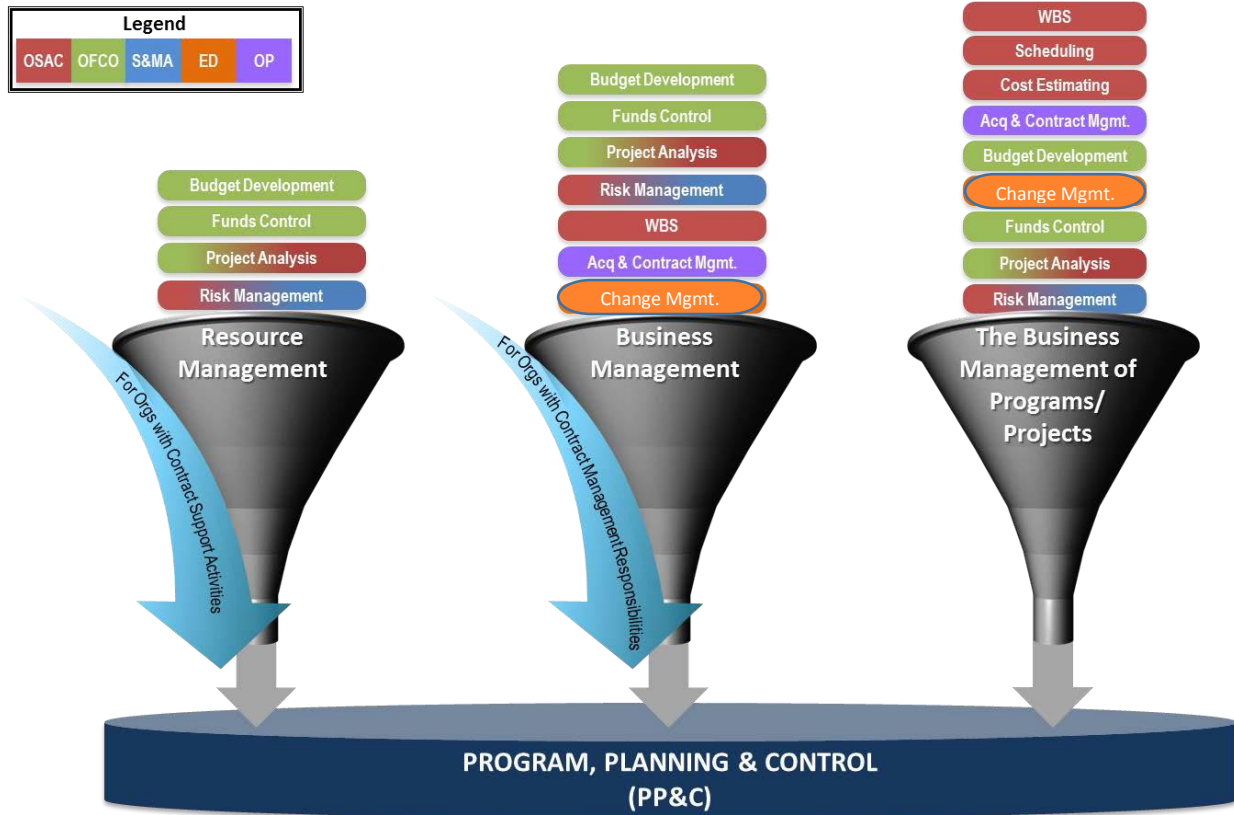


FIGURE 1. Business Management Functions at MSFC

Figure 1 Legend Acronyms

- Office of Strategic Analysis and Communication (OSAC)
- Office of Chief Financial Officer (OCFO)
- Safety & Mission Assurance (S&MA)
- Engineering Directorate (ED)
- Office of Procurement (OP)

Note: There are many disciplines/functions that comprise PP&C, with subject matter expertise located in various organizations throughout MSFC.

This handbook describes contemporary practices and policies employed at MSFC in project and mission support business management organizations for the following: schedule and budget development and execution; financial accountability; Earned Value Management (EVM); workforce assessment; programmatic analysis and reporting; and the technical, quality, risk, and change management aspects affecting PP&C. This handbook is not intended to be a specification, but rather should be used as guidance based on best practices in the programmatic execution of projects and Center-provided mission support. It may also serve to orient newcomers and outsiders to the PP&C processes used at MSFC in the development and management of space systems and associated infrastructure, and the Center’s mission support functions. While all process activities and general guidance are addressed, a project manager (PM), working with their business and technical support, may adapt or customize implementation to the specific needs of the project consistent with project size, complexity, criticality, and risk.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 14 of 230

1.3 Reference Documents

The following documents influence this handbook to the extent specified in the text. Within the text of this handbook, reference to the applicable documents is by basic number only. The current revision is applicable unless a specific revision is specified.

Type/Number	Title
OMB Circular A-11, Appendix	Principles of Budgeting for Capital Asset Acquisitions
NPD 1050.1	Authority to Enter into Space Act Agreements
NID 9090.1	Reimbursable Agreements
NPR 1441.1	NASA Records Management Program Requirements
NPR 7120.5	NASA Space Flight Program and Project Management Requirements
NPR 7120.7	NASA Information Technology and Institutional Infrastructure Program and Project Management Requirements
NPR 7120.8	NASA Research and Technology Program and Project Management Requirements
NPR 8000.4	Agency Risk Management Procedural Requirements
NPR 8800.15	Real Estate Management Program
NPR 9060.1	Cost Accruals
NPR 9420.1	Budget Formulation
NPR 9470.1	Budget Execution
NPR 9501.2	NASA Contractor Financial Management Reporting
NRRS 1441.1	NASA Records Retention Schedules
NFS 1834.2	Earned Value Management System
MPD 1150.1	Establishment of Councils, Boards and Committees
MPD 2800.1	Management of Information Technology and Services at MSFC
MPR 1440.2	MSFC Records Management Program
MPR 7120.1	MSFC Engineering and Program/Project Management Requirements
MPR 7120.4	MSFC Center Management Council (CMC) Process
MPR 7123.1	MSFC Systems Engineering Processes and Requirements
MPR 8000.4	Mission Support Risk Management
MWI 5100.1	Initiating Procurement Requisitions
MWI 5113.1	Government-Wide Commercial Purchase Card Operating Procedures
MWI 5115.2	Procurement Development Team (PDT) & Source Evaluation Board (SEB)
MWI 7120.6	Program, Project and Institutional Risk Management
NASA-HDBK	NASA 2008 Cost Estimating Handbook
NASA SD	NASA EVM System Description
NASA/SP-2010-3403	NASA Schedule Management Handbook
NASA/SP-2010-3404	NASA Work Breakdown Structure Handbook
NASA/SP-2010-3406	NASA Integrated Baseline Review Handbook
NASA/SP-2010-576	NASA Risk-Informed Decision Making Handbook
NASA/SP-2012-599	NASA EVM Implementation Handbook
MSFC-HDBK-3173	Project Management and Systems Engineering Handbook
MSFC-STD-555	MSFC Engineering Documentation Standard
EIA 748	Earned Value Management Systems
MC-08	Marshall Space Flight Center Charter, MSFC Center Management Council
MC-21	Marshall Space Flight Center Charter, MSFC Integrated Management Systems Council
MC-22	Marshall Space Flight Center Charter, MSFC Business Management Committee

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 15 of 230

MC-25	Marshall Space Flight Center Charter, MSFC Strategic Planning Council
MC-38	Marshall Space Flight Center Charter, Program/Project Management Advisory Committee
RS01-OI-006	Collaborative Work Plan (CWP) Process and Requirements Handbook (Organizational Issuance from the MSFC Office of the Chief Financial Officer.)

2.0 Relationship of PP&C to the Project and Mission Support Life-Cycles

2.1 The MSFC/NASA Project Life-Cycle

MSFC projects vary significantly in scope, complexity, cost, and criticality; however, all have a life-cycle that begins by maturing a concept into a specific scope and set of requirements that define the project deliverable. These requirements typically drive a design phase that leads to product fabrication, integration, and testing. Many project products culminate into space flight and operational systems. Other products may be basic or applied research results, or a deliverable technology development end-item for further development, or eventual incorporation into space flight operational systems. NASA Headquarters is organized into major mission and support directorates that manage portfolios of programs and supporting projects. MSFC work ranges from very large space flight projects to much smaller research and technology development projects, each following specific life-cycles. MSFC work also include MSFC managed efforts in support of projects that are managed at other Centers. These efforts are referred to as Mission Type 4 or 5 Activities. These activities follow a simplified, streamlined set of life-cycle requirements and report to MSFC governance on their implementation of the requirement flowed down to them from their parent project at the other Center.

The project life-cycle management process receives oversight from a Governing Project Management Council (GPMC). Depending on the project size and complexity, the GPMC may be the MSFC Center Management Council (CMC), a MSFC project directorate, an Agency Mission Directorate, or the Agency Program Management Council.

After initial project authorization approval is granted, projects formalize their life-cycle phases, life-cycle gates, and major events such as key project reviews. MSFC single-project programs and space flight projects follow the project life-cycle and its associated decision gates and major events as shown in Figure 2. Each type will follow the associated requirements as specified in Marshall Procedural Requirements (MPR) 7120.1, *MSFC Engineering and Program/Project Management Requirements*.

A Key Decision Point (KDP) is the point at which the Decision Authority (DA) determines the readiness of a project to progress to the next phase of the life-cycle. KDPs for projects are labeled with capital letters (e.g., KDP A). Transition to a subsequent phase occurs immediately following KDP approval except for transition from Phase D to E where transition occurs after on orbit checkout and initial operations.

2.1.1 Project Formulation

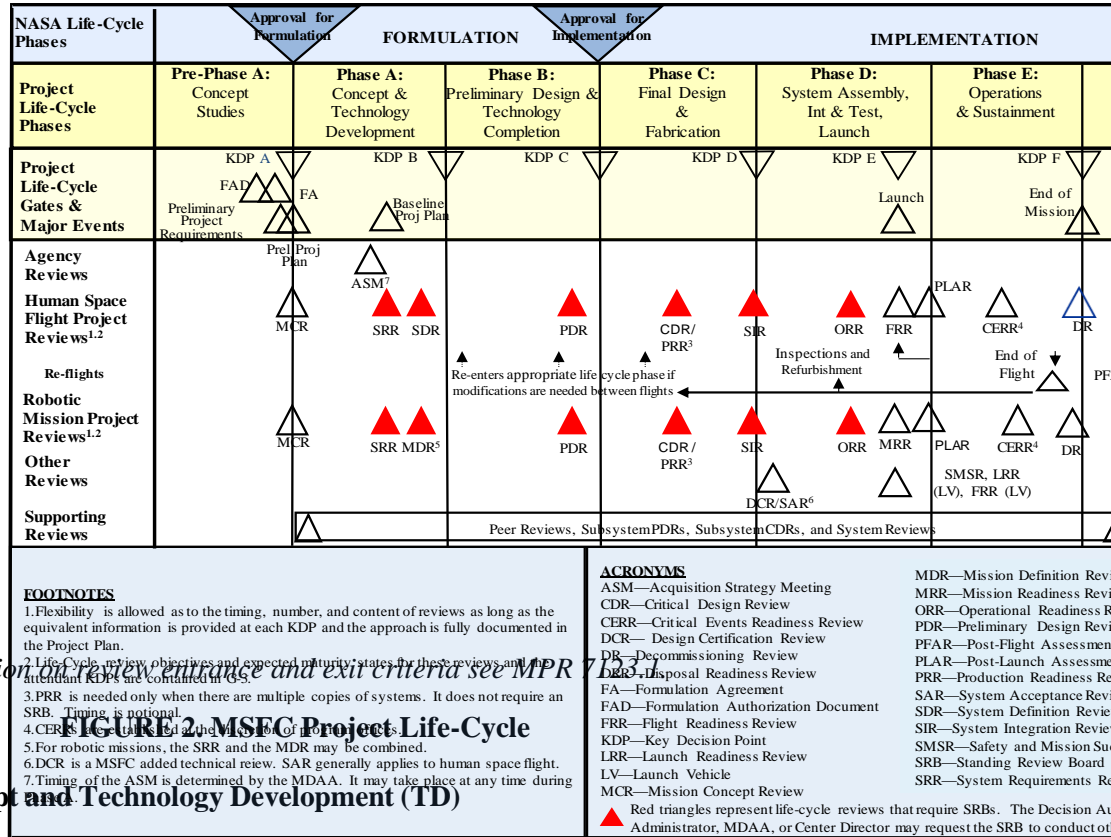
During project formulation (Pre-Phase A, Phase A, and Phase B), Project Planning & Control (PP&C) personnel ensure that sufficient planning has occurred to develop and integrate the technical baseline with the associated budget and schedule, integrating identified risks with this baseline. Overlooked or ill-defined requirements could have a significant impact on the project, possibly resulting in project cancellation.

2.1.2 Pre-Phase A: Concept Studies

During Pre-Phase A, a pre-project team studies a broad range of mission concepts, which helps the team identify promising mission concept(s) and draft project-level requirements. A major focus of Pre-Phase A is to conduct technology and engineering systems assessments to identify risks that are likely to drive the project's

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 16 of 230

cost and schedule range estimates. The team identifies potential technology needs (based on the best mission concepts) and assesses the gaps between such needs and current and planned technology. The team also identifies engineering development risks, payload risks, supply chain risks, and heritage hardware and software risks. The team defines risk mitigation plans and resource requirements for the top risks. Cost modeling used during Pre-Phase A facilitates high-level “what-if” drills. Successful completion of Pre-Phase A culminates in



Key Decision Point (KDP) A.

Note: For more information on review criteria and exit criteria see MPR 7123.1

FIGURE 2. MSFC Project Life-Cycle

2.1.3 Phase A: Concept and Technology Development (TD)

During Phase A, a project team is formed to update and fully develop the mission concept and assumes responsibility for the technology development, engineering prototyping, heritage hardware and software assessments, and other risk mitigation activities. This work, along with interactions with customers and other potential stakeholders, enables updating of the concept documentation and supports baselining the project requirements. The Project Planning & Control (PP&C) team participates in the integration of technical and programmatic requirements to meet project objectives, and work with project and technical leads to develop a Work Breakdown Structure (WBS) and WBS Dictionary, that capture all known project deliverables and the efforts required to manage and integrate those deliverables into existing systems (launch vehicle, crew capsule, International Space Station (ISS), etc.). The System Requirements Review (SRR) or System Definition Review (SDR) is conducted during this phase. Successful completion of Phase A culminates in Key Decision Point (KDP) B.

A Project Plan is developed and baselined during Phase A. One section of this plan (or a stand-alone plan) covers the subject of Data Management, which will address project data management processes, responsibilities, and location of project data. Project records are maintained by the responsible manager or their designee in accordance with MPR 1440.2, NPR 1441.1, and NRRS 1441.1, Schedule 8, items 101-117. The exact retention used depends on the type of project that generates the records. MPR 7123.1 requires a list of project records, retention schedules, custodians, locations, and any other project-unique records management requirements, to be established and maintained by the project. These records include, but are not limited to, documentation

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 17 of 230

concerning project planning, formulation, and implementation. Keep in mind that at the end of the project (during Phase F), PP&C personnel may be asked to lead or contribute to the development of a set of project lessons learned. Comprehensive records that cover the entire project lifecycle are valuable assets which are useful in the development of good project lessons learned as well as providing a foundation for future projects.

2.1.4 Phase B: Preliminary Design and Technology Completion

During Phase B, the project team continues to conduct technology development, engineering prototyping, heritage hardware and software assessments, and other risk mitigation activities identified. The team also completes the preliminary design and establishes the schedule and life-cycle cost (LCC) estimates for the project. These activities are focused on updating the Project Plan, completing the preliminary design, and assuring the systems engineering activities are complete. Project Planning & Control (PP&C) analysts also work with technical and acquisition personnel to develop statements of work (SOW) and data reporting requirements for government procurements. Successful completion of Phase B culminates in Key Decision Point (KDP) C. The Preliminary Design Review (PDR) and KDP C are the most critical reviews for the project, in that they drive the budget and schedule baseline (that is reported to Congress for projects with development costs of greater than \$250 million), and a poor KDP C review will likely lead to project cancellation.

2.1.5 Approval for Implementation

The Project Planning & Control (PP&C) team develops a number of products (integrated, time-phased budget and schedule baselines; approved risk list with an evaluation of cost and schedule impacts associated with approved risk mitigation; and cost, schedule, and risk assessment of any approved project design changes as a result of the Preliminary Design Review (PDR) that is conducted during this phase) for the Key Decision Point (KDP) C review that are required to demonstrate that the technical challenges, major risks, and the cost and schedule are sufficiently understood, and stakeholder expectations and formulation requirements have been met. By approving the project, the Decision Authority (DA) commits the budget resources necessary to continue into implementation.

2.1.6 Project Implementation

The role of Project Planning & Control (PP&C) analysts shifts from planning to monitoring and control during project execution. Project performance during Implementation (Phases C, D, E and F) can only be determined by continuous monitoring and analysis of the integrated cost, schedule, and technical baseline; assessment and decisions associated with identified risks; and reporting of results to project stakeholders.

2.1.7 Phase C: Final Design and Fabrication

During Phase C, the project completes the design that meets the detailed requirements and begins fabrication of test and flight architecture (e.g., flight article components, assemblies, and subsystems). These activities focus on implementing the project in accordance with the Project Plan, completing the final design, and assuring that the systems engineering activities are performed to determine if the design is mature enough to proceed with full-scale implementation. Phase C is focused toward the Critical Design Review (CDR) and the System Integration Review (SIR). Completion of Phase C culminates in Key Decision Point (KDP) D. Project costs (labor, equipment, test facilities, etc.) peak at the end of Phase C and early into Phase D; therefore, unexpected problems and delays are most costly (and critical to be resolved as quickly as possible) during this time.

2.1.8 Phase D: System Assembly, Integration, Test, Launch, and Checkout

During Phase D, the project performs system assembly, integration, test, launch, and system checkout activities.
CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 18 of 230

These activities focus on preparing for the Design Certification Review (DCR)/System Acceptance Review (SAR), Operational Readiness Review (ORR), Flight Readiness Review (FRR) for human space flight projects or the Mission Readiness Review (MRR) for robotic space flight projects. Key Decision Point (KDP) D marks the decision to conduct launch and early on-orbit operations, launch, and the Post-Launch Assessment Review (PLAR). Entrance and success criteria for PLAR and all major project technical reviews are documented in MPR 7123.1, *MSFC Systems Engineering Processes and Requirements*, Appendix E. The transition to Phase E occurs after on-orbit checkout at the conclusion of the PLAR. Project Planning & Control (PP&C) analysts should understand the Safety and Mission Assurance (SMA) processes that occur throughout the project, and ensure that they are adequately planned and funded. Any SMA issues that are identified or remain open in Phase D will result in costly launch delays (in the case of space flight projects).

2.1.9 Phase E: Operations and Sustainment

During Phase E, the project implements the Missions Operations Plan (MOP) developed in previous phases. This phase begins after the Post-Launch Assessment Review (PLAR) where the development team transitions mission operations to the project operations team following the initial check out period after launch. Mission operations may be periodically punctuated with Critical Event Readiness Reviews (CERR). Human space flight missions may conduct Post-Flight Assessment Reviews (PFAR) specific to the project needs. The mission operation phase ends with the Decommissioning Review (DR) and Key Decision Point (KDP) F (mission termination is approved).

2.1.10 Phase F: Closeout

During Phase F the project implements the Decommissioning Plan developed and approved in Phase E; and the Disposal Readiness Review (DRR). The project disposes all spacecraft ground systems, data, and returned samples, including safe and adequate disposal of the spacecraft and other in-space assets, and ensures all project activities are closed out in accordance with the Decommissioning Plan.

2.2 The MSFC/NASA Mission Support Life-Cycle

While projects have a product maturity life-cycle as described in the previous section, they also operate within an annual [fiscal year (FY)] budget life-cycle as described in Section 3.7. Mission Support activities function exclusively within this budget planning, budget execution, and budget forecast life-cycle. Tracking the budget plans against actual budget commitments, obligations, and costs (also covered in Section 3.7) within any given budget execution year is a critical part of Mission Support work. Mission Support organizations have the responsibility for converting project funding into “in-house” product realization by purchasing materials for in-house deliverables, securing the needed skills of support contractors for project support, and providing office space, Information Technology (IT) infrastructure, and test facilities required to meet project needs.

The execution of all these activities, and tracking and reporting the associated costs and schedules, require significant effort by Project Planning & Control (PP&C) personnel within Mission Support organizations that often goes unnoticed by most Center personnel. Timely execution of these activities and duties, however, are critical to the success of MSFC projects.

3. Project Planning & Control (PP&C) Disciplines/Relationships

3.1 Project Planning & Control (PP&C) Overview and Description

Almost every technical decision (including SMA) associated with a project (or the institutional support of a project) has an associated cost, schedule, and risk impact. In cases where multiple technical solutions are

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 19 of 230

available, the projected impacts associated with each (if understood and quantified at the time) will drive the optimum solution. It is imperative that business, technical and project leadership work closely together to ensure that the necessary analysis has been performed and communicated to all parties, including mission support partners, so that optimum decisions can be made. This handbook will discuss the planning and control of projects and institutional work, and the responsibilities of the individuals involved.

The MSFC PP&C approach designates the business manager as ultimately responsible for assuring that all related project business processes and practices are performed accurately. In turn, each respective business function on the project business team [e.g., resource analyst, project planner/scheduler (P/S)], is responsible for providing procedures, resources, products, and tools in support of the business manager's needs. Each business manager and respective team member should utilize PP&C-related knowledge and guidance that are available through the NASA Lessons Learned Information System (LLIS) at: <https://llis.nasa.gov> and <https://nen.nasa.gov/web/ll/msfc>. Lessons learned are brief summaries of mishaps or success stories that are likely to be of interest to other projects. Unlike a "best practice," they:

1. Describe a specific "driving event" that occurred; and
2. Provide recommendations for avoiding a repetition (or obtaining a repeat of a success). The recommendations merely provide pointers to subject matter experts on measures that have worked in the past.

PP&C personnel should also share any appropriate lessons they have learned as candidate to be added to the NASA LLIS. For more information on lessons learned see MPR 7120.1, *MSFC Engineering and Program/Project Management Requirements*, and in Chapter 5.0 of this document.

The Center line organizations also play a role in ensuring that business practices are implemented. They provide resource deployment, training, policy/procedure development, and systems support to the business team. Business teams within these organizations frequently perform skill mix and technical capability assessments and analysis, and identify and evaluate mission support risks and present recommendations to Center management to watch, mitigate, or accept such risks.

The project business manager (or PP&C or Program Control Manager) coordinates and directs individuals deployed by the line organizations. The major activities include, but are not limited to the following:

- a. Work Breakdown Structure (WBS) and WBS Dictionary development and maintenance
- b. Schedule development, maintenance, and analysis
- c. Cost estimates, budgets, and forecast development
- d. Financial data analysis
- e. Ongoing performance measurement, including implementing Earned Value Management (EVM)
- f. Financial and schedule reporting to project, institutional, and customer management
- g. Probabilistic schedule risk assessments (SRA) development
- h. Task agreements (including intra- and inter-Center agreements) development and monitoring
- i. Facility requirements determination
- j. Workforce levels monitoring
- k. Risk identification and management process support
- l. Acquisition and procurement processes support
- m. Programmatic contract oversight

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 20 of 230

- n. Funding status (commitments, obligations and costs) monitoring and reporting
- o. Independent cost estimates (ICE) development support
- p. Pricing estimates development support
- q. Cost accounting standards and Federal Acquisition Regulations (FAR) compliance assurance

With regards to PP&C activities supporting institutional management, mission support managers coordinate activities in support of the financial processes of the Center and ensure that these processes are integrated into the overall programmatic and institutional business framework. These support activities include, but are not limited to the following:

- a. Institutional business forecast development support
- b. Operating plans development support
- c. Requirements and priorities for capital investment development support
- d. Center workforce needs establishment in concert with business forecasts
- e. Civil servant and contractor burden rates development and analysis
- f. Integrated business systems and tools development and implementation
- g. New institutional financial initiatives coordination and/or development
- h. CMO baseline service levels evaluation

3.1.1 Effective Project Planning & Control (PP&C) Functions and Attributes

The PP&C team (or Business Office) plays a key role in the execution of the PP&C discipline, and receives support from various mission support managers and from business managers within institutional line organizations. Subject Matter Experts (SME) for the various aspects of PP&C that are discussed in this handbook exist in various project and institutional organizations throughout the Center. Office of Strategic Analysis and Communication (OSAC), as the sponsor of the PP&C discipline, will assist any user of this handbook in locating needed expertise. Common attributes of an effective PP&C team member are listed in the following subsections (3.1.2 and 3.1.3) below:

3.1.2 Knowledge, Skills, and Abilities

The following knowledge, skills, and abilities will improve the proficiency of the Project Planning & Control (PP&C) community:

- a. Knowledge of pertinent statistical; accounting; and economic principles and techniques.
- b. Understanding of project objectives, content (technical, budget, schedule, and risks), key milestones, and interrelationships.
- c. Ability to maintain status and cost estimates, and assess programmatic trends for project elements at all levels.
- d. A high degree of analytical ability.
- e. Ability to integrate, analyze, and understand project elements and how they fit together.
- f. Ability to identify high risk areas and their relationship/impact on the technical, budget, and schedule baseline.
- g. Ability to identify and clearly communicate the issues to management.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 21 of 230

3.1.3 Characteristics of Project Planning & Control (PP&C) Team Members

The following are key characteristics the PP&C team members should possess and exhibit in their effort to better manage MSFC projects and provide institutional support, as originally developed and published by Thomas Newman, NASA Comptroller in the 1980s, in his 1981 paper entitled *Controlling Resources in the Apollo Program*.

Reliability - The management should be able to depend on the PP&C team member to be reliable and provide good judgment in carrying out any assignment.

Curiosity - The PP&C team member should always ask “why” when reviewing information, in order to fully understand any impacts to the project. Whenever the PP&C team is given information, they should automatically question why this information should be accepted at face value and how it relates to what they already know. This approach is not one of questioning the integrity of the person providing the information but, in many cases, the person will have not gone through this thinking process. Before using the information, the PP&C team member needs to understand it.

Numbers Sense - A good PP&C team member needs a real feel for the numbers.

Interest in the Project – To fully excel on the job, the PP&C team member should closely identify with and acquire the basic knowledge of their project.

Ability to Work with Others – The PP&C team member is always reliant on the work of other people. Project success is dependent on our ability to maintain a satisfactory rapport with the people with whom the PP&C team member works. The main elements in this capability are:

- a. Openness in letting others know what we are doing
- b. Giving others a sense of confidence on how we will use the information
- c. An ability to distinguish between friction that arises in business and your personal relationship with an individual

Detail Work – The PP&C team member should understand and enjoy working with a large amount of detail information.

Big Picture - All the detail work is done for a purpose, but to be effective, the PP&C team member should be able to see the big picture as related to the project.

Communication – The PP&C team member should be able to express ideas and conclusions both orally and in writing, and must be able to tell the story beyond the numbers.

Sense of Timing - This involves judgment as to which deadline needs to be met. It also means acceptance of the fact that a 70% job available a half-hour before a meeting is usually better than a 100% job a half-hour after the meeting. One of the most important aspects of support is providing it when needed. As a PP&C team member, the individual needs to be willing to take the risks involved in providing something less than a completely satisfactory product in time to do some good. This is a matter of accepting the goals involved in the overall purpose of the work rather than taking particular pride in any individual piece of the total effort.

Common Sense and Goal Judgment - A requirement for these characteristics is inherent in any responsible job. It is implied in all of the above points. The need for common sense and judgment becomes especially

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 22 of 230

important when guidance is inadequate, when there is not enough time to meet all requirements, or when dealing with matters which have become emotional issues.

Technical Aspects of PP&C - The PP&C team members have varying technical backgrounds, but they should be prepared to interact with engineers when technical and risk management issues arise. Above all, the PP&C team member should be prepared to ask the project questions based on these issues, and assess related resource and schedule impacts.

3.2 The Role of the Project Work Breakdown Structure (WBS) in Planning and Organizing Project and Institutional Work

Proper project and mission support organization helps to ensure that each part of the integrated management process is established in a manner that effectively supports PP&C. This is accomplished by defining the work content to be performed, assigning it to organizations responsible for performing the work (including major subcontractors), facilitating the collection and development of project data for management purposes, and identifying organizational resources that facilitate the preparation of accurate and timely estimates of project cost and schedule completion. Initial assignment of work begins during the Formulation phase when the project team is first established. Responsibility for accomplishing the work, defined at the lowest WBS elements, is assigned to the line or functional organizations.

After a project progresses into Formulation, the definition and assignment of work is further refined and formalized as the Project Manager (PM), Subproject or Element Managers (EM), and/or Project Control Account Managers (P-CAMs) continue to structure the project. They establish the project team, further define the lower-level WBS elements, and integrate the WBS with the line or functional organization to define the correct packaging of work to be assigned to each responsible management lead or Integrated Product Team (IPT) lead.

The following parameters apply:

- a. There is only one WBS for a project.
- b. A WBS Dictionary is prepared that describes the scope for each WBS.
- c. The organization responsible for accomplishing the authorized work is identified.
- d. The WBS is integrated with the line organization structure, also known as the Organization Breakdown Structure (OBS), to identify management control points from which cost and schedule performance is measured and managed.
- e. Effort contained within the specified control points can span line organizations via an IPT.
- f. The integration of the WBS and OBS is known as the Responsibility Assignment Matrix (RAM).
- g. The WBS is to be consistent with the NASA Structure Management (NSM) numbering format.
- h. When a project is authorized by a Formulation Authorization Document (FAD), the WBS becomes formalized as the project outline; changes to it should be formally approved by the project office.
- i. Not all top-level WBS elements will be subdivided to the same level of detail. As associated element risk, cost, and/or complexity increases, further breakdown may be necessary.

3.2.1 Work Breakdown Structure (WBS)

The work content contained in the project scope of work is analyzed and used to develop a WBS by hierarchically decomposing the work. This analysis and iterative decomposition results in the development of

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 23 of 230

the WBS, the WBS Dictionary, and the project organization structure to meet the requirements, and identification of the functions and activities required by the scope. The WBS Dictionary and the scope are cross-referenced to ensure that all required work is captured in the WBS Dictionary, and there is no “work” in the dictionary that is not in the approved scope definition.

A WBS is developed early in the project development cycle. It identifies the total project work to be performed, which includes not only all MSFC in-house work content, but also all work content to be performed by contractors, international partners, universities, or any other performing entities. Work scope not contained in the project WBS should not be considered part of the project. The WBS divides the work content into manageable elements, with increasing levels of detail.

The WBS is a product-oriented family tree that identifies the hardware, software, services, and all other deliverables required to achieve an end project objective. The purpose of a WBS is to subdivide the project’s work content into manageable segments to facilitate planning and control of cost, schedule, and technical content. It will serve as the basis for uniform planning, progress and performance reporting, project visibility and communication, and the assignment of responsibility. The WBS will be updated, as required, to reflect changes to the technical content and contractual changes.

The Project Manager (PM), in conjunction with the Project Planning & Control (PP&C) team and sub-system, Element Managers (EMs) or Project Control Account Managers (P-CAMs), and mission support representatives, are responsible for establishing the lower levels of the WBS. The WBS is approved by the PM, the Project Business Manager, and the sponsor, and is maintained by PP&C. The WBS expands and subdivides a project into its hierarchical component elements, beginning at the highest level with the identification of the major project elements. The major elements are then divided into systems, subsystems, and components (hardware, software, services, or facilities) to the point where the work is performed (see Figure 3).

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 24 of 230

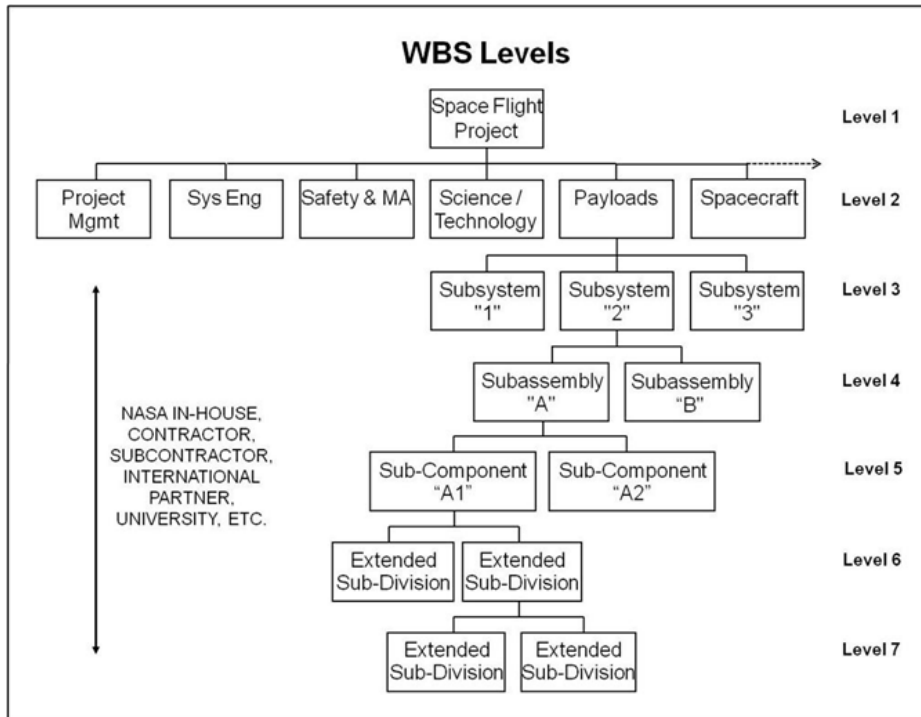


FIGURE 3. WBS Levels

All MSFC projects have the capability of subdividing the work content down to any level necessary for management and insight. The Agency’s NASA Accounting System currently limits the ability to capture costs to a maximum of seven levels, however, which are defined below and illustrated in Figure 3:

- a. Level 1 is the entire project.
- b. Level 2 elements are the major operational product elements along with key common, enabling products (See Appendix F for NASA standard WBS templates).
- c. Levels 3-7 contain further definable subdivisions of the products contained in the Level 2 elements (e.g., subsystems, components, documents, functionality.)

Normally, in projects where prime contractors are involved, they will further subdivide the WBS structure down to the lowest level required to complete their effort, with concurrence of MSFC management. MSFC’s PP&C involvement will assure that the contractor’s WBS will provide clear levels of reporting and control of cost performance. A WBS dictionary describing the content of each WBS element should be provided by the contractor for the review, which will be addressed during the Proposal evaluation period.

The project WBS should be coordinated with the MSFC Office of the Chief Financial Officer (OCFO) to assure it supports the NASA Financial System. The OCFO, along with the PM, will assign the appropriate WBS numbers in the NASA Accounting System (sometimes referenced as “SAP (Systems, Applications, and Products)”; the trademark software backbone of the NASA Accounting System) to be used as the accounting charge numbers for tracking project funding and costs.

3.2.2 Work Breakdown Structure (WBS) Coding: NASA Structure Management (NSM) System

The NSM System is the internal coding schema used by the Agency to define and organize project work content. The WBS with its NSM nomenclature provides a common management framework for project

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 25 of 230

management decisions and communication, the definition and authorization of work, the development of project schedules, and the planning and allocation of resources. This same coding system is also used to account for all financial activities associated with funds appropriated by Congress to accomplish project work. When developing a project WBS, the management team, assisted by Project Planning & Control (PP&C) team members, coordinates with all appropriate technical leads and involved enabling support organizations (e.g., Financial Management, Systems Engineering, SMA) to establish a WBS coding structure that accommodates both the technical and business management of the effort. The approved project WBS structure should encompass the entire project’s approved scope of work. All MSFC projects have the capability of subdividing the work content down to any level necessary for management and insight. However, the Agency’s NASA Accounting System currently limits the ability to capture costs to a maximum of seven levels. (See example in Figure 4 below.)

NASA Structure Management (NSM) WBS Numbering System

- 6-digit Project (Numeric only)
- 2 digits for remaining Levels 2 – 7 (Numeric)
- 1 digit for period between each Level 2 - 7

(Example) 123456.02.03.04.05.06.07

Project

WBS Levels 2-7

❖ *Center designator is not part of WBS number – Center designator is placed in an associated attribute field within SAP*

FIGURE 4. NSM – Project Level

Each WBS element is assigned a unique element code to be used as a reference point for its technical and financial identification throughout the life of the project. A simple decimal coding system is applied to logically indicate the level of an element and related lower-level or subordinate elements. A common coding system facilitates communications among all project participants. All project efforts (i.e., all MSFC in-house, contracted, international partners, university, and any other performing entity efforts) should be included. MSFC Project Managers (PMs) should work with their contracts organization, procurement organization, or other performing entities to develop the desired contractual language for each WBS element and the associated WBS coding system. It is strongly recommended that the coding system be traceable to the NSM coding structure.

All Programmatic and Mission Support WBS element codes are not recognized as official NASA structures until first being approved and established in the Agency’s Metadata Management (Mdm) system. The Mdm system is a web-based enterprise application that contains the Agency’s official NSM data elements and associated attributes. Mdm is the only Agency application used for identifying, creating, tracking, organizing, and archiving of appropriation, mission, theme, program, project, and WBS 2 through 7 NSM structural elements.

Process instructions for entering new or modifying existing WBS elements within the Mdm system may be obtained from the designated Mdm code requester within the MSFC OCFO. Additional information regarding the Mdm system may also be obtained by contacting the Mdm Help Desk (mdmhelppdesk@hq.nasa.gov). All modifications made to existing WBS element codes contained in Agency management systems listed above should also first be initiated and approved through the Mdm System. A WBS code that has been approved and officially entered into the Mdm System cannot be removed. This restriction enhances a project’s ability to

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 26 of 230

maintain accurate historical project data. MdM interfaces with the Budget and Funds Allocation System (BFAS) for management of authorized Center projects and WBSs.

3.2.3 Preparing Work Breakdown Structure (WBS) Element Tree Diagrams

WBS tree diagrams are routinely developed to provide a visual display of a WBS. A pictorial view of the overall WBS aids all project staff in understanding how lower-level project components support and contribute to higher-level components. This type of diagram is often called a “product tree” diagram.

An example of a WBS tree diagram is shown in Figure 5, which reflects a portion of a Flight Project WBS structure with several key recommended development practices noted.

The degree to which WBS elements are decomposed or extended is governed by the following:

- a. Sponsor’s reporting requirements.
- b. Level where elements of work are managed and performed by one line organization.
- c. Subcontractor work.
- d. Risk, complexity, and criticality of elements of work to meet project requirements.
- e. Cost of the elements of work.
- f. Visibility needed by management for controlling the element of work.
- g. Limitations of the NASA Accounting System and the NASA Structure Management (NSM) coding structure.

Note: For additional information, see NASA/SP-2010-3404, *NASA Work Breakdown Structure (WBS) Handbook*, <http://evm.nasa.gov/handbooks.html>, (refer to paragraph 3.4.3, Preparing Element Tree Diagrams.)

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 27 of 230

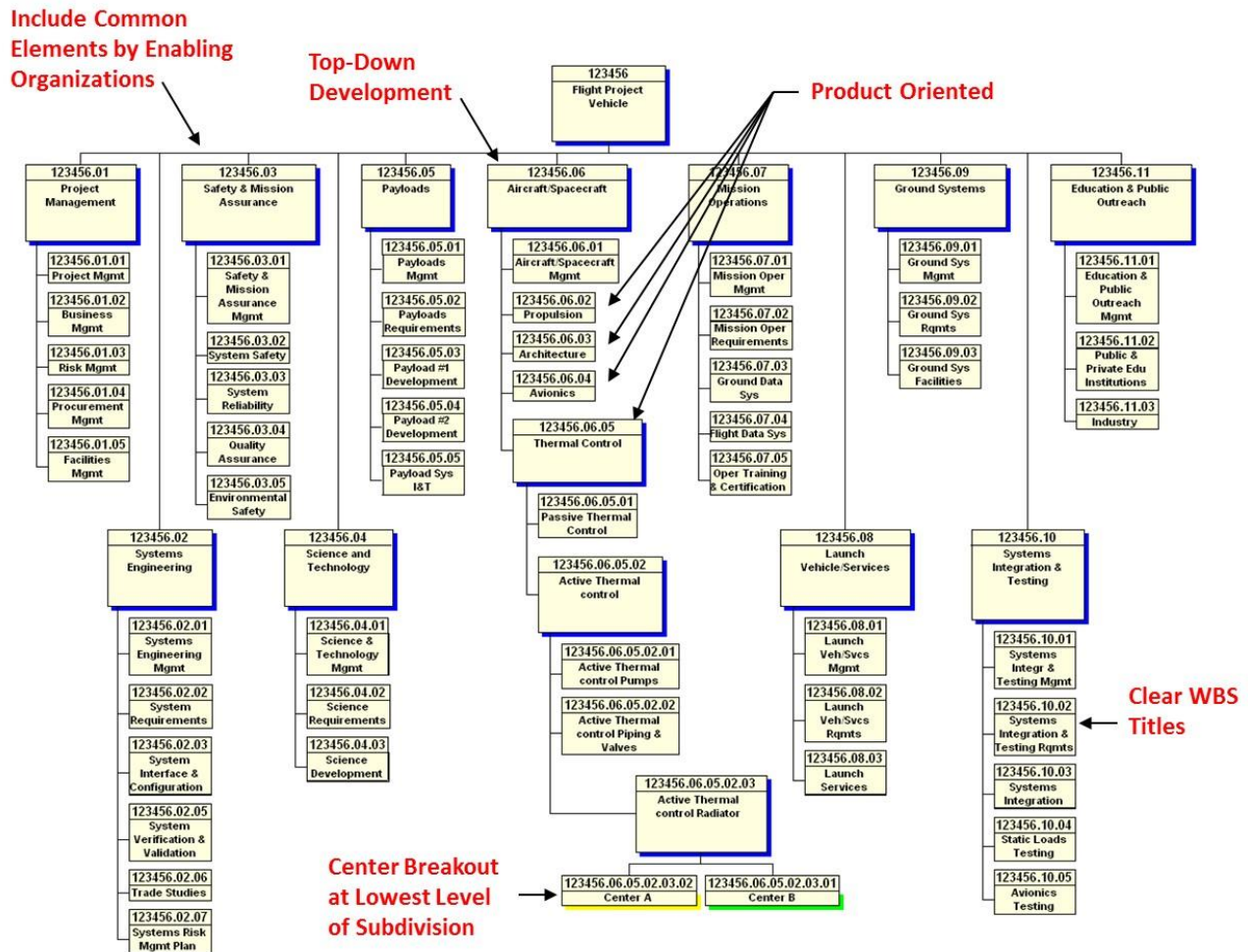


FIGURE 5. Partial Project WBS Element Tree

Note: Recommended WBS development practices shown in red.

3.2.4 Work Breakdown Structure (WBS) Dictionary

The Project Manager (PM), Element Managers (EMs), and responsible Management Leads develop the WBS Dictionary that is maintained by the business management team or Project Planning & Control (PP&C). The WBS dictionary provides a description of work and identifies each Control Account (CA). The WBS Dictionary (see Figure 6) does not replace the scope contained in the Project Plan, Space Act Agreements (SAA), or Intra-Agency/Center Work Agreements, but provides a logical cross-reference and traceability between them.

The WBS dictionary contains the following:

- Title Page:** Project title, document revision date, and approval by the PM and Business Manager. Also contained is the revision designator and approved changes from previous revisions.
- Index:** The index provides a tabular listing of all WBS elements indicating the level and title of each element. While not a requirement, the WBS index may also include other program/project element information also such as the responsible element technical lead (or Project Control
CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 28 of 230

Account Manager (P-CAM), or the cross-referencing of each WBS number to the appropriate Project Plan and/or Intra-Agency/Center Work Agreement paragraph number.

- c. **Element Description:** Technical content narrative containing a definition of the WBS element stating what the element is and the efforts associated with the WBS element (such as design, development, and manufacturing), as well as its technical content. This narrative is the dictionary part of the WBS Dictionary.
- d. **WBS Element Number and Title:** Each description will be identified with the WBS code and the title or name of the element. The elements should be in the same order as the WBS Index.
- e. **Deliverables:** Define the key deliverables resulting from performing the work, as applicable.

<u>WBS Dictionary</u>	
<u>WBS Element Title:</u> Develop Prototype Code	<u>WBS Element No:</u> 123456.08.05.09.01.03
<u>Parent WBS No:</u> 123456.08.05.09.01	<u>WBS Level:</u> 6
<u>Parent WBS Title:</u> Develop Prototype	<u>Scope Def. Ref:</u> 02.01.01
<u>Project:</u> Project XYZ Software Development	
<u>Originator:</u> Samuel L. Kates	
<u>WBS Element Description:</u> The scope of this element includes the development of all necessary software code required to satisfy the functional requirements established for prototype software. This effort will include the identification of all prototype use-case functions, code development for all identified use-case functions, informal use-case testing, integration of all use-case code, and software preparation for full prototype user testing.	
<u>Technical Specification Document:</u> SPEC-SW-AA000765-1 SPEC-SW-AB000767-2	
<u>Procurement Packages:</u> None	
<u>Related Work Excluded:</u> 1) Associated supervision 2) Prototype requirements validation 3) PP&C planning and control effort	
<u>Requirements Doc. No:</u> NASA SRD-BR549-01	
<u>WBS Index:</u> See pages 16-18	
<u>Revision No:</u> 01c	
Page <u>15</u> of <u>31</u>	
<u>Revision Date:</u> 11/30/2009	<u>WBS Element No:</u> 123456.08.05.09.01.03

FIGURE 6. Sample Project WBS Dictionary

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 29 of 230

3.2.5 Work Breakdown Structure (WBS) and the Project Life-Cycle

A preliminary WBS is developed early in the formulation phase of the project. It is established as soon as project management believes the project has reached a stage of definition where it is feasible. It is used to assist in the preparation of the Formulation Authorization Document (FAD) and the preliminary Project Plan. The preliminary project planning process through Formulation is an iterative process (see Figure 7). Once the project is established with sufficient and stable scope definition, then both the MSFC in-house work elements and, if required, the contractor WBS elements can be adequately planned and established at the necessary levels of detail.

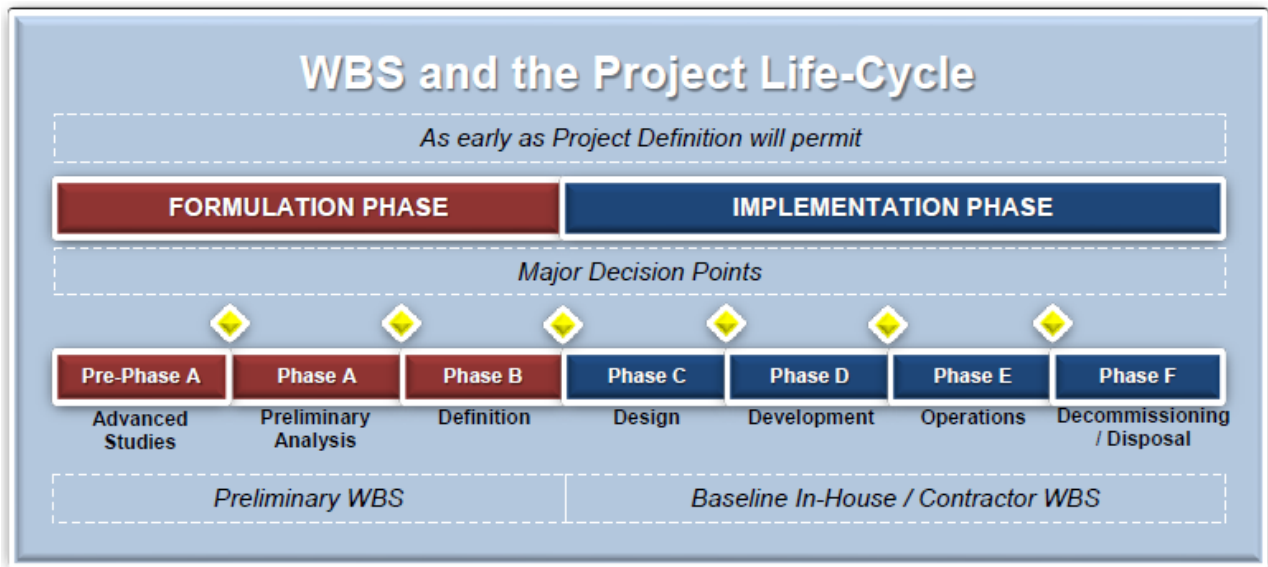


FIGURE 7. WBS Development and the Project Life-Cycle

CAUTION: To avoid collecting costs with a WBS that proves to be inadequate or inappropriate, do not enter the full preliminary WBS into the M&M System until the scope has stabilized or until specific Control Accounts (CAs) are needed for cost collection.

Baseline approval of the WBS is achieved during the latter stages of project life-cycle Phase “B”. Once approved, the WBS should not be revised except through the formal approval process at major transitional points in the project.

For additional information, see NASA/SP-2010-3404, *NASA Work Breakdown Structure Handbook*, Section 3.1, “WBS and the Project Life-Cycle,” available at <http://evm.nasa.gov/handbooks.html>.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 30 of 230

3.2.6 Integrating the Work Breakdown Structure (WBS), Organization Breakdown Structure (OBS) and Responsibility Assignment Matrix (RAM)

3.2.6.1 Organization Breakdown Structure (OBS)

A project is managed and administered by a team that is led by the Project Manager (PM) and possibly Element Managers (EMs). The EMs are responsible for the intermediate or “functional” management of the scope, schedule, and budget of significant segments of the overall project scope called elements. Designated intermediate-level managers within the project, sometimes called Project Control Account Managers (P-CAMs), are responsible for the direct or “hands-on” management of the scope, schedule, and budget for their assigned packages of work content. The full management team is identified in a Project OBS. Each of the primary OBS Elements, as depicted conceptually in Figure 8, is structured on the basis of administrative responsibility and technical (functional) expertise. In the case of prime contracts, MSFC projects require that contractors employ best project management practices in managing their efforts; MSFC Project Planning & Control (PP&C) activities are also involved in supporting the oversight of these efforts.

Organization Breakdown Structure			P-CAM	
Project Manager	MS Dept	MS01	Management	Wilson
		MS02	Analysis	Smith
		MS03	Design	Canty
		MS04	Development	Kerby
		MS05	Testing	Smart
		MS06	Training	Schumann
		MS07	Documentation	Poole
		MS08	Pilot	Black
		MS09	Deployment	Nugent

Figure 8. OBS (Partial)

3.2.6.2 Responsibility Assignment Matrix (RAM)

In order to ensure that a single line (or functional) organization is clearly identified as responsible for performing each element of the defined work, a RAM is developed. The RAM is an integration of the Work Breakdown Structure (WBS) with the line organization structure - the Organization Breakdown Structure (OBS). The intersection points of these two structures produces specific packages of work where defined effort is to be accomplished. Each management lead identified in the RAM, with the support of Center Project Planning & Control (PP&C) personnel, reviews the allocated work scope and prepares plans, schedules, and budgets accordingly. The formal RAM for the project should be maintained by PP&C personnel and retained in a clear format, depicted in Figure 9, for the duration of the project.

Responsibility Assignment Matrix (RAM)				Work Breakdown Structure																		
				123456																		
				123456.08																		
				123456.08.05																		
				123456.08.05.09																		
Organization Breakdown Structure				P-CAM			123456.08.05.09.01			123456.08.05.09.02			123456.08.05.09.03									
							X	X	X	X	X											
												X	X	X	X							
																X	X	X				
																	X	X	X			
																				X	X	X
Project Manager	MS Dept	MS01	Management	Wilson	X	X	X	X	X													
		MS02	Analysis	Smith						X	X	X	X									
		MS03	Design	Canty										X	X	X						
		MS04	Development	Kerby											X	X	X					
		MS05	Testing	Smart														X	X	X		
		MS06	Training	Schumann																		
		MS07	Documentation	Poole																		
		MS08	Pilot	Black																		
		MS09	Deployment	Nugent																		

FIGURE 9. RAM

3.2.6.3 Control Account (CA)—Intersection of Work Breakdown Structure (WBS) and Organization Breakdown Structure (OBS)

The intersection of WBS elements and the OBS is a management strategy generally employed by the contractor community, but is also sometimes used by MSFC’s in-house projects to identify the key points for cost, schedule, technical, and risk management. These intersections are referred to as CAs, and are illustrated conceptually in Figure 10. A CA may also be subdivided further into Work Packages (WPs) and Planning Packages (PPs). A WP provides further detail on work content that is considered near-term, while a PP defines far-term work at a summary level. Each project branch within the WBS only needs to be subdivided as far as needed to allow for adequate management, insight, and control.

The CA is the level at which organizational responsibility exists for an individual WBS element. Additionally, the CA can function as a focal point for collecting costs and assessing performance. It is the point at which analytical comparisons can be made between the value of work accomplished, the planned cost for work scheduled to be done, and also the actual cost of work that was accomplished. Through analysis of these dollarized comparisons the Center’s Project Planning & Control (PP&C) community can assist in providing project performance assessment and also predictive judgments that can be effective in supporting management decision making. Work that resides within a CA is managed by a Control Account Manager (CAM). Frequently these CAMs reside within a project office (P-CAMs (Project Control Account Manager)).

While it is preferred that the NASA Accounting System WBS and the project technical WBS be one and the same, this is not always possible. In cases where there are multiple NASA Accounting System WBS charge codes that belong to one CA in the project structure, it is acceptable to map these to the appropriate account. This mapping must occur outside of the NASA Accounting System and is usually handled in a separate spreadsheet or third party cost tool. It is not acceptable to map one NASA Accounting System WBS charge code to more than one CA.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 32 of 230

When this management method is used, the CA becomes the primary juncture for planning and control of authorized work because all aspects of the system including budgets, schedules, work assignments, cost collection, progress assessment, problem identification, and corrective actions come together at that point. For this reason, the levels selected within the WBS for establishing CAs should be carefully considered to ensure that the work is defined into manageable units and that organizational responsibilities are clearly and reasonably established.

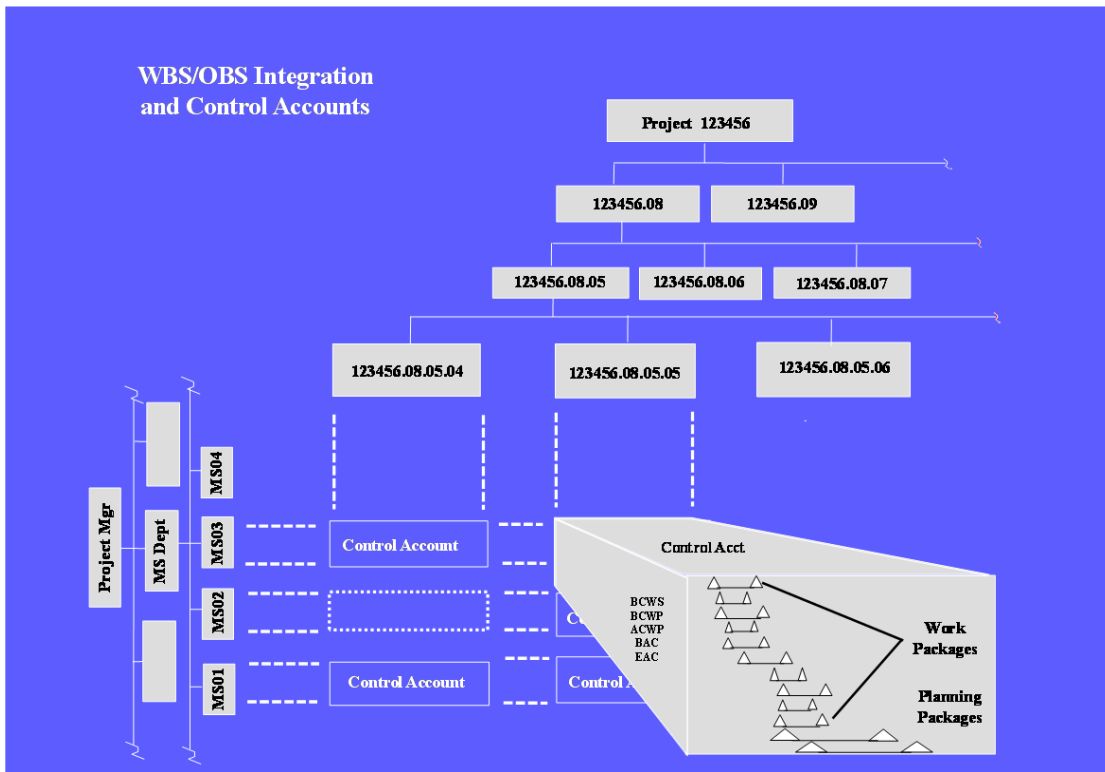


FIGURE 10. WBS/OBS Integration and CAs

3.3 Planning and Scheduling

Planning and scheduling encompasses the development, maintenance, control, and archival of the Integrated Master Schedule (IMS). The IMS constitutes the basis for time phasing and coordinating all project effort to ensure that objectives are accomplished within approved commitments. Integrated schedules are crucial for all levels of management oversight within MSFC and its contractor community. Schedule management at the project level entails the identification and integration of tasks and milestones for both contractor effort and all effort being worked by in-house NASA government personnel. Regardless of the type of project being implemented, it is critical that the IMS contain data addressing the total scope of work at a consistent level of detail to allow for discrete progress measurement, management visibility, and critical path identification and control. Project planners and schedulers work to assure the schedules accurately represent the project status and planning of the work. This approach will allow Project Managers (PMs) greater visibility and capability to adequately plan the necessary resources, and ensure adequate budget will be available to accomplish the work when it is planned.

The project-level IMS is an integrated set of schedule data containing a logical network of all detailed project activities. Within the IMS, the Master Schedule is the highest level of schedule data which is supported by Intermediate Level Schedules and by lowest level detail schedules. The IMS serves as the basis for planning and performance insight for all project effort. The IMS provides the management

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 33 of 230

vehicle which enables integration of the approved project work scope reflected in the Work Breakdown Structure (WBS), budget, and certain project risks. The IMS reflects both baseline and current schedule data.

This is to say, the IMS will reflect both the project approved time-phased plan (*including all subsequent approved changes*), and the time-phased plan with its current task progress, sequence, and forecasts. The time-phasing of tasks provided by the IMS is critical to the development of a Performance Measurement Baseline (PMB).

The IMS provides the PM with a single integrated source of schedule data that accurately reflects how the planned work is to be implemented. This dataset will be maintained in an automated schedule management tool and consist of tasks/milestones, task durations, interdependencies, project constraints, contractor data, and an assigned data coding structure. Using the assigned coding structure, the scheduling tool is able to filter and summarize schedule data to provide reports at the summary Master Schedule, intermediate, and detail schedule levels. It is a recommended best practice that all levels of schedule reporting are provided from a single IMS dataset and not from separate schedule sources. Horizontal traceability between all detail tasks along with vertical traceability from detailed tasks to higher level project milestones should exist. Detailed schedules should contain the lowest level planning segments. These segments generally correlate to groupings of associated work and are reflected as detailed tasks and milestones which may be summarized to a level of detail called work packages (WPs). Groupings of WPs may also be summarized to a higher detail called CAs. While different techniques and formats may be employed within detailed schedules, it is critical that tasks be defined at a low enough level to allow for finish-to-start interdependency relationships where feasible, accurate progress measurement, issue identification, and correlation to higher level milestones.

A properly prepared schedule will provide a roadmap by which the project team can execute all authorized efforts and determine where deviations from the original plan have created a need for corrective action. A sound schedule planning process includes the integration of the technical, schedule, and cost aspects of the project. The schedule planning process will also provide for the identification of both internal and external interdependencies between work content contained in all WBS elements at a level of detail appropriate for efficient and effective project management.

The following parameters apply:

- a. There is only one IMS for the project.
- b. All active and future work scope has a detailed schedule within the IMS.
- c. Assigned management leads, from the Responsibility Assignment Matrix (RAM), generate and maintain detailed schedules in accordance with established scheduling parameters. Detailed schedules contain activities and milestone events which indicate the development effort to be accomplished for in-house and contractual services and products.
- d. Assigned management leads from the RAM identify activity and milestone sequences through the assignment of predecessor and successor interdependencies within detailed schedules. Vertical and horizontal traceability is established through the use of schedule interdependencies.
- e. The IMS is created by integration of all detailed schedules, including schedules for contracted effort, and forming a critical path method (CPM) schedule representing the project's total scope of work.
- f. The IMS reflects both baseline and current schedule data.
- g. The IMS is updated and progressed at least monthly.
- h. Once the IMS is approved it is placed under the baseline control process and is only revised after the change approval process has occurred.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 34 of 230

- i. Schedule reports contain identification of the baseline schedule and current schedule, as well as the reporting status date.

3.3.1 Scheduling Methodology

A project Integrated Master Schedule (IMS) is developed utilizing critical path method (CPM) scheduling techniques. Critical path methodology entails the development of a logic network based schedule that enables the calculation of schedule slack (or float) for all activities and milestones contained in the IMS. CPM produced data enables analysis and identification of schedule drivers, cause and impact narrative analysis, and presentation of possible Corrective Actions. The IMS will contain baseline schedule data, as well as current schedule status and projections. A monthly comparison of current schedule progress against the established baseline schedule plan provides the necessary data to assess schedule performance.

This dataset is established and maintained in an automated scheduling tool and consists of the following elements:

- a. Activities and milestone events
- b. Realistic activity durations
- c. Activity/milestone interdependencies (sequencing)
- d. Activity resources (recommendation only)
- e. Valid activity/milestone date constraints
- f. Contractor and Subcontractor schedule data
- g. Necessary schedule coding structure

From the Project Planning & Control (PP&C) community, the P/S serves as the primary project point of contact for IMS data entry, progress updates, logic maintenance, integrity assessment, performance analysis, issue identification, work-around planning, and report generation. All designated schedule reports, metrics, and analyses are made available as necessary to the full project management team and appropriate involved stakeholders. It is critical to project success that the Project Manager (PM), Business Manager, Element Managers (EMs), and Management Leads designated by the Responsibility Assignment Matrix (RAM), and other key project team members are kept apprised and communicated with in regards to current schedule progress and issue resolution.

3.3.2 Schedule Management Tool Considerations

Schedule management tools are used to develop, maintain, analyze, and control project schedules. Agency-wide adherence to schedule management tool recommendations can improve data sharing capability, increase interoperability with other agency standard tools, and potentially enable speedy accessibility through common Agency-wide procurement vehicles. Prior to selecting a schedule management tool, it is recommended that project functionality requirements and desires be defined. This approach will help ensure that tools are selected that best satisfy those needs.

It is a recommended best practice that automated schedule management tools be used on all MSFC projects. It is also recommended that these tools satisfy the functional capabilities listed below:

Schedule management tools should perform the following functions:

- a. Provide for entering and editing of baseline plan, current/forecast plan, and accomplished (actual) schedule data.

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 35 of 230

- b. Specify relational dependencies between tasks and milestones (including lag and lead values as needed, but kept to a minimum).
- c. Define project calendars that reflect the business schedule (e.g., workdays, non-workdays, holidays, and work-hours).
- d. Display and print project schedules in Gantt and network diagram form.
- e. Calculate total slack (float) and free slack for all project tasks and milestones.
- f. Provide user-defined code fields for filtering, grouping, summarizing, and organizing data.
- g. Create, view, and print basic reports such as task, cost, and resource listings.
- h. Provide capability for resource loading and leveling.

Tools selected for use in the implementation of recommended schedule management practices should also provide interface capabilities to other specified MSFC management software.

3.3.3 Pre-Schedule Development Activities

The first steps in developing a new project schedule include understanding the work scope, developing a Work Breakdown Structure (WBS) and Organization Breakdown Structure (OBS), understanding funding dynamics, and reviewing pertinent agreements and authorization documents. Project schedule content should be consistent with applicable project documentation and requirements.

Project schedules may be the product of both in-house and contractor efforts. The pre-schedule considerations may include the development and tailoring of a schedule Data Requirements Description (DRD) to be included as part of the request for proposal (RFP) or contract. For work performed in-house, a Work Authorization (WA) process should be in place that identifies schedule requirements in addition to the approved budget.

It is critical that the Planner/Scheduler (P/S) be assigned early in the life-cycle of every project. To ensure the information necessary for schedule management and insight is received early, the P/S should be assigned by the start of a project or at least no later than Phase A of the project life-cycle. The P/S should also participate in the gathering of needed schedule data needed for IMS development (e.g., reports, studies, authorizing documents, WBS). The P/S should also work to establish a process for schedule status with team members, as well as a process for controlling changes to the baseline. The P/S should be trained in all areas, including software tools, schedule maintenance and control, and scheduling techniques.

3.3.3.1 Project Scope and the Integrated Master Schedule (IMS)

An understanding of the work content should exist before a valid schedule can be developed. The initial step in gaining this understanding is a thorough review of the project scope definition. It is important to realize that all project personnel may not have the same interpretation or understanding of the approved Statement of Work (SOW). Resolving these differences is necessary for the development of an accurate and useable schedule for project management. The Planner/Scheduler (P/S) can play a significant role in helping to resolve these differences by asking the right questions (e.g., in what WBS element does specific effort belong? What type of deliverable is required? What type of testing is required?), and by bringing to light the areas of conflict so that responsible managers can come to an agreement on the work scope.

It is imperative to identify and plan the total work content as early in the planning process as possible to help determine potential conflicts that can lead to schedule changes. The later in the project life-cycle a required change is identified, the more costly it will be to the project in terms of time and money. Many cost and schedule project risks can be mitigated with better up-front planning.

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 36 of 230

3.3.4 Schedule Basis of Estimate (BOE)

A schedule BOE is the documented foundation on which a plan for project implementation is conceived. The project schedule is created to depict the time frame required to accomplish the defined work. It is part of an enhanced management best practice to document all aspects (e.g., technical, cost, and schedule) from which the project can be defined and planned. The schedule BOE is intended to be developed within the realistic parameters of the known and expected project requirements. While every project has a specific start and finish, the credibility of the path planned for implementation to reach the finish is what will determine the project’s success, and that path is what a BOE should help detail. It should always be remembered that the accuracy and credibility of the schedule plan is only as good as the accuracy and credibility of the information that has been input and integrated within it.

As the Project Planning & Control (PP&C) team works with project technical and business leads to plan the baseline cost and schedule plans, caution should be taken to avoid pitfalls that generally come into play during the planning process. The following listing reflects several factors that can individually or collectively contribute to adverse impacts on the BOE development process:

- a. Misalignment of capabilities to requirements.
- b. Subject Matter Expert (SME) optimism.
- c. Lack of adequate historical references and/or documentation.
- d. Constrained deliverable requirements.

While SMEs often have firsthand knowledge of a requirement, pride of ownership can often lead to personal bias for how long it takes to complete the requirement, or they do not consider that a specific experienced resource may not be available during execution of the requirement. The result is that when developing the schedule BOE inherent optimism can often result in underestimation of a task duration and/or resource requirements. Other project stakeholders may also exert unrealistic optimism when providing input to PP&C during planning by not considering known constraints with regard to what it really takes to execute a task or the plan as a whole. The bottom line is that bias and faulty optimism will likely lead to downplaying potential future risk impacts that are not captured within a BOE.

3.3.4.1 The Basis of Estimate (BOE) Process

For the Project Planning & Control (PP&C) team, the schedule BOE development should be an iterative process and, in general, should be developed in a sequential manner to ensure that all requirements are properly defined, technical strategies are outlined, and a course of action detailed so that realistic estimates can be developed (see Figure 11). Developing the schedule BOE should be a collaborative process executed in a structured manner that leads to definitive estimates that are easily defensible and traceable. It should be a key element to provide insight into the execution strategy in terms of resource allocation, Fiscal Year (FY) funding, potential requirements for cost and schedule reserve and so forth. Utilizing the schedule BOE process should also provide additional insight for developing more reliable cost estimates and budget plans.

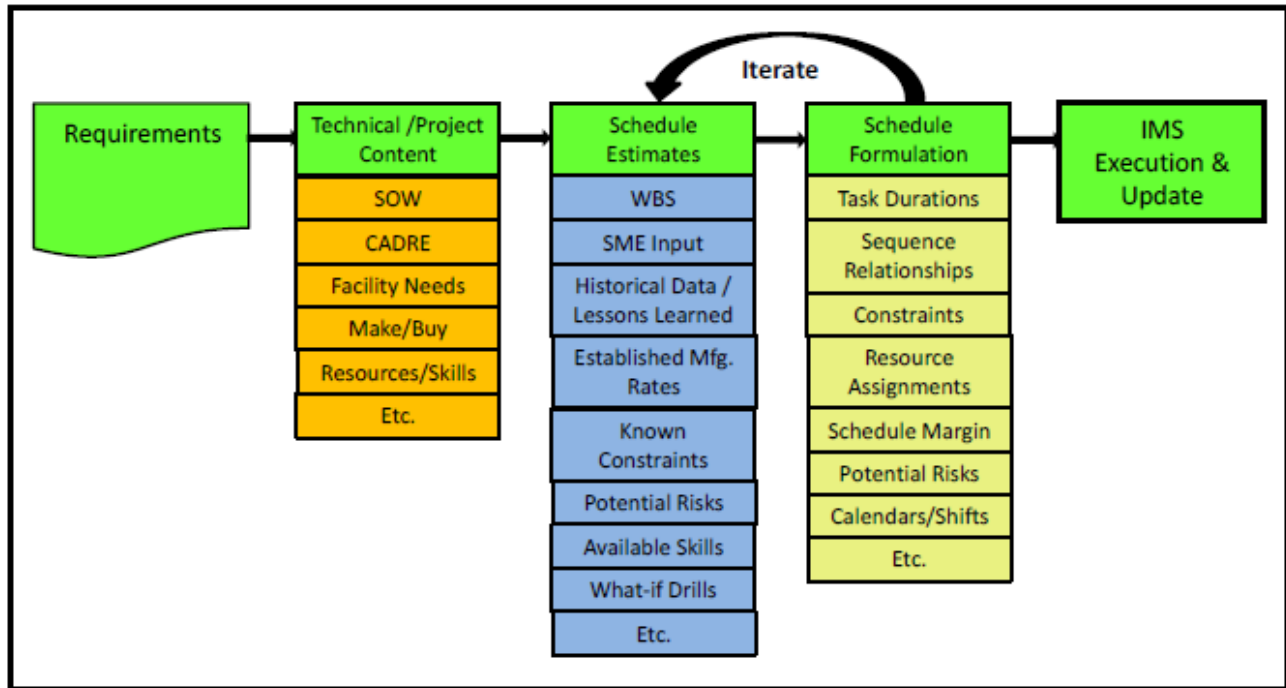


FIGURE 11. BOE Development Process Flow

The *NASA Schedule Management Handbook* (NASA/SP-2010-3403) states the following: “It is recommended for project schedulers to always seek valid sources and processes to assist in deriving the most accurate task durations possible for schedule development. It is also recommended that the BOE for task durations within the Integrated Master Schedule (IMS) be documented. This practice will help to ensure schedule credibility is maintained, and also provide a critical source for schedule rationale during later project reviews.” Documenting BOE sources and reference points provides defensible justification, as well as supports other areas in the development process to align programmatically. Identifying sources in the IMS not only supports future programmatic reviews, but also provides reference points for future BOE developments.

A schedule BOE is currently a new schedule development strategy and therefore does not have an established format designated for use by MSFC projects. However, the following guidance should help PP&C teams develop sound and meaningful schedule BOE products for MSFC projects.

Figure 12 reflects a very simplistic (and incomplete) example that illustrates a recommended format that the PP&C team could employ for BOE development. It should be noted that this illustration does not reflect all information necessary. A sound BOE should also contain much more detail, specifically with regard to capturing sources of input, potential risks, and resource allocation.

On the surface, a schedule BOE resembles any other project schedule, but differs in the type and amount of associated task information details included based on maturity and progress. The following suggested content provides examples of associated task details expected within the schedule BOE:

- a. Schedule BOEs should have tasks with descriptions, durations, and defined logic.
- b. Source of estimation should be captured within the notes or comments of the task.
- c. Assumptions regarding milestones, resources, and risk elements on the projected critical path should also be captured within the schedule BOE.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 38 of 230

The key take away here is that a schedule BOE should be developed in accordance with MSFC requirements, and in a manner that is quantifiable, traceable, defensible, and most importantly repeatable.

WBS	Task Name	Minimum Duration	Duration	Maximum Duration	Cost	Preced	Success	Resource Names	Risks	Notes
1.0	Imaginary Program	0 days	395 days	0 days	\$2,546,000.00					
1.1	Program Management	0 days	395 days	0 days	\$2,546,000.00			PM		
1.1.1	Program Start	0 days	0 days	0 days	\$0.00		4,6			
1.1.2	Launch Vehicle Design	100 days	120 days	145 days	\$192,000.00	3	5	Eng	Design Delay (25 Day delay)	Estimate based on Project XYZ
1.1.3	Payload Design	135 days	150 days	165 days	\$240,000.00	4	7	Eng	Design Delay (15 Day delay)	Estimate based SME input
1.1.4	Software design	235 days	250 days	300 days	\$400,000.00	3	7	Eng	Design Delay (50 Day delay)	Estimate based on Project ABC
1.1.5	Vehicle Payload Integration	110 days	125 days	150 days	\$150,000.00	5,6	8,9	Int,Test[1]	Design Delay (25 Day delay)	Estimate based SME input
1.1.6	Launch	0 days	0 days	0 days	\$0.00	7				
1.1.6.1	Launch Delay Risk	0 days	0 days	60 days	\$0.00	7		Eng,Int	Launch Failure (60 Day Delay)	

FIGURE 12. Sample BOE Format

NASA/SP-2010-3403 also provides the following additional information that could be considered as desired content for the schedule BOE:

- Established Standards – Hourly or daily rates based on historical records of accomplishment.
- Expert Experience – Time estimates based on personal knowledge/experience with same personnel or similar project types.
- Analogous comparisons using historical/related data.
- Time estimates based on historical data from past/related projects.
- Parametric Analysis – Calculated time estimates based on factors such as weight, power, mass, cost, etc.
- Brainstorming – Time estimates derived from knowledgeable team discussions and insight.
- Extrapolations from known data and trends containing predicted time estimates calculated from existing known relationships (e.g.; 3-point expected values for “minimum, maximum, and most likely” durations).

The schedule BOE development process should be a collaborative process involving PP&C and other Center organizations as needed (i.e., technical, cost, facilities, procurement, SMA, and risk communities). Schedule BOEs should provide the foundation on which project baselines are established and also serve as a key for successful implementation.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 39 of 230

3.3.5 Schedule Levels within the Integrated Master Schedule (IMS)

3.3.5.1 Integrated Master Schedule (IMS) Development

This section provides a description of the scheduling process used to develop schedules that support management’s decision-making process, utilizing a top-down approach, supported by bottoms-up schedule development. Project schedules depict the time frame required to accomplish the defined work. The scheduling process supports multiple levels of related schedules, with each succeeding level more fully defining the work to be accomplished. The various schedules depict a continuous logical sequence of in-house and contract milestones from the Top Level schedule down to the detailed schedules, and from the beginning of the project to final delivery.

The schedule development process is initiated upon receipt of the following project specific documentation: scope definition, Work Breakdown Structure (WBS) and WBS Dictionary, Program Plan and Project Plan, Test and Verification Plan, internal Task Agreements, project cost estimate, funding guidelines, and Intra-Agency Work Agreements (IAWA), contract Data Requirements Description (DRD), or Project Proposal. These documents are used to define the structure and time frame for authorized implementation activities. Utilizing a product oriented WBS provides a logical outline of the scope of work that can be further decomposed within the schedule.

Things to consider when developing the IMS Baseline:

- a. Ensure that tasks, milestones, and schedule logic are established by product within detailed schedules for specific work packages, leading to separate and specifically defined deliverables.
- b. Ensure that schedule detail represents the approved scope of work and is aligned with the appropriate WBS element and/or specific work package.
- c. Ensure the level of schedule detail provided is adequate to ensure objective status reporting by the managing and performing organizations (POs).
- d. Identify and segregate external efforts (e.g., contractor, university partners) in alignment with the WBS. Analyze the manner in which performance of these tasks are captured and validated.
- e. Identify and document schedule risk items, (i.e., technical/schedule risk, complexity, and criticality of effort) to meet implementation requirements.
- f. Ensure that an appropriate and allowable amount of schedule margin is included in the IMS.
- g. Consider schedule visibility required by management for controlling the element of work.
- h. Ensure that all formats of presented schedule data are traceable to and representative of the content of the IMS.

3.3.5.2 Top Level Project Schedules

The Top-Level Schedule encompasses the total project life-cycle, structured by upper-level Work Breakdown Structure (WBS) elements, if implemented across all phases (e.g., Concept Studies, Technology Development, Preliminary Design, Final Design and Fabrication, System Assembly, Integration and Test, and Operations). This schedule, at a minimum, should reflect significant summary-level activities, contract and control milestone events, major decision points, significant identifiable schedule margin, and gate transitions that are required to meet project milestones for all deliverables required by the Program Plan (if applicable), Project Plan, and Intra-Agency/Center Work Agreements.

The Top-Level Schedule also depicts a variety of information on project activities, product subsystem and

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 40 of 230

system summaries and major project milestones. Caution should be exercised when attempting to reflect the project critical path within the Top-level Schedule due to the summary nature of activity detail and the inability to reflect all associated detailed critical path interface points. From a hierarchical planning perspective, the Top-Level Schedule is a summary-level schedule product generated from the detailed activities within the Integrated Master Schedule (IMS) and providing traceability to activities and/or milestones contained within. Figure 13 depicts a Top-Level schedule for a Flight Mission.

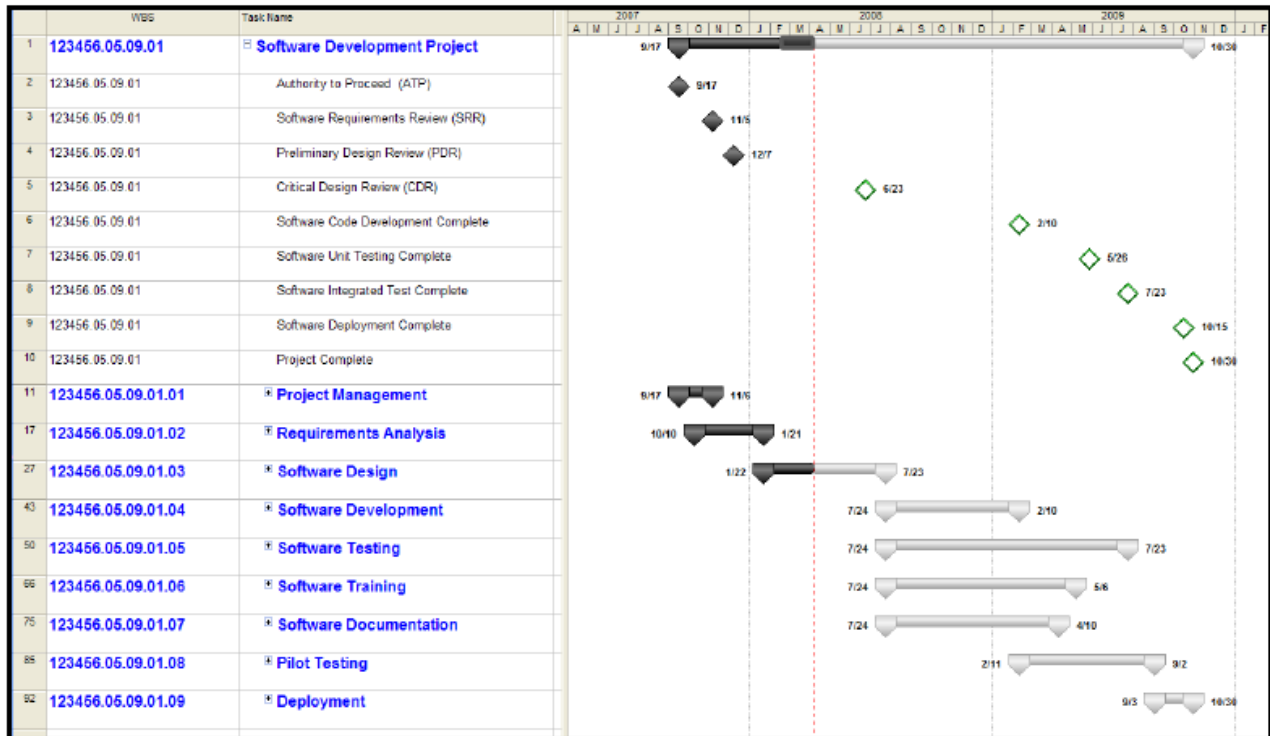


FIGURE 13. Top Level Schedule

3.3.5.3 Intermediate Level Project Schedules

The Intermediate Schedule may also be referred to as a Project Summary Schedule, Level 2 Schedule, or Tier 2 Schedule. The Intermediate Schedule contains both milestones and summary tasks, such as a single task representing system or component details, or a single task representing a grouping of similar tasks such as testing or design tasks. Intermediate schedules are representative summaries of the key detailed-level activities and milestones necessary to accomplish the scope of work within a selected Work Breakdown Structure (WBS) element, Control Account (CA), or another package of designated work. From a hierarchical planning perspective, intermediate level schedules are summary rollup products generated through the use of specific assigned task coding assigned within the detailed Integrated Master Schedule (IMS). The Project Control Account Manager (P-CAM)—working with the Planner/Scheduler (P/S), project office team members, and subproject and Element Managers (EMs)—accomplishes specific coding required in order to provide the correct and desired Intermediate schedule.

Intermediate schedules derived in this manner will not be used for in-depth management analysis since the horizontal interdependencies required for critical path identification and analysis will only exist at the detailed Control Account Plan (CAP) task/milestone level. Generally, intermediate level schedules are used effectively to communicate schedule progress, downstream forecasting, and available schedule margin to upper-level management and key project stakeholders. Representing a schedule plan at the subsystem or system level, as

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 41 of 230

reflected in the Intermediate schedule roll-up, provides an effective schedule format for highlighting moderate-high risk work elements. Again, caution should be exercised when attempting to reflect the project critical path within the intermediate-level schedule. Figure 14 depicts an Intermediate Level Schedule.

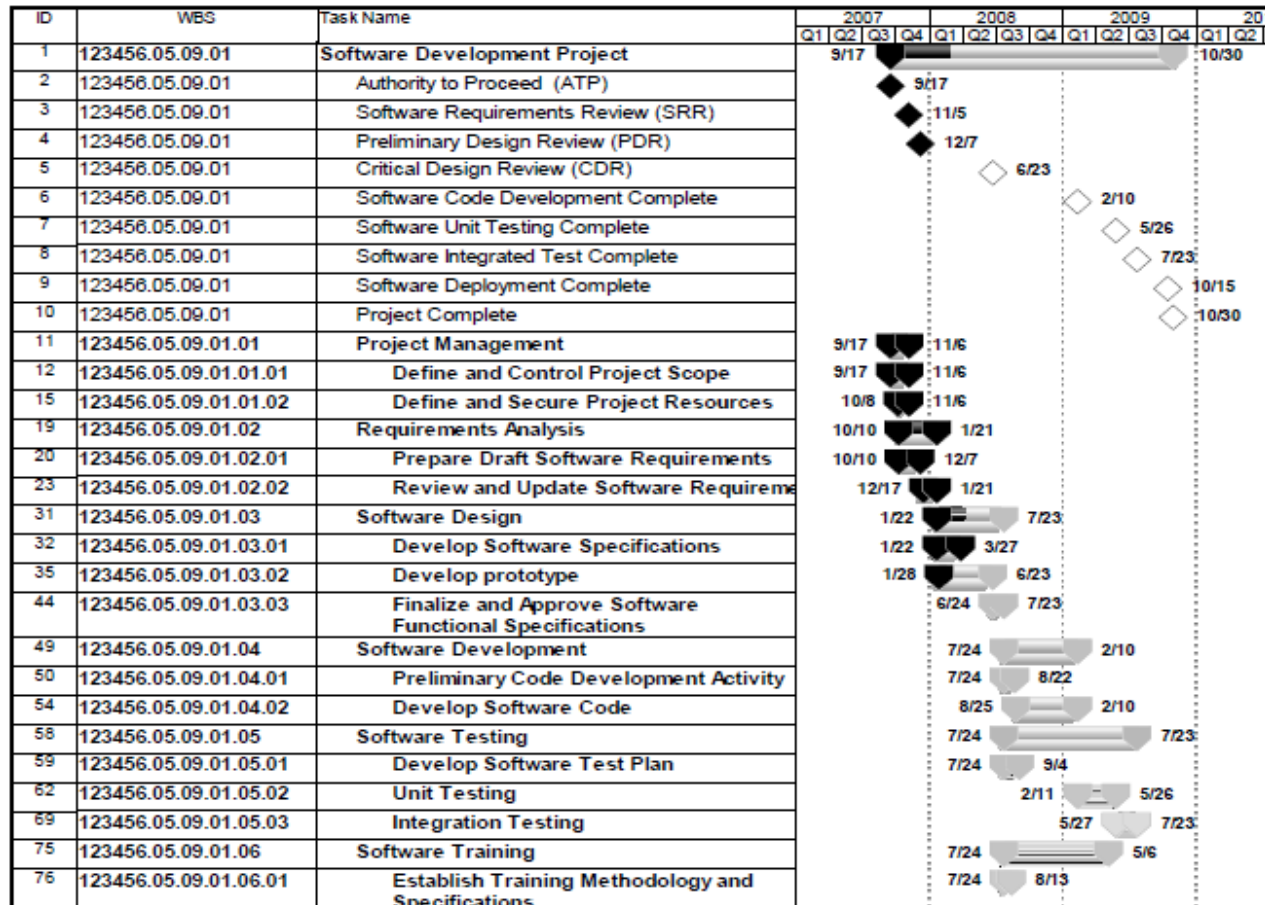


FIGURE 14. Intermediate Level Schedule

3.3.5.4 Detailed Level Project Schedules

Detail schedules that adequately describe the work to be done for effort contained in all Work Breakdown Structure (WBS) elements are essential in the development of a credible project schedule. Integration of all detail schedules and applicable contractor schedules form the project Integrated Master Schedule (IMS).

Within MSFC, the detail-level schedules are the level at which the schedule network logic is created. The network logic is simply a model for how the project effort will be implemented. Network logic incorporates the five key schedule components listed below that enable the scheduling tool to accurately time phase and sequence all project tasks.

- Tasks and milestones at a discrete and measurable level of detail
- Task durations (recommended in day time units)
- Task interdependencies (predecessors/successors using Finish to Start, Start to Start, Finish to Finish, and Start to Finish relationships)
- Tasks Constraints (i.e.; Start No Earlier Than, Must Finish On, etc.)

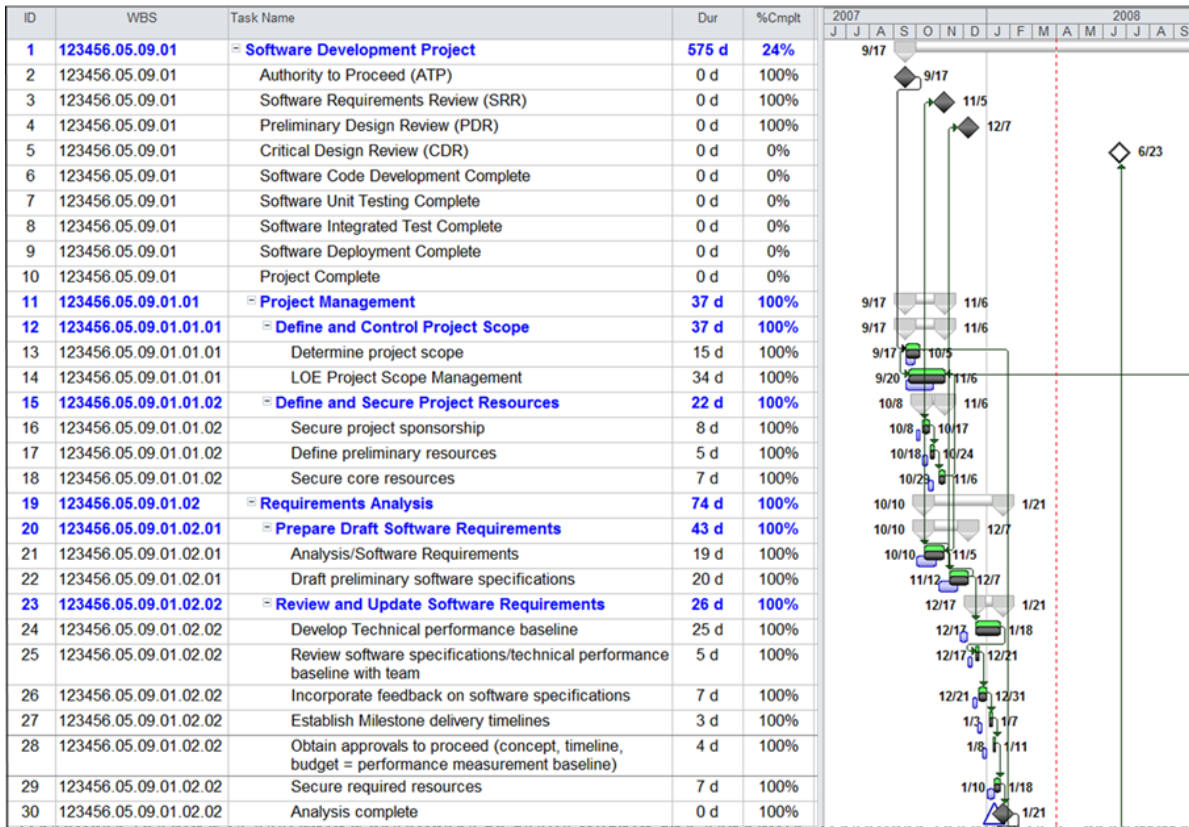
CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

**MSFC Technical Standard
CS40**

Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 42 of 230

e. Task calendars

When the above schedule components are appropriately integrated within the IMS, the result should be an accurate and usable IMS which provides sound forecast dates, proper sequencing of tasks, total slack calculations for all tasks/milestones, and the capability to identify the project critical path. Figure 15 illustrates a portion of a detail project schedule.



Resource loading is assigning resources to tasks within the schedule. Resource loading is a recommended best practice in schedule management and enhances the project's ability to adequately allocate resources, estimate project costs, and ensure schedule credibility. Resources are generally defined as workforce, equipment, and consumables. However, further clarification indicates that project resources should include anything that has an associated cost and is needed to complete the project (e.g., contracts, grants, travel, etc.). Workforce resources are the people assigned to do work. Equipment resources are reusable items such as test or manufacturing equipment and facilities. Consumable resources are resources that have a specified quantity. When that quantity is used up, the resources may be replaced (e.g., fuel, steel, cabling).

Resource loading can be done in an automated scheduling tool, in an external spreadsheet, or in a robust Earned Value Management (EVM)/cost management tool. To ensure adequate cost and schedule integration, however, it is generally recommended to implement resource loading within an automated scheduling tool. Prior to assigning resources to IMS tasks, it is recommended that a listing of potential resources (resource pool) be established within the automated schedule tool (see Figure 16). The resource pool should contain all types of resources that will be needed for the project, regardless if it is workforce, equipment, or consumables.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 43 of 230

Resource Pool: Includes specific planning information for each resource listed										
	Resource Name	Initials	Group / Center	Branch	Type	Max. Units	Std. Rate	Accrue At	Calendar	
Resource Sheet	7	ER32 - Combustion Devices	CS	MSFC	ER32	Work	150%	\$60.10/h	Prorated	CLV
	8	ER32 - ODC	ODC	MSFC	ER32	Material		\$10,000.00	Prorated	
	9	ER32 - Travel	Travel	MSFC	ER32	Material		\$1,000.00	Prorated	
	10	ER33 - Component Engineering/Design	CS	MSFC	ER33	Work	50%	\$60.10/h	Prorated	CLV
	11	ER33 - Travel	Travel	MSFC	ER33	Material		\$1,000.00	Prorated	
	12	ER33 - Component Test	CS	MSFC	ER33	Work	50%	\$60.10/h	Prorated	CLV
	13	ER34 - System Design	CS	MSFC	ER34	Work	100%	\$60.10/h	Prorated	CLV
	14	ER41 - Structural/Stress Analysis	CS	MSFC	ER41	Work	100%	\$60.10/h	Prorated	CLV
	15	ER42 - CFD Analysis	CS	MSFC	ER42	Work	125%	\$60.10/h	Prorated	CLV
	16	ER43 - Thermal analysis/modeling	CS	MSFC	ER43	Work	150%	\$60.10/h	Prorated	CLV
	17	ER43 - ODC	ODC	MSFC	ER43	Material		\$10,000.00	Prorated	
	18	EV34 - Thermal Analysis & Control	CS	MSFC	EV34	Work	50%	\$60.10/h	Prorated	CLV
	19	EV41 - Ctrl Sys Des & Analysis	CS	MSFC	EV41	Work	100%	\$60.10/h	Prorated	CLV
	20	JP30 - ODC	ODC	MSFC	JP30	Material		\$10,000.00	Prorated	
	21	GRC - Civil Servant	CS - GRC	GRC		Work	100%	\$69.33/h	Prorated	CLV
	22	JP30 - ESTS	ESTS	MSFC	JP30	Work	100%	\$0.00/h	Prorated	CLV
	23	ER23 - SDOS	SDOS	MSFC	ER23	Work	150%	\$0.00/h	Prorated	CLV

FIGURE 16. IMS Resource Pool

When developing the resource pool, care should be taken to use a consistent resource naming convention. This will enhance accuracy and consistency in the planning, integration, analysis, and reporting of project resource data. It is recommended that projects not use individual names of personnel as resources due to the size of projects and the need for flexibility to allow multiple people within a single organization to work specific tasks. Once this listing is complete, task resource assignments can then be made from the available resource pool listing as shown in Figure 17.

All resources required to perform a specific task should be selected and assigned to that task along with quantity required. It is recommended that labor quantities should be loaded in hours. Non-labor resources may be input either as a specific dollar amount that corresponds to each assignment of the specified resource, or as a per use amount that has an associated cost rate that is applied within the automated tool.

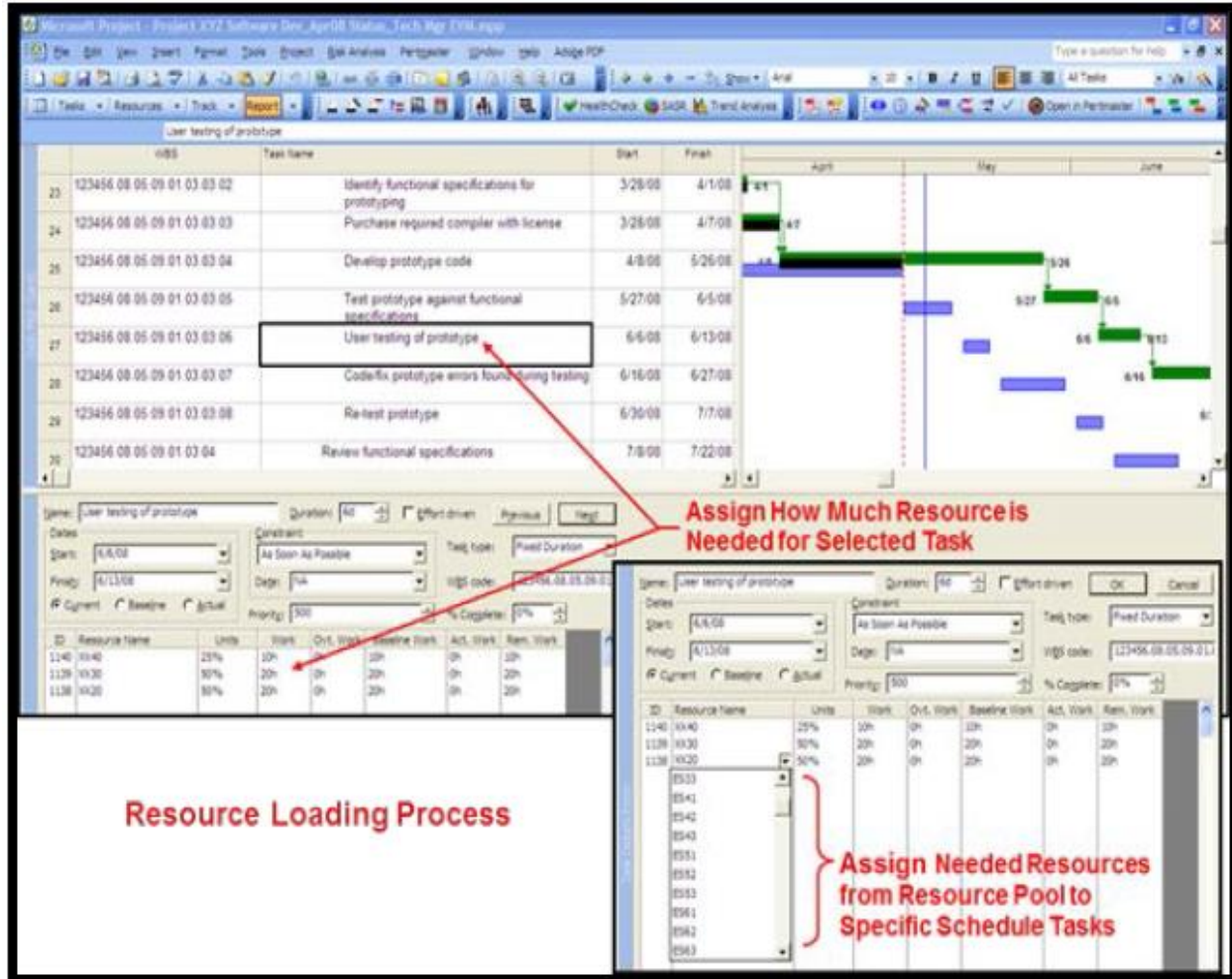


FIGURE 17. Resource Loading the Schedule

Resource loading is not currently a Center requirement; it is, however, an industry recommended practice that provides many additional benefits that greatly enhance the Project Planning & Control (PP&C) process. The traditional resource loading approach described above is recommended for use in both in-house MSFC project implementations and contracted efforts.

Examples of benefits gained from traditional resource loading include, but are not limited to, ensuring accurate integration of work and budget plans (see Figure 18); generating or validating grassroots project cost estimates, accurate inputs for the Center Planning, Programming, Budgeting & Execution (PPBE) process, and also the Performance Measurement Baseline (PMB) development; and providing greater insight into workforce adequacy and allocations, cash flow and budget profiles, and quicker, more effective analysis for “what-if” exercises. It should be noted that there are also cautions associated with resource loading which may indicate that it should not be done, such as: insufficient team skills for effective implementation and maintenance, inadequate scheduling tools, an undefined project resource pool, and a project team culture that is resistant to its use.

**MSFC Technical Standard
CS40**

Title: Project Planning and Control Handbook

**Document No.: MSFC-HDBK-3684
Effective Date: September 25, 2017**

**Revision: A
Page 45 of 230**

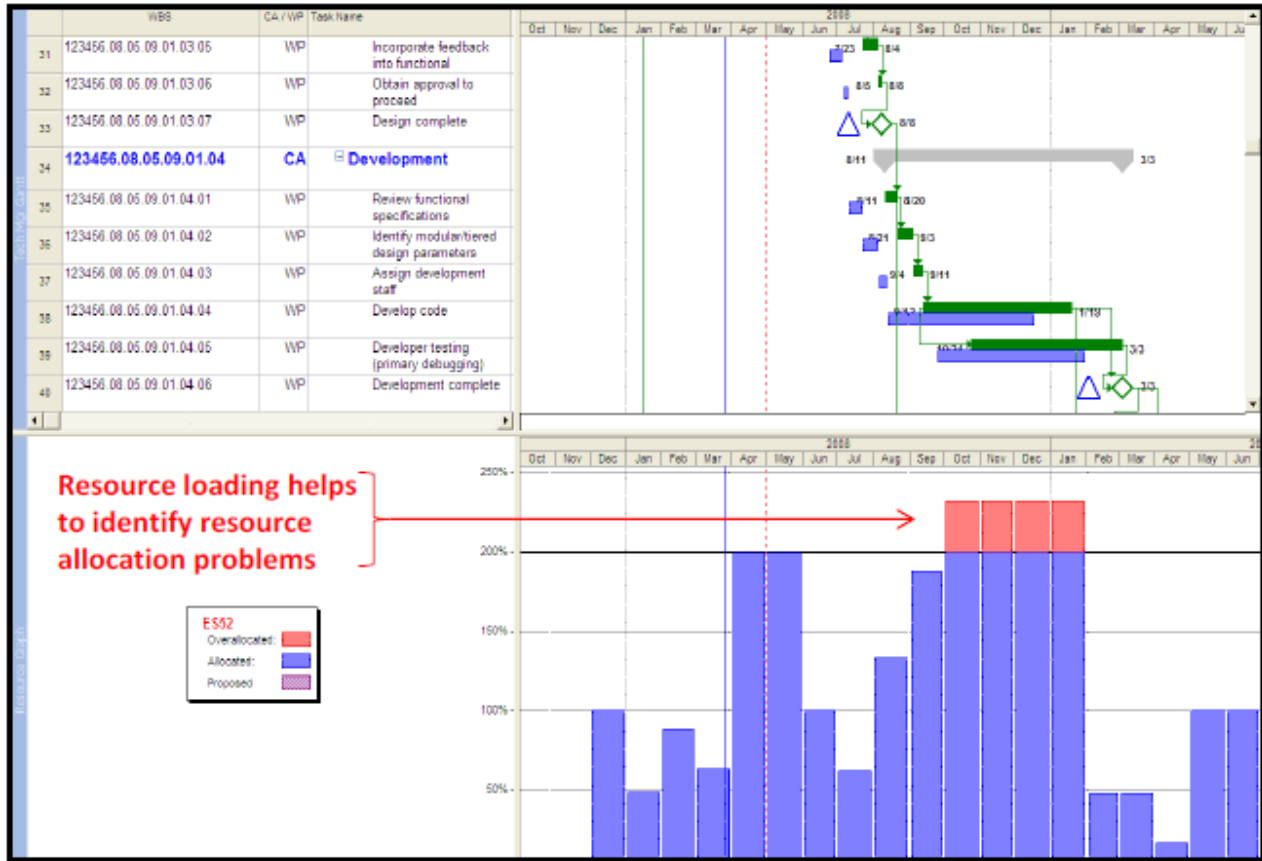


FIGURE 18. Managing Resource Allocations through Resource Loading

3.3.7 Status Updates and Schedule Maintenance

As project work is executed, all tasks/milestones in the schedule should be updated to reflect their current status. This will involve timely updates to network logic, task percent completes, resource allocations, remaining durations, and actual start and finish dates. It is critically important for the Integrated Master Schedule (IMS) to accurately and realistically reflect the current plan to complete the remaining authorized scope as contained in the baseline. To ensure accurate project analyses, it is important that all incomplete tasks/milestones in the schedule be updated to a single status date, including tasks/milestones that should have started or completed, but have not. See Chapter 6 of NASA/SP-2010-3403 for a more detailed discussion of this topic.

3.3.7.1 Schedule Update Methodology

For projects not requiring Earned Value Management (EVM) discipline, the Integrated Master Schedule (IMS) update process may be carried out with a little more flexibility in the techniques used. However, particular attention and discipline should still be provided by each Planner/Scheduler (P/S) during schedule updates to ensure that the IMS continues to reflect an accurate model of what has been accomplished and also of the on-going implementation plan. The following guidance is provided to address the process flow encountered during a routine IMS update:

- a. Copy and archive IMS versions prior to each update cycle. This will ensure proper historical records for future audit activity, and also provide a source of reliable schedule duration information for future duration estimating and validation.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 46 of 230

- b. Gathering task/milestone status may be accomplished in various ways such as providing task owners with a printout containing their specific tasks that require update information, face-to-face meetings with task owners to discuss and reline the schedule copy, or establish weekly, bi-weekly, and/or monthly project IMS update meetings with all task owners participating by verbally providing their status. Regardless of the strategy for gathering updates, the P/S should ensure that progress given is consistent with the pre-established task completion criteria.
- c. Incorporate the gathered status updates into the IMS. It is important to understand that many scheduling tools offer different “% complete” fields with different functions. The “% complete” commonly in the default view for most scheduling tools is actually “percent duration complete” and may or may not be directly related to the “physical work percent complete.” This is particularly important when using EVM.
- d. Do not leave any task or milestone un-progressed and time phased to the left of the current status date. Reflect tasks as actually started and in-progress (with proper completion forecast), actually completed, or re-forecasted to a more accurate start and/or completion date. (Beware that some schedule management tools, such as Microsoft® (MS) Project, do not force the user to update the status of on-going or behind schedule tasks/milestones).
- e. Use “Remaining Duration” as the primary method of statusing in-progress tasks. This will keep projected finish dates accurate, as well as succeeding linked tasks/milestones properly time phased.
- f. After all status updates have been incorporated into the IMS, it is important to analyze schedule impacts and resolve all issues resulting from the new status updates. This analysis includes, but is not limited to: identifying the current critical path and comparing to the previous critical path, identifying and correcting status input errors, identifying tasks/milestones with missing status, identifying new schedule related risks, identifying necessary logic, resource, and calendar changes that are required, etc.

After status updates are incorporated and impact analysis and resolution is complete, provide updated schedule reporting to project management and necessary customers.

Status updates should be made as frequently as feasible. The frequency is often dependent upon what phase the project is in, who is doing the work (in-house MSFC, contractor, or both), as well as the number of resources available to gather, input, and analyze the new status updates.

3.3.7.2 Schedule Maintenance

Schedule maintenance should consist of, but not be limited to, verifying/modifying task/milestone durations, revising or adding logic interdependencies, additions of new tasks or milestones and their associated logic ties, re-allocation or assignment of resources, calendar changes, and other miscellaneous minor schedule adjustments. Schedule maintenance is an on-going process that is carried out in parallel with incorporating status updates; however, it should be done as Integrated Master Schedule (IMS) modifications are necessary apart from the normal status update cycle.

Revising task/milestone data may entail a change of task/milestone dates, duration, resource allocation, or location within the data structure (i.e., Work Breakdown Structure (WBS)). Actual task/milestone dates (start or finish) should be entered as accurately as possible. Planned task/milestone dates should be calculated by the scheduling tool used, not manually entered by the tool user. Duration, or remaining duration, should be updated to reflect the most current estimate. Resource allocation changes should also reflect the most current estimate. When changing a task/milestone location within the data structure, ensure the existing interdependencies with other tasks/activities are still valid and accurately reflected.

New tasks and/or milestones may be added to better define existing work scope or to add new work scope. Both scenarios should adhere to existing schedule controls for descriptions, structure, coding, network logic,

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 47 of 230

duration, resource allocation, and risk data. Oftentimes the addition of new tasks/ activities results in a longer duration for the overall schedule, making it necessary to address some of the analysis functions discussed in Section 3.12.3 of this document.

Minor modifications to network logic are necessary on occasion to maintain an accurate reflection of the work being performed. Logic modifications have a direct impact on the planned (calculated) dates for activities, including contractually required and management-directed events. Before and after any significant logic modification, it is recommended that an electronic copy of the schedule should be made and stored for safekeeping.

3.3.8 Schedule Control

Schedule control is a disciplined process for managing baseline schedule data, as well as current Integrated Master Schedule (IMS) content. It should be understood that baseline schedule data represents firm commitments while current schedule data reflects actual and forecasted outcomes. Baseline and current schedule changes are to be clearly identified, evaluated, documented, and approved. Disciplined schedule control provides assurance that the baseline and current IMS includes all of the work authorized and is maintained in a manner that is accurate, traceable, and defensible. Schedule control techniques put in place depend upon programmatic requirements, project size, and complexity of the schedule. Examples of common schedule controls include Baseline Change Requests (BCR), Schedule Change Boards, Configuration Control Boards, IMS change logs, and version controls. Application of the principles in this section applies equally to all contractor and MSFC schedules. However, approvals and notifications may vary depending upon the contract or organization. The project team should refer to the authorizing documents for specific schedule control best practices.

For non-Earned Value Management (EVM) projects, it is recommended that the project focus the management baseline schedule control process on a carefully selected and meaningful set of tasks and/or milestones from the IMS. This set of control tasks and milestones may include, but is not limited to, items such as contract milestones, major integration milestones, key procurement milestones, critical test activities, hardware deliveries, facility readiness milestones, technical reviews, verification milestones, and operational readiness milestones. Using this approach, the control of the baseline IMS is limited to control of these approved tasks and milestones. Changes to other task and milestone dates will not require approval through the baseline change control process unless their movement impacts a task or milestone that is baseline controlled.

For projects requiring the implementation of EVM processes, there is a more direct and rigorous relationship to be maintained between the total baseline schedule and performance measurement processes. The management baseline schedule becomes an integral component for development and time phasing of the Performance Measurement Baseline (PMB). The PMB is a time-phased budget based on the cost estimates for resources allocated to IMS tasks. The PMB should remain stable and only be modified due to changes in authorized work scope, authorized re-plans, or authorized re-baseline activity.

Therefore, a requested change to future plans contained in the baseline that result in changes to the task sequence that impact Control Account (CA)/Work Package (WP) budget phasing for remaining work will require an approved change to the PMB. If these changes are not controlled, documented, and reflected accurately in the revised baseline, then project performance will not be measured accurately and variance identification will be compromised. The impacts could potentially result in additional and unnecessary variance reporting requirements and more importantly, faulty schedule information for management decision-making use.

Generally, it is recommended that for those changes that are reflected only in the current schedule, such as a

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 48 of 230

simple re-ordering of task sequence, and are determined not to require a formal baseline change, that they also be informally logged and communicated to project team members, line management, and other stakeholders using a process established by the project office so that on-going resource planning by management can be maintained in an effective manner.

As stated above, MSFC organizations will use a change management process to manage various types of technical and programmatic baseline changes. What follows is a description of the process sequence for a project engaged in baseline schedule control. This process is used regardless of whether the proposed change is to the external or internal schedule baseline. Terms and details reflected below may vary to some degree between projects.

- a. A Change Request (CR) for the IMS is initiated by a responsible project Technical Lead, responsible contractor, or other outside customer source (See Figure 19).
- b. The responsible change initiator who originates the CR documentation should coordinate with the project Schedule Office to determine the resulting impacts caused by the proposed change. Impact analysis should be conducted on both external and internal schedule baselines by preparing “what-if” versions to assess the impact of the proposed change utilizing the original baseline plan, the currently approved baseline plan, or the current updated IMS.
- c. The CR not only documents a clear description of the proposed change, but also the “from” and “to” proposed changes on the internal and external schedule and budget baselines.
- d. The CR is then brought to the governing project Configuration Control Board and reviewed in accordance with the project’s Configuration Management Plan (CMP). If the proposed schedule change impacts the external schedule baseline, then review and approval will also be required by the appropriate governing change board at the Center, program, mission directorate, or Agency level.
- e. Once the schedule CR has been formally approved by all the applicable change control boards, the project Planner/Scheduler (P/S) issues an updated schedule with a new revision designator assigned to the baseline IMS.
- f. The project P/S should maintain a log of all revisions to the baseline IMS. This log provides the on-going baseline schedule traceability which is crucial to sound project configuration control.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 49 of 230

ICESAT-2 PROJECT OFFICE ESTIMATE / BASELINE CHANGE REQUEST FORM (See attached Instructions)						
1 Change Request #: 11-0001			2 Date Initiated: 4/7/11			
3 Description (Title) of Change: To correct an oversight in planning.						
4 WBS/CA #: 883151.05.05.02.02			5 WBS/CA Title: Structures			
6 Originator: Danielle Vigneau			7 Approval Date Required: 5-1-11			
8 ECR Reference (if applicable): N/A						
9 Change Type: (Enter Yes or No)	Scope Yes	Budget Yes	EAC Yes	Schedule (Baseline) No	Schedule (Estimate) No	
10 BAC Increase/Decrease (\$): \$755K			11 New Baseline Start/End Dates: No change			
12 EAC Increase/Decrease (\$): \$755K			13 New Estimated Start/End Dates: No change			
14 Description and Justification (attach supporting documentation):						
<p>Scope: Based upon review of the control account planning and the BOE, it was discovered that certain efforts required to support the Flight Structure Environmental Testing were inadvertently omitted. This change request corrects this oversight. Two work packages will be created, one for Test Plan Development-883151.05.05.02.02.0L.13 and Flight Structure Environmental Test Support -883151.05.05.02.02.0L.14.</p> <p>Budget: Management Reserve of \$755K is requested to budget these required work efforts. The supporting estimates are attached.</p> <p>EAC: This will increase the EAC by a like amount of \$755K.</p> <p>Schedule: There is no impact to the control account start or completion date associated with this change.</p>						
15 Impact to linked activities? (Yes or No) No			16 WBS/WBS Dictionary Change? (Yes or No) No			
17 Insert WBS/WBS Dictionary Change when applicable: Not applicable						
18 Impact if change not approved: The test plan development and support requirements to the Flight Structure Environmental Testing are required and must be performed. If not approved, will result in an overrun to the control account and an unfavorable CPI.						
19 Approvals Yes or No		Approver Signature				Date
Yes		P-CAM		Need E/BCR that was not approved with appropriate signatures and Comments.		4-7-11
		Func/Div Mgr				
		Planner/Scheduler				
		Bus Mgr/Analyst				
		Project Manager				
20 Comments:						

FIGURE 19. CR Form

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 50 of 230

3.4 Cost Estimating

3.4.1 Introduction

Cost estimates are critical to project planning and good project management. They provide the basis for programming the total funding requirement and the recommended phasing of budgets. Obtaining accurate cost estimates can be difficult as MSFC projects usually involve new technologies and take years to complete. Inaccurate estimates can result from an inability to predict and/or define requirements, technological advancements, task complexity, economic conditions, schedule requirements, support environments, or system employment concepts. However, the number one contributor (according to the recent IG report: "NASA's Challenges to Meeting Cost, Schedule, and Performance Goals") to cost growth are unrealistic estimates caused by a culture of optimism. Unrealistic estimates lead to unexecutable plans. PP&C must address the optimism bias in the NASA project management culture directly by insisting on credible cost estimates supported by facts and data.

Office of Strategic Analysis and Communication (OSAC) is the process owner for cost estimating at MSFC. Cost estimates are the basis of the Planning, Programming, Budgeting & Execution (PPBE) submittals, and are used by decision makers to determine if a project is affordable and executable within MSFC's projected budget. Therefore, it is extremely important for Project Planning & Control (PP&C) to ensure that the estimates are as complete and credible as possible given the level of project and technical definition. This is especially true prior to Key Decision Point (KDP) C, when early estimates become locked in during the budget planning activities despite the fact that requirements, designs, and programmatic details are still being determined.

NASA Policy Directive (NPD) 1000.5, *Policy for NASA Acquisition*, explicitly states that it is NASA policy to "Base acquisition on realistic cost estimates..." This policy also lays out the requirement for Joint Cost and Schedule Confidence Level (JCL) assessments to support budget baselines. MPR 7120.1 calls for Life Cycle Cost (LCC) estimates, cost risk analyses, and JCL analyses to support key decision milestones and Center commitments. See Section 3.4.5 for a description of JCL. In addition, MPR 7120.1 calls for a documented Basis of Estimate (BOE). PP&C is responsible for ensuring that all cost estimates, JCL analyses, and documentation are developed to support key decision milestones.

PP&C is responsible for developing the initial project cost estimates during the early formulation phases. PP&C develops the Independent Cost Estimate (ICE) for the Source Evaluation Board (SEB) activities; therefore, PP&C should be a member on the Project Control Board and will provide cost estimates and schedule impacts for proposed changes. Upon contract selection, the PP&C will develop estimates for any authorized changes to be used in negotiations of these changes.

The Engineering Cost Office (ECO) at MSFC (CS50) specializes in performing cost estimates and JCL analysis for projects, and can support the PP&C function. ECO/CS50 provides LCC estimates, cost risk analyses, cost/schedule risk analyses, engineering economic analyses, cost benefit analyses, and financial/business case analysis.

3.4.2 Cost Estimating Process

The *NASA Cost Estimating Handbook Version 4.0* at <http://www.ceh.nasa.gov> defines a "how to" twelve step process for performing a cost estimate and cost risk analysis. These steps can be grouped into three parts: Project Definition; Cost Methodology; and the Estimate as depicted below in Figure 20.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 51 of 230

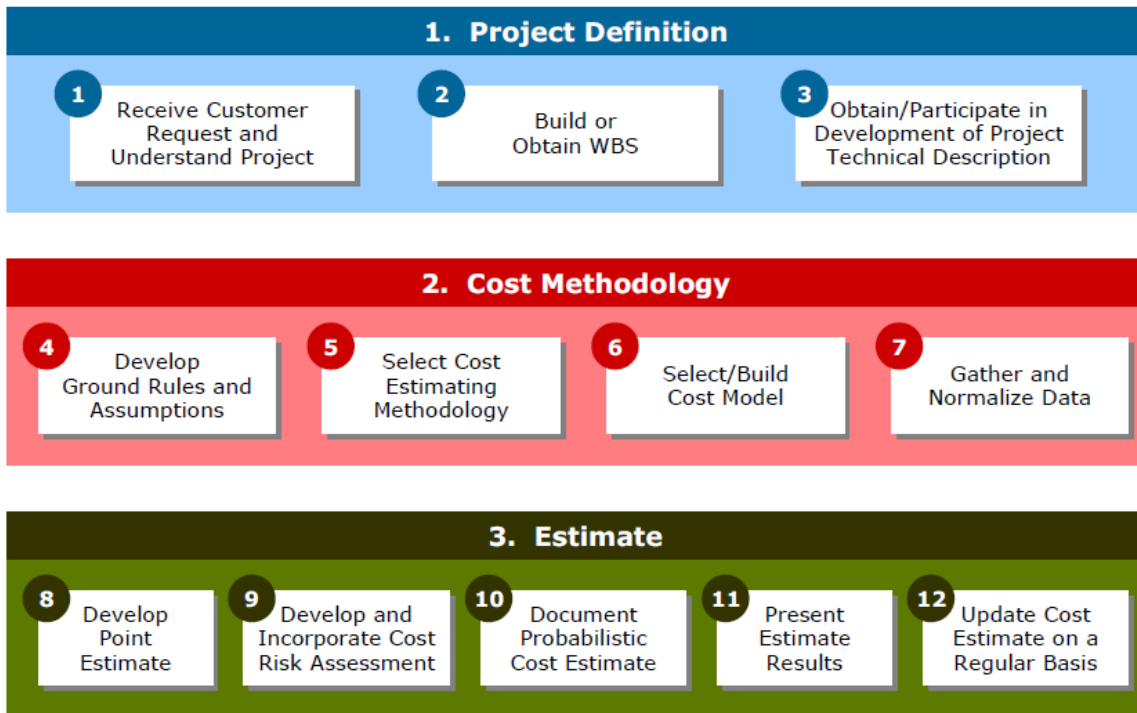


FIGURE 20. Cost Methodology Process

During Project Definition, the estimator clarifies the reason for the estimate, defines expectations, and begins to understand the project that will be estimated. As the estimate is being defined and data is gathered, a WBS and technical description are obtained. These items help define the project and form the foundation for the estimate. As the estimator continues through the estimating process, these steps may be revisited as new information becomes available. Project Definition process is broken down into the following tasks:

- a. Task 1: Receive Customer Request and Understand the Project - Every cost estimate begins with a need or requirement. It is incumbent on the estimator to work with the customer to fully understand the requirement for the estimate, know how the estimate will be used, and identify key stakeholders.
- b. Task 2: Build or Obtain Work Breakdown Structure (WBS) - The WBS forms the backbone of the cost estimate. The WBS must include the full scope of the project being estimated, regardless of scope of the estimate. If a project WBS is not available the analyst will have to develop one. All WBSs should be related or map to NASA Standard WBS as defined in NPR 7120.5E.
- c. Task 3: Obtain/Participate in the Development of Project Technical Description - The project technical management, and operations baseline provides the basis for the cost estimate. The cost estimator must obtain and understand project documents that define the baselines, as well as any other documents that describe the project.

Part 2 of the cost estimating process, Cost Methodology, addresses four tasks that create the approach and framework for the estimate. These tasks will guide the development of the estimate. Cost estimating methods are discussed further in the following section. The Cost Methodology process is broken down into the following tasks:

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 52 of 230

- a. Task 4: Develop Ground Rules and Assumptions - The objective of developing ground rules and assumptions is to communicate the scope, context, and environment within which the estimate is being developed.
- b. Task 5: Select Cost Estimating Methodology - Based on their understanding of the project and suitability of various estimating methods the analyst must select the best cost estimating methodology (or combination of methodologies) for the data available to develop the most accurate cost estimate possible.
- c. Task 6: Select/Construct Cost Model - The objective of this task is to select the most appropriate tool/model or to create a model to estimate the cost. Factors that influence the selection process include the level of project definition and data resource availability, tool and model availability, schedule, and cost.
- d. Task 7: Gather and Normalize Data - Credible data is extremely important to producing defensible cost estimates. The analyst must work with the project, using the documentation provided in Task 3 as well as information collected from technical and programmatic experts, to ensure that the most accurate information possible is being used to develop the estimate. In some cases project data will need to be normalized for model input or historical data will need to be normalized to facilitate the development of cost methodologies.

Part 3 of the cost estimating process, the Estimate, defines the tasks needed to perform and document the cost estimate. The Estimate process is broken down into the following tasks:

- a. Task 8: Develop Point Estimate - In this task the analyst creates an initial Life Cycle Cost (LCC) point estimate. The analyst will use the data gathered and normalized in Task 7 to exercise the cost model constructed in Task 6.
- b. Task 9: Develop and Incorporate Cost Risk Assessment - The cost risk assessment (or analysis) is a technique for addressing all the uncertainties in the cost estimate as well and the known risks to project execution. The general approach to performing a cost risk assessment is to determine the level of uncertainty in the estimate, estimate the probability and consequence of the major risks, and apply a technique such as Monte Carlo simulation to generate the probability density function, more commonly known as the “S-Curve”.
- c. Task 10: Document Probabilistic Cost Estimate - The purpose of the documentation is to provide a written justification of the cost estimate and the cost risk analysis. The documentation must be complete and thorough, capturing the input data, ground rules, assumptions, approaches, model settings, etc. that were used to develop the estimate and any associated analyses.
- d. Task 11: Present Estimate Results - The analyst develops briefing material and present the cost estimate and associated analyses to the customer, key stakeholders, and other interested parties. The analyst must be prepared to defend their cost estimate against criticism.
- e. Task 12: Update Cost Estimate on Regular Basis - As the project becomes better defined the cost estimate will need to be updated. Very early in the information process these updates will occur frequently. As the project moves into implementation updates may only be done on an annual or as-needed basis.

3.4.3 Cost Estimating Methods

Cost estimating methods (or techniques) provide the approach for determining the cost of the project for budget planning, procurement support, and effective management. Selection of the appropriate cost estimating method is dependent upon the maturity of the technical design, the amount of applicable historical data, the availability of project actuals, and the status of the project relative to the specific milestone reviews. Often different elements of the Work Breakdown Structure (WBS) will be costed using different methods

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 53 of 230

depending upon which technique provides the best estimate. The five basic cost estimating methods are as follows:

- Expert Opinion/Delphi Approach
- Analogy
- Parametric
- Engineering Build-Up or Bottom-UP
- Extrapolation

Note that all estimating methods require judgment on the part of the estimator. This judgment should be documented and becomes part of the estimate uncertainty captured in the cost risk and joint cost schedule confidence level analysis. Additionally, Project Planning & Control (PP&C) personnel must work closely with the cost estimators to ensure that the estimates correctly capture the technical design, programmatic plans, and any other nuances of the project.

An expert opinion estimate is a high level estimate based on a basic set of requirements or early concept design. Expert opinion estimates are useful for deriving a rough order of magnitude estimate for planning purposes. The Delphi Approach is a multi-round survey method that seeks to build consensus within a group of experts regarding the cost of the system. The Delphi Approach uses anonymity, iteration, controlled feedback, and statistical aggregation to develop an estimate. Used correctly, the Delphi Approach is an improvement over individual expert opinion. However, neither method is appropriate for near term budget planning, budget submits, or procurement activities.

The analogy approach estimates the cost of the system by extrapolating from one or more analogous historical systems. The analogy approach requires that you have one or more appropriate analogies. To use the analogy approach you begin with the cost of the analogies and modify (or adjust) that cost to account for differences between the analogy and the system being estimated. For example, the cost of the analogy may be adjusted upward to account for increased complexity in the new system or downward to address a difference in technology readiness level. The analogy approach can be used for budget planning, submits, and procurement. Analogy estimates are also a good approach for validating the results of other estimating techniques.

The parametric cost estimating approach uses models based on historical space flight system data. These models relate cost to technical and programmatic parameters that are usually available early in the concept exploration and refinement phase. Thus, parametric estimates are particularly useful early in the design process, but can also be used throughout the life-cycle. By estimating the cost based on historical data, parametric estimates (along with analogy estimate) are typically more complete than other methods (fewer "I forgot"). Parametric estimates can also be conducted relatively quickly and are easily replicated. The process for developing parametric cost models and performing a parametric estimate is depicted below in Figure 21.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 54 of 230

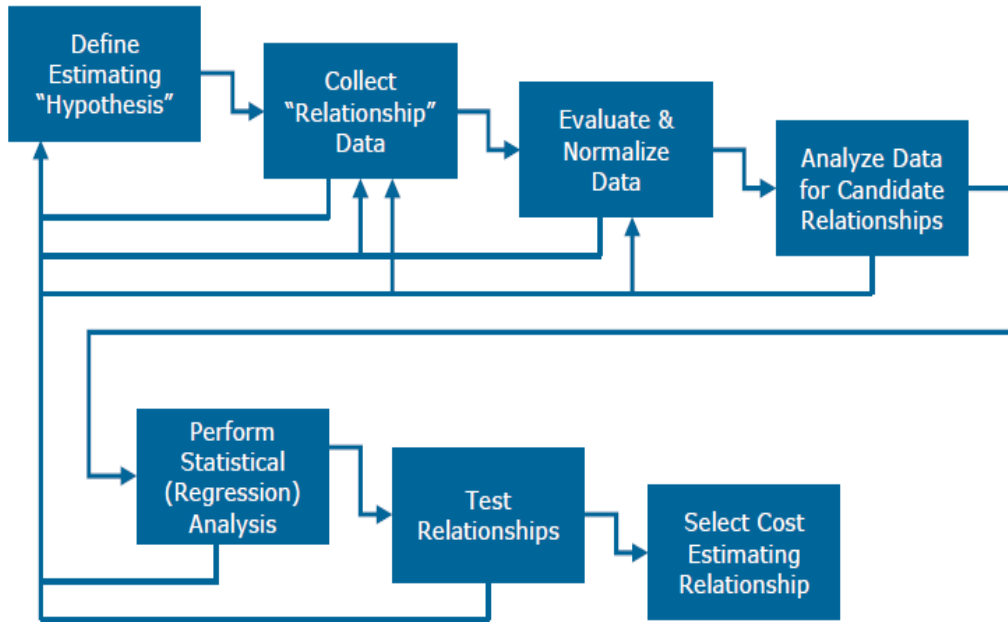


FIGURE 21. Parametric Cost Estimating Process

Engineering buildup estimates, sometimes referred to as “grass roots” or “bottom-up” estimating, is an aggregate of individual estimates performed at the detailed WBS level. This costing methodology involves the computation of the cost of a WBS element by estimating at the lowest level of detail (often referred to as the Work Package (WP) level) wherein the resources to accomplish the work effort are readily distinguishable and discernible. Often the labor requirements are estimated separately from material requirements. Overhead factors for cost elements such as Other Direct Costs (ODC), General and Administrative (G&A) expenses, materials burden, and fee are generally applied to the labor and materials costs to complete the estimate. A credible engineering build-up estimate requires a significant level of detailed design data. Therefore, it is often not appropriate before a project has reached a Preliminary Design Review (PDR) level of maturity.

Figure 22 illustrates a method for deriving an engineering buildup estimate. While this is a simple illustration of the engineering buildup methodology, it is important to remember to conduct other detail activities such as documenting the Basis of Estimates (BOEs) and schedules, and applying wage and overhead rates.

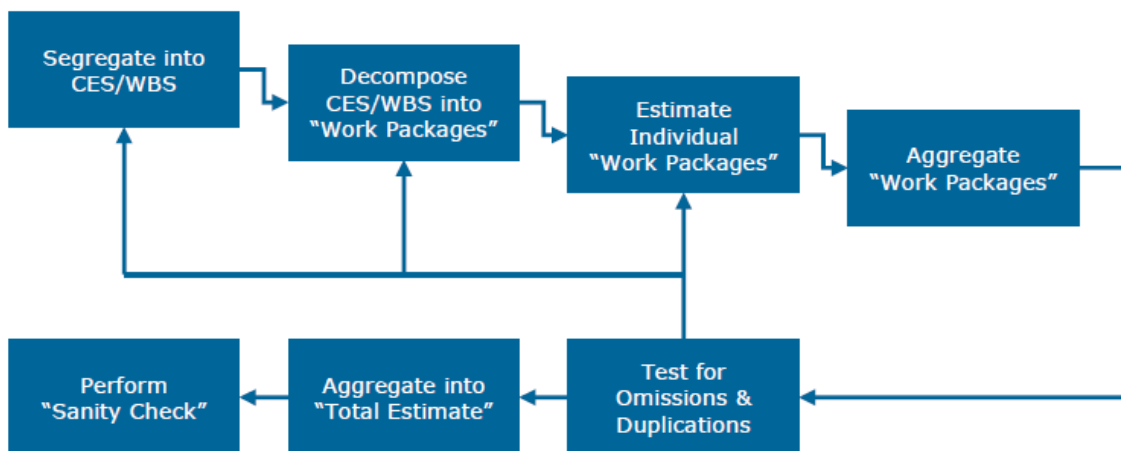


FIGURE 22. Development of Engineering Buildup Estimate

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 55 of 230

If actual cost data is available the project can use the data to extrapolate to an estimate for a hardware item, test, etc., or for an estimate at completion. Extrapolation from actuals uses costs incurred on the project for test hardware, flight elements, partially complete items, etc. to project the cost for a future item. In addition, if earned value management (EVM) data is available and EVM statistics can be used along with one or more estimate at completion (EAC) techniques to develop a project estimate.

3.4.4 Basis of Estimate (BOE)

The BOE is the information, assumptions, judgments, logic, and data used to determine the resources required to perform the effort and the assessment and quantification of project risks. The BOE should:

- a. Be traceable to the associated-cost input data
- b. Include sufficient summaries and cross-references to provide an adequate audit trail
- c. Be clear, concise, and understandable in order to avoid misunderstandings or misconceptions regarding the effort and associated costs
- d. Include the assumptions made to enable or support the cost estimates
- e. Include all the information necessary for a third party to re-create the estimate.

BOEs capture the rationale and estimating methods used to calculate the cost. The BOE provides the traceability from the project definition through the cost estimating method(s) to the project estimate. All assumptions, model adjustments, ground rules, project data, historical data, and any other information relevant to calculating the cost estimate and the cost risk analysis should be captured as part of the BOE. The BOE also explains any schedule issues that may impact the required resources. It is important that the BOE be clearly and completely documented, as this will be used to perform the independent cost assessment for project milestones per MPR 7120.1. The BOE is also critical to procurement personnel during negotiations with contractors.

When Earned Value Management (EVM) is required on in-house projects, the BOE will need to be aligned with the Control Accounts (CAs) or Work Packages (WPs) to provide a valid estimate for the work that will be integrated into the Performance Measurement Baseline (PMB).

3.4.5 Joint Cost Schedule Confidence Level (JCL)

A JCL analysis is a specific application of probabilistic risk analysis techniques that results in a probability (confidence) that a project will be able to successfully execute within the available budget *and* schedule. A JCL is a requirement for Category 1 and 2 projects at Key Decision Point (KDP) C per NASA Procedural Requirement (NPR) 7120.5E. The project is responsible for collecting the data, preparing the JCL, and presenting the results to the Standing Review Board.

The purpose of the JCL is to improve the cost and schedule performance of the Agency's projects. The Inspector General's Report (IG-12-021, "*NASA's Challenges to Meeting Cost, Schedule, and Performance Goals*") identified a serious problem with over optimism in the NASA project management community. For the JCL analysis to be of value, the Project Planning & Control (PP&C) team needs to diligently work to avoid optimistic inputs and assumptions. The goal of the analysis is to make sure the project has adequate budget and schedule consistent with their risk posture. Unrealistic inputs to the analysis will result in an unexecutable plan and project failure, possibly leading to cancellation.

Per 7120.5E, the only acceptable technique for the JCL is a bottoms-up resource loaded schedule (BURLS). The BURLS requires a detailed IMS that meets basic good scheduling practices (see Section 3.3). In many

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 56 of 230

cases, a special summary level "analysis schedule" will need to be developed to support the JCL analysis. Once the Integrated Master Schedule (IMS) is developed, the schedule tasks are loaded with resources. Those resources (costs) are identified as either time dependent (cost change as schedule changes) or time independent (cost does not change as schedule changes). Uncertainties are then applied to the cost and schedule durations and correlation between the costs and schedule tasks are assigned. The final step in developing the BURLS is to account for how the project risks will impact the cost and schedule at the task level (again, over-optimism must be guarded against). Once the BURLS is developed, the JCL is calculated using a Monte Carlo simulation. The results of a typical JCL analysis is shown in Figure 23.

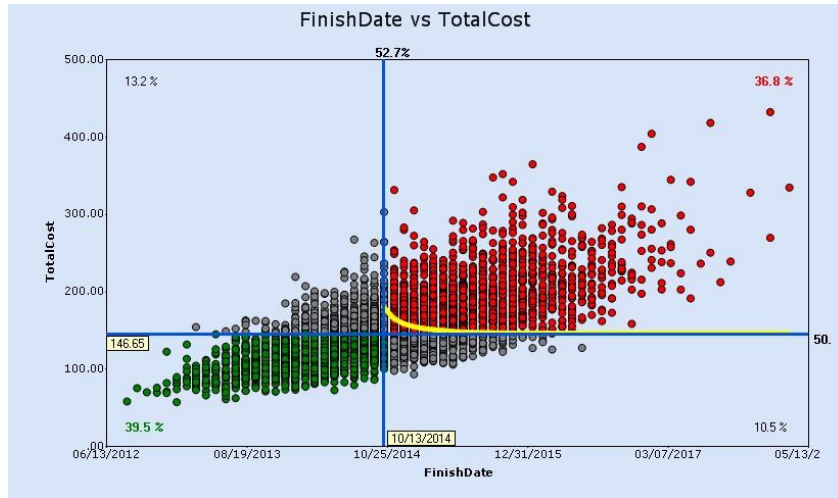


FIGURE 23. JCL Simulation Calculation

With the JCL results, the project can determine its joint confidence level. In the example above it is about 63%. NPD 1000.5 requires projects to be budgeted to a 70% JCL, and projects to be allocated a minimum funding level equivalent to a 50% JCL. The difference between the project funding and 70% JCL value is known as Unallocated Future Expenditures (UFE). UFE is held at the Program Level (see Figure 37).

Development of the BURLS and performance of the JCL requires specialized tools and skills. NASA Headquarters has sponsored the development of two JCL tools: POLARIS by Booz Allen Hamilton and JACS by Tecolote. Microsoft Project can also perform a JCL using a version of @Risk, a Monte Carlo simulation tool. Proper applications of these models require skills in probabilistic risk analysis and schedule resource loading. Probabilistic risk analysis capability is provided by the Engineering Cost Office (ECO/CS50) and various contractors. The ECO can assist the PP&C professional with the proper development and application of the JCL, and presentation of the results to the SRB.

Once the project passes KDP C, there is no requirement to update or maintain the JCL, unless the project is rebaselined. However, several project management teams have found the JCL to be a useful tool for estimating the cost and schedule impacts of various decisions or changes in budget. The PP&C team will need to evaluate the usefulness of the JCL model to continued management of the project post KDP C and make a recommendation to management.

3.5 Contract Management Overview

A substantial amount of a project's or mission support organization's budget is expended through contracts. The MSFC Office of Procurement (OP) is responsible for administering contracts and ensuring that all applicable public laws and prime contract flow down requirements are adhered to in a professional and highly

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 57 of 230

ethical fashion. However, contract management is a team effort that includes inputs from PMs, contracting officer’s representatives (COR), Project Planning & Control (PP&C) personnel, the responsible Contracting Officer (CO), contract specialist, MSFC technical managers, etc.

This section addresses the key activities involved in effective contract planning and execution as it relates to the roles and responsibilities of the PP&C team. The acquisition process itself consists of three distinct phases: an acquisition planning phase; a solicitation award phase; and a contract management phase. Each phase consists of specific activities that should be accomplished prior to the completion of one phase and movement to the next, if a successful acquisition is to occur. PP&C responsibilities include timely initiation of acquisition planning; preparing the budget and overseeing its execution to ensure adequate funding is available for the procurements; preparing inputs to the procurement requisition (PR) packages to include the Statement of Work (SOW), Data Requirements Descriptions (DRDs), etc.; providing the in-house cost estimate; performing the cost and business proposal analysis; and monitoring contractor compliance with the programmatic and business requirements and deliverables.

When the planned contract meets the requirements for Earned Value Management (EVM) (see Section 3.10), the Project Manager (PM) and the PP&C team coordinate with the MSFC EVM Focal Point (see Appendix B – Glossary, for definition) in OSAC, for assistance in defining the appropriate EVM requirements for each contract and to facilitate effective EVM implementation after contract award. For more information, see the *NASA EVM Implementation Handbook*, <http://evm.nasa.gov/handbooks.html>.

3.5.1 Contract Considerations

Supplies and services are obtained through various avenues depending upon the specific requirement. Procurement actions vary in scope and complexity and should be tailored to the specific requirement. The specific components of the Procurement Requisition (PR) package and the Project Planning & Control (PP&C) contributions will depend on the nature of the work, whether the contract is to be awarded competitively or non-competitively, and risk.

Whether procurement is done on a Purchase Order or a contract is not dependent on the dollar value of the procurement. Commercial items and services are placed on purchase orders, while items and services that are not commercially available, and consequently include an equipment specification and a Statement of Work (SOW), are placed on a contract. Purchase Orders are not appropriate for noncommercial items and services. Contracts are appropriate for both non-Research and Development (R&D) and for R&D items and services.

If the procurement requires the development or manufacture of a prototype or engineering model, it probably is not a commercial item. If the procurement requires support for analysis or application of plasma physics or quantum mechanics it probably is not a commercial service, and this type of support should be placed on a contract. Additional procurement methods include some of the following [see Marshall Work Instruction (MWI) 5100.1, *Initiating Procurement Requisitions* for a full listing]:

- a. Requisitioner purchase card for actions \$3,500 or less (see MWI 5113.1, *Government-Wide Commercial Purchase Card Operating Procedures* for details);
- b. MSFC Retail Supply Source for office supplies, furniture, and chemicals. Purchases of \$3,500 or less may be made with the Government-wide Purchase Card;
- c. Center Information Technology (IT) contracts managed by the Office of the Chief Information Officer (OCIO) for IT products and services (reference Marshall Policy Directive (MPD) 2800.1, “Management of Information Technology Systems & Services at MSFC”);
- d. Training and Incentives Office for off-the-shelf training courses (see MWI 5113.1 for details); and

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 58 of 230

e. Agency Consolidated End-User Services for NASA for desktop computing services.

One of the most critical procurement decisions early in the project or with mission support activities is the determination of what contract type to use. There is a wide selection of contract types available to the Government in order to provide flexibility in acquiring the large variety and volume of supplies and services required. Contract types are grouped into two broad categories: fixed-price contracts and cost-reimbursement contracts. The specific contract types range from firm-fixed-price (FFP), in which the contractor has full responsibility for the performance costs and resulting profit (or loss), to cost-plus-fixed-fee (CPFF), in which the contractor has minimal responsibility for the performance costs and the negotiated fee (profit) is fixed. In between are the various incentive contracts, in which the contractor’s responsibility for the performance costs and the profit or fee incentives offered are tailored to the uncertainties involved in contract performance. Incentive contracts are designed to obtain specific acquisition objectives by: establishing reasonable and attainable targets that are clearly communicated to the contractor; and including appropriate incentive arrangements designed to motivate contractor efforts that might not otherwise be emphasized, and discourage contractor inefficiency and waste.

For commercially available goods and services, the project PP&C can work with Office of Procurement (OP) to execute a purchase order, which is FFP. Payment for goods is made either against partial deliveries per line item or in full upon delivery of all goods. Payment for services is made as a lump sum when all services have been received.

For details on contract types see Appendix C of this handbook and Federal Acquisition Regulations (FAR) Part 16, “Contract Types and Agreements.”

3.5.2 Acquisition Planning Phase

The Project Planning & Control (PP&C) provides programmatic, business, and financial management guidance and support to the “requisitioner” during the acquisition planning process. In accordance with MWI 5100.1, *Initiating Procurement Requisitions*, the requisitioner is the person who prepares or is otherwise responsible for initiating the Procurement Requisition (PR) for supplies or services required by their respective organizations, including the furnishing of appropriate specifications or Statement of Work (SOW), recommended sources, market research, data requirements, special approvals as required, evaluation criteria, and any other required documentation in accordance with this instruction.

The PP&C team coordinates the acquisition communication process between the technical and programmatic community and Office of Procurement (OP) to develop the acquisition strategy that is in accordance with Federal Acquisition Regulations (FAR) and MSFC policies. MPR 7120.1 is an integral part of acquisition strategy and planning for projects. As part of the Project Plan development phase (Phases A-B), items that will be contracted will be identified (make/buy list), the appropriate reporting and management requirements defined, and estimates attained from contractors. The recommended Make/Buy listing is then reviewed and approved internally. Identification of the major and non-major contracted efforts will fall out from this review. Appropriate management, reporting, review and flow down requirements are then determined. These in turn are included in the subsequent solicitation issuance or RFP.

Advance planning of procurement activity is essential in order for MSFC to meet its procurement, programmatic, safety, environmental, quality, and financial commitments. The PP&C should provide input on potential procurement needs to the OP to support their semi-annual procurement planning updates. The information provided includes the following:

- a. Type of procurement
- b. Description of requirement

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MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 59 of 230

- c. Estimated dollar value
- d. Name of Requisitioner (this is the technical initiator of the requirement which may be the Project Manager (PM) or the Contracting Officer Representative (COR))
- e. Organization code and phone number
- f. Fiscal Year (FY) quarter when requirement is to be procured
- g. Number of procurement actions
- h. Is the requirement to be procured commercially or non-commercially?

The Requisitioner (PP&C works programmatic, business, and financial issues for the Requisitioner) prepares or is otherwise responsible for initiating the PR for supplies or services required by their respective organizations.

The PP&C team should adhere to the important acquisition strategy considerations when planning procurements that include maximizing the competition, clearly identifying requirements, carefully analyzing past performance, and providing a fair opportunity for small businesses to compete. The project should obtain input from the MSFC organizations responsible for Safety & Mission Assurance (SMA), occupational health, environmental protection, Information Technology (IT), export control, and security. One example of such requirements would be compliance with all aspects of MWI 85505.5, *Hazardous Material Management*, for any products or services which fall within the scope of this MWI.

PP&C guidance and support to the Requisitioner and the OP acquisition planning activities include:

- a. Provide recommendation on appropriate contract type.
- b. Develop the independent government cost estimate.
- c. Provide inputs to the draft SOW, contract clauses, Data Requirements Descriptions (DRDs), etc.
- d. Review industry feedback on the draft SOW and specifications; prepare/finalize SOW input.
- e. Support development of a procurement cycle schedule for all contracts and critical purchase orders for the project.
- f. Provide input to the evaluation criteria and approach as needed.
- g. Provide input to the PR package to include the business and financial reporting DRDs and appropriate instructions and tailoring to include those listed in Table I. When Earned Value Management (EVM) is required, ensure incorporation of the appropriate Earned Value Management System (EVMS) solicitation and contract clauses (see NASA FAR Supplement (NFS) 1834.2, *Earned Value Management System*).

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 60 of 230

Table I. Project Control Contract Reporting Requirements Example

MSFC DRD Title/No.	WBS and WBS Dictionary, STD/MA-WBS	Program/Project Schedules, STD/MA- PS	Integrated Program Management Report (IPMR), STD/MA-IMS	Earned Value Management System (EVMS) Description, STD/MA-MSD	NASA Financial Management Report, NF 533M, STD/MA- FMMR; NF 533Q and NF 533M, STD/MA- FMR	Final Scientific and Technical Report, STD/MA- FSTR
DRD Reference	NASA WBS Handbook	NASA Schedule Management Handbook	NASA EVM Implementation Handbook	NASA EVM Implementation Handbook	NPD 9501.1 NPR 9501.2 Contractor Financial Management Reporting	MPR 2220.1, Scientific and Technical Publications
MSFC OPR	CS40	CS40	CS40	CS40	RS20	IS02
Purpose	To subdivide the project/contract work content into manageable segments to facilitate planning and control of cost, schedule, and technical content.	Provide the time-phased plan, current status, key milestones, task interdependencies, and major development phases necessary to accomplish the total scope of work.	To communicate program cost and schedule information between the prime contractor and the Government. It may also be tailored for use on intra-government work agreements.	To provide a description of the contractor's plan in implementing a compliant EVMS in accordance with the Electronic Industries Alliance Standard 748 (EIA-748).	To provide monthly (and quarterly if applicable) financial reports for monitoring program costs. The 533 reports are the official cost documents used at NASA for cost type, price redetermination, and fixed price incentive contracts.	To provide a summary of the results of the entire contract effort, including recommendations and conclusions based on the experience and results obtained.
When Required	All program/projects /contracts subject to 7120.5, .7 and .8; and contracts with NF533 requirements. Required when the IMS is required; also NF533 and CPR	All program/ projects/contracts subject to 7120.5, 7120.7, 7120.8; and when EVM is a requirement.	Required for contracts equal to or greater than \$20M in accordance with NPR 7120.5 and NFS 1834.201.	The EVMS Description is required for designated contracts in accordance with EIA-748. NPR 7120.5 and NFS 1834.201 define the requirements and thresholds for applying EVMS to contracts.	All cost type and incentive contracts. <u>533M Required (533Q optional)</u> - \$500K to \$999K and 1 year or more; \$1 million & over and less than 1 year. <u>Both 533M and 533Q Required:</u> \$1 million plus and 1 year or more	This DRD is applicable to contracts containing the clause NFS 1852.235-73.

For copies of these DRDs and other PP&C related DRDs, see the MSFC Integrated Library on Inside Marshall at https://masterlist.msfc.nasa.gov/drm/drd_masterlist.taf.

For major project acquisitions the OP chairs the Procurement Strategy Meeting (PSM), which is attended by all interested MSFC organizations. The PSM is a meeting to seek approval for the proposed acquisition approach. At the meeting, the acquisition plan topics and structure are presented. The PP&C develops the business and programmatic charts for the PSM presentation to include whether EVM will be required and, if so, the EVM implementation approach.

For complete details of acquisition strategy/planning and the Requisitioner's roles and responsibilities, refer to MWI 5100.1, *Initiating Procurement Requisitions*, which also provides direction for the development of evaluation criteria during the acquisition planning phase.

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MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 61 of 230

3.5.3 Solicitation and Award Phase

Once the Procurement Requisition (PR) package is finalized, the solicitation and award phase of the acquisition process begins. In this phase, the government solicits quotes, offers, bids or proposals, evaluates them, and awards contracts. Source selection, including NASA competitive negotiated acquisitions, is covered in NFS 1815.3. Pursuant to NFS 1815.370(a), the Source Evaluation Board (SEB) procedures are used for those acquisitions identified in NFS 1815.300-70(a)(1)(i). The NASA Source Selection Guide provides agency-wide guidance to individuals participating in the SEB process and is available on the NASA Headquarters Procurement Library at https://prod.nais.nasa.gov/portals/pl/sol_to_award.html. For detailed information, see MWI 5115.2, *Procurement Development Team (PDT) & Source Evaluation Board (SEB) Process*.

The SEB assists the Source Selection Authority in decision making by providing expert analyses of offers and proposals in relation to the evaluation factors contained in the solicitation. The Project Planning & Control (PP&C) serve as evaluators or advisors on the SEB. They are appointed to the SEB evaluation team by the SEB Chairperson and asked to furnish advice, findings, analysis, and/or reports in a specific field of expertise or discipline. It should be noted that evaluators are not from the originator's organization. PP&C responsibilities during this phase include all of the above responsibilities discussed in the planning phase and:

- a. Evaluation of the offers and proposals against the technical and programmatic requirements/ evaluation factors (e.g., Work Breakdown Structure (WBS) and Dictionary, management approach, etc.).
- b. Assessment of proposed cost (Basis of Estimate (BOE)) by WBS and Statement of Work (SOW) (cost realism).
- c. Assessment of past performance on comparable or related work.
- d. Advise/assist the negotiation process as needed.
- e. Support contract negotiations as needed.

3.5.4 Contract Management Phase

The final phase in the process is contract management, which begins immediately after the contract award. The process of contract performance begins and is monitored throughout its development to closeout. The overall administration of the contract (seeing that the specifications and conditions are met) is the direct responsibility of the Contracting Officer (CO) and the Contracting Officer Representative (COR).

Promptly following the award, the government and contractor attend a post award orientation that will assist in clarifying all contract requirements. This meeting is a good time to introduce the project's representatives and set the stage for good working relationships under the contract. The PP&C team participates along with the COR, CO, Project Manager (PM), and technical leads. Project Planning & Control (PP&C) discussions with their contractor counterparts include review of business and financial reporting requirements and Data Requirements Descriptions (DRDs), monthly reviews, and when Earned Value Management (EVM) is required, establishment of the PMB and the expectation for the initial Integrated Baseline Review (IBR).

Throughout the life of the contract, both technical and financial monitoring is necessary. Fee determinations are periodically made through performance evaluations for award fee contracts. In addition, any changes and/or contract modifications should receive close scrutiny and management. PP&C will continue to play a primary role in the management of the contract. Analysis of the NF 533 and various other reports and evaluative tools should be utilized. PP&C will assess the performance of the contractor through the Earned Value Management System (EVMS) if required, and various other cost, work force, and schedule analysis.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 62 of 230

Agenda items for the Monthly Management Reviews include:

- a. Engineering or budget changes being requested by the contractor that impact the baseline plan.
- b. Liens and threats.
- c. Cost and schedule status through the current period.
- d. Variance analysis and estimate at completions (EAC).
- e. Workforce.
- f. Reserves.
- g. Funding.
- h. Status of open contract issues between MSFC project and the contractor or between the contractor and lower-tiered subcontract relationships.

PP&C activities during this phase include:

- a. Analyze the contractor’s technical, schedule, and cost performance and provide analysis to project management team.
- b. Analyze the contractor’s EAC and develop an independent EAC with input from the project team.
- c. Support the Project Control Account Manager (P-CAM) in generating variance analysis reports when significant variances occur.
- d. Assist in the monitoring of contract costs.
- e. Oversee the integration of contractor cost and schedule data into the project’s data.
- f. Assist in the reporting of cost/schedule status for contracted items and the accumulation of variance analysis reports when significant variances occur.

3.5.4.1 Integrated Baseline Review (IBR)

All contracts with Earned Value Management (EVM) are required to have an IBR to finalize the agreement on the baseline and ensure all risks are identified and understood. The Project Manager (PM) and his responsible technical managers, with Project Planning & Control (PP&C) support, should conduct an IBR within 6 months of contract award as required by NFS 1852.234-2(c). This timeline applies to the authority to proceed on letter contract awards as well. An IBR is also conducted within 6 months following the exercise of significant contract options or 60 days after a major contract modification. The PP&C is responsible for facilitating the IBR for the PM as well as participating in the review. The *NASA IBR Handbook* provides further guidance on the IBR process.

The PP&C facilitates the program/project IBR planning and execution. Specifically, PP&C will support the PM in developing the IBR approach and schedule, coordinating requirements with the contractor, conducting IBR training for the project team, conducting the IBR to include the schedule assessment, documenting the results, and monitoring all action items for satisfactory closure.

3.5.4.2 Earned Value Management System (EVMS) Surveillance

When a contractor has a requirement for an accepted or validated EVMS, the project is expected to periodically test or survey the EVMS. This function is normally delegated to the Defense Contract Management Agency (DCMA), via a delegation letter from the MSFC Contracting Officer (CO), in order to ensure that the contractor is still managing the contract in accordance with its validated EVMS. The Project

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 63 of 230

Planning & Control (PP&C) will participate in the DCMA EVMS surveillance as appropriate. If the surveillance is not delegated to DCMA or another outside source, however, then the project PP&C should perform this activity at least quarterly to ensure that the contractor is adhering to the EIA-748 *Earned Value Management Systems* guidelines and its own internal EVMS process. This will ensure that the information that is received and incorporated into the project baseline is valid and reliable. If any discrepancies are found then the contractor’s EVMS organization and its project team will develop a corrective action plan and provide monthly progress on the plan until full correction is achieved. The *NASA EVM Implementation Handbook* provides further guidance on the surveillance process.

3.5.4.3 Contract Closeout/Termination

Ideally, a contract runs its normal course without being terminated. The closeout of cost reimbursement-type contracts can take considerably longer than fixed price (FP) contracts since the Government usually conducts an audit of the contractor’s records to ensure that all costs incurred in performance of the contract were allowable and allocable. This audit takes place after settling all overhead rates, which can sometimes take several years after the contract’s period of performance ends. The Contracting Officer Representative (COR) may be called upon to comment on the reasonableness of or the necessity for certain items of cost, which encourages the COR to seek Project Planning & Control (PP&C) assistance.

In the event the contractor fails to fulfill their obligations, then it becomes necessary to end the relationship prior to completion of the contract by the process known as termination. Terminations fall into one of two categories: terminations for default and terminations for the convenience of the Government.

There are a variety of situations that lead to a contractor being considered in default. Under a cost reimbursement-type contract, the contractor is entitled to all normally allowable and allocable costs incurred up to termination and, if fee was included in the contract, to a pro rata portion of the fee based on work accepted by the Government. Under FP contracts, the contractor is not reimbursed for work performed prior to the termination which has not yet been accepted by the Government, and the Government is entitled to repayment of any unliquidated advance or progress payments applicable to such work.

All terminations not made for default are, by definition, for the convenience of the Government. Terminations for convenience involve no wrongful acts on the part of the contractor. Accordingly, the terms of the contract settlement are more favorable for terminations for convenience. For detailed information on contract closeout and termination, the PP&C team should refer to MWI 5100.1, *Initiating Procurement Requisitions*.

3.6 Work Authorization (WA)/Collaborative Work Plan (CWP)

3.6.1 Work Authorization (WA) Process

A formal WA process is considered a best practice and is also required for in-house work associated with MSFC projects that utilized Earned Value Management (EVM). When a WA process is used, scope, schedule, and budget are *transferred* from a project to a Purchase Order (PO), which “procures” civil servants and support contractors, and manages that work, similar to a “mini-project,” including the reporting of monthly status, to the sponsoring project organization.

The WA process is a critical aspect of any integrated management control system. Before work begins, the WA system defines and identifies the work to be accomplished, the organizational unit responsible for that work, the completion criteria for the work, the schedule (i.e., at a minimum, the period of performance) within which the work is to be performed, and the budget negotiated for the work. For a more detailed explanation and instruction, see the *NASA EVM System Description*.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 64 of 230

The following parameters apply to WA:

- All authorized work is clearly defined using the framework of the project Work Breakdown Structure (WBS) decomposed or extended to the Control Account (CA) level.
- A specific individual is assigned from the responsible organization to manage a specific CA scope of work, schedule, and budget. This individual has direct responsibility for the work and directs the resources required to accomplish the work.
- If there is a change to assignment of responsibility, WBS, scope of work, period of performance, or a revision to an existing Work Authorization Document (WAD), a revised WAD is issued.
- All authorized work is clearly traceable to the authorized project phase (e.g. Formulation vs. Implementation).
- Work is not performed, costs are not incurred, and procurement is not initiated unless authorized by a WAD.

The WA process is a documented method that subdivides the authorized work into manageable units of work and identifies the organization and individual responsible for its accomplishment. The further down the WA trail (see Figure 24), the more specific is the scope of work and the responsibility assignment. Project activities are authorized and initiated through the use of a NASA Program Plan, Project Plan, and WAD that authorizes a Project Control Account Manager (P-CAM) to accomplish tasks within a project. See MPR 7120.1 for additional information regarding the preparation, review, approval, and maintenance of project plans.

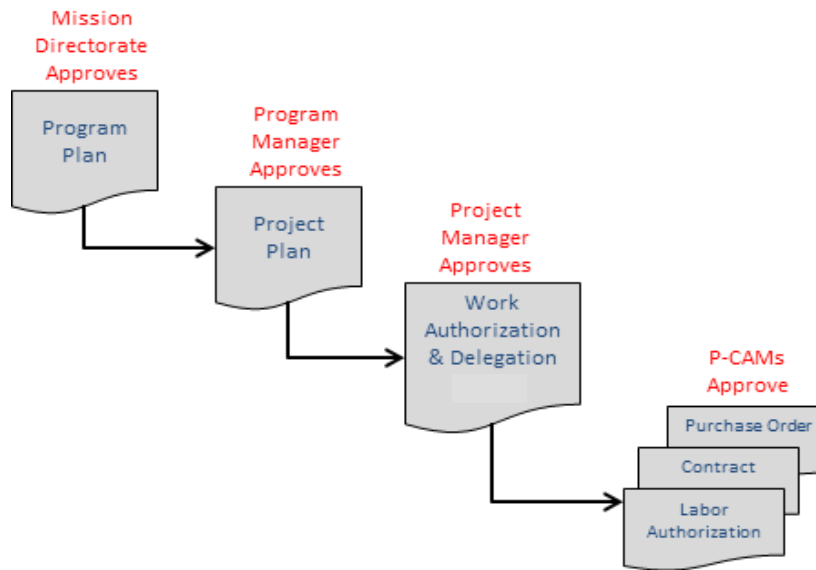


FIGURE 24. Project WA Trail

Approval of the Project Plan by the Project Manager (PM) (or appropriate approving official) constitutes formal authorization to proceed by MSFC. The Project Plan includes an integrated baseline plan for all work provided by the project and includes scope of work, requirements, period of performance (schedules), and the project’s total value which includes the summed budgets, Management Reserve (MR), and UFE. The Project Plan is the “contract” or commitment between the project, MSFC, and the project sponsor.

The primary objective of the WA process is to enable the PM and subproject/Element Manager (EM) to authorize scope, schedule, and budget for each CA; and for the P-CAM, and the P-CAM’s organization, to

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 65 of 230

accept responsibility to perform within the parameters of that authorized scope, schedule, and budget. Approved WADs demonstrate alignment between the project and the responsible organization for scope, schedule, and budget for a given work element, as well as an unbroken chain of authority for work authorized via a Project Plan down to the lowest WBS element or CA. The nature of WA necessitates that all elements of the WBS where costs are being incurred are documented and approved.

An example of a WAD is provided in Figure 25. The project’s Project Planning & Control (PP&C) organization will define the project forms that will be used such as the WAD, Change Request (CR), etc., in the project EVM Implementation Plan (or Project Plan, if EVM is not required). The issuance and approvals of the WAD to the P-CAM completes the initial top-down authorization process. The P-CAM continues that process by fully defining the assigned scope of work into lower level near-term tasks (Work Packages (WPs)) and far term tasks (Planning Packages (PPs)). The WPs and PPs are time-phased and budgeted based on the resources required to complete the work contained therein. When the P-CAM completes the Control Account Plan (CAP), PP&C work with the P-CAM, subproject/EMs, and PM to reconcile any differences between the scope, schedule, and budget originally assigned and those same elements as defined in the baseline CAP (see Figure 45 for an example of a CAP). The scope, schedule, and budget are determined for the entire scope of work for the CA before the final “baseline” approvals of the CAP documentation occur.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 66 of 230


XYZ Project Work Authorization Document			
			
Authorizing Section			
Project	XYZ Project	Element	Develop Prototype Code
Issued by	XYZ Project	WBS #	123456.08.05.09.01.03.03.04
WBS #	123456.08.05.09.01.03	WAD Revision No.	Initial
WAD No.	Initial	WAD Revision No.	Initial
Authorized Section			
Issued To: (Title/Name)	John Doe, Project Mgr	Date of this Issuance	3/20/2008
Scope Definition			
<p>This authorization is for all labor and travel associated with software development tasks necessary for build, code and unit test of prototype software.</p> <p>For a detail Statement of Work, reference the Project Plan and XYZ WBS Dictionary.</p> <p>In accordance with the XYZ Project PP&C Process, Control Account Managers shall comply with the cost and schedule variance reporting thresholds defined in the Program Directive.</p> <p>Budget Breakout: Labor: \$46,390 Travel: \$3,000</p>			
Authorized Budget			
Total Budget (\$K)	Previous	Change	Current
	\$0	\$49,390	\$49,390
Estimate at Completion (\$K)	\$0	\$49,390	\$49,390
Schedule			
Scheduled Start Date	3/20/2008	Scheduled Completion Date	4/30/2008
Supporting Schedule Documentation	XYZ Integrated Master Schedule, Ver 1.0		
Signed Approvals/Acceptance			
Program Manager	Date:	Project Manager	Date:
N/A	N/A	ISI	2/22/2008
Sub-Project Manager	Date:	Element Manager	Date:
N/A	N/A	N/A	N/A
Institutional/Functional Mgr	Date:	CAM	Date:
ISI	2/21/2008	ISI	2/21/2008

FIGURE 25. Project WAD

Project PP&C organizational responsibilities include:

- a. Ensure that all budget transactions are logged in the appropriate project budget logs.
- b. Assist the responsible managers in establishing budgets.
- c. Reconcile the project budget with the project authorized value.
- d. Ensure that all WADs are developed, negotiated, and approved in a timely manner.
- e. Assist P-CAMs in planning their CAs.
- f. Integrate all time-phased budgets to the appropriate schedule.
- g. Provide the custodial archive for the BOEs, resource plans, WADs, CAPs, budget logs, etc.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 67 of 230

3.6.2 Collaborative Work Plan (CWP) Process

The MSFC CWP process is key to MSFC Project Planning & Control (PP&C) as it is used to develop an agreement, or CWP, between each Sponsoring Organization (SO), such as a project office, and Performing Organization (PO), such as the Engineering Directorate (ED), defining the SO scope of the work, including schedule and deliverables, and the PO resources required to perform the work. Resources include the funding for civil service workforce and dollars, contractor workforce and dollars, travel costs and Other Direct Costs (ODCs). The annual process normally begins in June with the Office of Chief Financial Officer (OCFO) releasing the Call Letter to the SOs and POs describing the guidance, expectations, and schedule for the CWP process. Both the SOs and POs use the CWP process to develop agreements on CWPs prior to the beginning of the upcoming FY. By following a standard planning process with specific responsibilities and expectations, the CWP process assures all responsible organizations and the MSFC Senior Management understand the current work content and associated resources required to complete the work, assess gaps and associated technical and schedule risks, and manage to changes during the FY using the CWPs. The process requires a focused relationship between the SOs and the POs, open and transparent communication, and documentation of ground rules, assumptions, results, and risks.

The process provides organizations and management a baseline and current status of planned work and resources and functions as a live system assisting organizations in defining, implementing and managing the work throughout the Execution Year (real time updates are coordinated between the SO and PO, submitted into the system, and approved). The CWP process is one of several processes within the MSFC Resources Community that, when integrated, should: (1) function to define the budget for a project or activity over the 5-year budget horizon (eBud (MSFC Electronic Budgeting Tool)), (2) define the work plan for year of execution (CWP), and (3) outline the fiscal plan for resource expenditures (Phasing Plan).

The CWP Process requires the use of the latest eBud data for the CWP SO Guidelines and supports and guides the SOs and the POs in the negotiation and documentation of tasks, required resources, resource gaps (variances), and associated technical and schedule risks. The CWP records can be updated and changed per the process to reflect the changes in resource allocations or resource availability.

The CWP Process requires the SOs to load each CWP with the following PP&C information, as provided by both the technical and business SO experts:

- a. Task Description.
- b. Scope.
- c. Business and technical owners and other key points of contact with contact information.
- d. Top level schedule/milestones.
- e. Deliverables.
- f. WBS to the level managed by the SO.
- g. Ground rules and assumptions.
- h. Constraints.
- i. Notes.
- j. Full Time Equivalent (FTE), including inherent civil service responsibilities as defined in the CWP handbook, Labor Dollars, Work-Year Equivalent (WYE), Procurement Dollars, ODCs, and known travel requirements. The tool will calculate the Labor Dollars for all CWPs (for Center Management & Operations (CMO) CWPs, labor will be calculated based on choosing the proper CMO labor calculation from a drop down menu, such as Technical Excellence, Institutional Admin, Engineering Services, etc.).

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 68 of 230

The CWP Process requires the POs to verify/refine each CWP to the four-digit organization level based on the data loaded by the SOs with the following PP&C information as provided by the technical and business PO experts:

- a. Scope.
- b. Business and technical owners and other key points of contact with contact information.
- c. Detailed schedule tasks/milestones.
- d. Deliverables.
- e. Facilities required.
- f. Ground rules, assumptions, and associated notes.
- g. FTE, WYE, Procurement Dollars, ODCs, and known travel requirements. The tool will calculate the Labor Dollars for all CWPs (for CMO CWPs, labor will be calculated based on choosing the proper CMO labor calculation from a drop down menu, such as Technical Excellence, Institutional Admin, Engineering Services, etc.).

The CWP Process is documented in the OCFO Organizational Issuance RS01-OI-006, *Collaborative Work Plan (CWP) Process and Requirements Handbook*, and can be found at:
<http://cfo.msfc.nasa.gov/documents/RS01-OI-006.pdf>.

The CWP Process flow diagram is located in Figure 26.

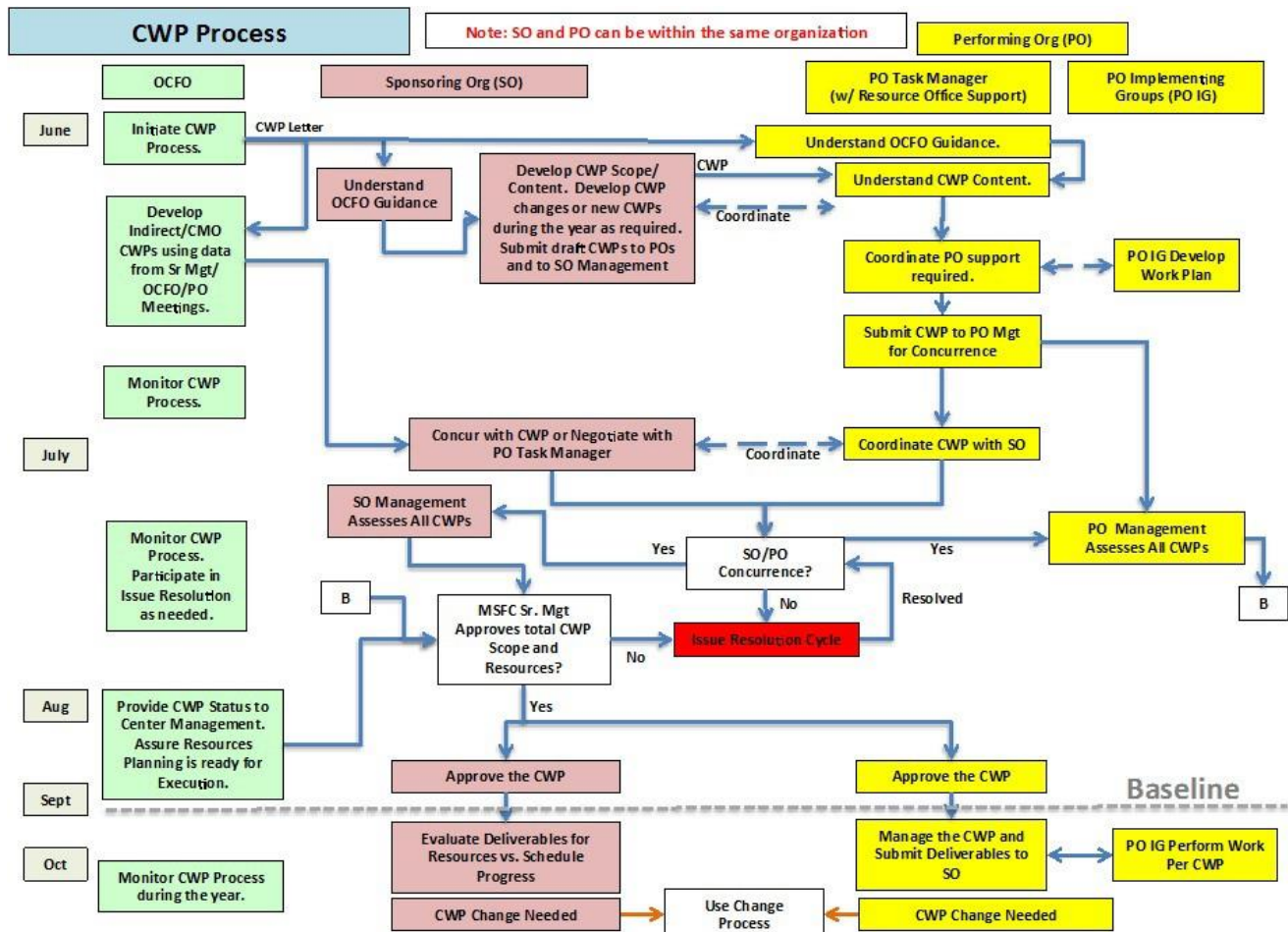


FIGURE 26. CWP Process Flow Diagram

3.6.3 Intra-Agency and External Work Agreements

MSFC project implementations are encouraged to utilize facilities, resources and capabilities available across NASA Centers, other government or non-profit entities or partners. This collaborative approach encourages the responsible Project Office to negotiate Work Agreements (including SAAs) with the performing or implementing Center. Documenting the agreed upon scope, schedule, and budget via an Inter-Agency Work Agreement (IAWA) is similar to negotiating a contract with an industry partner. The MSFC Project Office is responsible for managing these Work Agreements—including scope, schedule, and budget—as well as ensuring flow down requirements are adhered to in a professional and highly ethical fashion.

The Earned Value Management System (EVMS) requirements applicable to contracts also apply to all NASA Centers and any other government agencies or non-profit partners (see Section 3.10 for EVMS requirements). The objectives of EVMS for IAWAs are as follows:

- Document the agreed upon scope of work.
- Ensure proper cost and schedule planning and application of project resources.
- Enable accurate and timely cost and schedule performance measurement of project resources.
- Ensure adequate accountability of project resources.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 70 of 230

When an Earned Value Management (EVM) requirement is imposed on an IAWA, then this scope of work should be included in the overall project’s Integrated Baseline Review (IBR). See NASA/SP-2010-3406 for specific details on conducting an IBR.

For work performed at other NASA Centers, similar documentation (Implementation Plan, Work Authorization (WA) agreement, etc.) that captures the information shown above for IAWAs. Intra-Agency, Intra-Center, Space Act, or other external work agreements should be represented within the project WBS, at the lowest element level (See Figure 5).

3.7 Budget Development and Execution

The Project Planning & Control (PP&C) function should include the knowledge, planning, execution and evaluation of a resources budget and its related financial activities. The Federal Budget process, which flows from the White House and Congress to the Government Agencies including NASA, is utilized to assure integrity, accountability and success as Agencies execute their missions. The Budget process can be viewed from four levels: the Federal Budget, the Agency Budget, the Center Budget, and the Program/Project/Mission Support Budget. The SATERN training class Chief Financial Officer (CFO)-101, which is a Federal/NASA/MSFC Budget Overview, and its accompanying handout, were used to prepare this budget discussion and should be pursued for a more in-depth view of the Federal Budget process.

3.7.1 Federal Budget

The United States federal budget can be defined as:

- a. A financial plan that provides a summary of intended expenditures, along with proposals for how to meet them.
- b. A political instrument that allocates scarce public resources among the social & economic needs of the jurisdiction.
- c. A managerial/administrative instrument that ensures all programs/activities will be reviewed at least once a year.
- d. An economic instrument that can direct a nation’s economic growth and development.
- e. An accounting instrument that holds government officials responsible for the funds with which they have been entrusted.

The federal budget process involves the Executive and Legislative Branches of the United States Government. The Executive Branch, led by the President, manages the Agencies. The Legislative Branch, or Congress, consisting of the Senate and the House of Representatives, drafts laws, oversees federal agencies and departments, and provides funding. The federal budget authority comes from the Constitution (“Promote the general welfare”), and Article 1 of the Constitution (“Congress shall have the power to levy and collect taxes, duties, imports, and excises to pay debts and provide for the common defense and general welfare of the United States” and “No money shall be drawn from the Treasury, but in consequence of appropriations made by law”). The federal budget consists of Mandatory Spending (i.e. Social Security, Medicare, and Medicaid) and Discretionary Spending [i.e. Department of Defense and NASA]. The revenues that fund the Federal Budget come from taxes collected by the Internal Revenue Service and held by the Treasury Department. Numerous Federal Acts, such as the 1870 Anti-deficiency Act and the 1990 Chief Financial Officers (CFO) Act, provide legislative governance for Agencies.

The Federal Budget process, as seen in Figure 27, is an 18-month process that begins with the Federal Agencies developing proposed budgets based on guidance and the Agencies’ requirements.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 71 of 230

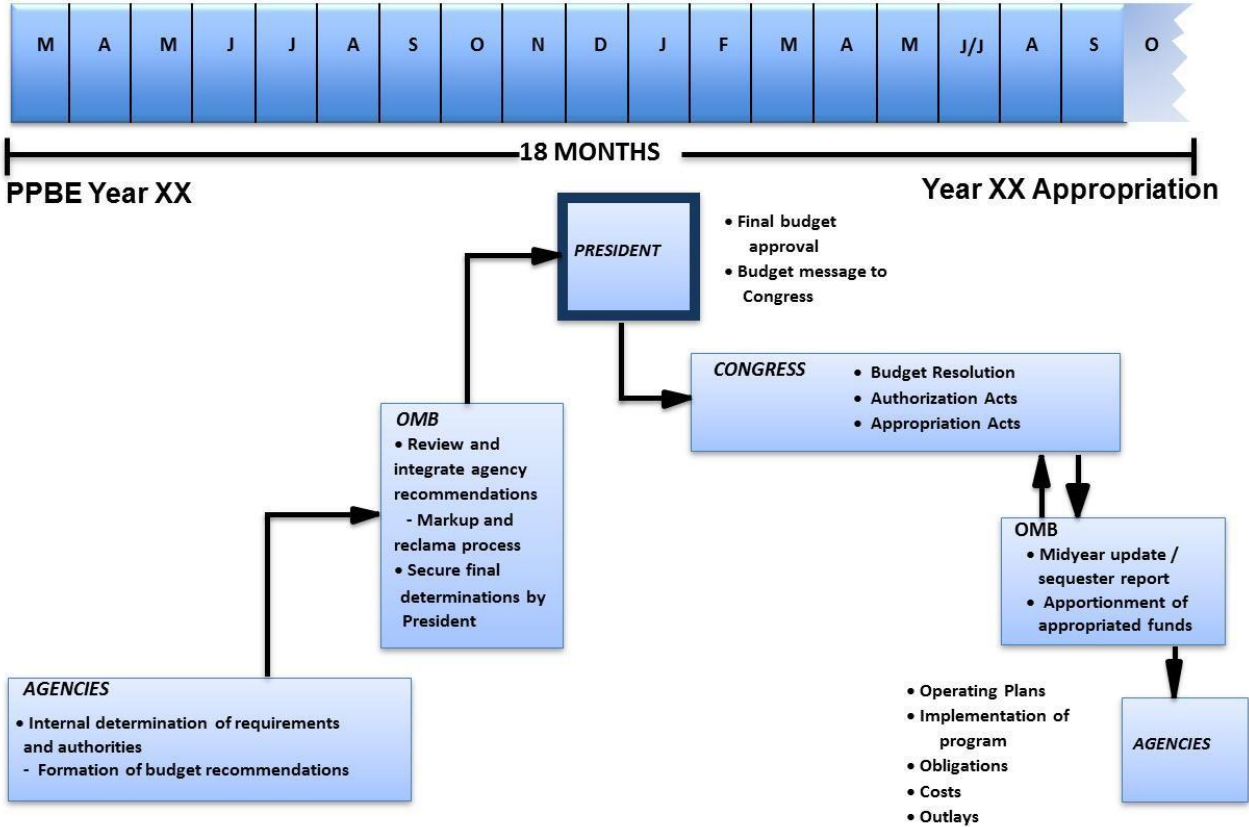


FIGURE 27. Federal Budget Process

Each Agency provides a budget recommendation to the Executive Branch’s Office of Management and Budget (OMB) that reviews and integrates the Agency’s recommendation, coordinates budget concerns with the Agencies through the reclama process, and finalizes the budget for review by the President. The President is responsible for finalizing his budget proposal and submitting it by the first Monday of February to Congress. The Congressional Budget Office (CBO) assists the House and Senate Budget Committees by preparing reports and analyses. The CBO’s mandate is to provide objective and impartial analysis with no policy recommendations. The CBO provides an independent analysis of the President’s budget proposal. The House and the Senate utilize Budget Committees to formulate separate budget resolutions of the President’s budget proposal. If the Budget Committees converge on a common budget resolution, the resulting concurrent resolution is sent to the House and Senate floors for vote. If approved, the House and Senate use the concurrent resolution to develop Authorization and Appropriation Acts, which may be signed or vetoed by the President. Authorization laws have two basic purposes: to establish, continue, or modify federal programs, and to appropriate budget authority for programs.

Authorizations *should* precede the Appropriations process, but sometimes do not. Authorization committees provide Congressional oversight of agency programs and plans, and the bills often include limits on the amount that can be appropriated for the program/agency. Some programs/agencies are authorized annually, and others for a specified number of years, or even indefinitely. Congress may enact appropriations for a program/agency even though there is no specific authorization for it (waive rules). The Appropriation process provides budget authority to agencies (how much and for what). The desired Appropriation receipt is October 1 (beginning of Fiscal Year (FY)), and it allows an agency to incur obligations. The Appropriation originates in the House of Representative and a point of order can be raised on an Appropriations bill containing funding for a program that is not authorized.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 72 of 230

The four Appropriation segments include:

- a. Appropriation Bill: establishes funding to be used for a specific purpose.
- b. Omnibus Bill: single bill covering various agencies or changes.
- c. Mini-bus Bill: multiple bills dealing with a single or limited appropriation.
- d. Continuing Resolution: interim appropriation that provides funding to allow operations to continue on October 1 if appropriations have not been approved. The level of spending is equal to the lower of:
 1. President’s request
 2. Last year’s appropriation level
 3. Congress conference action
- e. Earmarks: funding set aside for a specific purpose, use or recipient.

If Congress is unable to pass appropriation bills by October 1st, a continuing resolution is typically approved to provide interim authority for federal operations to continue. Absent an appropriation or continuing resolution, federal operations are suspended and non-critical employees are furloughed. The continuing resolution provides stop-gap funding for Agencies that have not received a regular appropriation by the start of the FY. Continuing resolutions are enacted in the form of a congressional joint resolution; have the same legal effect as a regular Appropriation; are limited in duration, scope, and financing; and no two continuing resolutions are alike. During a continuing resolution, no new initiatives or program accelerations are allowed.

The Impoundment Control Act of 1974 established the act of rescission that occurs when previously appropriated funds are withheld from obligation authority permanently. The rescission is used as a budget reduction tool and is proposed by Congress or the President.

The investigative arm of Congress, or the congressional watchdog, is the Government Accountability Office (GAO), and is the agency that works for Congress and the American people. This independent and nonpartisan agency studies programs and expenditures of the federal government, advises Congress and the heads of executive agencies about ways to make government more effective and responsive, and evaluates federal programs, audits federal expenditures, and issues legal opinions. When the GAO reports its findings to Congress, it recommends actions that can lead to laws and acts that improve government operations, and save federal dollars.

3.7.2 Agency Budget

The NASA Budget is based on the authority received by Congress and the direction received by the White House administration and is utilized to plan, execute and evaluate NASA Programs in support of the NASA Strategic Plan. The NASA Chief Financial Officer (CFO) oversees all financial management activities relating to the programs and operations of the agency, and reports directly to the NASA Administrator. The NASA CFO interfaces with the many stakeholders including the Mission Directorates, the HQ Institutional Support Offices, the Centers, Congress, and Office of Management & Budget (OMB).

For NASA, the key Congressional oversight committees are, for Authorizations, the Committee on Science in the House, and the Committee on Commerce, Science and Transportation in the Senate. Both the House and the Senate provide oversight through their respective Committee on Appropriations. The NASA budget is part of the Discretionary budget, and is less than 0.5% of the entire federal budget. For 2012, the NASA budget was \$17.8B. The NASA budget comes from several appropriations, and the funds are available for 1, 2, or multiple years. The funds are designated for a specific directorate or purpose and are not interchangeable.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 73 of 230

3.7.3 Planning, Programming, Budgeting & Execution (PPBE)

The PPBE is the Federal process of planning and budgeting used by NASA to integrate plans and convert strategies and priorities into programs and budgets. The annual PPBE phases and steps are shown in Figure 28 and are described in NPR 9420.1, *Budget Formulation*.

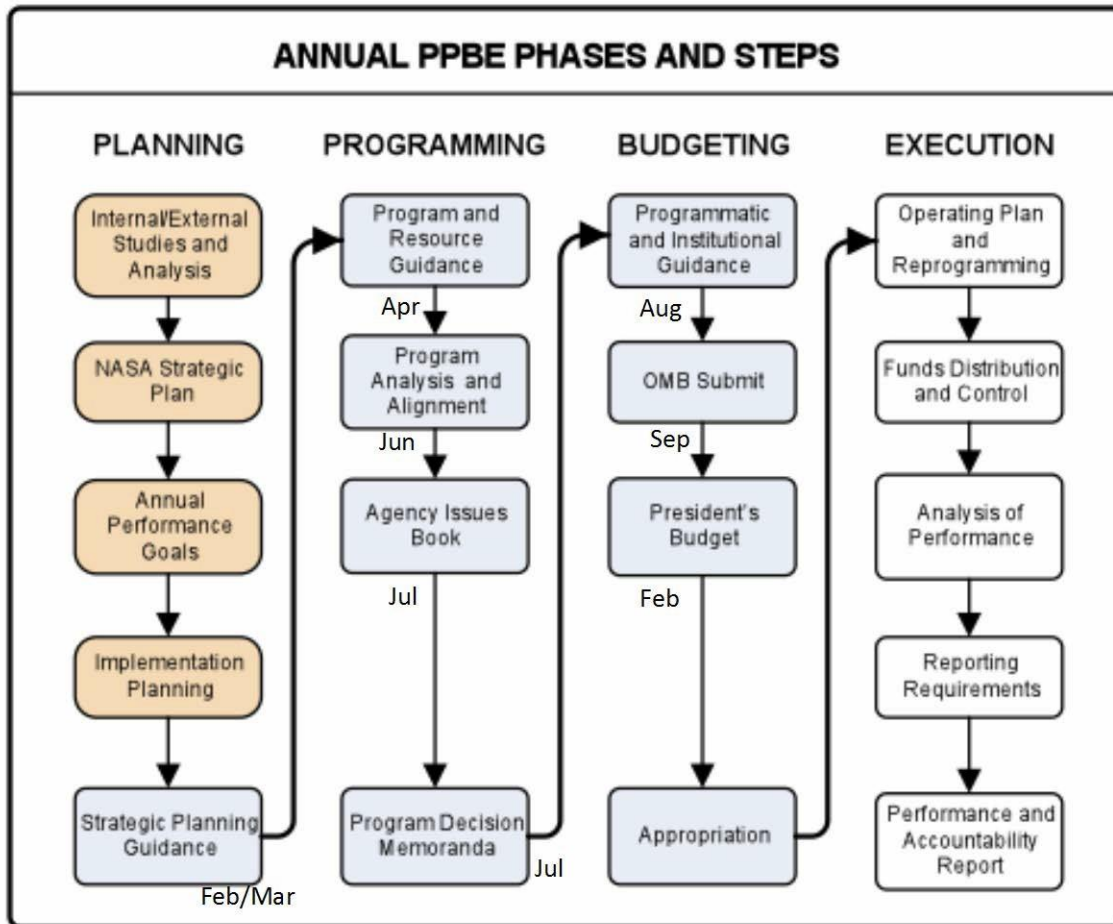


FIGURE 28. NASA Annual PPBE Phases and Steps

The PPBE Planning Phase provides strategic high-level guidance and direction. The planning involves defining long-term strategic goals, multi-year outcomes, and short-term performance goals. The planning process includes the NASA Strategic Plan, annual performance goals, and implementation planning. The output of the PPBE Planning Phase includes the Strategic Planning Guidance for the PPBE Programming Phase. The Agency-developed Strategic Planning Guidance provides high-level strategic guidance for developing a programmatic and financial blueprint.

The PPBE Programming Phase is a planning and budgeting process with high-level, multi-year, and structured analyses of alternative uses of capabilities and capacities. The programming involves defining project objectives, resources, and risks, and balancing resources among various programs and projects based on Agency priorities. The programming process includes the Program and Resource Guidance (PRG), the Program Analysis and Alignment (PAA), and Agency Issues Book. The output of the programming phase includes the Program Decision Memorandum (PDM) for the PPBE Budget Phase. The PRG provides the initial budget and workforce plans (at the six digit level (project WBS/charge account number)). The PAA establishes the major

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 74 of 230

issues to be raised to senior management. The Agency Issues Book provides issue analysis for senior management. The PDM, issued mid-July, is required to ensure that all parties in the budgeting phase clearly understand the decisions made and the control totals established.

The PPBE Budgeting Phase provides a detailed financial plan for planning resources. The PPBE Budgeting Phase involves the formulation and justification of the financial plan (Budget Year + 4 out-years). NASA submits a proposed budget to the OMB, and to the President, who submits the final budget to Congress. The PPBE Budgeting Phase process includes the Programmatic and Institutional Guidance (PAIG). The PPBE Budgeting Phase outputs are the President’s Budget and Congressional Appropriation. The PAIG, issued late-July, provides N2 (NASA budget database) resource control totals. The Centers use the PAIG information as a baseline for development of OMB Budget at the detailed level. The OMB Budget, submitted in early-September, provides the comprehensive financial and workforce plan. The President’s Budget, released to Congress on the first Monday in February, provides the financial proposal to Congress. The President has a “State of the Union Address” to the American people that includes the proposed budget released to Congress in early February. Finally, Congress passes the Appropriation Bill, which establishes the funding for the President’s signature. The Appropriation Bill should be approved on or before October 1.

To understand the Federal budget process, the budget horizon, as seen in Figure 29, should be understood. For a given year of execution, such as FY13, the Adjustment Year is FY14. The Budget Year, which anchors the PPBE15 effort, is FY15. The following four years, FY16 through FY19, are Budget Year + 1, Budget Year + 2, Budget Year + 3, and Budget Year + 4. For the PPBE15 effort, a five-year budget is formulated for the Budget Years, and the FY14 budget can be adjusted.

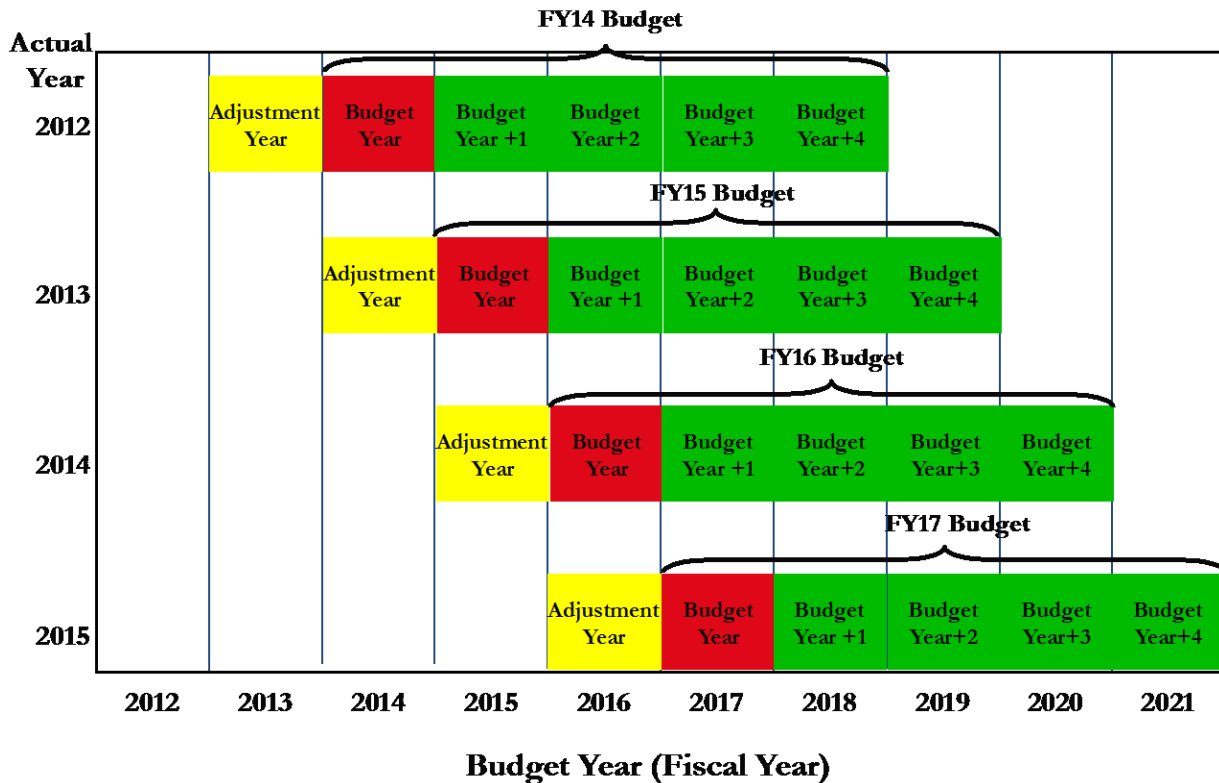


FIGURE 29. Budget Horizon

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 75 of 230

3.7.4 Center Budget

The MSFC Chief Financial Officer (CFO) oversees all financial management activities relating to the programs and mission support operations of MSFC, and reports directly to the NASA CFO and the MSFC Center Director. The MSFC CFO interfaces with many stakeholders including the NASA CFO, MSFC Senior Management, MSFC Institutional Support Offices, and MSFC Directorates. The OCFO is also responsible for the financial distribution of reimbursable funds and development of the annual reimbursable budget. The OCFO distributes funds received from the Agency, Programs, and Projects outside the Center. Under a reimbursable agreement, the partner pays for work MSFC conducts for the partner’s benefit. Under a non-reimbursable agreement, each party assumes responsibility for its own costs.

The MSFC budget process is integral to the Federal and Agency budget process, and is illustrated in Figure 30. Assuming MSFC is operating in execution year Fiscal Year (FY) 13, the FY12 books are closed in early FY13 to assure financial correctness and closure of the FY12 execution year. Before the execution year begins, which is October 1st, either the Federal budget (budget appropriation bill) or a Continuing Resolution (CR) needs to be approved. Otherwise, the Government is required to shut down. For FY13, the Federal Government has approved a CR through March 2013. The CR provides funding guidelines, or specific budget allocations, to the NASA CFO who distributes the guidelines to the Centers and Directorates. The guidelines should reflect the PPBE14 adjustments to the FY13 budget, and cover the Center or Directorate content through March 2013.

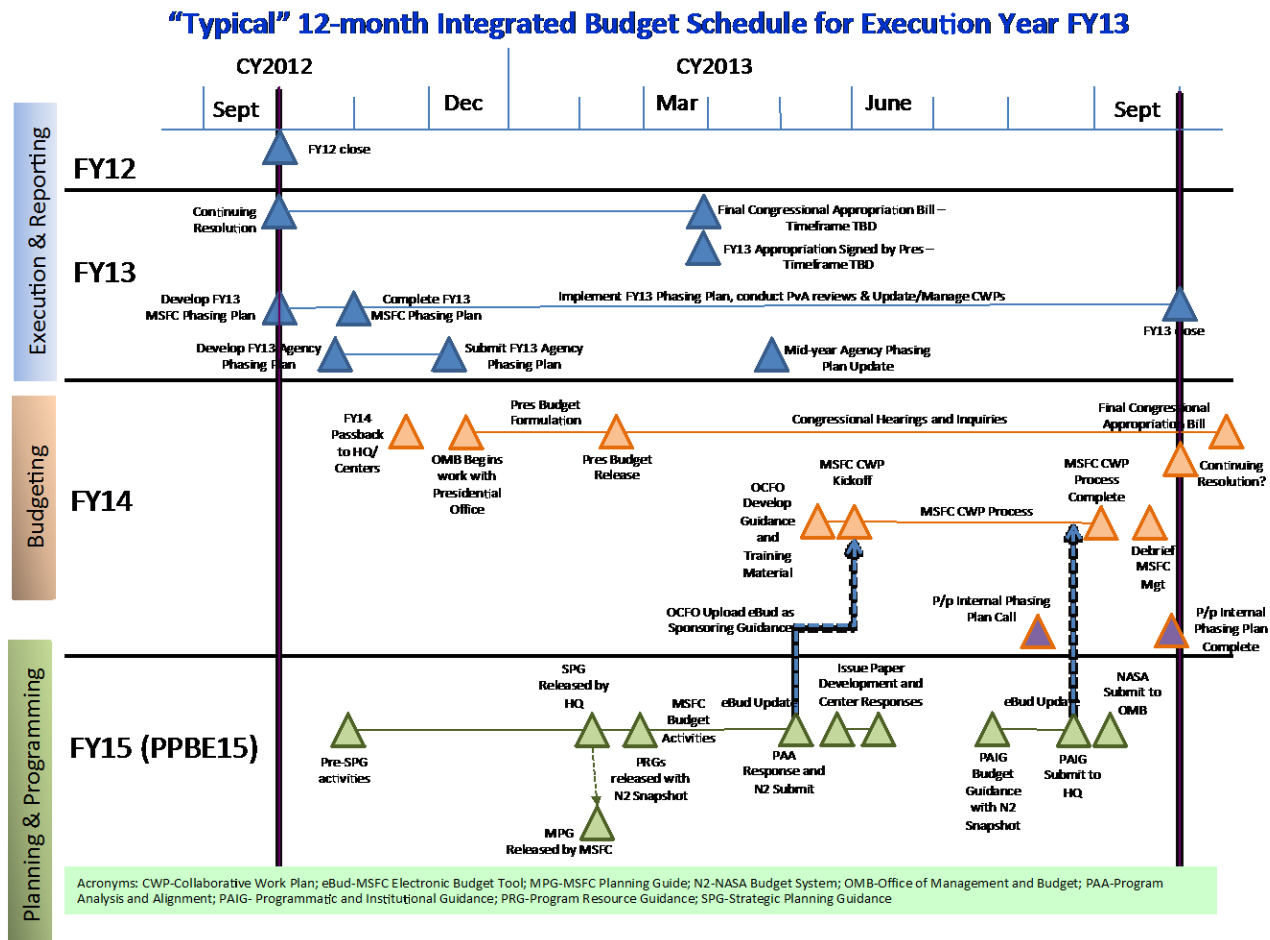


FIGURE 30. MSFC Budget Process Integrated into PPBE

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MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 76 of 230

Before the CR expires, another CR will be approved, a budget appropriation bill will be approved, or the Government will shut down.

To understand the FY13 MSFC Budget execution phase, including tracking and analysis, the planning process should be understood. As discussed in Section 3.7.3, the Planning, Programming, Budgeting & Execution (PPBE) process promotes detailed planning of out-year resource requirements and allocations. The FY13 budget was first planned in FY07 during the PPBE09 process. In other words, in FY07, the PPBE effort included the adjustment year (FY08), the primary budget year (FY09), plus the four out year budget years (FY10 – FY13). Each year through FY11, the PPBE process adjusted the FY13 budget. During FY11, the MSFC CFO reviewed the Agency CFO’s Strategic Planning Guidance, which led to the MSFC Planning Guide, and the Program and Resource Guidance (PRG). The PRG guidance was used within the MSFC eBud system, which was used by MSFC for multi-year resources planning, and led to the Program Analysis and Alignment (PAA) response to the Agency CFO. The eBud is a tool in the MSFC Resources Planning Tool (eMRPT) (see Section 3.11 for more information on business tools and systems) for documenting the Strategic Planning Agreements for the PPBE process. MSFC and the Agency refined the numbers within the PAA response that resulted in the Programmatic and Institutional Guidance (PAIG). The PAIG guidance was used to update the PPBE13 eBud effort, which led to the final MSFC PAIG submittal to the Agency. The Agency FY11/PPBE13 PAIG (FY13 budget) is then submitted by NASA to the President/OMB. For the FY12 (PPBE14) effort, the Agency or Congress adjusted the FY13 budget as needed. The final Agency FY13 guidance was submitted to MSFC in the summer of 2012 and was used as the guidelines for the MSFC FY13 planning effort.

The Collaborative Work Plan (CWP) process, as discussed in Section 3.6.2, is used by MSFC as a Work Authorization (WA) agreement to plan content for a 1-year budget for all tasks to be performed at MSFC. The CWP process is restricted by the Agency guidance, and results in task agreements between the Sponsoring Organizations (SOs) and Performing Organizations (POs) at MSFC. For FY13, the Collaborative Work Plan (CWP) process occurred in FY12 utilizing the PPBE14 adjustments to the FY13 budget as reflected in the PAA and the PAIG. The CWP process is an MSFC-internal process that leads to the MSFC monthly phasing plan used by MSFC to track and assess the resources plan versus the actual results. During the year of execution, the SO works with the POs to establish commitments for their work. A commitment occurs when funding is authorized to go on a contract. The funding is obligated when the contract or contract modification to the contract is completed. Cost occurs when the actual (or accrued) costs for the work is incurred or invoiced.

As part of the PPBE process, a phasing plan is developed to assure availability of funds and resources for adequate and timely distribution. Sufficient carryover funding should be planned to cover the normal delay in receiving funding at the start of a FY due to a CR. This should fund ongoing work that has been planned to continue in the upcoming FY. The resources community should limit funding commitments that will carry over cost into the next year. Planning for initiation of additional funding during the FY should provide sufficient time for the receipt and authorization of the funds through the NASA Financial System and procurement processes. This planning is normally a part of the PPBE process. Management of the distribution of funds uses the NASA Financial System process plus the Center Budget and Funds Allocation System (BFAS) (see Section 3.2.2 for additional information) to provide guidance on segregating funds by labor, travel, and procurement. Continuous surveillance by the resources community of incurred and accrued cost should be conducted to assure adequate funds are provided. During the year of execution, any variances in funding commitments contained in the previously developed phasing plan should be reported and coordinated with the MSFC Office of Chief Financial Officer (OCFO). For more information on budget execution, refer to NPR 9470.1, *Budget Formulation*.

The resources community should ensure that:

- a. Oldest money (earliest FY) is obligated first within the period of availability, and only for valid needs of that year.

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MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 77 of 230

- b. Oldest money is costed first, as close to the period of availability as possible and only for work that has been performed. When a task is complete, uncosted funding should be closely monitored by resource analysts to ensure that deobligation occurs and the contract is closed out.
- c. Deobligated expired funds will only be used for valid obligations that were incurred during their period of availability.

3.7.5 Program/Project/Mission Support Budget

The key to successful Program, project, or mission support activities, hereto referred to as the project, is in the planning. Creating a baseline plan (technical, cost, schedule, and associated risks) is key to starting any kind of project. Unfortunately, planning is often ignored in favor of starting the work. Developing a project plan and having a complete and mature set of project requirements leads to more accurate cost and schedule estimates, and increases the chance of a successful project. See NPR 7120.5, *NASA Space Flight Program and Project Management Requirements*, for greater information on these topics.

3.7.5.1 Initial Project Budget Development

As a project is planned, documented, and approved, the budget is developed and updated to assure resources are planned and documented within the project and in the annual Agency Planning, Programming, and Budgeting & Execution (PPBE) submittal. The budget should increase in accuracy as the planning matures, and reflect the annual resources required to accomplish the plan. The proposed budget is developed at the project level based on cost and schedule estimates for documented project content. The project budget is established at a higher level based on the Federal budget priorities, however, and flows down to the project level. Therefore, the budget may be different from the early or current estimates. The Program Planning & Control (PP&C) team should carefully track original estimates to the final budget submittals and guidelines, as well as identify and track all cost, schedule, and risk changes, including PPBE directed changes, to the original estimate or baseline.

To establish the budget required at the Center by the project, the PP&C team, together with the Project Manager (PM) and responsible organization, review the Work Breakdown Structure (WBS) dictionary, WBS Control Account (CA) structure, Responsibility Assignment Matrix (RAM), and detailed schedule data to develop cost estimates. The bottom-up estimate should be documented with a Basis of Estimate (BOE) for the cost and schedule. This data should be detailed enough to allow valid assignment of resources. The cost phasing should be driven by the estimated funding profile, the schedule and include the total project scope. Cost target objectives are formulated from cost proposals or other costing exercises for the project at the subsystem level of a project to provide an understanding of the lower-level cost objectives and goals expected to meet the total funding requirements of the project. The PM, with PP&C support, provides the targets to the subsystem Element Managers (EMs) and/or Project Control Account Managers (P-CAMs) so that they understand the project’s lower-level cost objectives and goals. The completed schedule data should be detailed enough to allow valid assignment of resources. For projects that require Earned Value Management (EVM), the level of detail required is down to the Work Package (WP) level with the intent of performing a lower-level schedule planning at the activity level. For projects not requiring EVM, the budget plans for resource planning can occur at the CA level. In both cases, the budgeted period of performance should match the scheduled period of performance at the lowest level of the WBS. In EVM planning, the cost and schedule should be integrated such that the period of performance for each WP in the schedule matches the budgeted period of performance in the EVM integration tool. For non-EVM projects, CA planning should align with the project’s major progress milestones to ensure that adequate resources are planned to meet various time constraints.

Figure 31 illustrates the budget review cycle in terms of the total project budget profile as compared to the funding profile. Each step is done in sequence and, as necessary, reiterated in sequence.

- a. If the budgeting exercise yields an amount that exceeds the funding profile, begin the review process with analysis of the cost estimates for any possible savings.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 78 of 230

- b. If no possible savings are identified, shift the scheduling of certain tasks to find out if this can help alleviate the funding issues.
- c. If changing the schedule does not help, redefine the scope of some of the tasks.
- d. If changing the scope does not resolve the funding issues, seek resolution from the PM.

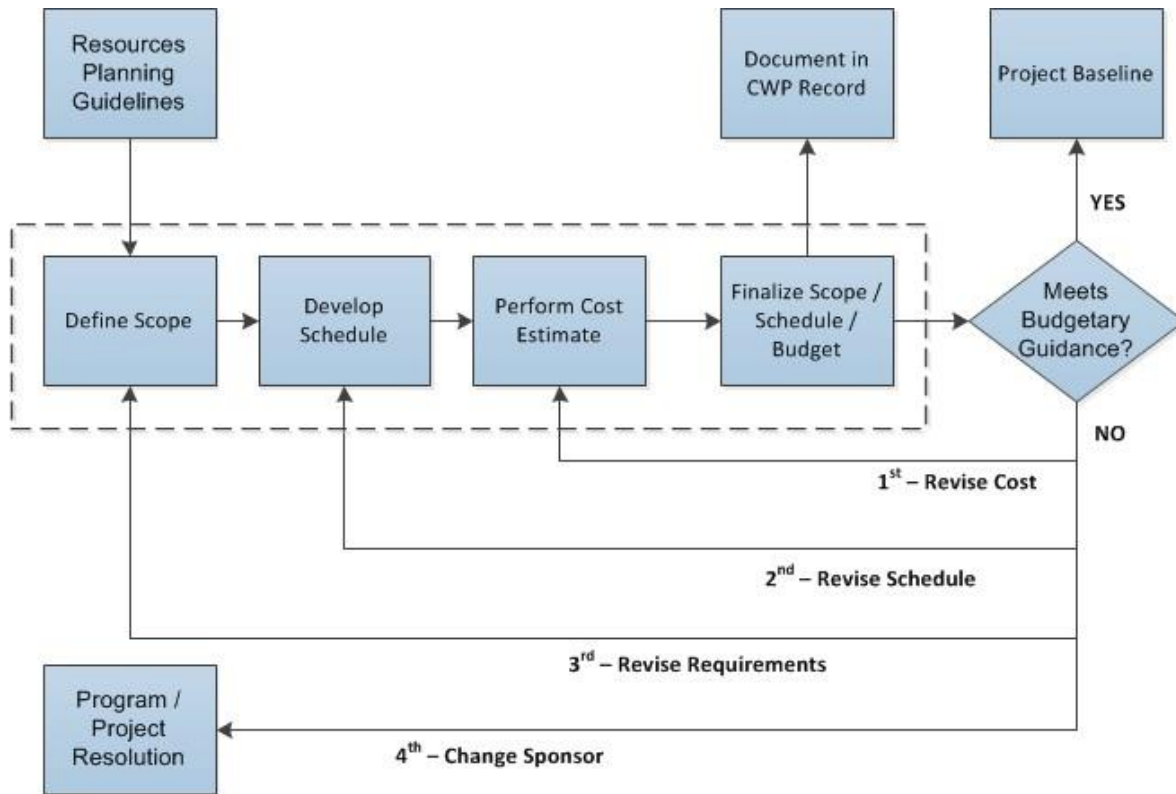


FIGURE 31. Budget Review Process

3.7.5.2 Mission Support Budget Planning

The Office of Chief Financial Officer (OCFO) will coordinate and integrate the CMO project budgets by assisting the Center Director and Associate Center Director (Management) in developing guidance, expectations, schedule of activities, and communicating the control and resource management process to the appropriate organizations. The OCFO coordinates the Center Management and Operations (CMO) budget with the Project Planning & Control (PP&C) personnel across the Center. The OCFO PP&C team briefs Center Management on the CMO budget, requirements, overguides and liens for approval and integration into the entire Center Planning, Programming, Budgeting & Execution (PPBE) submission.

3.7.5.3 Budget Formulation and Traceability

As part of the Planning, Programming, Budgeting & Execution (PPBE) process, Project Planning & Control (PP&C) teams work with the Performing Organizations (POs) and contractors to assure an understanding of the budget guidelines. The POs then develop their input into the PPBE. Prior to releasing the input back to the project, the PO's line management reviews the data. The size and/or criticality of the work will determine the management level of review. For contracted effort, the work should be carefully reviewed through the corporate structure prior to release to the project. The project PP&C team coordinates the PPBE data collection, analysis, and summarization, and the Project Manager (PM) reviews the data prior to release. The project PPBE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 79 of 230

submission is coordinated with the project’s Agency Mission Directorate as appropriate. Center Management reviews the proposed project PPBE submission for consistency and compliance with Center commitments and responsibilities. The integrated PPBE submission is provided to the Agency Chief Financial Officer (CFO) for review. The PPBE process also requires the budget reviews to report on how institutional resources are adequately assigned to satisfy project requirements, schedules, and are properly applied to projects. Also, project risk reports and technical and programmatic reports are reviewed in relation to budget requests.

When the funding profile or guidelines are different from the estimated plan, the project budget should be developed according to reasonable schedule changes and/or possible technical content reductions. Traceable paths from the original estimate to the final budget submittal should be maintained throughout the life of the project. This baseline trace, which is maintained by PP&C, should identify all resource reductions, schedule extensions, technical content reductions, and any associated cost or risk changes.

The annual formulation of the project budget may be altered through the PPBE process as described above. Project/Center specific directions for submittals should be followed. If the project cannot accomplish the content within the guidelines, decision packages should be established to identify the content reductions required to “fit” within the guidelines. Occasionally, the Agency will allow “over-guide” submittals. If so, decision packages should be developed with supporting rationale and risk assessments if the over guide request is not approved. A project may be directed to take a budget challenge, where both the guidelines and the project content are not changed, and risk assessments are developed and provided by the project to identify potential reserve threats. In either case, PP&C should maintain traceability of the baseline.

Once the project has received the budget or any budget revisions as an output of the PPBE process, PP&C will conduct an integrated assessment and, in conjunction with the technical personnel and project management, determine if any changes to technical content or schedule are required. After the assessment, PP&C will provide a budget to each project element, along with any programmatic and/or technical changes. These changes can result in a Re-Planning or Re-Baselining effort. The Collaborative Work Plan (CWP) process, as described in Section 3.6.2, captures the annual task agreements between the SOs and the POs, including the requirements and associated resources. The projects utilize the results of the CWP process to develop an annual resources phasing plan that phases the estimated monthly obligations and costs.

3.7.5.4 Project Budget Reviews

The primary budget formulation review process is the Planning, Programming, Budgeting & Execution (PPBE) process (usually preceding deliverables at major milestones). After the plan has been approved and the year of execution begins, the project is responsible for managing to the budget and providing statuses to its customers. While it is important to adhere to the discipline of managing to an authorized plan, many projects implement a process and/or system to periodically formally update the plan being managed for authorized changes. In that case it is important to clearly communicate the plan being managed, and explain changes to prior authorized plans as required for the reviewers.

Along with the Agency’s “dual path” management structure that holds both Mission Directorates and Center Directors accountable for mission performance, reviews of project performance are conducted in parallel. The MSFC Office of Chief Financial Officer (OCFO) Planned versus Actuals review (held for both projects and institutional activities) is a monthly review of the actual budget obligations and cost performance versus the developed phasing plan. This review, which typically discusses resources performance to include cost, workforce, schedules, technical, risks and issues, provides the OCFO and Center Management with a snapshot and trending of MSFC resource utilization to allow for adjustments to assure Center tasks are successfully completed within schedule and cost constraints. This meeting may only occur if OCFO health assessments of project/institutions reveal unhealthy trends.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 80 of 230

3.7.6 Strategic Workforce Planning (SWP)

Office of Strategic Analysis and Communication (OSAC) assists Center management in developing long-term mission and strategic objectives. A strategic and integrated perspective to workforce planning provides the context of how it fits with the Center's mission and strategic objectives. In order to assure that MSFC retains and develops the technical capabilities and core competencies to perform likely future mission portfolios (3-10 years and beyond), OSAC, in conjunction with the Office of Human Capital (OHC) performs an annual Strategic Workforce Planning (SWP) forecast (See Figure 32).

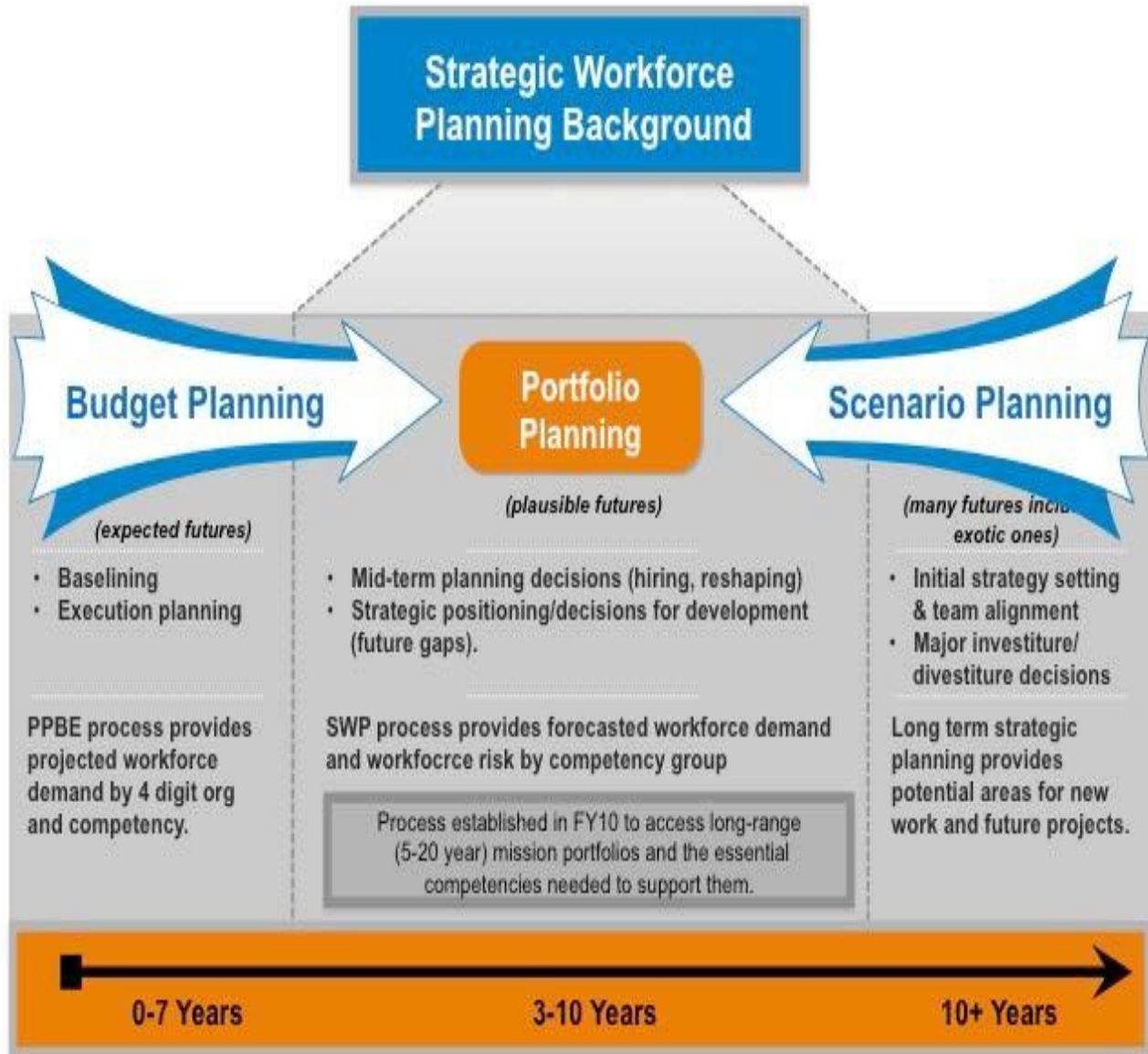


FIGURE 32. Strategic Workforce Portfolio Planning

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 81 of 230

The process is closely integrated with the annual Planning, Programming, Budgeting & Execution (PPBE), Collaborative Work Plan (CWP), and Technical Capabilities processes in order to assure a smooth transition from supporting current budget horizon mission content to anticipated future mission portfolios and long term strategic planning (See Figure 33).

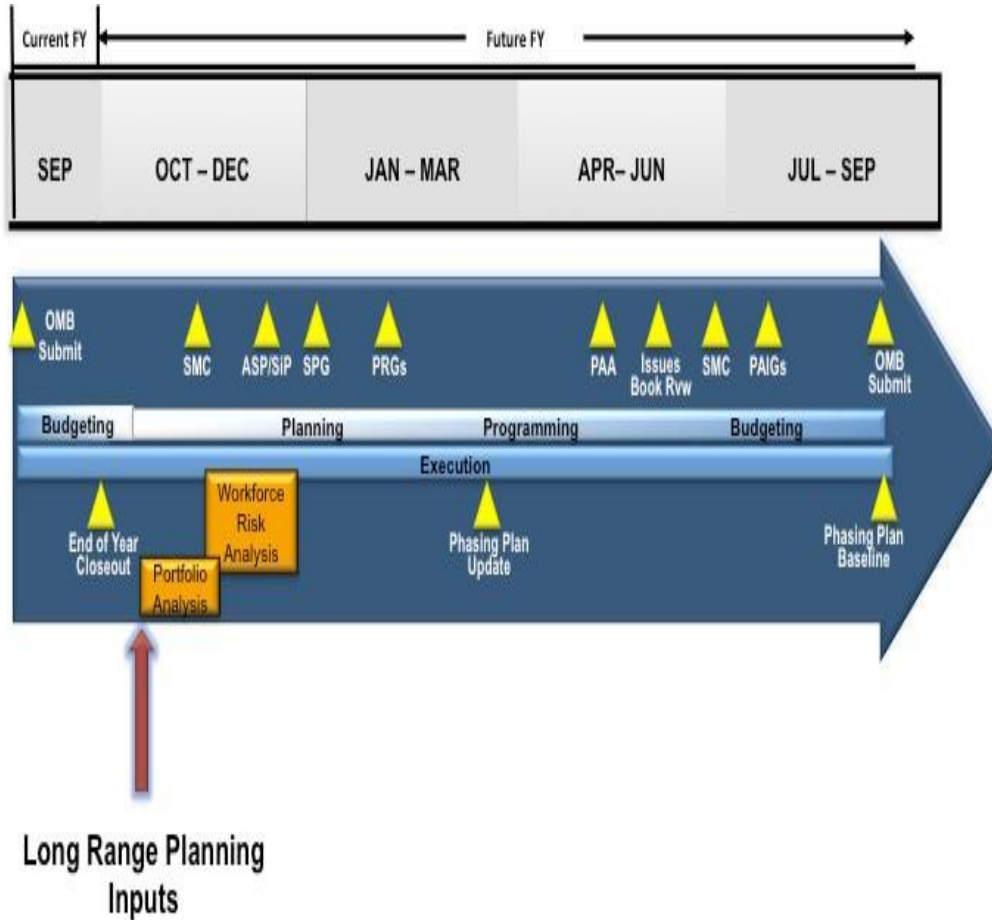


FIGURE 33. SWP Planning Integrated with Yearly PPBE Process Cycle

The Center’s Strategic Planning Council (SPC) determines potential mission portfolios. Workforce demand by competency group is forecasted for these portfolios by modeling potential future programs, projects, and activities. These models are developed using actual demand from historical projects, and from consultation with Subject Matter Experts (SMEs). Historic workforce demand is based on data residing in electronic Marshall Resource Planning Tool (eMRPT), and provided by the MSFC Office of Chief Financial Officer (OCFO) and other sources such as Project Offices, Engineering Directorate (ED), and Safety & Mission Assurance (SMA). Planned demand for the budget horizon and current supply are provided by the Office of Human Capital (OHC) and OCFO from the Workforce Integrated Management System (WIMS) and the Collaborative Work Plan (CWP).

The results of the forecasted workforce demand are used to perform a gap analysis by competency group against current workforce supply documented in the Competency Management System (CMS). This gap analysis and other data such as retirement eligibility, retention and sustainability by competency group are then used by the OHC to perform a Workforce Risk Analysis. This data informs Center Management of potential skill mix demand and supply issues to enable hiring and workforce shaping strategies.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 82 of 230

Current Strategic Workforce Planning (SWP) activities for mission portfolio planning utilize an evolving process (see Figure 34) that is being enhanced each year to better serve the Center’s workforce near and long-range planning needs. Since the SWP process is not yet formally documented, the information and process guidance provided here should be revisited and updated as it changes or becomes an approved and formalized process.

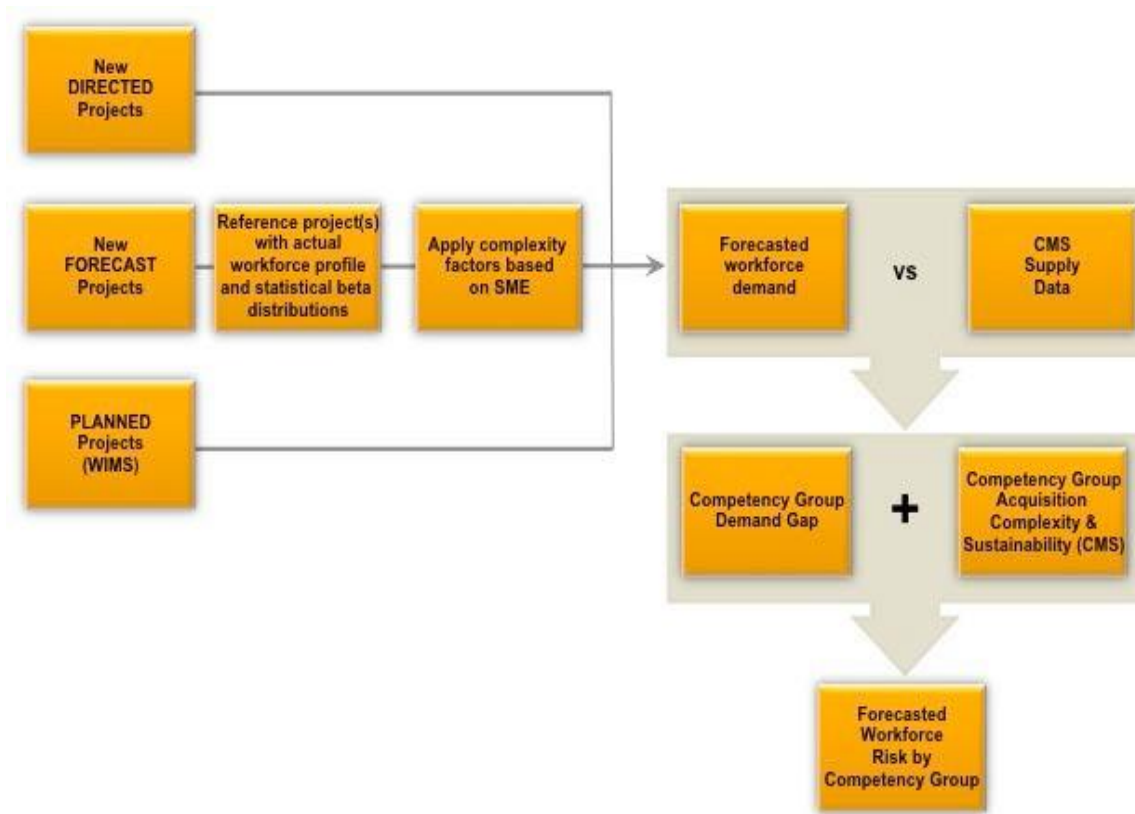


FIGURE 34. Current Workforce Mission Portfolio Approach

3.7.7 Project Reserve Management

The establishment of a reserve management process is a major element of the budget implementation activity. The management of reserve necessitates that several guidelines be established, especially when Earned Value Management (EVM) is required on the project. The first is that Management Reserve (MR) should not be used to cover overruns. The funding for project overruns are covered by project Unallocated Future Expense (UFE) but no budget is added to the Project Management Baseline. MR should be utilized for “in scope” changes and not growth. As an example, the requirement for an additional test that was not originally planned would be considered a new requirement as far as the baseline is concerned, but would be “in scope” to the project. It should be noted that performing a retest should be considered growth since the successful completion of that test was in the baseline. Project UFE are maintained to support project “out of scope” requirements. Examples of this could be the redesign of a spacecraft as a result of cuts in project budget, scope added such as additional hardware requirements, and delays as a result in the delay of the launch date or major project milestone decision.

In managing the reserve, the Project Planning & Control (PP&C) team should develop a reserve log, which: tracks each outlay of reserve; identifies the date and amount of reserve dispersed; identifies the purpose for the use; and includes the WBS to which it was applied. This log should include both UFE and MR usage. In developing the amount of reserve the project should plan for and its funding profile, the PP&C should assess

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 83 of 230

the areas of risk, the projected impacts of problems, and the time frame in which they are expected to occur. Normally, the early part of a project is less likely to require large reserves than the middle and latter part of a project (i.e. concept development and early design activities are less likely to require significant reserve, as would system manufacturing and testing).

Also, from a funding new obligation authority (NOA) standpoint, problems in the front end of a project can utilize funds planned for other tasks that are being delayed as a result of the problems, allowing the request for additional funds to be delayed to the “out years”. The Joint Cost & Schedule Confidence Level (JCL) process is used to establish the UFE level for Category 1 and 2 projects (as defined by MPR 7120.1), and PP&C should be involved in this process. See Section 3.4.5 for a description of JCL and Figure 35 for the relationship of MR to UFE. See MPR 7120.1 for project reserve requirements.

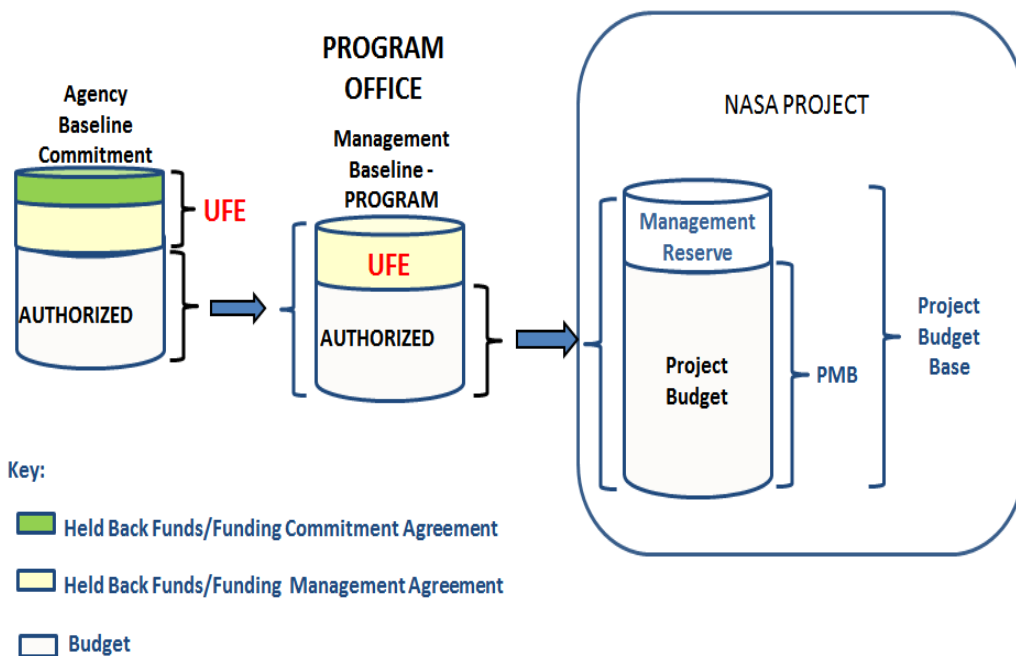


FIGURE 35. Budget UFE and MR

For smaller projects that do not require a JCL analysis at Key Decision Point (KDP) C, Center reserve requirements should all be treated as UFE, or in the case of projects that require EVM, any required reserves in excess of an established MR should be treated as UFE.

3.7.8 Funds Management

The budget formulation (including funds management) process is described throughout Section 3.7. This section provides additional clarification on the Project Planning & Control (PP&C) role in the funds management process for projects, in relation to their approved budgets.

Budget represents the performance target – a number for the planned work – for a specific effort. Funds represent the dollars available for expenditure in the accomplishment of the effort. During the budget development process described earlier in Section 3.7, budgets were established for relevant elements of the Work Breakdown Structure (WBS) and time-phased. MSFC employs a variety of “budget” processes to satisfy the various Stakeholders such as the Agency Baseline Commitment, Management Agreement, Project Budget Base (PBB), Funding Budgets and Operating Plans, and the Performance Measurement Baseline (PMB) established when Earned Value Management (EVM) is employed.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 84 of 230

The budget baselines and relationships are discussed below:

- a. Agency Baseline Commitment – Establishes and documents an integrated set of project requirements, cost, schedule, technical content, and an agreed-to Joint Cost & Schedule Confidence Level (JCL) that forms the basis for NASA’s commitment to the external entities of OMB and Congress for Category 1 and Category 2 projects, as defined by MPR 7120.1. Only one official baseline exists for a NASA Category 1 or 2 project, and it is the Agency Baseline Commitment.
- b. Management Agreement – Within the Decision Memorandum, the parameters and authorities over which the Project Manager (PM) has management control constitute the project Management Agreement. A PM has the authority to manage within the Management Agreement and is accountable for compliance with the terms of the agreement. It includes the project’s approved funding budgetary target.
- c. The Project Budget Base (PBB) – The project’s authorized value (with an associated scope and schedule) to which the project’s distributed budget, undistributed budget, Management Reserve (MR) (if applicable), and authorized unpriced work should reconcile. All detailed planning below the project level is constrained by the PBB. The PBB is established on the foundation of a funding construct. For the purposes of planning and controlling the project, and measuring performance accomplishments, the PBB transitions to, and is managed as, a budget baseline.
- d. Performance Measurement Baseline (PMB) – Time-phased budget expressed in dollars with separate identification of cost elements. It applies to the entire scope of authorized work and spans the project’s period of performance. The PMB is time-phased via integration with the network schedule at the Work Package (WP) or Planning Package (PP) level. The PMB consists of the aggregation of individual time-phased Control Account (CA) budgets, including all burdens, for current project plans. Time-phasing based on when work will be performed, not when funds are committed, obligated, or disbursed. Therefore, it is a budget baseline not a funding plan.

From a financial management point of view, the project forecast data is used to prepare the annual project budget submission in support of the annual program budget submissions. This forecast represents the fiscal resources required to cover the cost incurred in performing work. To support this forecast, Project Planning & Control (PP&C) time-phases the funding based on financial transactions for the commitment, obligation, and expenditure of costs incurred for the project effort.

The project budget is integrated with the Project Plan Statement of Work (SOW) and the approved project schedule, and represents a performance budget plan. Budget is representative of the dollar value associated with planned work and time-phased based on the work plan. It represents the performance target for a specific effort. Circumstances during execution of that work will result in either more or less funding being required for under runs or overruns to plan, which represents the project forecast. See Section 3.12.1.2 for more information on forecasts and examples of obligation and cost plans.

When the project team develops a baseline budget plan, the initial time-phased estimate is always cost-based. In order for the project to support budgetary funding requirements of New Obligation Authority (NOA), however, the PP&C team needs to understand how and when funds will be obligated. The process becomes more complicated when projects that have management responsibility factor in an understanding of the funding requirements for their partner centers. The project PP&C Office facilitates management of the cost baseline, the forecast, and the obligation baseline.

The PP&C team plans and reports obligations and cost. Obligation plans and forecasts are phased differently than the cost plans and estimate to complete (ETC). This is due to the time phasing for large purchase orders and Contractor commitments. The PP&C ensures the project management systems are configured to support obligation and cost planning and reporting.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 85 of 230

3.8 Risk Management

The SMA Office serves as the process manager for risk management at MSFC. IMSC-PLAN-8000.4, *MSFC Mission Support Risk Management Plan*, establishes the processes and responsibilities for the mission Support risk management process at MSFC. MPR 7120.1, *MSFC Engineering and Program/ Project Management Requirements*, provides requirements, and MSFC-HDBK-3173, *Project Management and Systems Engineering Handbook*, provides guidance on the project risk management process.

Risk is characterized by the combination of the probability that a program or project will experience an undesired event and the impact of the undesired event, were it to occur.

Risk = Likelihood (Probability) x Consequence (Impact/Severity)

Likelihood = the probability the risk will occur

Consequence = the impact or effect on a project if the risk occurs (Cost, Schedule, Technical and Safety)

The risks are then “plotted” on a risk matrix, pictured below in Figure 36.

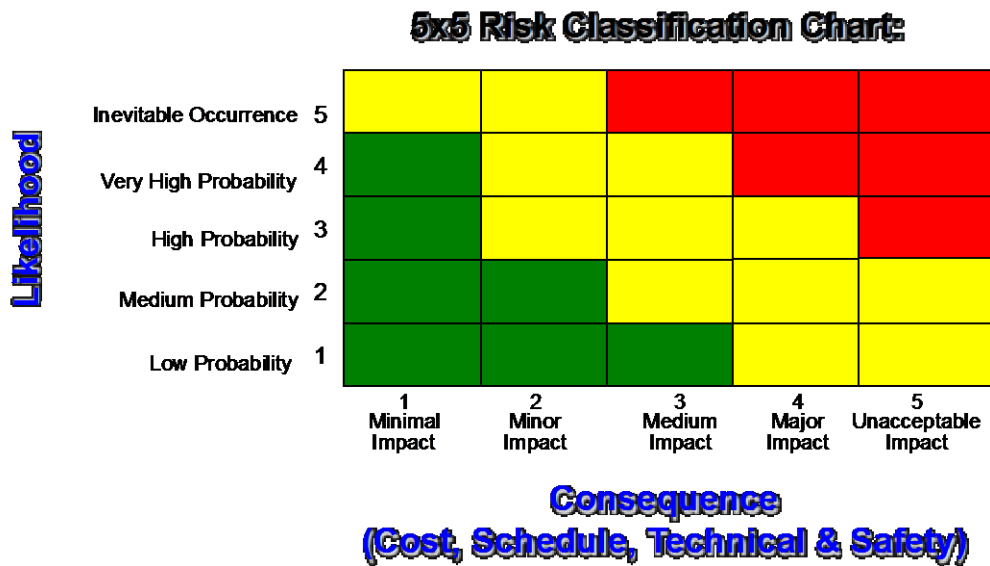


FIGURE 36. Example Risk Classification Chart

Risk management includes two complementary processes: Risk-Informed Decision Making (RIDM) and Continuous Risk Management (CRM), and both form an essential process for managing MSFC’s assets and projects.

The purpose of integrating RIDM and CRM into a coherent framework is to foster proactive risk management: to better inform decision making through better use of risk information, and then to more effectively manage implementation risks using the CRM process, which is focused on the baseline performance requirements emerging from the RIDM process. Within an RIDM process, decisions are made with regard to outcomes of the decision alternatives, taking into account applicable risks and uncertainties; then, as part of the implementation process, CRM is used to manage those risks in order to achieve the performance levels that drove the selection of a particular alternative. Proactive risk management applies to projects and institutional or mission support offices. For a more detailed explanation, see NASA/SP-2010-576, *NASA Risk-Informed Decision Making Handbook*.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 86 of 230

SMA is the process owner for the risk management process at MSFC. From a project perspective, the project chief (or lead systems) engineer may chair a risk management board. Ultimate approval concerning risk recommendations rest with the Project Manager (PM). Technical risks may be presented by a prime contractor, the Engineering Directorate (ED), the SMA directorate, and/or a Project Control Account Manager (P-CAM). A Project Planning & Control (PP&C) representative is a member of any risk control board and provides budget and schedule risk impacts and assessments needed for decision making. A project or mission support PP&C representative will evaluate institutional risks that impact the Center. MWI 7120.6, *Program, Project and Institutional Risk Management*, applies to Center personnel, programs, projects, and contractors (includes grantees, Cooperative Agreement recipients, Space Act Agreement partners, or other agreement parties). Figure 37 provides an overview of the institutional and program/project risk management and reporting process at MSFC.

PP&C personnel who clearly understand the identification and management of project risks should participate with the government acquisition team in the early Request for Proposal (RFP) planning stage to include consideration in the schedule and cost estimates for reasonable risks. Recognized risks that are not quantifiable should be considered when developing Management Reserve (MR) or Unallocated Future Expenses (UFEs). As the project advances in the life-cycle, linkage between the risks (recorded in the risk system) and project scope (reflected in the schedule and budget) are necessary to properly manage. The nature of this linkage should be defined during the early planning stages of RFP development.

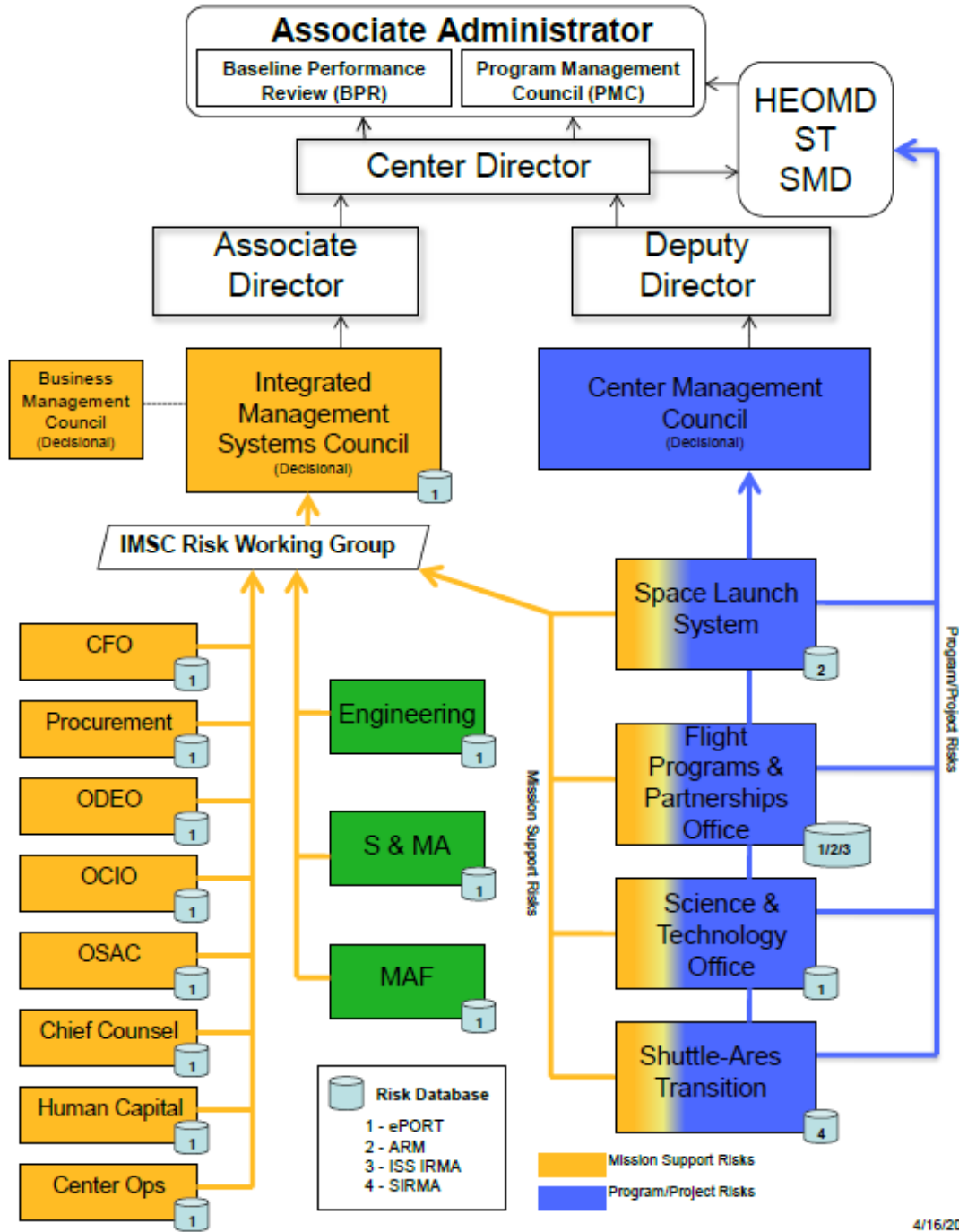


FIGURE 37. MSFC Mission Support and Project Risk Reporting

The PM develops and implements a risk management process that includes RIDM and CRM to form integrated risk management planning for all risks associated with project safety, cost, schedule, and technical performance, and documents it in a Risk Management Plan (RMP) as specified in MWI 7120.6. The project RMP includes: risk list generation; periodic risk reviews; Risk Management Review Boards; Quantitative/Qualitative Risk Assessments; operations risk management; primary risk; risk-based acquisition management process; Information Management System for problem reporting; risk acceptance; risk closure; risk surveillance reporting; risk supportability data; and risk trend analyses.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 88 of 230

Working with project management, PP&C is involved with the initial development of the RMP for the program/project. It is important that the PP&C play a vital role in establishing and assessing risks identified through this process. The PP&C involvement will include identifying PP&C risk, establishing mitigation plans, serving as a member of the project risk management team and on the Risk Management Review Boards to assess the cost and schedule impacts of risks to the project. By identifying these risks, PP&C can plan and focus on high risk areas, which can maximize resources on the project. The PP&C should also be involved in developing cost estimates and schedule assessments for risk mitigation plans for technical risks identified. As the project progresses, additional risk will be identified based on project cost, schedule, and technical issues.

In the context of mission execution, risk is defined as the potential for performance shortfalls, which may be realized in the future, with respect to achieving well defined and stated performance requirements. The performance shortfalls may be related to any one or more of the following mission execution domains: (1) safety, (2) technical, (3) cost, and (4) schedule (see NPR 8000.4, *Agency Risk Management Procedural Requirements*.) Some examples of undesired events include a cost overrun, schedule slippage, safety mishap, health problem, malicious activities, environmental impact, failure to achieve a needed scientific or technological breakthrough, or failure to meet mission success criteria. Throughout the execution of a project, the project and their sponsoring management ensure that the results of all analysis based on a Schedule Risk Assessment (SRA) are linked to their RMP, as applicable.

3.8.1 Risk Management Tools

A variety of risk management tools are used at the center, such as the Electronic Project Online Risk Tool (ePORT), Active Risk Manager (ARM), and Integrated Risk Management Application (IRMA). The ePORT tool is used for documenting and tracking Institutional Risks. MSFC projects may use this tool or another equivalent tool to document and track their risks. The project risk tools will be described in the project’s RMP.

3.8.2 Integrating Earned Value Management (EVM) with Risk Management

For projects that use EVM, by using the risk management techniques discussed above, a Project Manager (PM) can decide how much of the total PBB to set aside for MR budget to cover risks that were unknown at the project’s start. As the project develops according to the baseline plan, metrics from the Earned Value Management System (EVMS) can be analyzed to identify risks that have been realized, as well as emerging risks. By integrating EVM data and risk management, PMs can develop EACs for all management levels, including OMB reporting requirements. Figure 38 depicts how EVM is integrated with risk management for a better project view.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 89 of 230

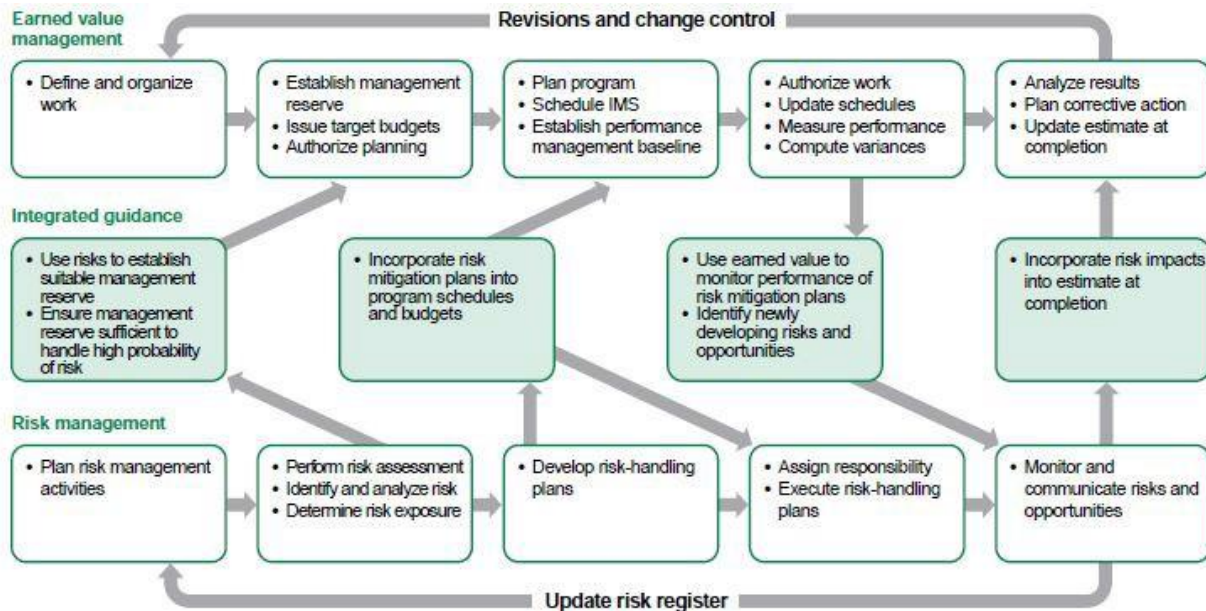


FIGURE 38. Integrating EVM and Risk Management

EVM systems require the supplier (project/contractor) to provide an Estimate at Completion (EAC) and written corrective action plans for any variances that can be assessed for realism, using risk management data and techniques. Moreover, during the Integrated Baseline Review (IBR), the joint customer and supplier team evaluates project risks associated with work definition, schedule, and the adequacy of budgets. This review enhances mutual understanding of risks facing the project, and lays the foundation for tracking them in the EVMS. It also establishes a realistic baseline from which to measure performance and identify risk early. The PP&C team should provide risk identification and mitigation plans to the IBR team prior to the IBR so they can be assessed as part of the IBR process.

3.8.3 Project Planning & Control (PP&C) Roles and Responsibilities in Risk Management

Roles and responsibilities of the PP&C team include the following:

- a. Attend risk management training.
- b. Use approved Risk Management Plan (RMP) and risk list to establish adequate Management Reserve (MR).
- c. Incorporate risk mitigation decisions into the schedules and budgets.
- d. Track reserve usage and trends (schedule and budget) and identify issues.
- e. PP&C ensures that risk items that have been realized (100% probability of occurrence) are incorporated into the Estimate at Completion (EAC) in a timely fashion—definitely prior to expending funds.
- f. Perform schedule and cost risk assessments and make recommendations.

A poor practice is for a project to maintain a risk system with approved mitigation decisions separate (as a lien) from the project technical, cost, and schedule baseline. A best practice is to integrate approved risks, using consistent methodology (such as estimated impact if risk is realized times the probability of occurrence), into the project baseline and show a corresponding depletion of project Management (budget) Reserve and/or Unallocated Funded Expense (UFE).

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 90 of 230

3.9 Configuration Management (CM), Data Management (DM) and Change Management

3.9.1 Configuration Management (CM) and Data Management (DM)

The purpose of CM is to document and control the functional and physical characteristics of hardware and software end items in order to ensure that the final product is designed, built and qualified to that project’s requirements. The configuration baselines contains all of the technical data (performance, functional, and physical) necessary for defining the hardware and software items that are scheduled to be produced. As the project configuration data changes, the configuration baseline will be updated. CM is a control technique, through an orderly process, of formal reviews, authorization, and release of end item configuration changes. Through the formal change management process, a Project Control Board (PCB) reviews and dispositions (approves/disapproves) all proposed changes to the programmatic (such as cost and schedule), and technical (such as requirements, design, and as-built) baselines. The Project Planning & Control (PP&C) manager or delegated analyst is typically a member of the PCB.

At MSFC, Data Management is defined as: *The timely and economical identification/definition, preparation, control, and disposition of documents and data required by a program, project, or activity.* Each Project Manager or Data Manager develops a Data Management Plan during the project formulation phase that describes the specific project implementation of the data management requirements. The Data Management Plan identifies/defines required data, and establishes data preparation requirements, control processes, and disposition processes.

MPR 7123.1, *MSFC Systems Engineering Processes and Requirements*, and MPR 7120.1, *MSFC Engineering and Program/Project Management Requirements*, establishes the requirements for CM, DM, and PDLM for MSFC Programs and Projects. MSFC-HDBK-3173, *Project Management and Systems Engineering Handbook*, provides guidance for successful implementation of CM, DM, and PDLM.

3.9.2 Project Change Management

MSFC projects follow formal change processes in order to facilitate their ability to manage, control, and ultimately report on the authorized work described in the project plan in terms of scope, schedule, and budget. The two types of authorized changes to a project baseline are external (customer driven) or internal (project driven). It is important for the project’s Project Planning & Control (PP&C) team to know which type of change they are dealing with because the nature of the change is what drives their subsequent actions.

Examples of external changes to the baseline are:

- a. Scope
- b. Delivery date
- c. Funding profile

Examples of internal changes to the baseline are:

- a. Shift in resources.
- b. Incorporation of risk mitigation tasks that are determined to be nonperformance-based cost growth.

Project and Center mission support reserves will be impacted by any change in the baseline. Project PP&C ensures that the changes are supported by correct documentation, and that the project Management Reserve (MR) and the project Integrated Master Schedule (IMS) correctly reflect the impact of the baseline change.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 91 of 230

Replanning occurs when conditions have changed such that the current plan is not executable as originally conceived. Only future work is involved in replanning. There is no change to prior budget activity. The budget associated with the remaining work is unchanged.

- a. The Project Control Account Manager (P-CAM) replans at the Work Package (WP) level.
- b. The PP&C ensures that project schedules reflect the new plan.
- c. The PP&C team takes the following into consideration:
 1. The replan requires that additional budget be made available if new scope is identified.
 2. The original profile (plan) has changed.
 3. The Estimate at Completion (EAC) may or may not change.
 4. The original budget and new budget should be traceable and reconcile with the total current available funding.
 5. The replan profile does not exceed the available funding profile (cumulative, or year-by-year).

Internal replanning is initiated with the preparation of the Change Request (CR) to include supporting rationale. See Figure 19: CR Form Illustration, for an example of a CR. The following are more definitive examples of conditions that warrant replanning activities:

- a. Requirements/design maturity—no change in scope. Assumptions:
 1. Since the original baseline, knowledge of requirements and design has significantly matured.
 2. Current cost variance (CV) and schedule variance (SV) are significant.
 3. Recommendations:
 - a) Incorporate expected variance into the Estimate to Complete (ETC) and the EAC.
 - b) Do not change baseline.
- b. Requirements/design maturity—scope change, assumptions:
 1. Since the original baseline, knowledge of requirements and design has significantly matured.
 2. Design maturity has led to functional requirements change.
 3. New hardware/software items are needed to meet the CR, resulting in need for new scope.
 4. Current CV and SV are significant.
 5. Recommendations:
 - a) Develop new Control Accounts (CAs)/Work Packages (WPs) for additional scope.
 - b) Incorporate new scope into the updated EAC.
 - c) Incorporate new scope into original baseline.
- c. Incorporating a hard lien—new scope, assumptions:
 1. Performance shows variance.
 2. New hardware required has been identified as a risk item.
 3. A decision has been made (by Project Control Board (PCB)/Project Manager (PM)) to accept and incorporate a lien for additional scope.
 4. New hardware will be designed and fabricated.

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 92 of 230

5. Project benefits from more robust design solutions.
6. Risk will be mitigated.
7. Recommendations:
 - a) Develop new CAs/WPs for additional scope.
 - b) Incorporate new scope and update EAC.
 - c) Incorporate new scope into original baseline.

3.9.3 Re-Planning

Re-planning occurs when changes are made to the time-phasing of remaining project baselined work and budget plans. The re-planning should stay within the authorized scope, schedule, and budget requirements. When replanning, there are no changes to past budgets; ONLY future work (and the budget associated with this work) can be re-planned. The re-planning is performed by the Project Control Account Manager (P-CAM) at the Work Package (WP) level. The PP&C team should take the lead when re-planning occurs.

3.9.4 Re-Baselining

The incorporation of Project Control Board (PCB)-approved changes that have a significant impact on internal and/or external baseline cost, schedule, and technical plans is called a re-baseline. Funding changes are one of the items that can trigger a PCB action, or under circumstances where the project's existing baseline schedule is no longer achievable and measuring performance and tracking variances is meaningless, the baseline schedule can be re-baselined with the proper governance change board approvals. Management decisions need to be made concerning the treatment of variances prior to the re-baseline activity. Such decisions are in regards to the retention or elimination of Schedule Variances (SVs), Cost Variances (CVs), or both for future planning reference, performance evaluations, or other management needs. Partial re-baselines to selected portions of the baseline schedule can be implemented for the same reasons and using the same process as a full project re-baseline. The original baseline and new baseline budgets should be traceable, and reconcile with the total available funding. The Project Planning & Control (PP&C) team should take the lead in maintaining this traceability. For projects over \$1M, the program/project activity has to get CMC approval, as referenced in MPR 7120.4, *MSFC Center Management Council Process*.

3.9.5 Project Planning & Control (PP&C) Roles in Configuration Management (CM) and Change Management:

- a. Review and support the proposed change with the responsible manager.
- b. Participate on the Project Control Board (PCB).
- c. Ensure that all budget transactions are properly documented.
- d. Ensure budget traceability to the latest authorized Project Budget Base (PBB).
- e. Integrate the project budgets with the contractual vehicle values by year.
- f. Integrate all time-phased budgets to the appropriate schedules.
- g. Ensure that all Change Requests (CRs) are approved in a timely manner.
- h. When Earned Value Management (EVM) is required, ensure that all change data are correctly entered into the Earned Value (EV) software application and the Agency's NASA Accounting System as appropriate.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 93 of 230

- i. Publish the revised baseline documentation (Work Authorization Document (WAD), Control Account Plan (CAP), Work Breakdown Structure (WBS), and Project Budget log).
- j. Maintain the integrity of the Integrated Master Schedule (IMS) Plan to the latest authorized Project Plan.
- k. Capture, review, and document proposed and approved changes to schedule, plan, detail, activities, logic, duration, etc., with project Control Account Manager (CAM), functional, and project management.
- l. Ensure all schedule transactions are properly documented and have validated rationale for the Project Control Board (PCB), when required.
- m. Maintain cognizance over classification of schedule changes and lead in the analysis, documentation, and approval of such changes.

3.10 Earned Value Management (EVM)

This section will provide pertinent EVM background information, a brief description of the overall EVM process, its purpose, applicable requirements, integration practices, analysis metrics and products, and the additional management tools required for its successful implementation. PP&C activities and skills addressed in the previous sections of this handbook (see Section 3.1.2) will obviously also apply, and sometimes overlap, for EVM implementation within any project endeavor.

3.10.1 Introduction and Requirements

The Office of Management and Budget (OMB) Circular A-11, *Part 7 Planning, Budgeting, Acquisition, and Management of Capital Assets and the Capital Programming Guide*, sets forth the policy, budget justification, and reporting requirements that apply to all agencies of the Executive Branch of the government that are subject to Executive Branch review for major capital acquisitions. The OMB Circular A-11 requires that Earned Value Management (EVM) be consistent with the guidelines in EIA-748 for developmental efforts for both government and contractor work, and that in-house work be managed with the same rigor as contract work. While a Project Plan or Inter-Agency Work Agreement (IAWA) replaces the contract for MSFC in-house work, the other best practices of good project management, including the use of EVM in accordance with the EIA-748 standard, are applicable for developmental and production efforts. The primary consideration for using EVM is the nature of the work and risk, as well as the value of the effort.

The Office of the Chief Engineer (OCE) is NASA’s policy and functional owner for EVM. The OCE has developed an Agency-wide EVM capability that will facilitate compliance with OMB EVM requirements, and provide for the effective and consistent implementation of EVM across NASA programs/projects. Use of the Agency EVMS will ensure projects meet their EVM requirements. Project Plans should include their EVM implementation approach and use.

EVM is a tool for measuring and assessing project performance through the integration of technical scope with schedule and cost plans during the execution of the project (see figure 39). EVM provides quantification of technical progress, enabling management to gain insight into project status and project completion costs and schedules. Two essential characteristics of successful EVM are system data integrity and carefully targeted monthly EVM data analyses (e.g., identification of risky Work Breakdown Structure (WBS) elements).

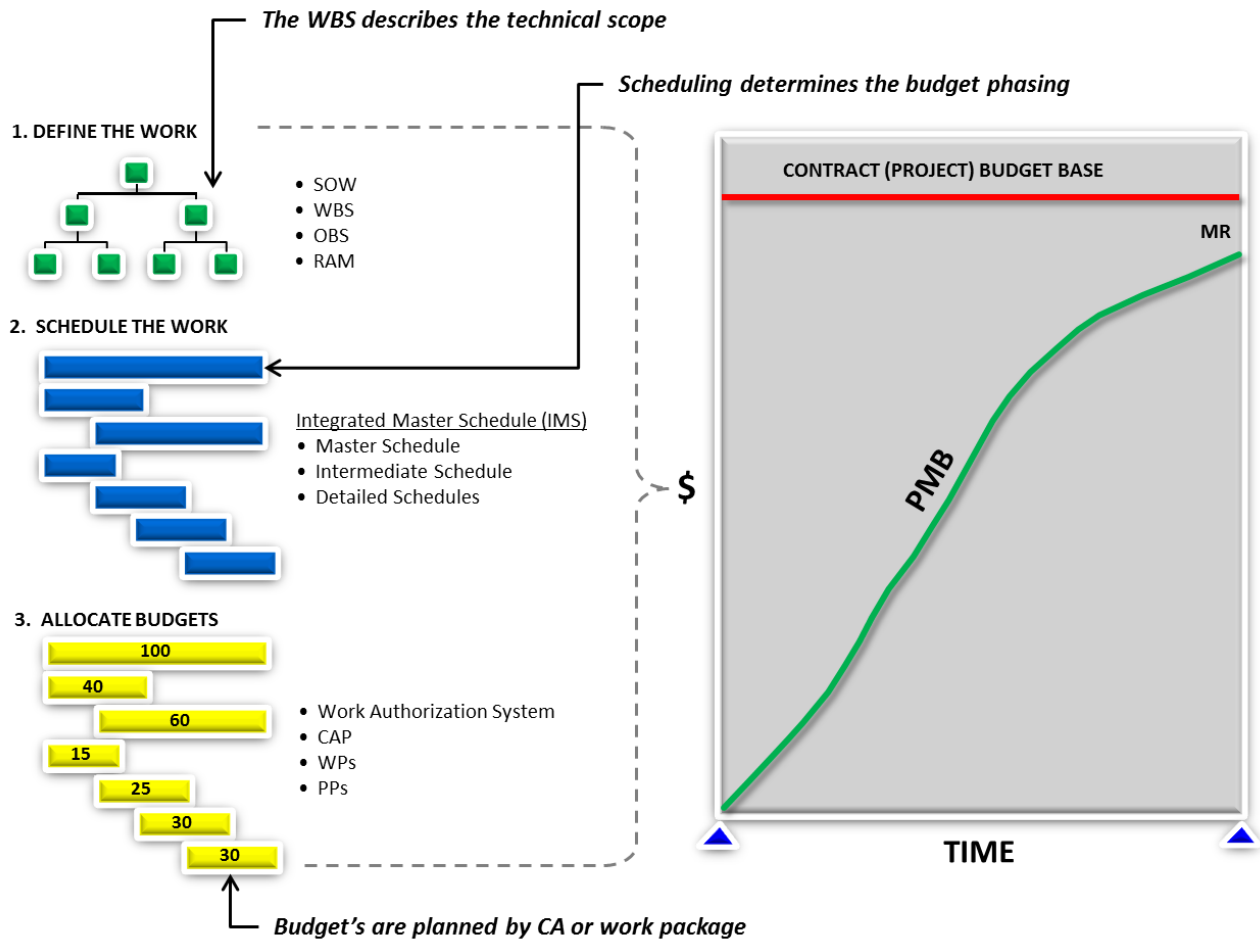


FIGURE 39. PMB

3.10.1.1 Earned Value Management (EVM) Overview

EVM is applicable to both in-house effort and contracts, thereby providing project management with objective, accurate, and timely data for effective decision making for the total content of a program/project by:

- Integrating technical, cost, schedule, with risk management (See Figure 38).
- Allowing objective assessment and quantification of current project performance.
- Helping predict future performance based on trends.

Project performance data gained from an Earned Value Management System (EVMS) may provide additional management insight into schedule performance. Remember that the EVM process works by integrating the project's budget plan with the approved schedule plan to provide an overall project PMB. As actual costs are accounted for, and actual schedule status is taken, evaluations can be made that address the following two key questions:

- Is the project getting a dollar's worth of work accomplished for every dollar spent?
- If project performance continues on the current trend, what will be the estimated cost of the project when completed, and when will it be complete?

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 95 of 230

These questions can be answered along with other performance assessment metrics, and insight can be determined through EVM data that is captured and maintained by a project's PP&C team (see Figure 40).

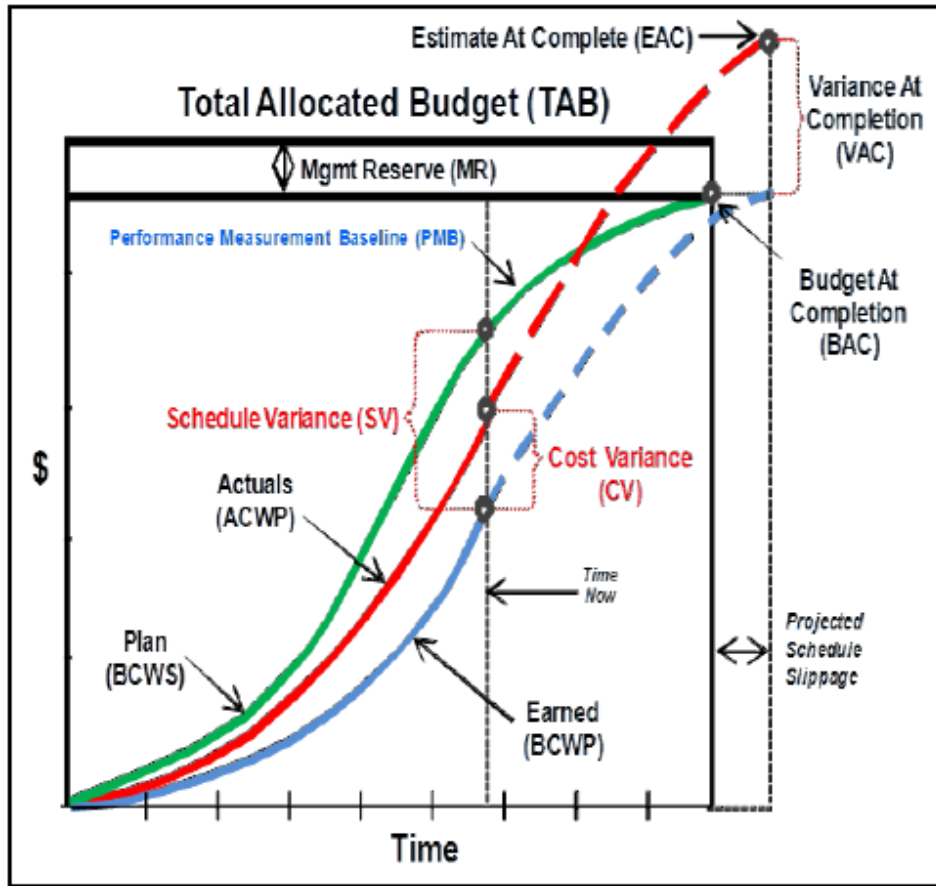


FIGURE 40. Project Performance Insight Using EVM

Numerous performance metric calculations can be performed using Earned Value (EV) data noted in Figure 40 above. The most basic of EVM metric calculations are noted in the paragraphs below and can be used for insight into project performance.

- 1. Schedule Variance (SV)** is determined by the following calculation:

Budgeted Cost of Work Performed (BCWP) – Budgeted Cost of Work Scheduled (BCWS)

SV can also be stated as the value of the work completed minus the value of the work that was planned to be completed. A positive result indicates favorable performance, while a negative result indicates an unfavorable performance position.

- 2. Cost Variance (CV)** is determined by the following calculation:

BCWP – Actual Cost of Work Performed (ACWP)

CV can also be stated as the value of the work completed minus the actual cost of the work that was completed. A positive result indicates favorable performance, while a negative result indicates an unfavorable performance position.

- 3. Schedule Performance Index (SPI)** is determined by the following calculation:

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 96 of 230

BCWP / BCWS

This formula provides a ratio of the value of work actually accomplished to the value of work that was planned. When the result of this calculation equals one, then the project is actually accomplishing all work that it had planned. When the result is less than one, then there is less work being accomplished than was planned. And when the result is greater than one, then more work is being accomplished than was planned in the baseline.

4. Cost Performance Index (CPI) is determined by the following calculation:

BCWP / ACWP

This formula provides a ratio of the value of work actually accomplished to the actual cost of work that was performed. When the result of this calculation equals one, then the project’s performance is proceeding as planned. When the result is less than one, then performance is less than was planned. And when the result is greater than one, then performance production is better than was planned in the baseline.

5. Estimate at Completion (EAC) is determined by the following calculation:

$$ACWP_{cum} + [(Budget\ at\ Completion\ (BAC) - BCWP_{cum}) / CPI_{cum}]$$

The EAC value represents an estimate of what the total value of the project work will be based on the project’s current cost performance.

EVM metrics enable the project management team to easily identify and prioritize those elements of the project that are not performing to their baseline plan.

3.10.1.2 NASA/MSFC Earned Value Management (EVM) Requirements

NASA/MSFC EVM requirements are found in MPR 7120.1, NPR 7120.5, NPR 7120.7, and NPR 7120.8. Policy for contracts is contained in NFS 1834.201. NASA procedural direction establishes in-house EVM requirements that comply with the 32 guidelines in EIA-748 (Appendix E).

Projects in phases C and D with a LCC estimated to be greater than \$20 million, and Phase E project modifications, enhancements, or upgrades with an estimated development cost greater than \$20 million, must perform EVM with a system that complies with the guidelines in EIA-748, Standard for EVMS. Use of NASA’s EVM capability and processes will ensure MSFC compliance with the EIA standard. This capability allows tailoring to match the individual needs of the program or project, while still meeting the EIA-748 guidelines. NASA’s EVM capability can be found on the Program and Project Management Community of Practice at <https://nen.nasa.gov/web/pm/evm>.

EVM will also be applied when modifications, enhancements, or upgrades are made during Phase E when the estimated cost is \$20 million or more. Figure 41 shows the relationship between the EVM requirements and the MSFC project life-cycle phases, key events/reviews, and significant activities during each phase.

Earned Value Management System (EVMS) requirements must also be applied to appropriate suppliers in accordance with the NFS, and to in-house work elements. For contracts that require EVM, an Integrated Program Management Report (IPMR), Integrated Master Schedule (IMS), and a Work Breakdown Structure (WBS) are required deliverables with the appropriate Data Requirement Descriptions (DRDs) included in the contract and/or agreement.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 97 of 230

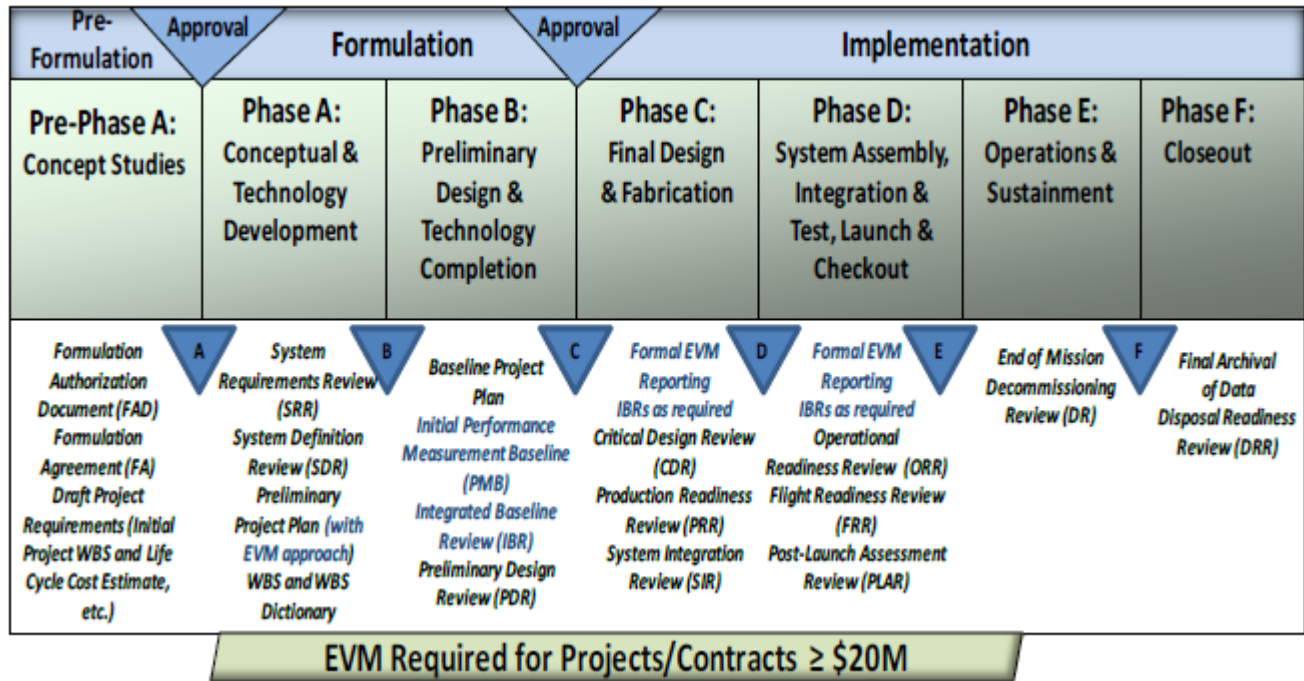


FIGURE 41. MSFC Project Life-Cycle Relationships and EVM Application

Project EVM reporting begins no later than 60 days after the start of Phase C. However, contract EVM reporting begins no later than 90 days after contract award regardless of the system acquisition phase.

The following chart (see Figure 42) summarizes the EVMS thresholds for compliance and validation:

NASA Projects (Category 1 and 2)		
\$0 to \$20M	\$20M to \$50M	>\$50M
Non-EVM Performance Mgmt	32 Guidelines NASA System	32 Guidelines NASA System
NASA Projects (Category 3)		
\$0 to \$20M	\$20M to \$150M	>\$150M*
Non-EVM Performance Mgmt	EVM for Small Cat. 3	32 Guidelines NASA System
Flow-Down to Contractors and Lower Tier Subcontractors		
\$0 to \$20M	\$20M to \$50M	>\$50M
Non-EVM Performance Mgmt Performance Mgmt Terms and Conditions of DRD	32 Guidelines Compliance Full EVM Terms and Conditions of DRDs	32 Guidelines Validated Full EVM Terms and Conditions of DRDs

FIGURE 42. EVM Compliance Thresholds

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 98 of 230

3.10.2 Earned Value Management (EVM) Implementation on MSFC Contracts

The contract type is a key element in determining EVM requirements. Contract types fall into two basic categories: Cost Reimbursable or Fixed Price (FP). For application of EVM to contracts, follow the policy as defined in NASA FAR Supplement (NFS), Part 1834.2 *Earned Value Management System*. In addition, NPR 7120.5 states that a Work Breakdown Structure (WBS), Contract Performance Report (CPR) (now Integrated Program Management Report (IPMR)), and IMS will be used on contracts with EVM.

3.10.2.1 Project Planning & Control (PP&C) Earned Value Management (EVM) Involvement Prior to Contract Award

For contracted efforts, PP&C involvement is very important in ensuring that the correct requirements for management and data reporting are included in the Request for Proposal (RFP). These requirements are defined through clear narrative direction within the Statement of Work (SOW), and also within specific Data Requirements Descriptions (DRDs) included in the solicitation document. Significant PP&C participation in supplying input, guidance, and review for the above requirements is definitely recommended to ensure that management processes and all data received will satisfy the project’s need for measuring the contractor’s on-going performance during implementation. PP&C involvement in the following areas is vital to project success.

3.10.2.2 Contract Performance Management and Reporting

The Integrated Program Management Report (IPMR) may be tailored as necessitated by the complexity of the contract and project management reporting requirements. Suggested tailoring instructions are included as notations to the standard Data Requirements Description (DRD). The MSFC Earned Value Management (EVM) Focal Point is always available to work with the Project Manager (PM) and his PP&C support team, or the Contracting Officer (CO) to ensure the DRDs are included and tailored as necessitated by the complexity of the contract and project management reporting requirements.

The IPMR is the primary report the government uses for obtaining EVM data. The IPMR requirement should be added as a DRD for all contracts that have an EVM requirement. In accordance with the NFS 1834.2, the appropriate solicitation provisions and contract clauses are to be used to implement IPMR reporting on these contracts. The IPMR is used by the contractor to provide MSFC with monthly cost, schedule, and technical performance information. The IPMR has seven formats, as reflected below with the appropriate content shown for each:

- a. Format 1 provides EVM data by Work Breakdown Structure (WBS) element.
- b. Format 2 provides EVM data by functional or organizational element – Organization Breakdown Structure (OBS).
- c. Format 3 provides the time-phased Performance Measurement Baseline (PMB) changes.
- d. Format 4 provides staffing of human resources (HR) requirements.
- e. Format 5 is the Explanations and Problem Analysis Report.
- f. Format 6 defines and contains the Integrated Master Schedule (IMS).
- g. Format 7 defines the time-phased historical and forecast cost submission.

The contract IPMR DRD provides contractor guidance for the preparation and submission of the IPMR, required formats, variance analysis thresholds, reporting frequency, reporting levels, distribution, and specific project instructions, if required. All seven IPMR formats are required for qualifying contracts greater than \$20

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 99 of 230

million. IPMR formats 1, 3, 5, and 6 are required, as a minimum, for contracts less than \$100 million but greater than \$20 million.

There are cases where a supplier will not meet requirements for EVM flow down (i.e., Firm Fixed Price (FFP) contracts, work with universities, grants, etc.). However, it is still necessary to require data reporting to support project-level EVM planning and analysis. Examples of recommended content for these special DRDs are addressed below that will ensure the needed project data is requested appropriately.

- a. Actual cost data by Work Breakdown Structure (WBS) is needed to support EVM planning and analysis and serve as the source for Actual Cost of Work Performed (ACWP). There are various methods, both formal and informal, that can be used to obtain cost data. If a NASA Form (NF) 533 is required on a contract, it will serve as the source for actual cost data. Another option for obtaining contractor cost data is to request access to the contractor’s financial data.
- b. Cost plans are needed to support the project-level PMB and serve as the basis for Budgeted Cost of Work Performed (BCWP) (also referred to as Earned Value (EV)).
- c. Status of work performed is needed to serve as the basis for the BCWP or EV. The most preferred way to obtain status of work accomplished is from an IMS that is current and delivered on at least a monthly basis.
- d. Explanations of cost, schedule, and at completion variances are also required for EVM planning and analysis. This data can be formally requested from the contractor on a monthly basis, or it may be discussed at Monthly Status Reviews.

3.10.2.3 Work Breakdown Structure (WBS) and Reporting

Normally, during the Request for Proposal (RFP) stage, the government team, with help and guidance from PP&C personnel, will develop and provide a product-oriented WBS down to level three and include in the solicitation. This upper level WBS will utilize the standard WBS Level 2 templates. The contractor will use this WBS and extend further to the appropriate level for their management oversight and control (see Figure 43). The contractor may also propose changes to the WBS. See Section 3.2.1, as well as *NASA Work Breakdown Structure Handbook* for specific guidance and best practices for developing the project and contract WBS.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 100 of 230

WBS/CWBS Relationship

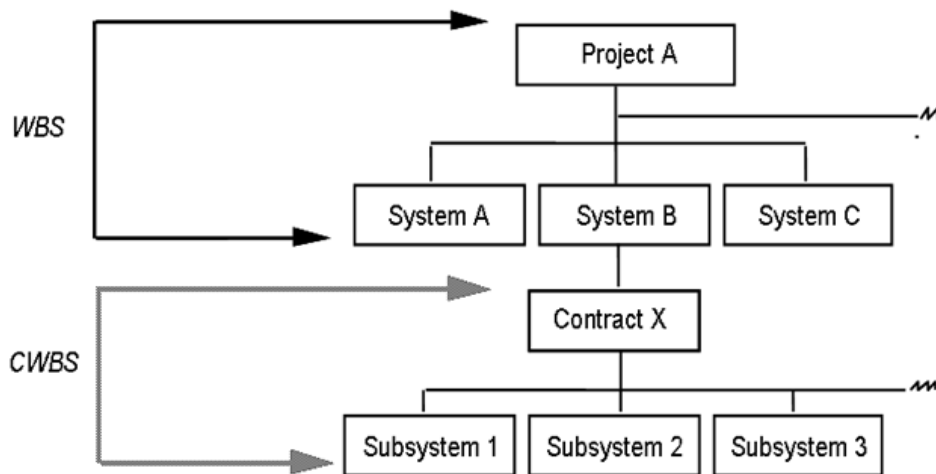


FIGURE 43. Contract WBS Extension Below Level Three

3.10.2.4 Schedule Management and Reporting

Appropriate Planning and Scheduling Project Planning & Control (PP&C) personnel should work with the government acquisition team to ensure that the RFP should include language that includes a logic network schedule and defines the logic network schedule requirements. These requirements should be consistent with MPR 7120.1 and satisfy the scheduling “best practices” addressed earlier in Section 3.3, “Planning and Scheduling”, and also in the *NASA Schedule Management Handbook*. Requirements should ensure the establishment, management, and control of the baseline master schedule and its derivative schedules. These requirements help ensure establishment of a valid framework for time phasing budgets and coordination of efforts into a master plan that also enables the measurement of accomplishments.

3.10.2.5 Contractor/NASA Management Reviews

Project Planning & Control (PP&C) personnel should work with government acquisition teams to ensure that the RFP description of work content includes the necessary management reviews which are held on a regular basis and involve government team members and contractors reviewing the work status.

Guidance from the MSFC Earned Value Management (EVM) Focal Point should be incorporated into the contract Statement of Work (SOW) or performance work statement to describe the role and content of EVM in these reviews. The review includes such topics as cost, schedule, and technical performance. It should also include a quantified risk assessment with impacts, and provide a means of identifying action items and ensuring that they are completed. As each manager presents, they should integrate the EVM data into the presentations to give an overall picture of cost, schedule, and technical performance.

3.10.2.6 Project Planning & Control (PP&C) Earned Value Management (EVM) Involvement Post Contract Award

This section describes key activities and PP&C involvement in the areas of Earned Value Management System (EVMS) compliance, validation, and analysis following contract award for any contract requiring EVMS application. PP&C responsibilities and activities are critical for ensuring that EVM processes are adequately

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 101 of 230

implemented and used by the MSFC contractor community. PP&C involvement in the analysis of contractor EVM data that are reported monthly is also critical to ensuring that MSFC’s management oversight team accurately understands the contractor’s performance status, issues, and the impacts to forecasted work and deliverables. PP&C involvement in the following areas is vital to project success.

3.10.2.7 Contractor Earned Value Management System (EVMS) Validation

An EVMS validated by the government is required on development or production contracts greater than \$100 million. NASA has a Memorandum of Understanding (MOU) with the Defense Contract Management Agency (DCMA) that delegates responsibility for validation and surveillance of contractors’ EVMS to the DCMA. The DCMA will review the contractor’s plan for validation and provide NASA with a report regarding the plan’s adequacy for the intended contract. When validation is necessary, the contractor is responsible for scheduling related reviews with DCMA and NASA. The National Defense Industrial Association’s (NDIA) EVMS Intent Guide and Acceptance Guide provide additional information on these reviews. NASA and the Project Manager (PM) will provide Project Planning & Control (PP&C) specialists in the areas of scheduling, budgeting, accounting, etc., to augment the DCMA team as appropriate to accomplish these reviews. If a contract is awarded to a contractor and DCMA is not involved, then it is the responsibility of the NASA PM, with the assistance of MSFC’s EVM Focal Point, to ensure the contractor conducts a validation review with an EVM authority appointed by the Office of Chief Engineer (OCE) to provide validation.

3.10.2.8 Contractor Earned Value Management System (EVMS) Surveillance

Contractor EVMS surveillance is conducted by the responsible Defense Contract Management Agency (DCMA) office, with the assistance of MSFC Project Planning & Control (PP&C) personnel as assigned by the Project Manager (PM), in accordance with the Memorandum of Understanding (MOU) between NASA and DCMA. PP&C personnel provide feedback to DCMA regarding the adequacy of contractor processes, practices, tools, and data associated with and used for carrying out Earned Value Management (EVM) requirements for MSFC projects. The MOU covers EVMS surveillance at a contractor site or multiple contractor sites. The MOU scope includes EVMS compliance assessment, validation, and/or evaluation of a contractor’s previously validated EVMS for adequacy. The MOU also describes duties, responsibilities, products, and methods of cooperation for contract-specific EVMS surveillance.

3.10.2.9 Contractor Integrated Baseline Review (IBR)

All MSFC contracts with Earned Value Management (EVM) will have an Integrated Baseline Review (IBR) to finalize the agreement on the baseline and ensure all risks are identified and understood. The Project Manager (PM) and his responsible technical managers, with the support of the EVM Focal Point, and Project Planning & Control (PP&C) personnel skilled in scheduling, budgeting, and project organization should conduct an IBR within 6 months (180 days) of contract award as required by NFS 1852.234-2(c). This timeline applies to the authority to proceed on letter contract awards as well. An IBR will also be conducted within 6 months following the exercise of significant contract options or 60 days after a major contract modification. The PM should ensure that training is available to each team member prior to the IBR. Such training may be conducted jointly with the contractor, and should consist of the basics of EVM and the IBR process. The PM should conduct a workshop just prior to the IBR to cover the mechanics of the review and examples of specific items to be reviewed.

The objective of an IBR is for all stakeholders to jointly assess the baseline to be used for performance measurement to ensure complete coverage of the Statement of Work (SOW), logical scheduling of the work activities, adequate resourcing, and identification of inherent risks. This will be accomplished by evaluating the Performance Measurement Baseline (PMB) to ensure it captures the entire technical scope of work, is consistent

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 102 of 230

with schedule requirements, has adequate resources assigned, and has sound management processes applied. To facilitate the credibility assessment of the Integrated Master Schedule (IMS), the PM’s schedule team may use the Center-developed Schedule Test and Assessment Tool (STAT). *The NASA IBR Handbook* provides further detailed guidance on the IBR process. This handbook can be found at evm.nasa.gov.

3.10.2.10 Conduct Earned Value Management (EVM) Analysis on Contractor Data

An Integrated Program Management Report (IPMR) is required when EVM is a requirement. IPMR data should be reported in a timely manner per the contractual Data Requirements Description (DRD). IPMR data should also be consistent and reconcilable with both the Monthly Contractor Financial Management Report (NF533M) and the Quarterly Contractor Financial Management Report (NF533Q), if applicable. Contractor performance data received in IPMR Formats 1-7 is imported into the Agency recognized EVM analysis tool” Empower”. The Empower tool provides the capability to quickly identify those areas of the project Work Breakdown Schedule (WBS) which are not performing well and are breaking the established thresholds for variance reporting. The Empower tool provides many analysis options for any level of the WBS, and is also able to categorize and format the results in an understandable and meaningful manner for management use and decision-making.

EVM data should be included in all management reviews. Project status based on EVM data should be reported at the level appropriate for all levels of management and utilized for insight and management actions. The Project Manager (PM) should understand and emphasize the importance of the integrated technical, schedule, cost, and risk analyses provided by EVM, in conjunction with other project information, to formulate an overall project status. Concentrating on the technical aspects or technical problems of the project alone will not provide for true integrated project management. The associated schedule implications, cost drivers, and corresponding risks should be considered.

Analysis is indicated when any of the previously established variance thresholds are exceeded. Focusing first on these problem areas is an efficient and effective management technique. The analysis for each variance that exceeds a threshold should address three areas:

- a. Root cause: Simply stating the variance is not identifying the root cause. A simple way to determine root cause is to question why until it no longer makes sense to do so. Another test for root cause determination is to quantify the root cause or causes as related to rates, usage, efficiency, or a combination of these.
- b. Impact: Each root cause will create an impact on one or more elements of the project—cost, schedule, technical, or a combination of these areas. The impact should be distinctly stated and quantified.
- c. Corrective actions and results: For each impact area, a correction action or recovery plan should be formulated. This plan should contain a description of the actions taken and the anticipated results in terms of the impacted area or areas, including time, cost, and technical components. If recovery is not possible, this should be clearly stated. As long as this variance exceeds the reporting threshold, each subsequent report should include the actual results of implementing corrective actions.

These steps may also be used when variance thresholds are not exceeded. It is recommended practice for Project Planning & Control (PP&C) personnel to routinely use the aforementioned methodology to analyze Control Accounts (CAs) for potential problems that have not yet exceeded a variance threshold.

These steps are intended to assist the project staff in understanding some of the monthly activities surrounding the EVM analysis process. The level of analysis activity is dependent upon many variables: the stage of the project, the value of the WBS, the contractor's performance, analyst availability and experience, the type of contract, and the EVM analysis tools available. All of these affect the project’s capability to

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 103 of 230

perform detailed analysis. The PM should understand the analysis requirements and arrange for the necessary PP&C support and analysis tools to ensure the adequacy of the EVM analysis process.

3.10.3 Earned Value Management (EVM) Implementation on MSFC In-House Projects

The Office of Chief Engineer (OCE), which is the Agency’s process owner for EVM, has developed an Agency-wide EVM capability that MSFC project organizations should use to achieve the NASA and Office of Management and Budget (OMB) requirements for compliance with the EIA-748 standards. Figure 44 provides an overview of the NASA Earned Value Management System (EVMS) architecture.

For small Cat3/Class D space flight projects, NASA policy recognizes the need to accommodate the unique aspects of each project to achieve mission success in an efficient and economical manner within acceptable risk. This flexibility, in regards to EVM implementation, can be achieved through appropriate tailoring of the OCE EVM capability process guidance for in-house EVM. EVM principles for small Cat3 projects may be applied per the process guidance provided in Appendix H of this document.

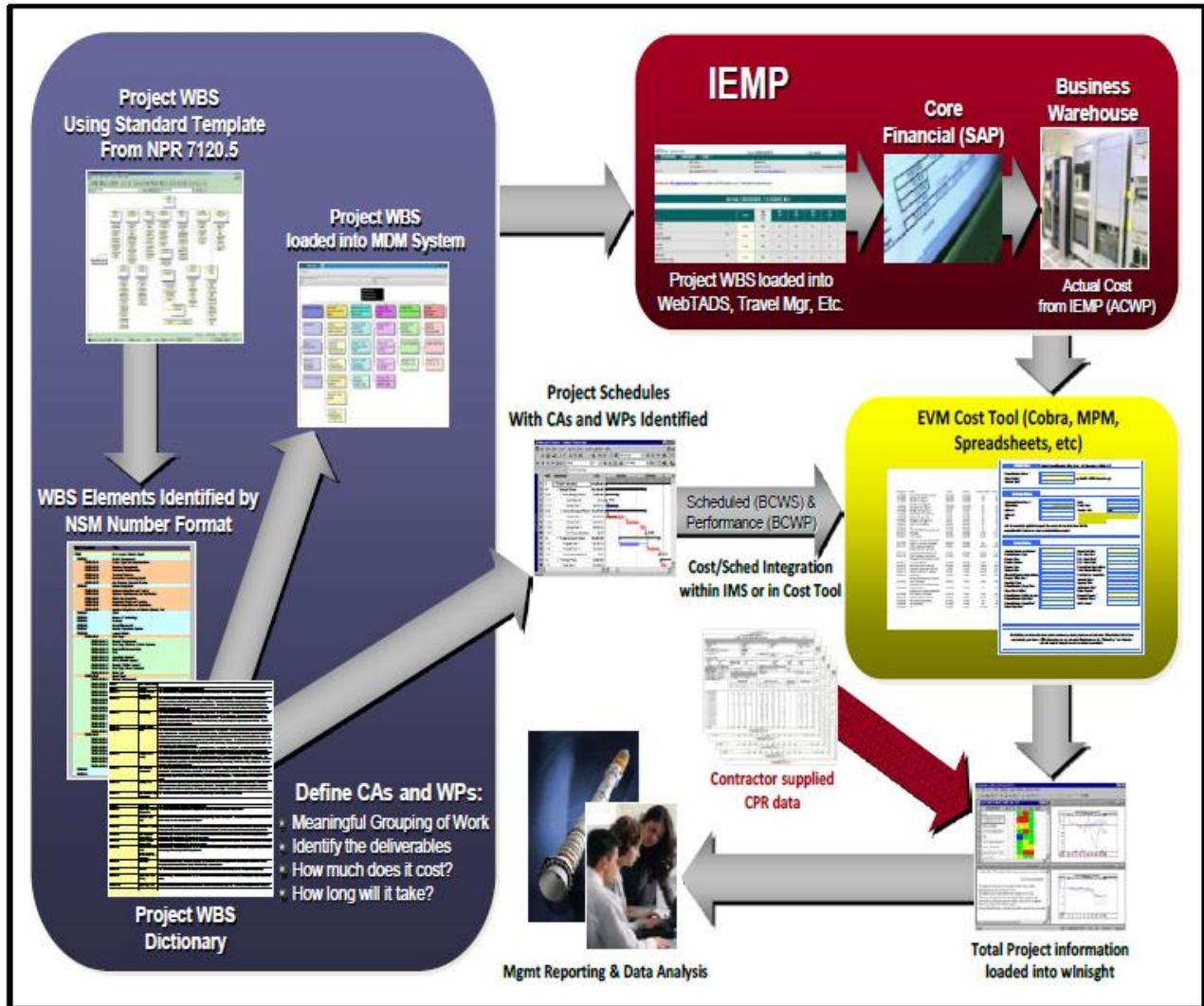


FIGURE 44. NASA EVMS Architecture

MSFC Project Planning & Control (PP&C) personnel should work to help ensure that Project Plans for those projects requiring EVM implementation should include the project’s EVM implementation approach and how the resulting data will be used. MSFC Project Managers (PMs) should engage the Center’s EVM Focal Point for assistance in developing, documenting, and implementing the *NASA EVM System Description* on their projects. A PM’s activities required for in-house EVM implementation are very similar to those required for monitoring EVM implementation on contracts. There are, however, many additional PP&C tasks involved to further breakdown the project scope of work into a more defined Work Breakdown Structure (WBS) and the identification of project CAs. The project’s Performance Measurement Baseline (PMB) can then be developed through the detailed planning and integration of all the CA schedules and budgets. CAs will also breakdown further into Work Packages (WPs) and Planning Packages (PPs).

The EVMS process begins with authorization via a Formulation Authorization Document (FAD) or equivalent document. The *NASA EVM System Description* provides more detail on each of these components.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 105 of 230

The PM develops the Project Plan, the overall Work Authorization (WA) document that represents the Formulation Agreement between the Sponsor and the Performer on work scope, schedule, and budget. Based on this scope, the WBS and WBS dictionary are created. Appendix F provides a template to begin WBS development for flight projects. Appendix F also provides guidance on WBS development for Information Technology (IT) projects. The WBS dictionary should also be developed as a companion document to the WBS and subjected to the same change management controls (see Section 3.2, for illustrations of the WBS and WBS Dictionary).

The project WBS and WBS dictionary data are used to establish a framework in the systems that support the EVMS, such as the accounting system, scheduling system, and EVM engine. Disciplined change management controls should ensure that this framework remains intact and identical in these systems. Additionally, the risk management system will use the WBS and WBS dictionary data as a framework, and should be included in these controls. Each PM is ultimately responsible for establishing and controlling the project WBS baseline. The WBS provides a means of rolling up project data to any desired level for analysis and oversight, and provides a common reference for all project communication, both internal and external.

As reflected in Section 3.2.7, an Organization Breakdown Structure (OBS) should also be developed to describe the organizations responsible for performing the authorized work. Once developed, the OBS should be cross-referenced to the WBS creating a Responsibility Assignment Matrix (RAM) to ensure responsibility and accountability for planning, performing, and reporting on all authorized work. The integration of the Work Breakdown Structure (WBS) and OBS creates Control Accounts (CAs) that facilitate schedule and cost performance measurement. The CA is the primary point for WA, work performance management, and work performance measurement (i.e., where the planned value is established, the Earned Value (EV) is assessed, and actual costs are collected). Each CA is assigned to a Project Control Account Manager (P-CAM). The P-CAM is responsible for ensuring the accomplishment of work in his or her CA, and is the focal point for management control. Project Planner/Schedulers and Budget Analysts work together to assist the P-CAM in developing a Control Account Plan (CAP) for each CA. Each CAP includes an integrated plan showing the detailed schedule and the time-phased budget for work contained in the CA (see Figure 45).

**MSFC Technical Standard
CS40**

Title: Project Planning and Control Handbook

**Document No.: MSFC-HDBK-3684
Effective Date: September 25, 2017**

**Revision: A
Page 106 of 230**

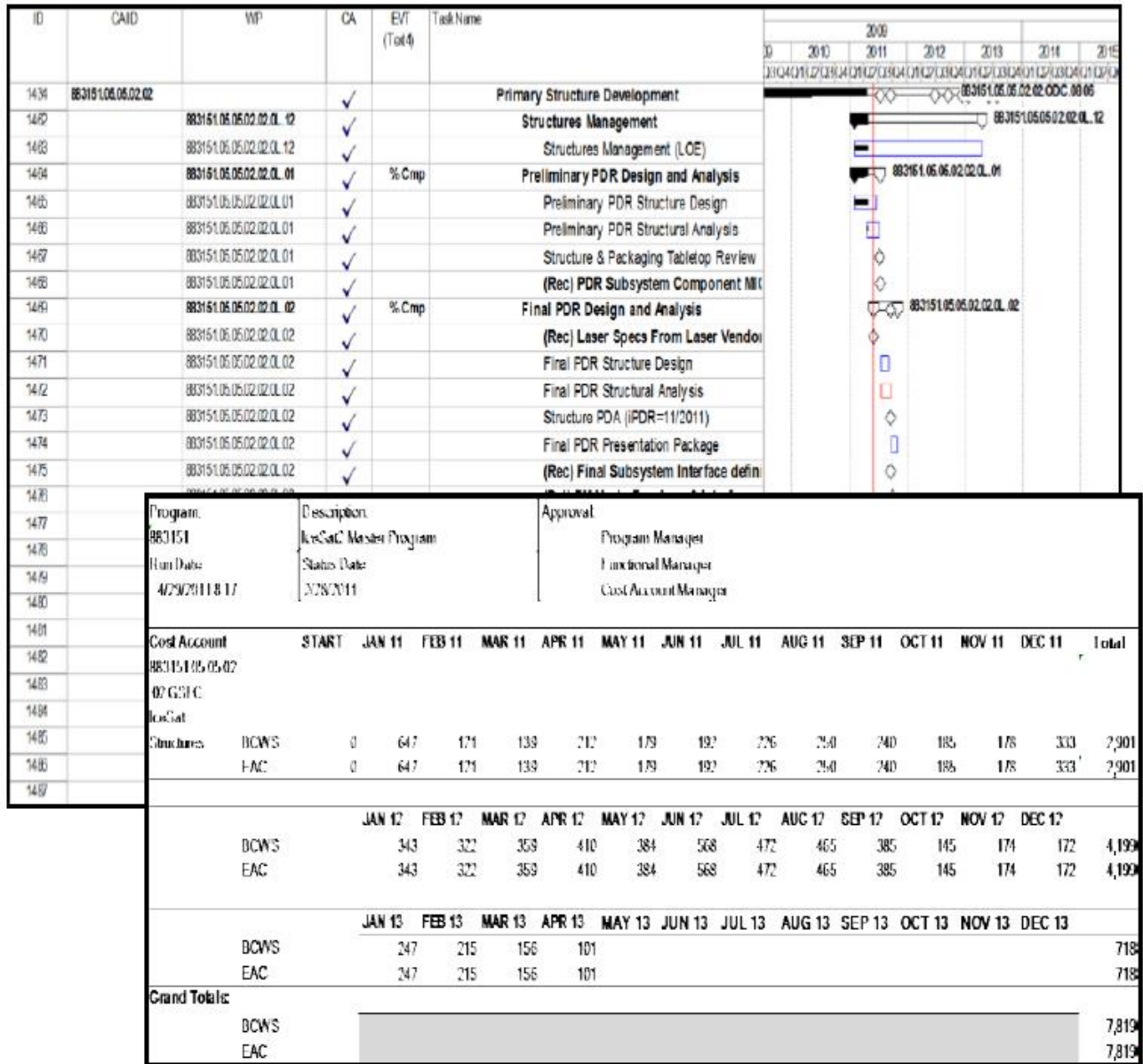


FIGURE 45. CAP

Accurate time-phasing of planned work is accomplished through an Integrated Master Schedule (IMS). The IMS is a single integrated source of schedule data that accurately reflects how the planned work is to be executed. At the core of the IMS is a logic network dataset that should be maintained in an automated schedule management tool. The dataset consists of tasks and milestones, task durations, task interdependencies, project constraints, Performance Measurement Techniques and data coding. Within the IMS all tasks and milestones are tagged with the appropriate coding to correctly identify the work associated with each CA, WP, and PP (see Figure 46). *NASA Schedule Management Handbook* contains additional guidance on schedule development.

**MSFC Technical Standard
CS40**

Title: Project Planning and Control Handbook

**Document No.: MSFC-HDBK-3684
Effective Date: September 25, 2017**

**Revision: A
Page 107 of 230**

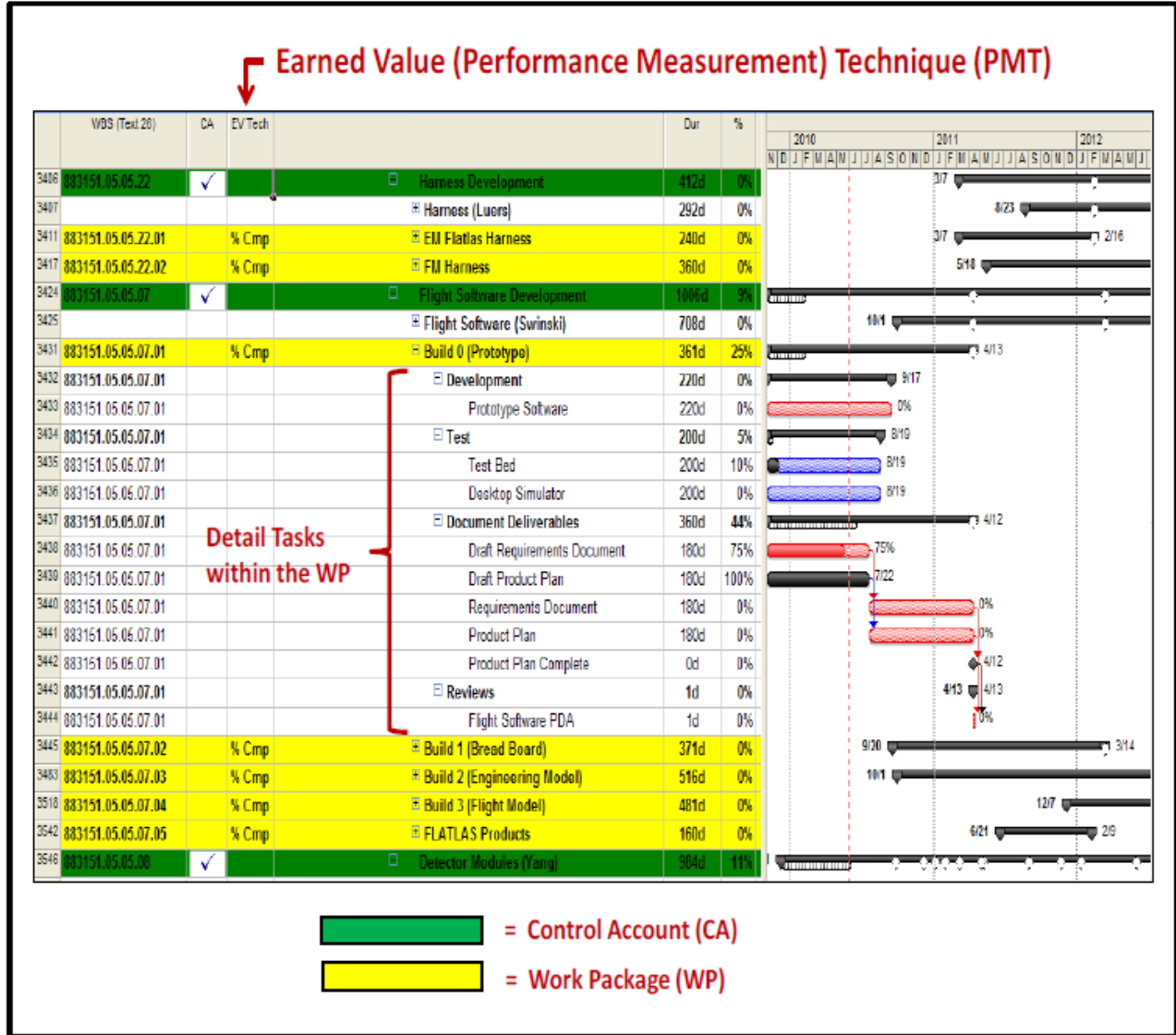


FIGURE 46. CA and WP Identification within the IMS

As work is performed, Actual Cost of Work Performed (ACWP) is captured within the financial reporting system. Budgeted Cost of Work Performed (BCWP) is the EV of the work accomplished. Budgeted Cost of Work Scheduled (BCWS) represents the value of the time phased work as it is planned. The integrated use of these three elements (BCWS, BCWP, and ACWP) provides the data needed to analyze schedule, cost, and technical performance. Methods and tools used for EVM data analysis in in-house MSFC projects are the same as are used when contractors are responsible for work implementation.

3.10.3.1 In-House Performance Measurement Baseline (PMB) and Integrated Baseline Review (IBR)

Project Planning & Control (PP&C) personnel are instrumental in the integration and management approval of all Control Account Plans (CAPs) into a single project baseline plan that establishes the in-house project PMB. The project's initial PMB is established in Phase B in preparation for Key Decision Point (KDP) C approval, and is assessed during the IBR. Mission Directorate should conduct pre-approval IBRs as part of their preparations for KDP C to ensure that the project's work is properly linked with its cost, schedule, and risk, and that the management processes are in place to conduct

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 108 of 230

project-level Earned Value Management (EVM). For in-house projects, the initial IBR will be conducted within 90 days after KDP C approval. In-house IBRs should be prepared for and conducted just the same as a contractor IBR.

For additional information, visit NASA’s public EVM website at <http://evm.nasa.gov> or its internal EVM website on the NASA Engineering Network at <https://nen.nasa.gov/web/pm/evm>, or contact the MSFC EVM Focal Point.

3.10.4 Establishing the Proper Earned Value Management (EVM) Analysis Tools

There are various ways to integrate cost and schedule information to evaluate performance. Commercial-off-the-shelf (COTS) tools are available that assist in the data integration and analysis functions. MSFC does not currently dictate specific tools to be used in the implementation of EVM; however, Project Planning & Control (PP&C) activities do necessitate appropriate EVM analytical methodologies and tools for project use. When implementing EVM processes on any size project, some type of EVM tool will be needed to function as the Earned Value (EV) engine to store, maintain, and integrate (*using the WBS*) the EVM baseline cost and schedule data, along with the on-going monthly actual cost and schedule data. This tool will consolidate the basic EV data to provide exports to an appropriate analysis tool which will assist PP&C personnel in understanding project performance and forecasting impacts. Multiple tools have been used by MSFC projects performing EVM (Primavera, MS Project, Cobra® or MPM™, Empower, XML Connect). The Empower is a COTS tool that is used for analyzing and reporting EVM data. The Empower tool provides for analysis and reporting capabilities, including standard IPMR formats 1 through 7.

Small projects may sometimes use basic spreadsheets as a simple EV engine approach, while larger projects will use a more robust EV engine tool such as Cobra. MSFC does currently provide access to Cobra and also to Empower. Additionally, MSFC has developed and makes available to PP&C personnel a tool known as STAT, which is compatible with MS Project scheduling software, and provides many schedule related assessment and analysis metrics. STAT consists of six functional modules: the Schedule Health Check Tool, the Schedule Performance Work-off Trend, the Schedule Assessment Summary Report, Schedule Compare, Schedule Trace, Margin Tracker, etc. To gain access to the Empower, Cobra, and Schedule Test and Assessment Tool (STAT) management tools, follow the instructions provided on the NASA EVM website (<http://evm.nasa.gov>), or contact the center’s EVM focal point.

The tools selected for use by the project should provide the functionality needed to comply with the requirements outlined in MPR 7120.1 and EIA-748. Each MSFC project management team is currently responsible for acquiring tools and should consult with the MSFC EVM Focal Point for approach and tool recommendations along with available lessons learned.

3.10.5 Project Planning & Control (PP&C) Responsibilities in Earned Value Management (EVM):

- a. Attend training in basic and advanced EVM, planning and scheduling, Integrated Baseline Review (IBR), NASA Earned Value Management System (EVMS), etc.
- b. Develop the EVM Implementation Plan for the Project Plan.
- c. Assist the Contracting Officer (CO), wherever MSFC policy requires the application of EVM on a MSFC contract, to ensure the inclusion of EVM solicitation provisions in the Request for Proposal (RFP) and the use of EVM contract clauses.
- d. Serve on the Source Evaluation Board (SEB) for evaluating the EVM aspects of contractor proposals.
- e. Facilitate project-related IBRs to include Project Manager (PM)–led IBRs on contracts with EVM.

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MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 109 of 230

- f. Assist project team in obtaining EVM training.
- g. Facilitate/participate in Defense Contract Management Agency (DCMA) contractor EVMS validation reviews and surveillance, as required.
- h. Facilitate the EVM implementation, training, and tools; maintain the project budget logs; provide Control Account (CA) documentation to Project Control Account Managers (P-CAMs); prepare the project Integrated Project Management Report (IPMR).
- i. Assist P-CAMs in establishing and maintaining their CA plans and performance analysis.
- j. Analyze performance data and prepare Estimate at Completions (EACs), as required; assist the PM with the annual comprehensive EAC to support the Planning, Programming, Budgeting & Execution (PPBE) process.
- k. Perform budget development and planning, resource planning, update financial forecasts, and process Baseline Change Requests (BCRs).
- l. Assist P-CAMs during planning to ensure budgets are planned in the same resource category that actual costs are expected.
- m. Assist responsible managers in verifying that actual cost data are applied to the correct charge numbers.
- n. Assist in the preparation and analysis of financial and performance reporting and input to the PPBE process.
- o. Assist responsible managers in developing schedules, including cost integration.
- p. Maintain existing schedules by updating progress, performance, and other data as necessary to reflect both the current plan and the approved baseline.
- q. Ensure horizontal and vertical schedule integration.
- r. Assist in the preparation and analysis of cost, performance, and schedule reporting.

See the *NASA EVM Implementation Handbook* at <http://evm.nasa.gov/handbooks.html>, and the *NASA EVM System Description* for additional guidance at <https://nen.nasa.gov/web/pm/evm>.

3.11 Business Tools

3.11.1 Business Systems/Tools and Interfaces

The Office of Chief Financial Officer (OCFO) is responsible for the integrity of the Accounting System and has developed, maintains, and controls several accounting tools to help the Project Planning & Control (PP&C) team. The PP&C team should work with OCFO personnel when using these tools. Information on many of these tools can be found in the Applications Inventory Module, <https://aim.msfc.nasa.gov/Dashboard/draw/>. Access to the systems can be requested through IdMAX at <https://idmax.nasa.gov/idm/user/dashboard/home.jsp>. Figure 47 shows the interaction of these tools/systems.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 110 of 230

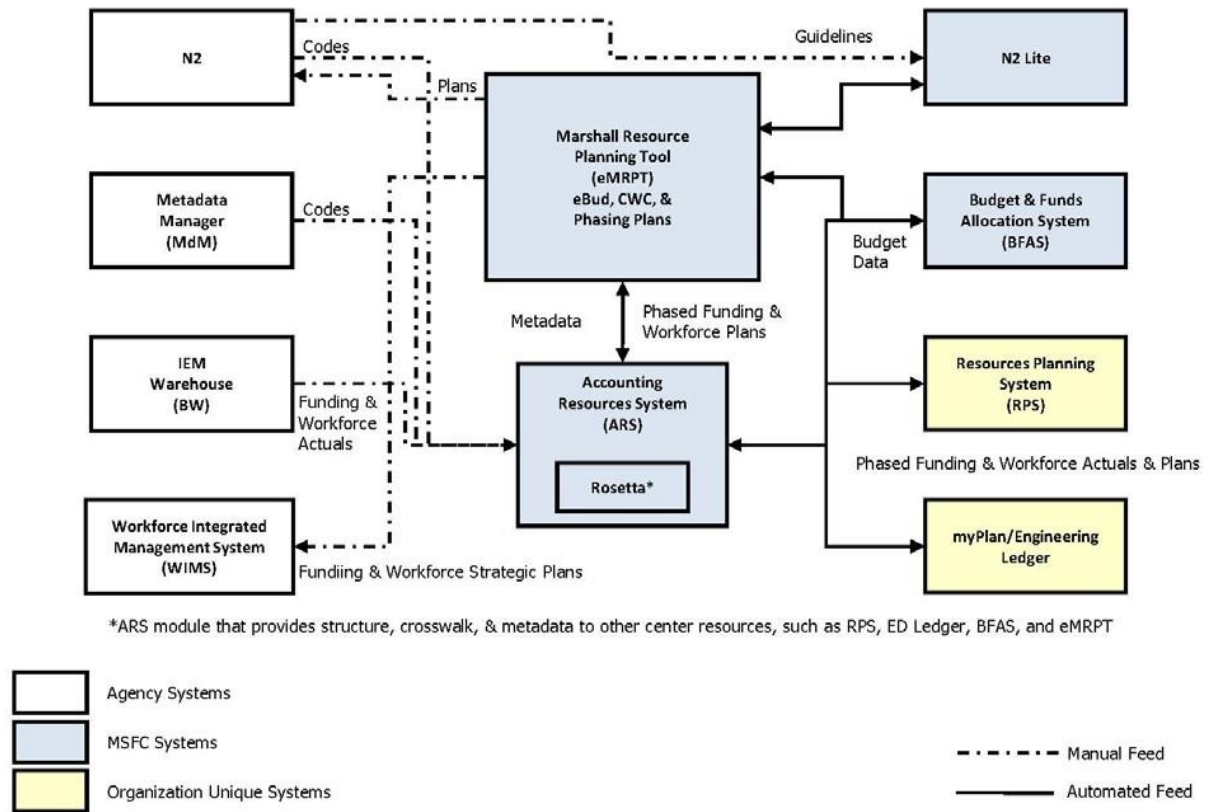


FIGURE 47. Business System Interfaces

The Planning, Programming, Budgeting & Execution (PPBE) budget process is critical to budget formulation and execution. MSFC uses several tools for budgeting, but the primary tool used is eBud, which is a module within the Electronic Marshall Resource Planning Tool (eMRPT).

The eMRPT tool set supports the MSFC PPBE and year of execution process with several resource planning tool modules, and provides the OCFO with tools to capture and manage Execution, Fiscal Year (FY), and project budget planning for civil service Full Time Equivalent (FTE), support contractor Work Year Equivalent (WYE), Travel, and Procurement data throughout the PPBE cycle. The tool provides presentation ready (Adobe PDF or MS Excel) reports for Center and Headquarters submission, and provides electronic data submission to the NASA Headquarters N2 Budget System. The eMRPT shares resource planning data with the Accounting Resource System (ARS) to generate MSFC project level plans versus actuals. The eMRPT consists of several different resource planning modules.

The eBud is a long term strategic resource planning tool that allows the PP&C team to plan resources at the project level or below for the current budget year out to an additional six years. The data collected by eBud are submitted to the Agency N2 Budget System per the PPBE cycle. In addition, N2 budget guidelines are important from the N2 Budget System to assist the Center user in budget planning/comparison. The eBud budget planning data is also rolled into the next PPBE planning cycle module for more detailed FY breakdown. This allows the PP&C team to plan the upcoming FY in detail, at the project level or below, phased by month. The data collected during the Phasing Plan is electronically shared with the ARS for Center planning versus actuals analysis. As stated above, refer to <https://aim.msfc.nasa.gov/Dashboard/draw/> for more information on these tools/systems.

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 111 of 230

3.11.2 Accounting and Indirect Cost Management

Those involved in Project Planning & Control (PP&C) activities at MSFC should have an awareness of the Accounting process used by NASA. The NASA Accounting System (sometimes referred to as the Core Financial System) includes various interacting electronic systems and subsystems. Below are some of the major components.

- a. Metadata Manager (Mdm) houses the Work Breakdown Structure (WBS) and supplies this information to the NASA Accounting System and other subsystems such as Web-based Time and Attendance System (WebTADS), Concur Government Edition (CGE), and Contract Management.
- b. WebTADS is the time and attendance system for civil servants that work for NASA. These data are provided to the Federal Personnel and Payroll System (FPPS) and the Agency Labor Distribution System.
- c. The FPPS provide the payroll process, including calculation of employee pay and pay distribution.
- d. Agency Labor Distribution System integrates Webtads time, attendance data, and WBS coding with the employee pay and hours, calculates Full-Time Equivalents (FTEs), and maintains the details for civil servant labor hours.
- e. CGE tracks travel obligations, costs, and reimbursements.
- f. Contract Management supports the purchasing and receiving functions, including generation of electronic Procurement Requisitions (PRs), purchase orders and subcontracts for requested goods and services. Ancillary purchasing systems include:
 1. Just-In-Time, a web-based application used to order, receive, deliver, and pay for off-the-shelf catalog items.
 2. Purchase Card (P-Card), which tracks credit card purchases for goods and services.
- g. The NASA Accounting System is the central repository of all accounting cost data at the level of general ledger account.
- h. Business Objects (BOBJ) is updated each night with the latest data from the NASA Accounting System and other subsystems to enable users and other stakeholders to extract information.

The NASA Accounting system provides the PP&C team with the status of the funds that have been provided to the project. Recording of cost and the integrity of the reported costs data is critical to NASA's Accounting System (System, Applications and Products (SAP)) and the Center's mission. The reported costs should accurately portray the work performed for the Center, since cost is the primary parameter used to measure performance. For costs reported in the NASA Accounting System, per NPR 9060.1, *Cost Accruals*, NASA's accounting records are maintained on an accrual basis (i.e., revenues are recorded in the accounts when earned, and expenses are recorded when incurred) even though disbursements and collections are not recorded until funds are paid or collected. Use of the accrual method is mandated by United States Law. The use of accrual accounting enables MSFC's management and PP&C team to more accurately measure the Center's performance and financial position using the financial data available.

Figure 48 shows a simplified diagram of the data flow between components of the NASA Accounting System.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 112 of 230

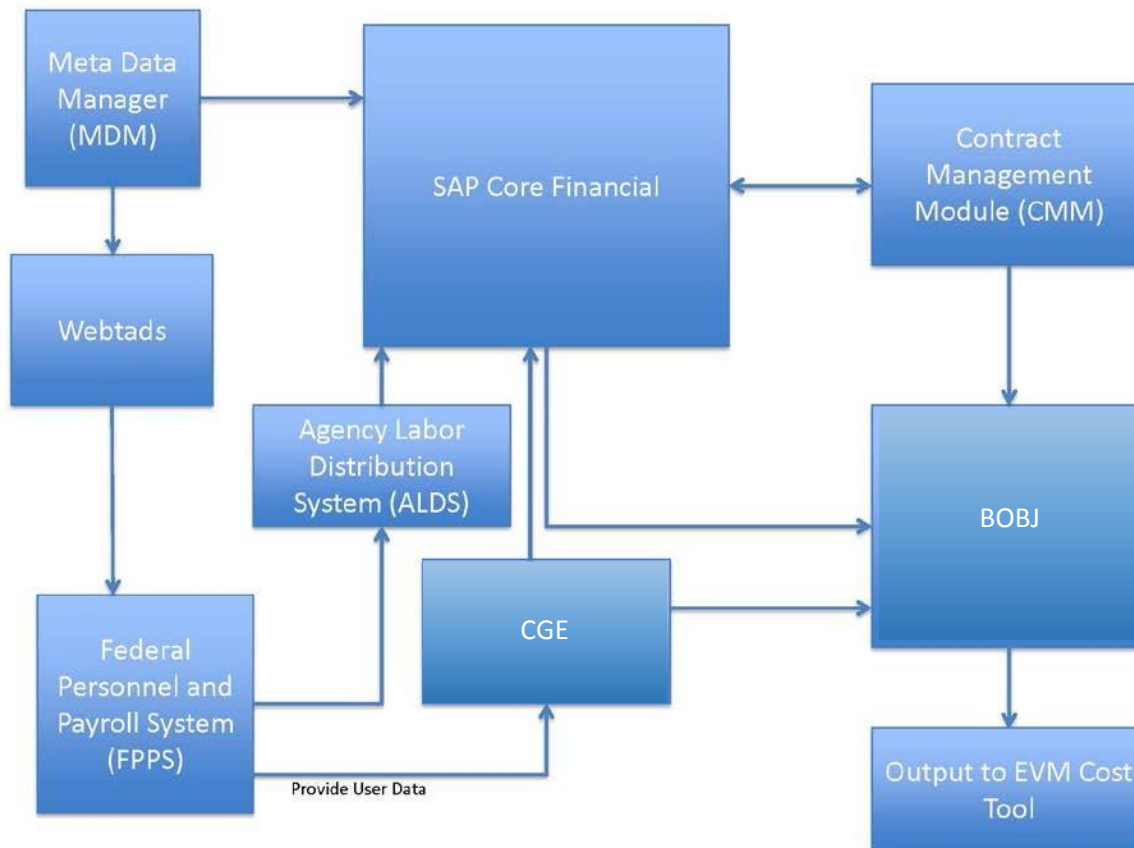


FIGURE 48. NASA Accounting System

The MSFC Office of Chief Financial Officer (OCFO) provides a website for MSFC and Agency OCFO practices, policies, and announcements for budget, accounting, travel, etc. The OCFO website can be accessed by going to “Inside Marshall ExplorNet” and selecting “Center Organizational Web Sites” under the “Quick Links” section, then select “Office of Chief Financial Officer”. Also the OCFO provides a SharePoint portal that is MSFC’s official repository and online warehouse for information delivery. It is used for distributing and receiving Planning, Programming, Budgeting & Execution (PPBE) information, guidance, and Center deliverables. Users may request access from the MSFC OCFO.

The NASA Accounting System also provides Elements of Cost and the Purchase Order (PO), funds source, etc. Elements of Cost are classified as direct or indirect. Direct costs are those which can be specifically identified with a particular objective, such as a system, subsystem, task, or function. Direct costs are classified as follows:

- a. **Labor** - Direct labor can be directly identified to a particular project.
 1. **Civil Service Labor** - is tracked by hours, FTEs, and dollar cost.
 2. **Support Contractor Labor** – is only tracked by dollar cost.
- b. **Materials** – Any material items (Commercial-Off-The-Shelf (COTS) or unique) that are purchased for project effort.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 113 of 230

- c. **Equipment** - Costs for project manufactured equipment (i.e., equipment produced to specific requirements that make it useless to anyone else without rework). In cases where actual costs are not readily available, the straight-line method for estimating accrued costs, or the use of supplemental information obtained from the vendor, is acceptable to calculate incurred cost.
- d. **Contracts/Subcontracts** – Contract and Subcontract costs incurred for project effort.
- e. **Travel** - Travel costs incurred for project effort.
- f. **Other Direct Costs (ODCs)** – Direct costs not identified above.

For additional information on elements of cost, see NPR 9501.2, *NASA Contractor Financial Management Reporting*.

There are other project costs that are not direct project costs that need to be handled by the project. These costs are sometimes called “Backpack Costs” or “Project Support Rates”, and are funds the project provides to the center or organizational directorates that are not direct cost for project work. These costs can best be monitored by establishing a unique WBS element for this purpose as the WBS is being developed.

Contractor costs are not readily identifiable to a specific objective are allocated to benefiting cost objectives by a statistical technique. The process of distribution of indirect costs can be simplified by restricting the distribution of overhead for reporting purposes to a logical level. It is generally desirable to develop a breakdown of the various types of burdens (e.g., engineering overhead, manufacturing overhead, material handling, and General & Administrative (G&A) costs) in order to provide the project with visibility.

G&A is an accumulation of indirect costs applicable to the direction and control of the contractors’ activities as a whole; includes costs for officers’ salaries, general and corporate offices, legal and auditing staffs, office supplies, insurance, and taxes. The contractor provides the G&A cost for the Contract in the Contract Performance Report (CPR) when Earned Value Management (EVM) is required.

If EVM is required on an in-house project (see Section 3.10 for EVM guidance) the Accounting system becomes the required source for actual cost data and the data should be reconciled between the EVM reporting and the Accounting system. Accurate recording of cost in the accounting system becomes critical to doing EVM. Also when the EVM process is being set up, close attention should be paid to the way cost are collected in the accounting system so work performed and the cost for the work come together at the same time.

3.12 Project Planning & Control (PP&C) Analysis and Reporting

This section covers the analysis of project and mission support performance to help Center management assess performance, and to facilitate management decisions based on monthly or quarterly evaluations. The main areas of discussion will be performance analysis; establishing variance thresholds, explanations, and corrective action planning; and Estimate at Completion (EAC).

Managerial analysis should include all components of the project and mission support activities, including technical, schedule, risk, and cost. This analysis provides all levels of management with early visibility of deviations from the plan. In addition, it provides trending data to help facilitate the development of corrective actions that may need to be implemented within the project. Figure 49 shows the types of data that will be reviewed during the analysis process.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 114 of 230

Source Data

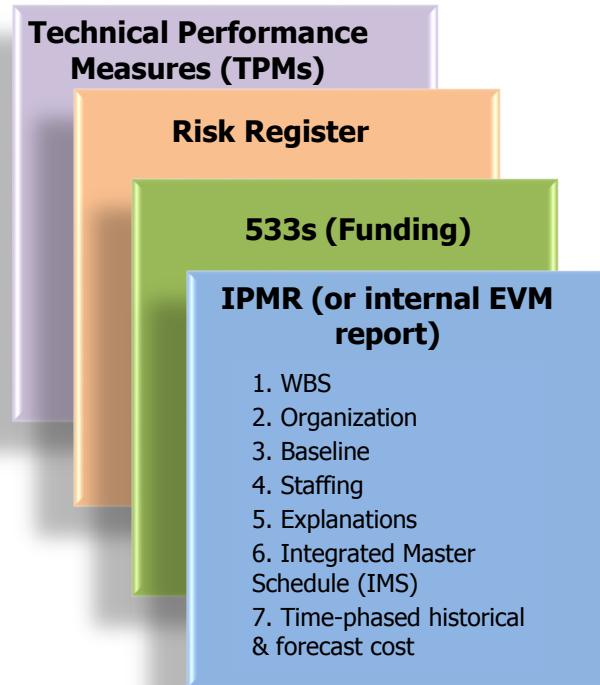


FIGURE 49. IPMR Source Data

Analysis Considerations

Any favorable and unfavorable variances should be carefully evaluated. PP&C analysts should examine and understand the reasons for under runs, as well as overruns, because they could be masking a serious problem. Good analysis helps identify the following:

- a. The Problem
- b. Cause of the Problem
- c. Impact to the Project (Cost, Schedule and Technical)
- d. Corrective Action

Good analysis will address the following areas:

- a. Poor initial planning or estimating
- b. Technical breakthroughs or problems
- c. Cost (or usage) of labor, material, or Other Direct Costs (ODCs)
- d. Front-end loading

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 115 of 230

3.12.1 Performance Analysis

Performance analysis consists of measuring the work that has been accomplished (in-house/mission support and contracted) against the technical, cost and schedule baseline, and identified risks against this integrated baseline. Variances from the baseline that breach the established thresholds (described in Section 3.12.2) should be identified so that the specific drivers or causes of the variance can be determined and documented. This analysis also helps the project team develop corrective actions and report the projects current status to customers. In addition, it provides trend data which can help project future performance. Performance analysis demonstrates the cost and schedule effectiveness, and provides estimates for completing the remaining work. In the following paragraphs, the discussion will be focused on various data analysis techniques.

A key point is that measuring the project’s cost performance is only one step of the analysis process. For a complete picture of the projects’ overall performance the analysis should include a review of the technical accomplishments, a schedule status, and an analysis of cost and other resources associated with the work objectives. After reviewing data from each source, comparisons can be made between the baseline plan from both a cost and schedule standpoint. The resulting variances are compared to established percentages and dollar thresholds to determine the significance of the variances. Figure 50 shows the cost performance of the project, but does not include the technical accomplishments or schedule assessment of the project. In the illustration, the actual costs are lower than the budget baseline which would imply that the project is doing fine in regards to cost. What the illustration does not show is the schedule status (i.e., technical content that has been accomplished).

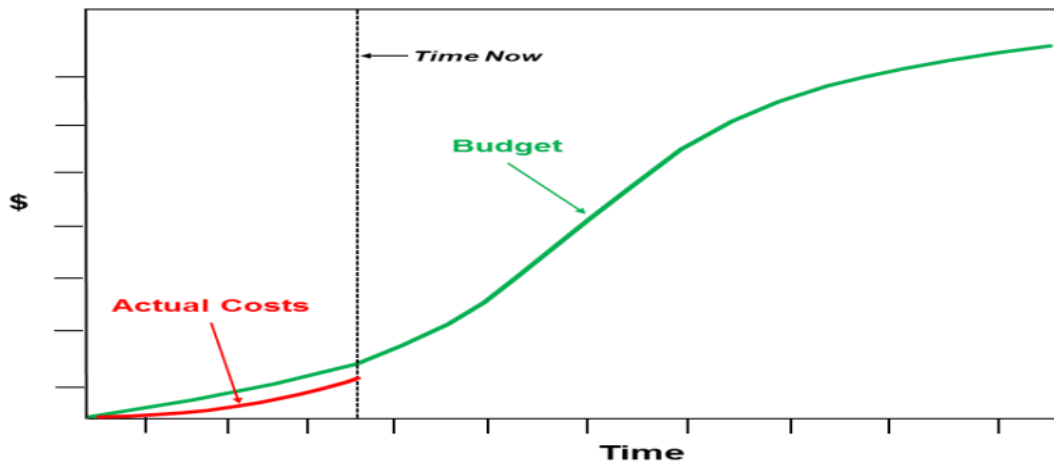


FIGURE 50. Budget vs. Actual Costs

In Figure 51, the schedule status is added to the chart, which results in a different assessment of the current state of the project. The schedule status is based on the technical content that was completed or accomplished at time now. Although it appears on the previous chart that the project was in a positive position in regards to cost, and now appears to be in a negative position in regards to cost and schedule. This can be determined by the fact that the schedule status is below the actual costs and the baseline budget lines. Therefore, what the project had anticipated to be completed at time now for the budget estimate at time now has not been completed, resulting in both a cost overrun and schedule slip. Based on the current project status, analysts can make projections that forecasts the final cost and finish date. This is a good example of why the project analysis needs to include the three key components of technical context, schedule, and cost. Remember that the analysis process is a continuous process which should provide information that can be used to make management decisions.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 116 of 230

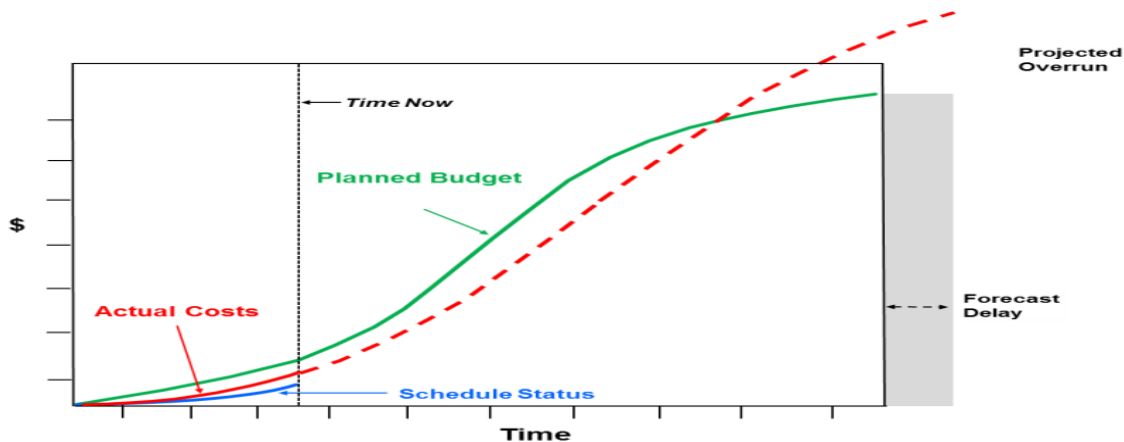


FIGURE 51. Budget vs. Actual Costs vs. Schedule Status

3.12.1.1 Cost Analysis

A key component of assessing the baseline performance is to measure cost performance against the baseline budget. This cost analysis should be done at the lowest level feasible to provide insight to the project team. The baseline and the associated cost data are planned at the lowest level that insight is needed. In the following paragraphs, the discussion will show different data sources and analysis that should be completed each month in regards to cost analysis.

3.12.1.2 Plan vs. Actuals

The project should perform analysis that compares obligations and costs to the planned baseline for both contracts and total project. Obligations occur when a government commitment (via a purchase order, credit card, contract award, time-sheet submittal, etc.) for a product or service is identified, approved, and entered into the NASA Accounting System. This amount represents the obligation of Agency funds for the contractor or Performing Organization (PO) at the given point in time for specific work. The obligation profile represents the total potential liability to the Government of funds committed for the entire effort.

NASA uses the accrual basis of accounting (see NPR 9060.1). Funds are considered “obligated” when an order or contract is in place (legally committing the Government to that purchase). Once the invoice(s) for the effort is recorded in the NASA Accounting System, the funding status has changed from obligated to “cost.” The cost profile follows the costs incurred/expended to date and is updated monthly, whereas the obligation profile represents the total potential liability of funds for the effort. For projects with a prime contractor and/or larger subcontractor(s), their costs are provided on the NF533, *Contractor Financial Management Report*, (discussed in Section 3.12.1.4). The actual cost of Civil Servant personnel from POs are collected and reported in the NASA Accounting System.

Project Planning & Control (PP&C) analysts perform cost analysis and assessment of plan vs. obligations and costs, at least monthly. All-years cost charts allow visibility into the entire project life-cycle while current-year charts provide visibility into monthly performance and how the project is performing against the Fiscal Year (FY) plan. The analysis includes actual numerical data and graphic display of the data, along with assessment of performance and identification of potential threats to the project and/or mission support. This assessment is critical to funds management success. Figure 52 is an example of an obligation plan, and Figure 53, on the following page, is an example of a cost plan. Sometimes these plans are combined and displayed on one chart/graph.

**MSFC Technical Standard
CS40**

**Title: Project Planning and Control
Handbook**

**Document No.: MSFC-HDBK-3684
Effective Date: September 25, 2017**

**Revision: A
Page 117 of 230**

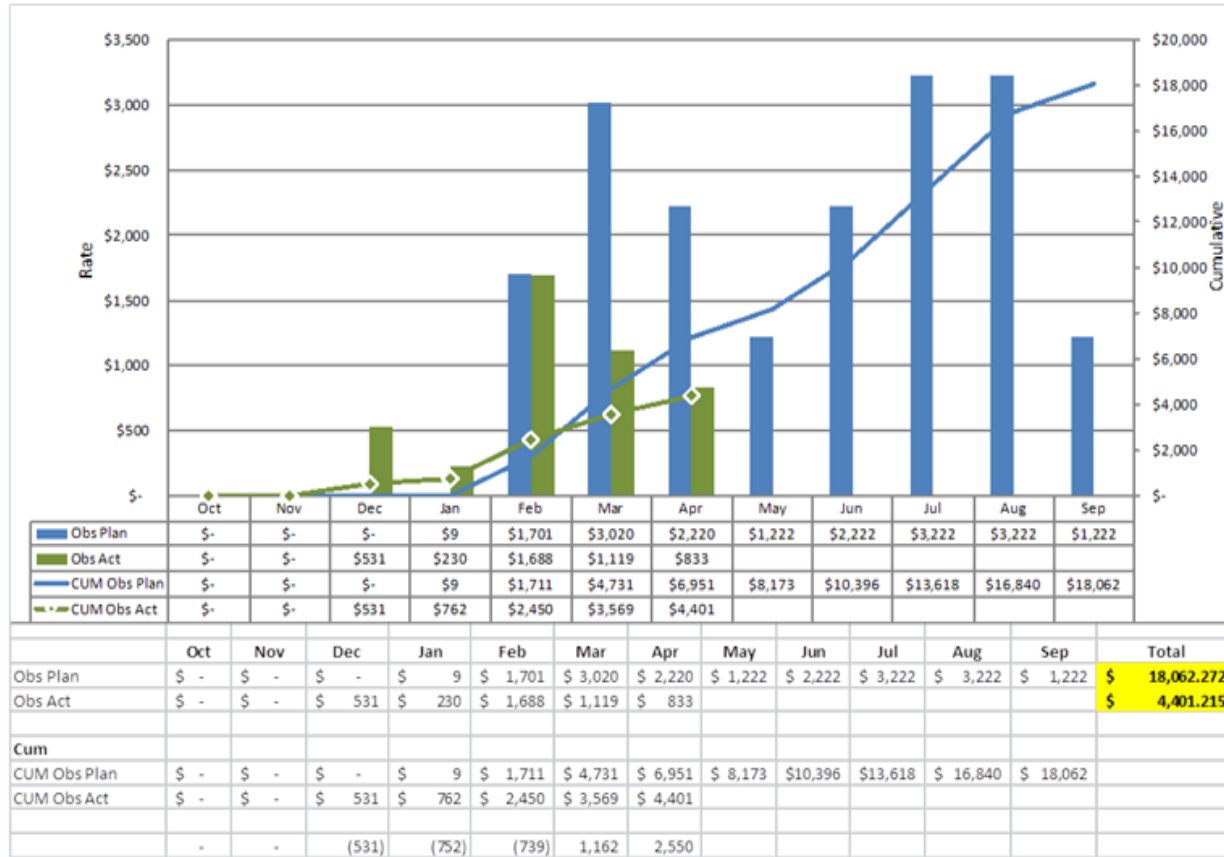


FIGURE 52. Obligation Plan

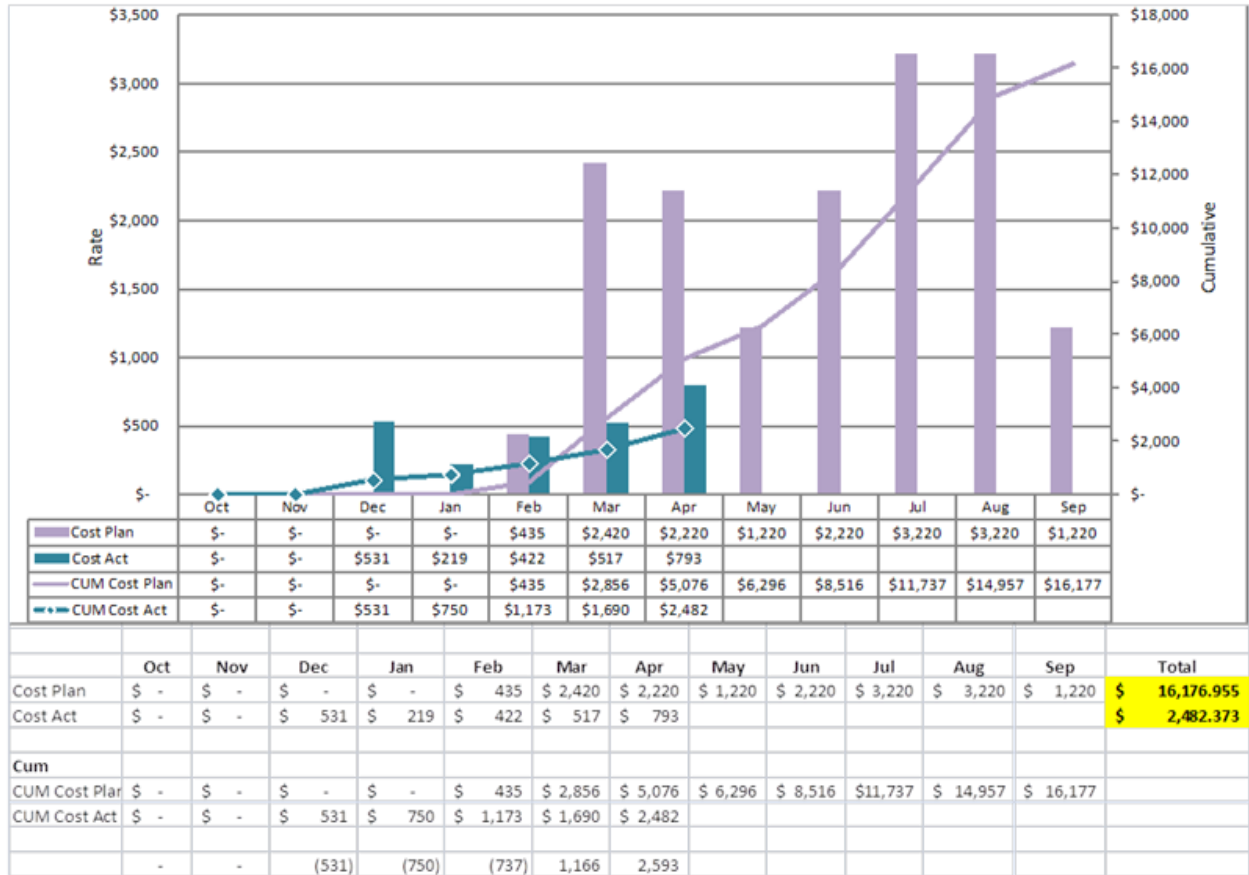


FIGURE 53. Cost Plan

In Figure 53, the project cost performance started in a negative or over-run position, but is currently in an under-run position. During the over-run time period, analysts would investigate what is driving this situation and vice versa for the under-run months. Variance explanations should be based on the deliverable quality versus budget (workforce allocation) and schedule, and not based on which individuals are (or are not) charging to the effort.

3.12.1.3 Workforce Analysis

Analysts should work closely with the project mission support activities and Center management to analyze, assess, and report workforce status monthly against the workforce allocations and/or prime/ sub contractor’s negotiated workforce allocations. In addition to reviewing monthly workforce data, the project should also analyze, assess, and report workforce year-to-date, cumulative, and total for the project. To perform this analysis, the workforce data is reviewed at the Control Account (CA) level or lower (Work Package (WP)), and integrated up through the Work Breakdown Structure (WBS) to provide summary reporting. Civil servant time-sheet data is reported in the Business Warehouse (BW) Report by WBS number and by individual names. Contractor’s workforce numbers (Not by name) are provided in the NF 533M by task or WBS elements.

If the project or mission support activities have a prime/sub-contractor, the prime/sub will report workforce actuals and estimates in the NF 533M and the Integrated Program Management Report (IPMR), as appropriate. Contractor workforce numbers are reported in Work Year Equivalent (WYEs) or head count. The project needs to pay close attention to the workforce plans particularly on the contracts. One problem that occurs is that it can be difficult to retain the right level of personnel as the contract is ending, or the

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 119 of 230

appropriate skill mix. Figure 54 is an example of a workforce analysis report.

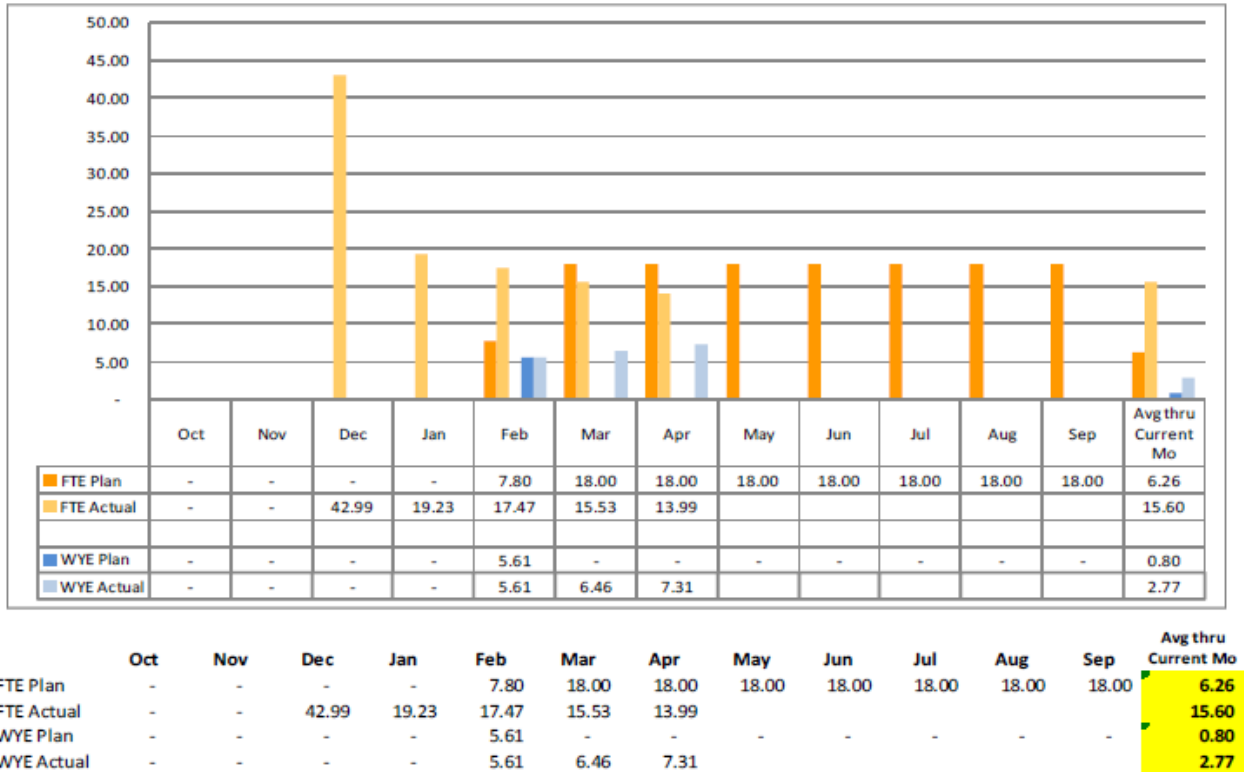


FIGURE 54. Workforce Analysis

3.12.1.4 NASA Form (NF) 533 Analysis

The NF 533 comes in two forms: 533M and the 533Q. The NF 533Q is a quarterly report that provides the agreed upon contract baseline on which to measure the contractor cost performance (See NPR 9501.2, Para 3.2). The initial NF 533Q cost plan should also be compared against the contract schedule to see whether the phasing of the cost seems reasonable in relation to the schedule tasks to be completed. This report is also important since it provides the planned cost and hours for the subsequent NF 533M reports.

The NF 533M provides monthly actual cost data, along with estimates for the next couple of months. The NF 533M should be compared with the NF 533Q periodically to ensure that the agreed upon contract value is accurate. In addition, monthly analysis of the 533M should be done to determine how the contractor is performing to its planned rates for labor, overhead, General & Administrative (G&A), etc. A sample NF 533M is shown in Figure 55 on the following page.

**MSFC Technical Standard
CS40**

Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 120 of 230

Actual Rate
Planned Rate

National Aeronautics & Space Administration		Monthly Contractor Financial Management Report		Form Approved O.M.B. No. 2700-003		2. Report for Month Ending and Number of Working Days June 30, 2011 - 18 working days				
TO: NASA / George C. Marshall Space Flight Center		FROM: AOC-CFO				3. Contract Value				
1. Description of Contract		b. CONTRACT NO. AND LATEST DEFINITIVE MODIFICATION NO. NNM 0A800C		4. Fund Limitations \$700,000		a. COST				
a. TYPE Cost-Plus-Incentive-Fee		b. AUTHORIZED CONTRACT REPRESENTATIVE (Signature) A. King		Date		b. Fee				
c. SCOPE OF WORK Development for COTR Class						5. BILLINGS				
						a. Invoice Amts. Billed \$300,000				
						b. Tot Pay Rec'd \$250,000				
8. REPORTING CATEGORY	7. COST INCURRED/HOURS WORKED				8. ESTIMATED COST/HOURS TO COMPLETE			9. ESTIMATED FINAL COST/HOURS		10. UNFULFILLED ORDERS OUTSTANDING
	DURING MONTH		CUM TO DATE		DETAIL		ESTIMATED FINAL COST/HOURS			
	ACTUAL a.	PLANNED b.	ACTUAL c.	PLANNED d.	31-Jul-11 a.	31-Aug-11 b.	BALANCE OF CONTRACT c.	CONTRACTOR ESTIMATE a.	CONTRACT VALUE b.	
1. Direct Labor Hours	212.00	215.00	2,787.00	3,237.98	215.00	215.00	1,634.01	4,851.00	4,851.00	
2. Direct Labor Dollars	\$ 10,000	\$ 10,712	\$ 140,936	\$ 160,206	\$ 10,712	\$ 10,712	\$ 77,946	\$ 240,306	\$ 240,306	
3. Fringe Benefits/Overhead	\$ 13,000	\$ 13,604	\$ 178,729	\$ 203,063	\$ 13,604	\$ 13,604	\$ 98,853	\$ 304,791	\$ 304,791	
4. Subcontracts/Consultants	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
5. Materials	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
6. M&S Overhead	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
7. Travel	\$ 750	\$ 759	\$ 3,840	\$ 17,542	\$ 759	\$ 759		\$ 23,237	\$ 23,237	
8. Other Direct Costs	\$ 330	\$ 346	\$ 13,172	\$ 6,518	\$ 346	\$ 346	\$ 4,749	\$ 9,116	\$ 9,116	
9. G&A	\$ 2,800	\$ 2,924	\$ 38,718	\$ 44,543	\$ 2,924	\$ 2,924	\$ 21,842	\$ 66,407	\$ 66,407	
10. Total Estimated Costs	\$ 26,880	\$ 28,346	\$ 375,395	\$ 431,872	\$ 28,346	\$ 28,346	\$ 211,770	\$ 643,857	\$ 643,857	
11. Fee	\$ 2,100	\$ 2,268	\$ 21,732	\$ 34,550	\$ 2,268	\$ 2,268	\$ 25,241	\$ 51,509	\$ 51,506	
12. FCCM	\$ -	\$ 57	\$ 695	\$ 864	\$ 57	\$ 57	\$ 480	\$ 1,288	\$ 1,290	
13. Total Estimated Cost and Fee	\$ 28,980	\$ 30,670	\$ 397,822	\$ 467,286	\$ 30,670	\$ 30,670	\$ 237,491	\$ 696,653	\$ 696,653	
Baseline Plane Identification (Col. 7b & 7d) Revision No. _____ Dated _____										

FIGURE 55. NF 533 Monthly Report

Using the above NF 533, analysts can determine that the contractor's actual cumulative labor rate is \$50.57/hr. This is determined by taking the cum-to-date actual labor dollars (\$140,936) and dividing it by the actual cum-to-date labor hours (2,787). The contractor's planned labor rate can be determined by taking the same two factors in the planned column under cum-to-date which is \$49.48/hr. Therefore, we know in this particular case, that the cumulative planned labor rate is less than the actual labor rates. Also, using these same types of calculations, we can determine the planned rate for all the elements of cost against the actual rate to provide some insight into the contractor's cost performance. Based on that analysis, analysts can answer questions such as, will this lead to cost overruns or cost under runs? To answer this question, other information in the NF 533M will provide additional insight.

For the Direct labor hours, under the balance of the contract column the number is 1,634.01 hours remaining. As mentioned earlier, the actual hours used cum-to-date is 2,787. When the hours remaining are added to the cum-to-date hours the projected hours needed to complete the contract are 4,421.01. However, the columns to the far right under the contractor estimate and contract value are both 4,851. Is the contract final Estimate to Complete (ETC) reasonable? In this case, the contractor's actual labor rate is \$50.57/hr. and when multiplied by the planned hours of 4,421.01 the total in direct labor costs are projected to be \$223,570. The current contractor estimate and contract value dollar amount is \$240,306. Therefore, since the projected dollar estimate is less than both the contractor estimate and contract value the contract cost performance seems to be in good shape and could experience a cost under run. This is an example of the kind of analysis that should be conducted each month on both contracts and in-house project work.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 121 of 230

3.12.2 Establishing Variance Thresholds, Explanations, and Corrective Action Plans

Cost and Schedule Variance (SV) thresholds should be established at the beginning of the project at the appropriate levels (see Section 3.2 for discussion of Work Breakdown Structure (WBS)/Control Account (CA)/Work Packages (WPs)). It is recommended that the reporting levels be established and stated in the Project Plan. Some things to consider when establishing the reporting levels are risks, technical difficulties, budget, etc. For example, the threshold reporting level for project management would be at a higher level since the risks are lower. The variance thresholds should be stated as a positive or negative percentage and dollar amount. As the established thresholds are breached, variance analysis and associated reporting should be done to address root cause, impact, and correction action. An example of variance analysis thresholds are listed in Figure 56. The Project Planning & Control (PP&C) team should consult with the Project Manager (PM), mission support, and technical managers for specific metrics and thresholds that provide an overall indication of project performance.

	Schedule Variance (SV)	Cost Variance (CV)	Variance at Completion
Current	+/- 10% and \$100k	+/- 10% and \$100k	
Cumulative	+/- 10% and \$100k	+/- 10% and \$100k	+/- 10%

FIGURE 56. Sample Variance Analysis Thresholds

In addition to the cost and SV thresholds described above, projects have technical performance metrics that will identify emerging problems with which the PP&C team should be familiar. For example, Technical Performance Measures (TPMs) define the planned progress of selected technical parameters such as reliability, weight, detector sensitivity, pointing accuracy, and availability, among others. The TPM plan is defined in terms of expected performance at specific points in the project as defined in the WBS and Integrated Master Schedule (IMS), the methods of measurement at those points, and the variation limits (or thresholds) for corrective action. During execution, TPMs record the actual performance observed of the selected parameters and assist the PM in decision-making (performance or resource tradeoffs) through comparison of actual vs. projected performance. TPM parameters that especially need to be tracked are the cost drivers on the program, those that lie on the critical path, and those that represent high technical risk items. Figure 57, on the following page, is an example of a TPM. Without TPMs, a PM could fall into the trap of relying on cost and schedule alone, with perhaps the verbal assurances of technical staff to assess project progress. This can lead to a product developed on schedule and within cost that does not meet all key requirements. Values are established to provide limits that give early indications if a TPM is out of tolerance.

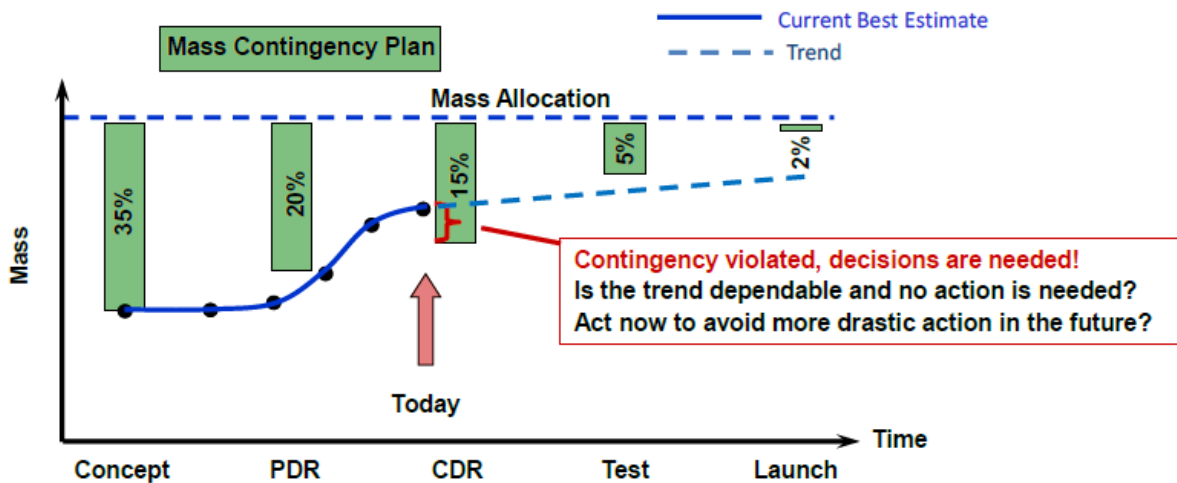


FIGURE 57. Example TPM for Mass

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 122 of 230

From an analyst position when reviewing the technical metrics and deciphering the data, there are specific questions that must be asked and understood before reporting results to the PM. For example: What does the data mean? Are the right parameters being used? What are the likely causes of the variances? Are the various analysis reports consistent with the technical data, cost and schedule reports? What corrective action could be taken to resolve an issue? What additional risks, if any, have been realized? The results of TPM analysis can be either positive or negative, so it's important to understand the impacts to the project (i.e., a positive TPM metric could result in cost savings, schedule improvements, risk reductions, and other opportunities. Conversely, a negative TPM could have an opposite effect, and possible decisions to reduce requirements or tolerances might be a potential solution). In Figure 57 above, analysts or non-technical personnel would need to understand that there is a certain mass (or weight) ceiling that cannot be breached. The closer it is to launch the less contingency is available. Early detection of a breach in the contingency will allow the project team to be proactive in determining if there is a real issue or not. If so, analysts will likely see impacts to cost, schedule, and/or risks associated with resolution of the technical variance. The analysts should not rely on just the technical data without comparing it to variance reports and cost/schedule data.

3.12.3 Schedule Analysis and Reporting

Schedule assessment is the process of determining schedule validity and performance at a given point in time. A thorough schedule assessment should always be performed prior to establishing the Integrated Master Schedule (IMS) baseline. Periodic assessment is also necessary to gain assurance that the IMS continues to generate valid data and to support the project's objectives throughout the life-cycle. A reliable schedule assessment checklist is an important aid that can benefit a project team or outside review team in determining schedule validity. A thorough Schedule Assessment Checklist example is contained in Appendix D, (Figure 117) of this document.

Schedule analysis is the process of evaluating the magnitude, impact, and significance of actual and forecast variances to the baseline and/or current schedules. After routine updates, schedule analysis begins with the calculation of the critical path and the determination of any change in the completion date of the project. Analysis continues by evaluating schedule performance metrics derived from the IMS and by using this information to assess project health. Analysis results should be reviewed with the project team. This process may be iterated as needed.

Schedule assessment and analysis strategies are the same for projects that require Earned Value Management (EVM) implementation and those that do not. All project schedules should be checked and analyzed thoroughly before formally establishing the baseline which will be measured against as the project proceeds forward. Whether the resulting data from measuring schedule performance against baseline are used in the EVM process or not, sound schedule assessment and analysis techniques should be used to ensure the project schedule is valid and can be used as a roadmap to guide the project and for management decision making.

IMS assessment and analysis is the same during and after schedule development, with the exception of progress evaluation. The processes should be continued routinely throughout the project life-cycle. The following recommended listing of schedule assessment and analysis techniques can be used to evaluate the project schedule and gain insight into its credibility.

- a. Schedule Health Check
- b. Critical path analysis
- c. Schedule performance trends analysis
- d. Probabilistic Schedule Risk Assessment (SRA)

Schedule reporting is the dissemination of meaningful information about the schedule's overall status, progress to date, and forecast to complete. Schedule reporting helps determine if the project's objectives are being met.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 123 of 230

Schedule reporting will vary based on the level of management interest in the elements contained in the project. Higher volume (dollars or hours) or critical/risk items may need lower-level detailed reporting, while lower volume, non-critical/risk, or level-of-effort (LOE) tasks may need only summary-level reporting. In today's projects where resources are pushed to the limit, having flexibility in reporting requirements is a valid approach.

The report listing below provides some types of schedule reporting that should be encouraged by Center projects.

- a. Project Schedule Logic Network
- b. Critical Path Narrative and Analysis Report
- c. Milestone Variance Report
- d. Schedule Margin Metrics
- e. Schedule Trend Reports

Detailed explanations of each analysis and reporting technique listed above, along with helpful illustrations, are provided in the paragraphs that follow.

3.12.3.1 Schedule Analysis

3.12.3.1.1 Schedule Health Check

Schedule credibility is determined by monitoring key indicators within the Integrated Master Schedule (IMS) that reflect both good and poor characteristics of schedule structure and maintenance. Examples of key indicators within the logic network that will be monitored include the following: number of missing predecessors and successors, invalid task constraints, omission of task status, improper status on future tasks, logic ties to/from summary tasks, inaccurate logic ties, and improperly reflecting tasks as milestones. These indicators are based on standard rules of logic network development utilized in Critical Path Method (CPM) scheduling techniques.

The indicators noted above should be identified and tabulated routinely from the remaining IMS detailed schedule tasks and milestones (not summary or hammock activities). This is normally accomplished by using the appropriate data-filtering capability provided by the automated management tool being used. Evaluating the number of key indicators will provide quick insight into the quality of the IMS. CPM scheduling guidelines call for logic networks to be structured so that all detailed tasks and milestones have accurate predecessor and successor relationships assigned. Additionally, it is crucial for only valid task date constraints to be used in a logic network, as well as an accurate reflection of current status (including new forecast dates for behind-schedule tasks) for each task and milestone in the IMS database. It is imperative that no uncompleted task or milestone be shown prior to the current status date in the IMS database. The higher the number of instances where these guidelines are not followed in the logic network, the more improbable it is to accurately identify the true critical path of the project schedule. It also indicates that the overall schedule lacks credibility in the data that it produces.

This assessment process additionally provides the basic statistics of the IMS content such as current number of total tasks, number of completed tasks, number of remaining tasks, current completion date, status date, and the number of remaining work days in the schedule. This information should be compared after each update to aid in understanding what changes have occurred since the last IMS update.

Figure 58 illustrates an automated schedule assessment product that utilizes the process outlined above and applies a spotlight credibility rating based on the number of key indicators tabulated from the IMS logic network. The assessment results should always be explained to the PM and his appropriate team members to help them get the weaknesses corrected so that the IMS can serve as a credible management tool. OSAC (CS40) can provide access to the Schedule Test and Assessment Tool (STAT), an in-house developed automated schedule assessment tool.

**MSFC Technical Standard
CS40**

Title: Project Planning and Control Handbook

**Document No.: MSFC-HDBK-3684
Effective Date: September 25, 2017**

**Revision: A
Page 124 of 230**

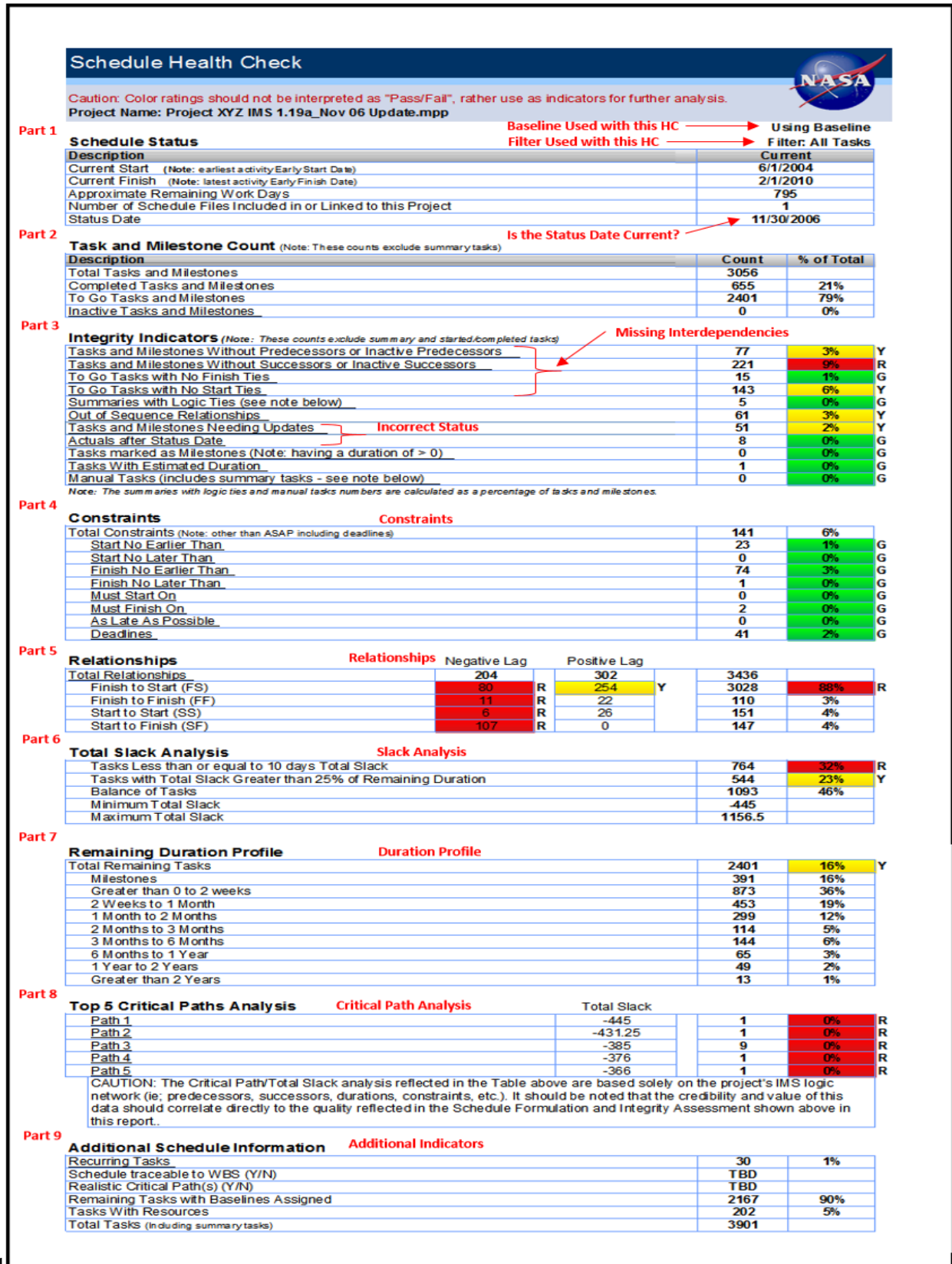


FIGURE 58. Schedule Health Check

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 125 of 230

Other key schedule structure assessments include checks on the credibility of sequence relationships used when logically linking the tasks and milestones together in the IMS. As indicated in Figure 59, the manner in which task sequencing is done may have an impact on the schedule quality and its capability for use in identifying the critical path.

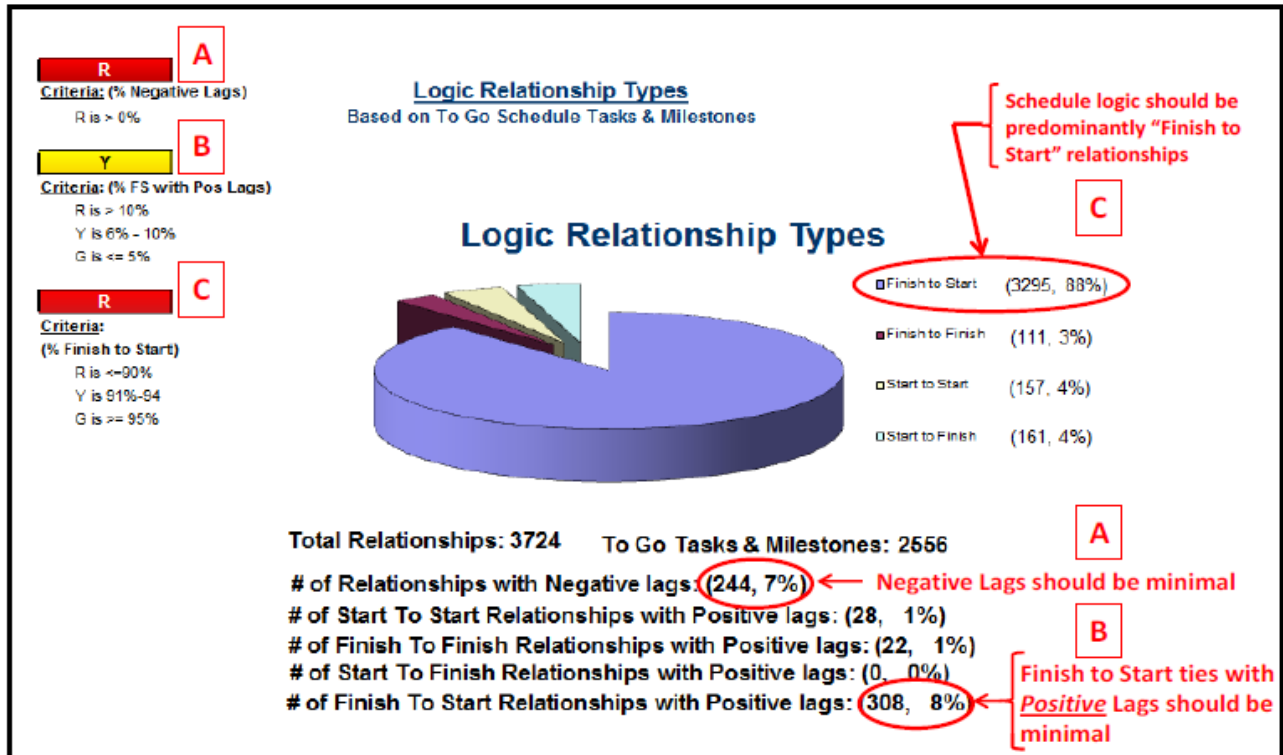


FIGURE 59. Schedule Assessment Summary Report – Logic Relationship Types

3.12.3.1.2 Critical Path Analysis

The schedule may become very dynamic during the implementation phase, and because of this, it is imperative to always know what sequence of tasks is the real driver affecting project completion. It is also important to monitor the consumption of schedule margin that may exist as part of the critical path. Management insight into the critical path is essential in making accurate resource and manpower decisions to successfully achieve project completion.

Critical path identification and analysis involves constant review of the validity of included tasks, durations, and types of relationships that are involved in the primary critical path, as well as near secondary paths. Often changes made to durations and/or logic relationships can be made to shorten the critical path and prevent project completion from moving to the right.

Common characteristics of a credible critical path include the following: it begins at “time now” and proceeds to project completion; the tasks and milestones are tied together with network logic in a sequence that is programmatically feasible or otherwise makes sense from a workflow standpoint; the path contains no Level-of-Effort (LOE) or summary activities; and there are no gaps in time between tasks that cannot be explained. It is recommended that after each update cycle of the Integrated Master Schedule (IMS), the critical path should be identified and compared to the previous month’s critical path. In making this comparison, it is important to clearly understand what has changed, why it has changed, and again validate that the sequence of tasks passes the common sense test.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 126 of 230

With sound IMS structure, the project critical path should be identifiable by isolating the sequence of tasks that has the least amount of total slack (float) as calculated using the Critical Path Method (CPM) technique of scheduling. With most scheduling tools, this can be accomplished through the use of filters or development of exception reports by filtering or isolating only those tasks/milestones that have zero slack. Keep in mind that if the task/milestone that represents the final completion of the project has a hard constraint date assigned to it, then there would be a possibility that the critical path could have a positive or negative total slack value instead of zero. Organizing this information by slack value and by date provides a waterfall format that enables management to clearly see what effort is driving the project completion (see Figure 60). The project critical path can only be identified accurately if all task and milestone interdependencies are satisfactorily incorporated into the IMS to form a complete end-to-end logic network. This type of schedule structure will allow the schedule management tool to accurately calculate slack values for each task and facilitate critical path identification.

Critical path identification and analysis are essential to ensure that management is focusing the necessary resources on the correct tasks to prevent slippage of the project end date. Close monitoring and analysis of the top three to five paths is also recommended and will ultimately provide management with the necessary insight to better keep the project under control and on track.

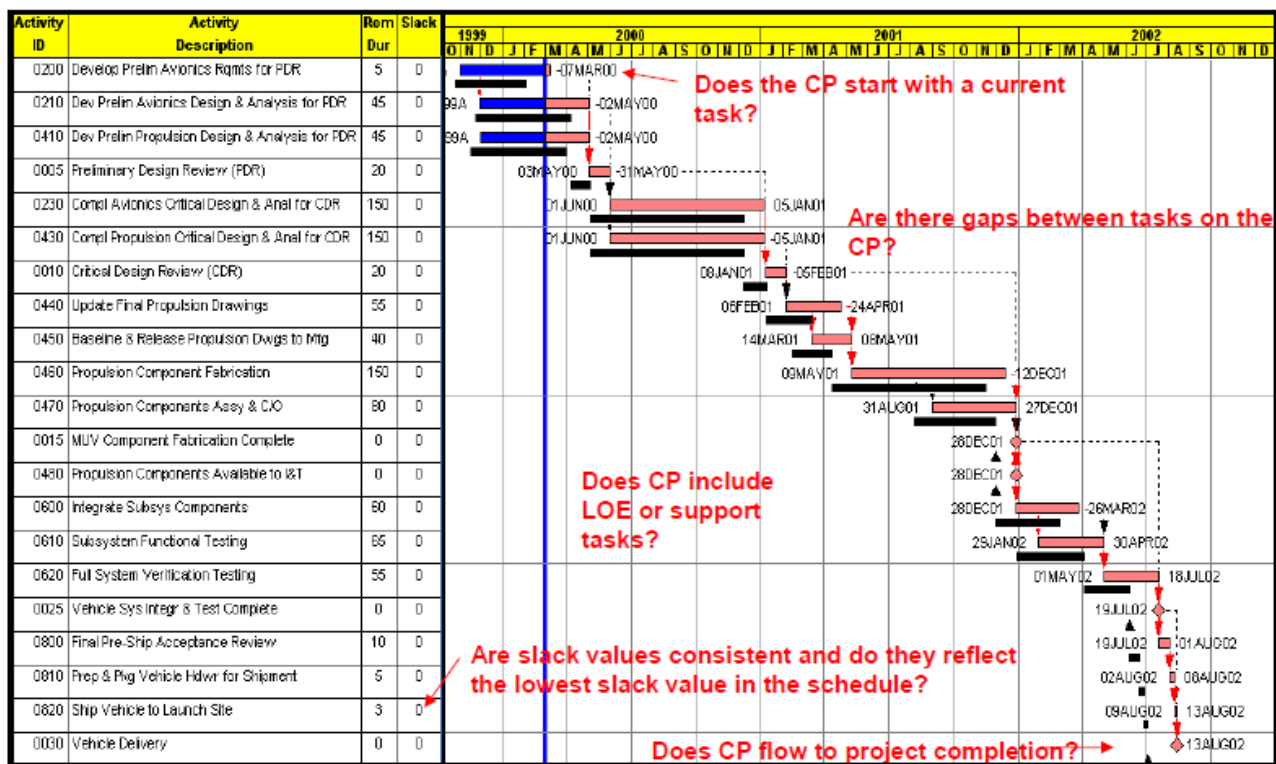


FIGURE 60. Identifying the Schedule's Critical Path

3.12.3.1.3 Schedule Performance Trend Analysis

Analysis on past performance can provide much insight into future expectations. Studies conducted using data from past projects clearly reflect that performance trends rarely improve after projects reach the 15% completion mark. Therefore, it is imperative that project teams establish sound performance analysis practices from the very start of project implementation. The management team needs as much meaningful and credible performance information as possible to help keep the project on track in order to meet planned objectives.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 127 of 230

It is recommended that periodic performance and work-off trend analysis be performed on Integrated Master Schedule (IMS) data as depicted in the graphics shown below. Figure 61 reflects analysis data that compares performance rates for accomplishing tasks in the past to the quantity of planned tasks required in future months. Caution should be taken if this analysis reflects an unrealistic bow-wave of tasks scheduled to occur with higher required completion rates than the project has been able to accomplish previously. This situation is indicative of a schedule that is most likely unrealistic. In this type of analysis, if the completion rates projected for tasks scheduled for the next 6 months are much higher than actual completions accomplished during the past 6 months, then a closer look should be taken at the type of tasks that are scheduled to evaluate the need for re-planning in order to keep the schedule realistic.

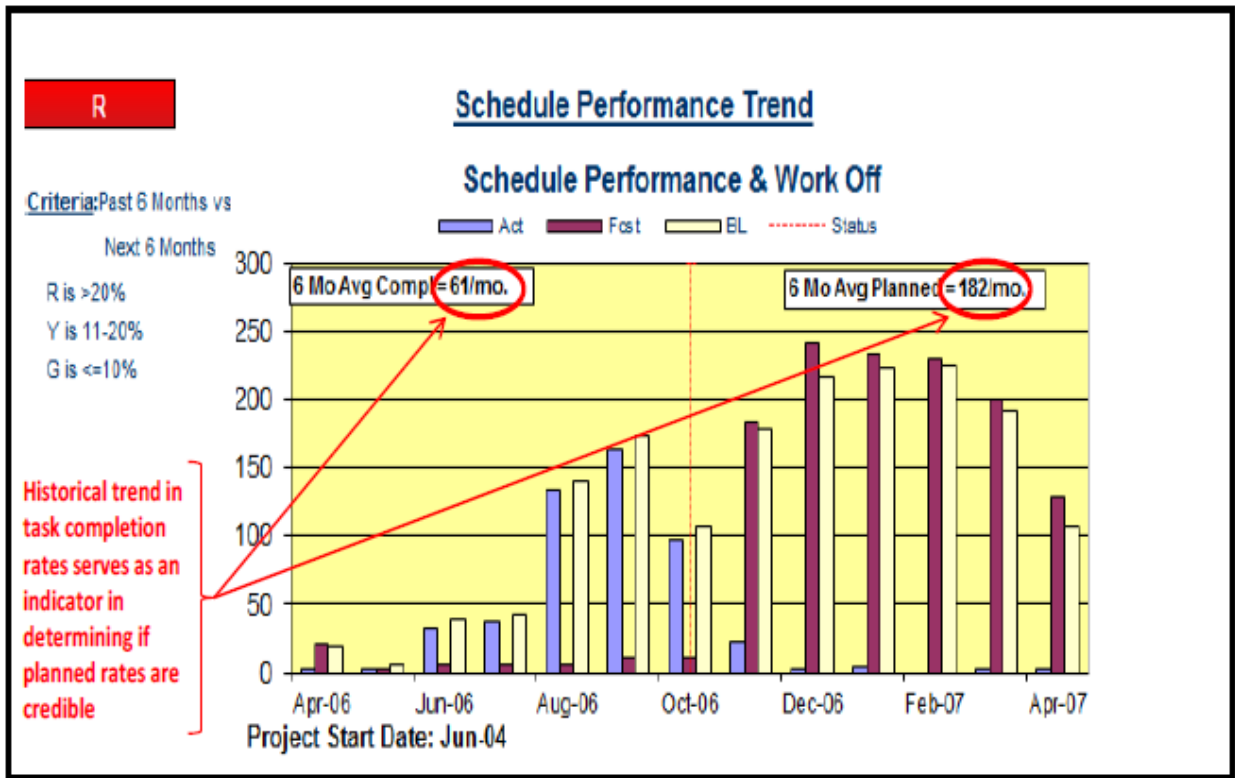


FIGURE 61. Schedule Performance Trend

Conducting on-going trend analysis on the schedule baseline plan vs. actual completions is a valuable technique to use when monitoring schedule performance trends. As shown in Figure 62, this metric reflects the basic monthly cumulative total of tasks/milestones that have actually been completed to-date versus the cumulative total of schedule items that should be completed to-date per the baseline plan. This metric is not concerned about whether tasks are completed during the correct baseline month or not, but rather a basic comparison of the total cum actuals to-date versus the total cum baseline plan to-date.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 128 of 230

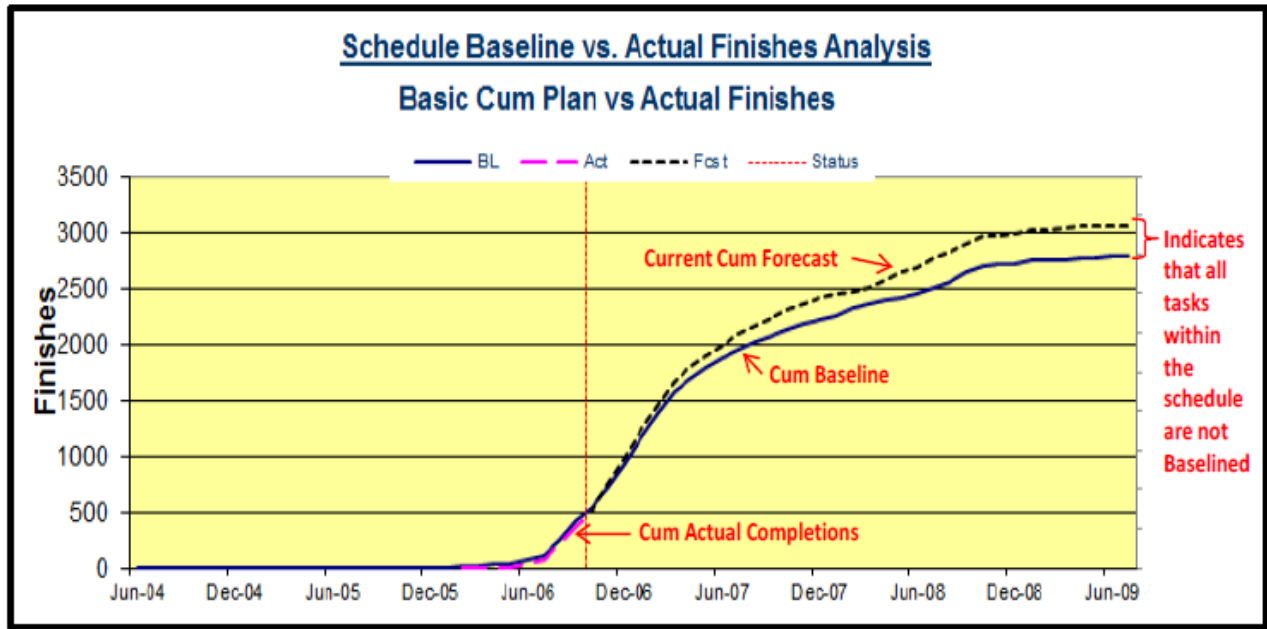


FIGURE 62. Schedule Baseline vs. Actual Finishes Trend

While this metric may not indicate whether the baseline plan is being completed per the correct time phasing, it does reflect whether or not that general progress is being made against the baseline plan. Additional assessment of the specific completion data is required to determine if the right baseline tasks are being worked during the correct months.

Figure 62 also reflects whether or not the baseline is being maintained properly. As shown in the figure above, if a gap exists between the cumulative (frequently referred to as “cum”) forecast curve and the cum baseline curve, then this is an indication that new tasks are being added to the schedule, but not being incorporated into the baseline plan. The baseline plan must be maintained by assigning baseline dates to new tasks as the necessary management approvals are received.

3.12.3.1.4 Baseline vs. Current Forecast Milestone Comparison

In the example in Figure 63, some of the project’s schedule milestones have slipped. Schedule slips lead to increased cost since overtime hours may be incurred to catch up on the schedule, or the schedule end date shifts, requiring resources to be maintained longer to complete the work. There are various reasons that the schedule may have slipped, but one possibility is that there were fewer resources available to work than what was originally planned. This cause could lead to a positive cost position since the workforce costs were lower, but a schedule slip. This is a good example of why it is important to look at indicators for both schedule and cost.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 129 of 230

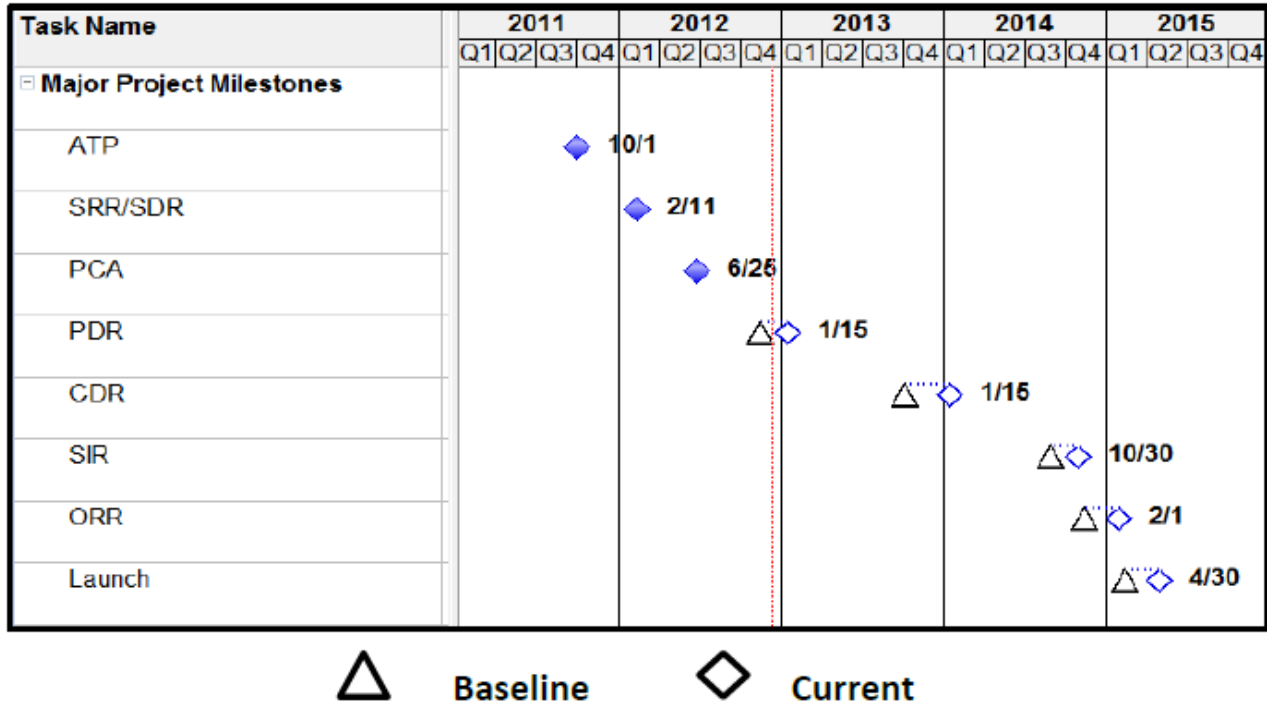


FIGURE 63. Project Milestone Status

3.12.3.1.5 Schedule Baseline Analysis

MPR 7120.1 requires that the project’s schedule baseline be integrated with the budget and technical baselines to form an overall project integrated baseline. This correlation is essential to ensure that adequate resources are available to accomplish the work when it is scheduled. Without this correlation and validation the project Integrated Master Schedule (IMS) loses credibility.

In cases where resource loading of the IMS has not been implemented, an alternate summary level cost/schedule correlation (see Figure 64) analysis technique may be used. From a summary level perspective, this technique will provide insight that will aid the management team in determining if the resource plan is consistent with the schedule plan. This process entails overlaying the total cumulative project level budget/resource plan on top of the project timeline with only the major milestones indicated. This graphic will clearly reflect budget/resource peaks in relationship to the key milestones and help management determine if the peaks are occurring at the appropriate time in the project plan. For a development project, the resource peak should occur a short time prior to the Critical Design Review (CDR). This is due to the required overlap of many skill types during the transition from hardware design to hardware fabrication and test. If this analysis indicates the peak is too early or late, the management team should review and adjust the budget/resource plan accordingly.

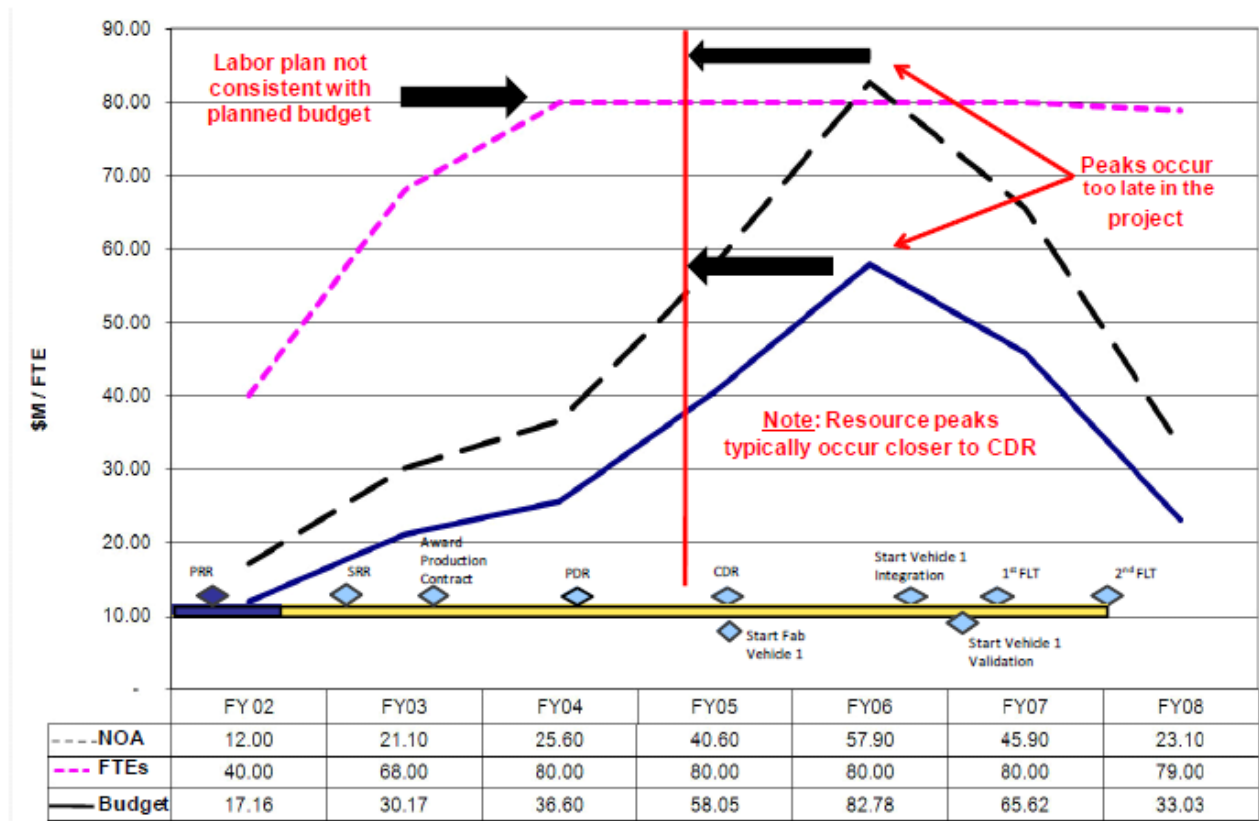


FIGURE 64. Summary Level Cost/Schedule Correlation

Figure 65 illustrates schedule trend data for cumulative task “finishes”, and serves as a “best industry practice” for tracking schedule performance against the schedule baseline. This metric provides a graphic which calculates the Baseline Execution Index (BEI). The BEI indicates how well the project is following the baseline plan and completing baseline tasks as they are scheduled to be completed. The BEI is calculated using the following formula:

BEI = cumulative number of baseline tasks completed divided by cumulative number of baseline tasks scheduled for completion.

A good performance rating is indicated when the BEI value is 0.95 or greater, and a moderate performance rating exists when the BEI value is between 0.85 and 0.94, and poor rating results if the index is less than or equal to 0.84. As the BEI value gets lower, it is less likely that the project will be completed on time per the baseline plan. If the BEI value is greater than 1.0, this is an indicator that the project is doing well and performing ahead of the baseline plan.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 131 of 230

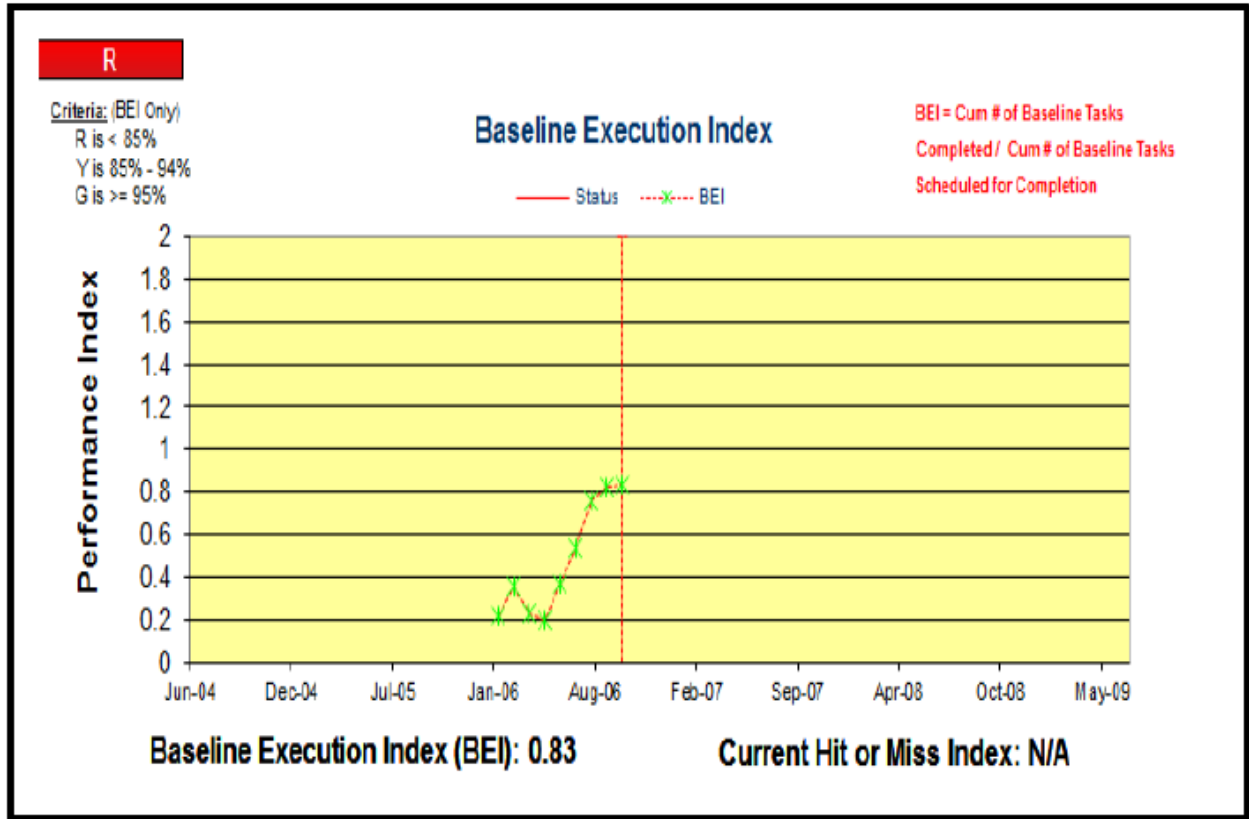


FIGURE 65. BEI

3.12.3.1.6 Schedule Risk Analysis (SRA)

Conducting a SRA is crucial during project formulation and throughout the on-going implementation life-cycle of a program/project. Although there are various ways of evaluating cost and schedule risks and confidence levels, a recommended technique is through the use of a proven probabilistic risk assessment tool with random sampling functionality. The SRA is an important analysis process that evaluates the likelihood that a project plan, reflected in the Integrated Master Schedule (IMS), is achievable within the planned finish date constraints.

This “best practice” approach utilizes an IMS with all work scope reflected in discrete tasks/milestones with all task interdependencies included. The random sampling functionality computes project schedule data simulations based upon realistic duration estimates and a probability distribution parameter assigned to tasks within the schedule. The duration estimates that are associated with schedule tasks include the minimum, maximum, and the most likely durations expected for each schedule task. The probability distribution parameter, also known as the Probability Distribution Curve (PDC), models the likelihood of task durations being successfully achieved between the minimum and maximum parameters.

As numerous simulations are executed and calculated, the SRA tool will factor into the random sampling calculations the assigned duration estimates, the selected distribution probability curves, the assigned task interdependencies, and known valid constraints to provide probability percentages for completion dates of all or selected tasks within the IMS (see Figure 66 below).

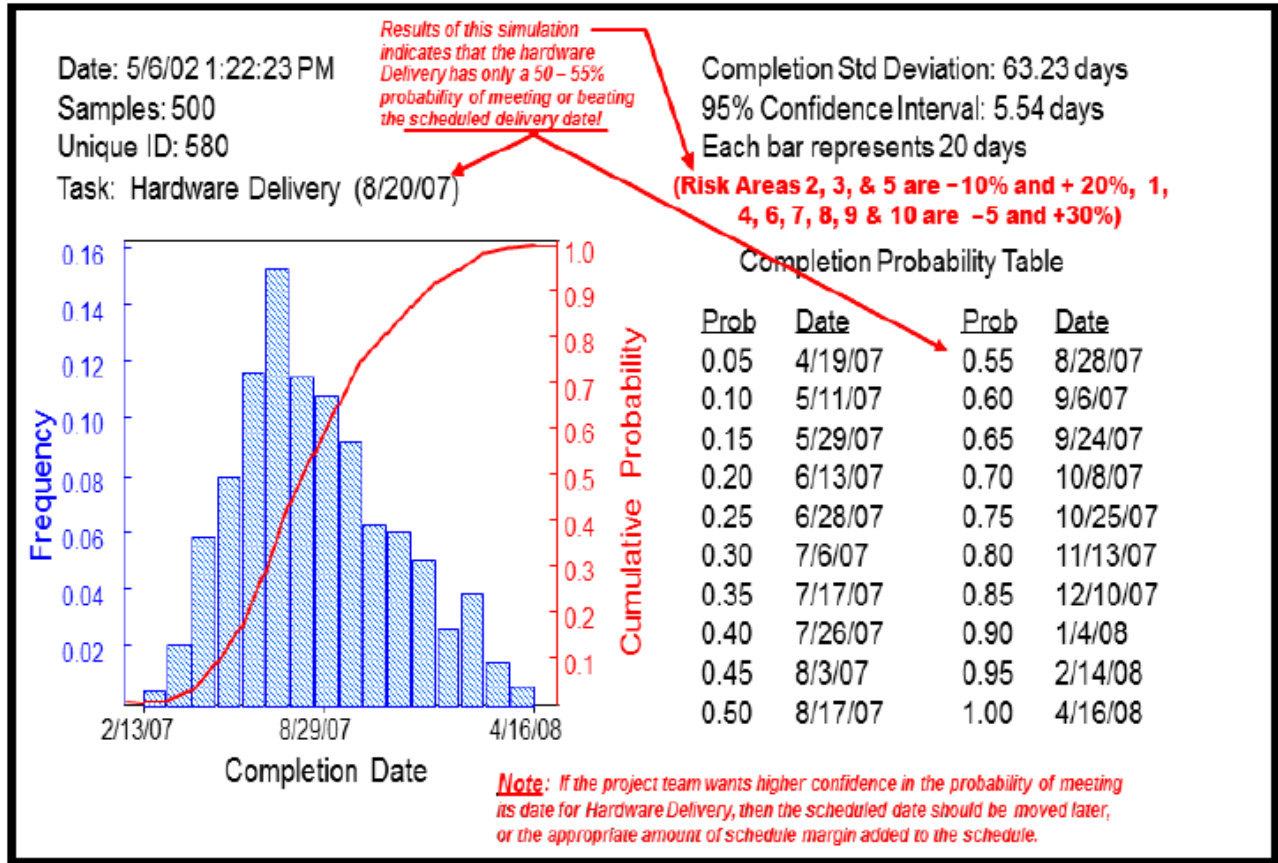


FIGURE 66. Probabilistic SRA

Schedule assessment and analysis strategies are similar for projects that require Earned Value Management (EVM) implementation and those that do not. All project schedules should be checked and analyzed thoroughly before formally establishing the baseline which will be measured against as the project proceeds forward. Whether the resulting data from measuring schedule performance against baseline are used in the EVM process or not, sound schedule assessment and analysis techniques should be used to ensure the project schedule is valid and can be used as a roadmap to guide the project, and for management decision making.

3.12.3.2 Schedule Reporting

3.12.3.2.1 Program Integrated Master Schedule (PIMS) Report

Each program should develop and make available, *in native file format*, an automated logic network database referred to as the PIMS. This schedule report consists of schedule data for all project effort included in the program scope, along with all effort that only falls under the responsibility of the program organization to perform. The level of detail contained in the PIMS will generally depend on three key factors: the level of management insight desired by the program team, the magnitude of program scope, and the amount of project data to be maintained and analyzed by the program team, and finally, the type and compatibility of schedule management tools used by all elements within the program. Due to these factors, the schedule content of the PIMS may be a compilation of all the project detailed schedules, or it could potentially be a compilation of summary versions of each project Integrated Master Schedule (IMS).

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 133 of 230

Accompanying the PIMS, this report should also contain narrative information that addresses current and potential schedule issues, work-arounds, critical schedule drivers, etc. The PIMS schedule report can be used by skilled Project Planning & Control (PP&C) team members for in-depth, program-level schedule analysis and decision making support.

3.12.3.2.2 Project Integrated Master Schedule Report

Each project should develop and make available, *in native file format*, an automated logic network database referred to as the Integrated Master Schedule (IMS) consisting of schedule data for all Work Breakdown Structure (WBS) elements. The entire scope of work should be broken into schedule tasks and milestones at a consistent level of detail to allow discrete progress measurement and visibility into the overall design, fabrication, integration, assembly, test, and delivery phases of each end item deliverable. Additionally, all schedule tasks/milestones should be integrated with the appropriate sequence relationships to provide a total end-to-end logic network leading to each end-item delivery. The IMS should contain all contract and controlled milestones, key subcontractor milestones, end item delivery dates, key data delivery dates, and key Government Furnished Property need dates. The database should contain the appropriate task coding attributes necessary to provide sort, select, and summarization capabilities for, but not limited to, WBS element, project phase, and Level-of-Effort (LOE) tasks. The IMS serves as the basis for Project Planning & Control (PP&C) team members to identify project critical paths, as well as critical detailed issue analysis, work-off and performance trending, Schedule Risk Assessments (SRAs), and “what-if” analysis.

3.12.3.2.3 Critical Path Narrative and Analysis Report

Each project should develop and make available a report for PP&C and management use that identifies the critical schedule driver(s) for the program/project. This report should be an extract from the Program Integrated Master Schedule (PIMS)/Integrated Master Schedule (IMS) and include all tasks and milestones with a specified amount of total slack (float). It is recommended that all tasks/milestones with ten workdays or less of total slack be included in critical path reports. The report should be submitted in a waterfall format and organized in manner such that the path with the least amount of slack is delineated first and followed by each successive path according to total slack values.

3.12.3.2.4 Milestone Variance Report

During the implementation phase of a project, it is likely that the current schedule will at some point deviate from the baseline schedule. This situation is not unusual and occurs for many reasons. It is very important to routinely conduct comparisons between the baseline and current schedule to identify and monitor significant variances, understand why the variances occurred (i.e., the root cause), and what the impacts are to project completion so that appropriate corrective action can be planned. Tasks that have significant deviations from the baseline may also cause a new critical path or a near secondary path (See Figure 67).

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 134 of 230

Criteria:

R is >= 20d
Y is 11d - 19d
G is <= 10d

ID	WBS	DESCRIPTION	BASELINE	CURRENT	VARIANCE
26	0	Systems Requirements Review (SRR)	7/11/2006	7/11/2006	0
27	0	Preliminary Design Review (PDR)	9/8/2006	9/8/2006	0
30	0	Critical Design Review (CDR)	2/20/2007	4/9/2007	34
32	0	System Test Readiness Review (STRR)	10/15/2007	10/15/2007	0
36	0	Vehicle I&T Complete (Sell off complete)	8/28/2008	8/28/2008	0
38	0	Flight Readiness Review (FRR)	10/21/2008	10/22/2008	1
39	0	Launch Readiness Review (LRR)	10/27/2008	10/28/2008	1
40	0	Launch	10/28/2008	10/28/2008	0

FIGURE 67. Milestone Variance Report

3.12.3.2.5 Schedule Margin Metrics Report

Including schedule margin (reserve) within a project schedule to reduce the impact of known and unknown risks is a best practice that should be encouraged and supported by Project Planning & Control (PP&C) at MSFC. Each project should develop and make available a report clearly showing the trend for schedule margin usage over the life of the project. Any change between reporting periods should also be clearly explained. The PP&C Team will be involved by supporting management in their creation and on-going maintenance of this report, or by assessing this type of report in monitoring the usage of schedule margin by the implementing contractor. An example of this type of report can be seen in Figure 68. Valid rationale for schedule margin usage should also be documented in this report and continually scrutinized to ensure adequate control is in-place. It is important that schedule margin be controlled by the project manager.

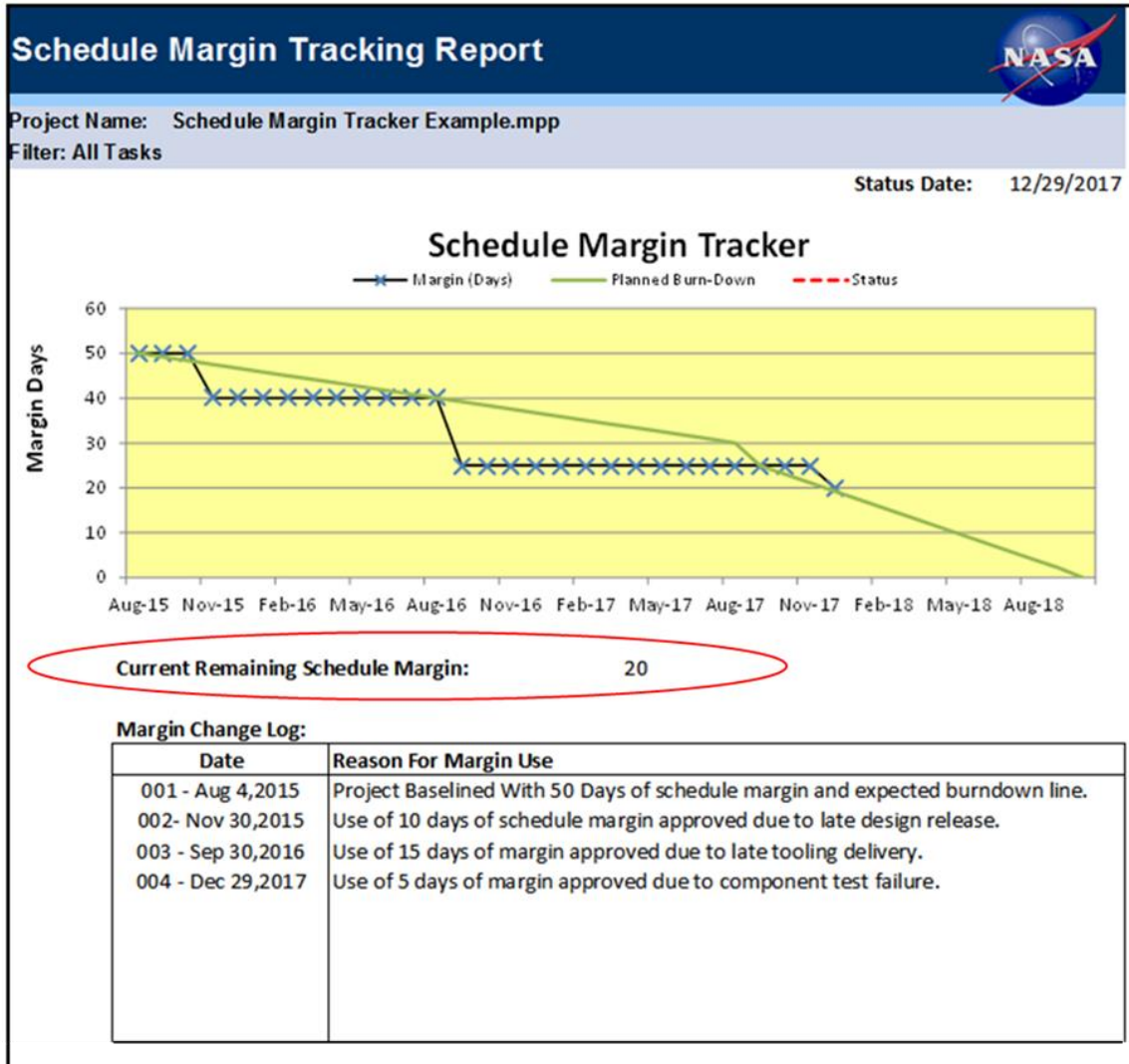


FIGURE 68. Schedule Margin Tracking Report

3.12.3.2.6 Schedule Trend Reports

Each project should develop and make available a report clearly showing the trends relating to schedule performance. Such trends should include, but are not limited to, monthly baseline finishes versus monthly forecast finishes versus monthly actual finishes, and cum baseline finishes versus cum current forecast finishes versus cum actual finishes. Significant changes between reporting periods should also be clearly understood by the Project Planning & Control (PP&C) team. An example of this type of report is illustrated in Figure 69.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 136 of 230

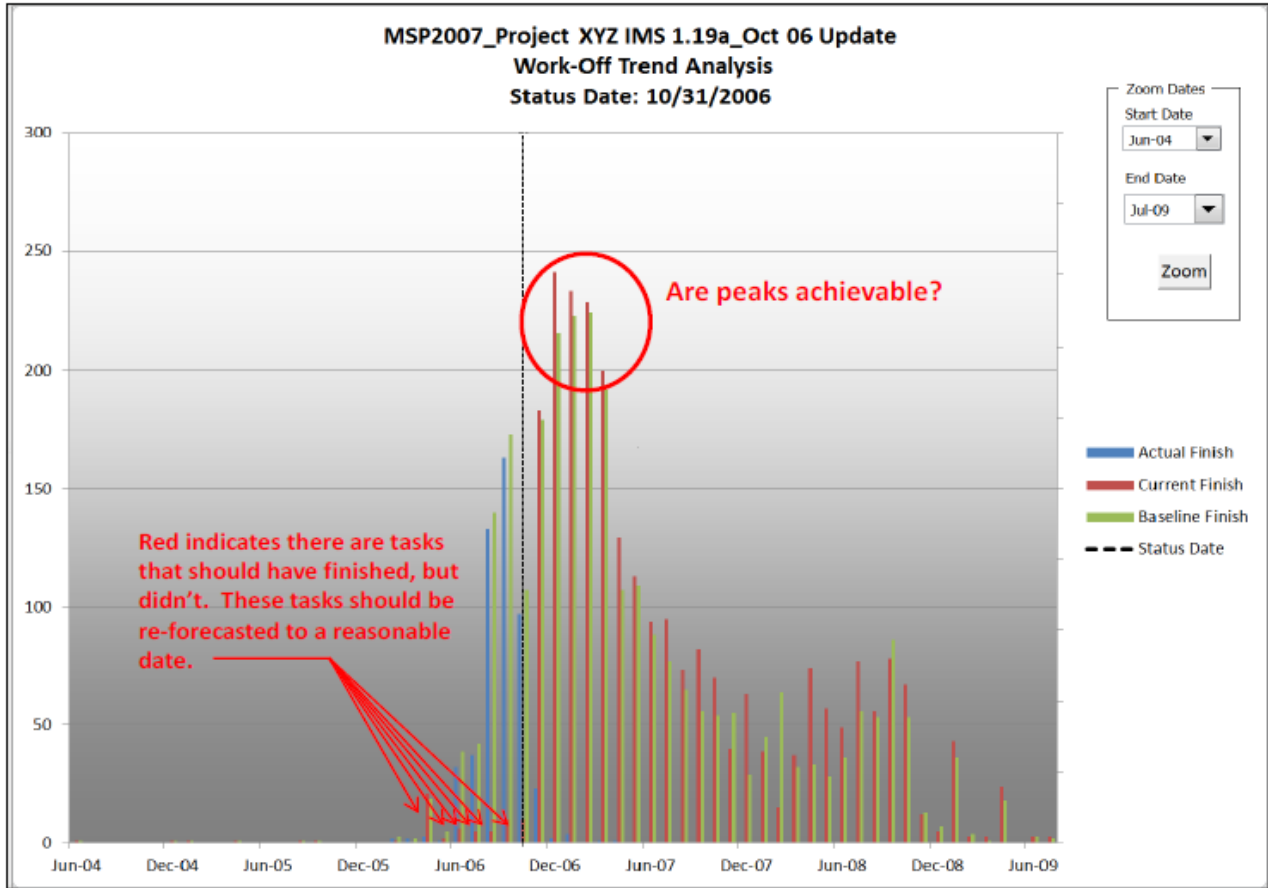


FIGURE 69. Work-off Trend Analysis

3.12.4 Earned Value Management (EVM) Analysis

EVM is a project management process that integrates the technical scope of work with the schedule and cost elements. The metrics that are produced by EVM provide independent and objective estimates for both schedule and cost performance, along with independent Estimate at Completion (EAC) projections. When EVM is implemented on a project, basic performance reporting is accomplished by analyzing the monthly Integrated Program Management Report (IPMR) of in-process work to reflect the current status on the project. (See Section 3.10 for EVM Overview and Requirements.) From that information schedule comparisons are made between Budgeted Cost of Work Performed (BCWP) and Budgeted Cost of Work Scheduled (BCWS) and cost comparisons between BCWP and Actual Cost of Work Performed (ACWP). The resulting variances are compared to the established percentage and dollar thresholds to determine the significance of the variances.

The project EVM reporting of cost and schedule performance measurement plays an integral part in providing information to support the decision making process used by management to determine the appropriate actions. The project reporting thresholds are provided to management to ensure that cost and schedule performance issues that can impact the project are identified early, and appropriate action can be initiated.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 137 of 230

3.12.4.1 Integrated Program Management Report (IPMR)

The IPMR is a deliverable from the contractor that supports monthly variance reporting by the project. IPMR Formats 1 through 7 should be prepared as required, and the content of each format is listed below.

- a. Format 1 -- Progress by Work Breakdown Structure (WBS)
- b. Format 2 -- Progress by Organization
- c. Format 3 -- Performance Measurement Baseline (PMB)
- d. Format 4 -- Personnel Resources Forecast (by Full-Time Equivalents (FTEs))
- e. Format 5 -- Narrative Variance Analysis
- f. Format 6 -- Defines and contains the Integrated Master Schedule (IMS)
- g. Format 7 -- Defines the time-phased historical and forecast cost submission

The IPMR delivery date, reporting levels and variance explanation are established as part of the contractual requirements. The standard Data Requirements Descriptions (DRDs) for Earned Value Management (EVM) can be found on Inside Marshall, MSFC Integrated Document Library, under the MSFC Data Requirements Management System.

3.12.4.2 Earned Value Management (EVM) Metrics

EVM provides the project with performance metrics that can be used to assess project performance and determine the impact to cost and schedule. The key metrics are the Cost Variance (CV), Schedule Variance (SV), Cost Performance Index (CPI), and the Schedule Performance Index (SPI). The CV and SV are stated in whole numbers or percentages so a positive number is favorable and a negative number is unfavorable. The CPI and SPI are expressed in decimals which show the efficiency of cost and schedule to the plan. Perfect efficiency with no deviation from the plan for cost or schedule is 1.0. An index less than 1.0, such as .90, signifies that the project is 90% efficient.

Stated another way, the project has accomplished 0.90 worth of work for each \$1.00 that it planned to accomplish. For example, a CPI that is > 1.0 signifies that the element is under-running budget, < 1.0 the project is over-running budget and vice versa for the SPI. The EVM formulas shown in figure 70 below are used in this analysis. There are tools (Empower) available that do the calculations for project analysts so it is not important to remember the formulas. The Empower tool also has many charts, graphs, reports that can be used in the analysis process. In the following paragraphs we will use some of these charts to illustrate the analysis that can be done using EVM data.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 138 of 230

Variances: (Favorable is Positive, Unfavorable is Negative)

$$\begin{array}{lll}
 \text{CV:} & \text{CV} = \text{BCWP} - \text{ACWP} & \text{CV\%} = (\text{CV} \div \text{BCWP}) * 100 \\
 \text{SV:} & \text{SV} = \text{BCWP} - \text{BCWS} & \text{SV\%} = (\text{SV} \div \text{BCWP}) * 100 \\
 & \text{Variance at Completion (VAC):} & \text{VAC} = \text{BAC} - \text{EAC}
 \end{array}$$

Performance Indices: (Favorable is > 1.0, Unfavorable is < 1.0)

Cost Performance Index (Efficiency): $\text{CPI} = \text{BCWP} \div \text{ACWP}$

Schedule Performance Index (Efficiency): $\text{SPI} = \text{BCWP} \div \text{BCWS}$

To Complete Performance Index (TCPI)

$$\text{TCPI}_{\text{EAC or LRE}} = \text{Work Remaining} \div \text{Cost Remaining} = (\text{BAC} - \text{BCWP}_{\text{CUM}}) \div (\text{EAC} - \text{ACWP}_{\text{CUM}})$$

$$\text{TCPI}_{\text{BAC}} = \text{Work Remaining} \div \text{Budget Remaining} = (\text{BAC} - \text{BCWP}_{\text{CUM}}) \div (\text{BAC} - \text{ACWP}_{\text{CUM}})$$

FIGURE 70. EVM Formulas

3.12.4.2.1 Cost Variance (CV)

A CV is calculated by the formula Budgeted Cost of Work Performed (BCWP) minus Actual Cost of Work Performed (ACWP). The CV is an assessment of the cost performance for work accomplished. The CV percentage is calculated by dividing the CV by BCWP and multiplying the resulting quotient by 100. A Cost Performance Index (CPI) can be calculated by dividing BCWP by ACWP. The index indicates the cost efficiency at which the work has been performed. For example, a CPI of 0.92 indicates that \$0.92 cents worth of work has been accomplished for every \$1.00 spent. When the CPI is greater than 1.0, a favorable variance or efficiency exists. A CPI of less than 1.0 indicates an unfavorable variance or efficiency.

3.12.4.2.2 Schedule Variance (SV)

SV is calculated by the formula Budgeted Cost of Work Performed (BCWP) minus Budgeted Cost of Work Scheduled (BCWS). While the Cost Variance (CV) provides an accurate assessment of performance, the SV should only be used as an indicator because it does not consider the criticality of tasks, only their associated dollar values. Nor does the SV provide insight to time variances. When a SV is required to be reported, analysts should review the program schedule status to ensure that the actual schedule problem(s) is sufficiently addressed. The SV percentage can be calculated by dividing the SV by BCWS, and multiplying the resulting quotient by 100. A Schedule Performance Index (SPI) can be calculated by dividing BCWP by BCWS. The index indicates the schedule efficiency at which work has been performed. For example, an SPI of 0.92 indicates that for every \$1.00 worth of work planned, \$0.92 cents worth of work was accomplished. However, the work accomplished may not be the same work that was planned. Therefore, this is only an indicator and the schedule should be reviewed to determine schedule status. When the SPI is greater than 1.0, favorable schedule efficiency exists. An SPI of less than 1.0 indicates unfavorable schedule efficiency.

3.12.4.2.3 Variance at Completion (VAC)

A VAC is calculated by the formula, Budget at Complete (BAC) minus Estimate at Completion (EAC). When the EAC exceeds the BAC or total budget, an overrun is being forecasted. The VAC percentage can be calculated by dividing it by the BAC and multiplying the resulting quotient by 100.

3.12.4.2.4 Earned Value Management (EVM) Reports and Trend Analysis

Trend analysis using graphs often reveals trends that go unnoticed by statistical analysis. The trend charts can be in percentages, dollars or other factors, such as hours, Full Time Equivalents (FTEs), etc. Figure 71 provides four

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 139 of 230

commonly used EVM trend charts. Project analysis should take into account the projects percent complete. Although percent complete may be derived by many methods, for EVM performance measurement purposes it is calculated by dividing Budgeted Cost of Work Performed (BCWP) by the Budget at Complete (BAC) and multiplying by 100. This formula yields a relatively accurate percent complete because BCWP is a representation of the amount of work accomplished, and the BAC represents the total amount of work planned. As seen in the charts below, analyzing the trend data provides tremendous insight into the projects performance to date.

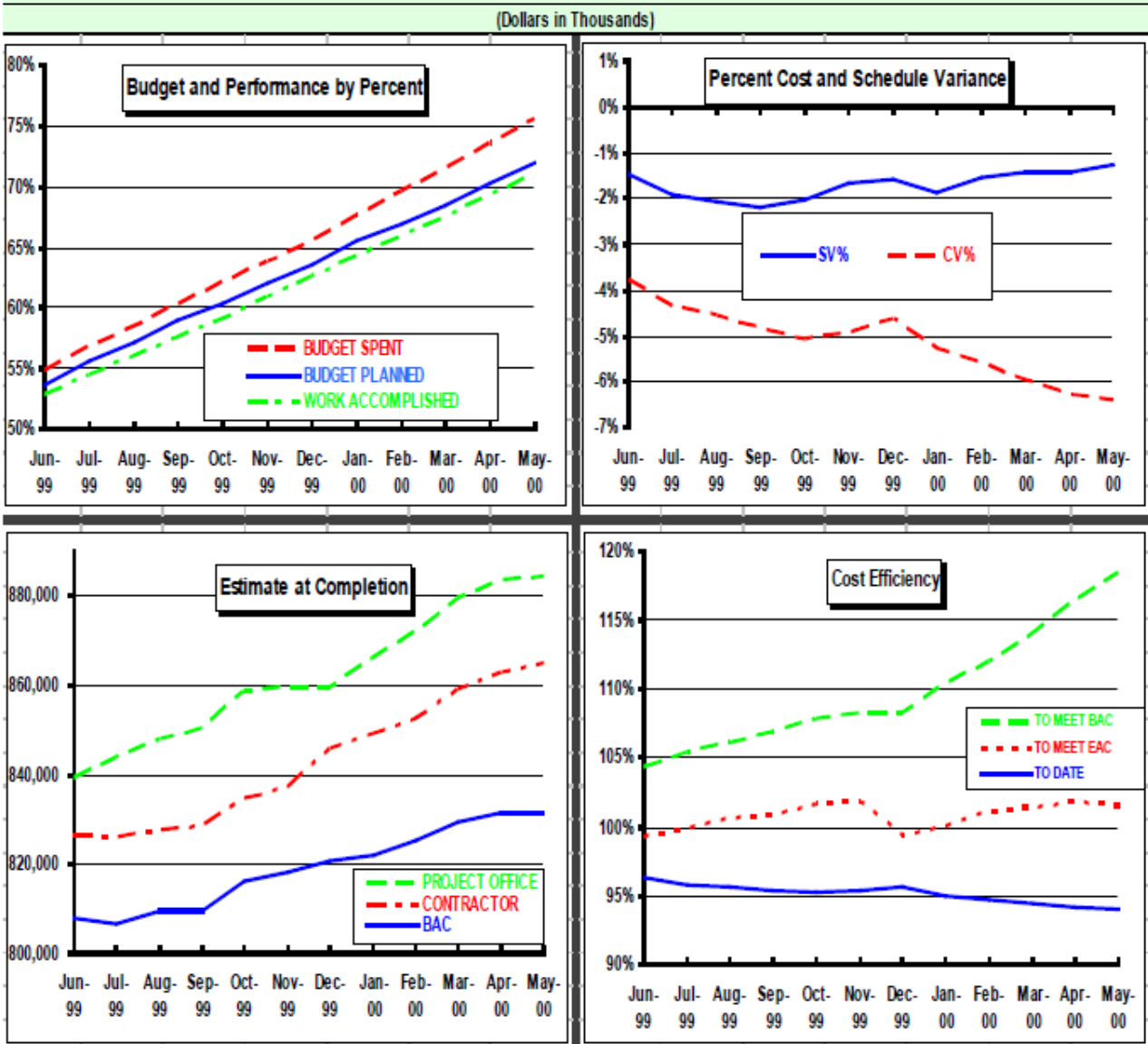


FIGURE 71. EVM Performance Trends

This trend data will allow analysts to make projections on the final costs and completion dates. For example look at the chart above on the bottom right. It shows that the project will have to perform at about 120% efficiency rate to meet budget (BAC). Also, the project will have to perform at about 102% to meet the current EAC projection by the contractor. Finally, the current performance of the project is below 95% efficiency indicating that it will be difficult to meet its cost objectives. The predictive capabilities of EVM will be discussed in Section 3.12.5.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 140 of 230

Further EVM analysis can be done by reviewing the data in the Integrated Project Management Report (IPMR). From this report, Project Planning & Control (PP&C) analysts can produce many EVM metrics that can be used to assess performance. It is useful to obtain an electronic copy of the IPMR and download it into the Empower data analysis tool. A key point is that the project should ensure that it flows down the appropriate DRD for the IPMR that follows the standard on the MSFC integrated document library website on Inside Marshall or in the *NASA EVM Implementation Handbook*, <http://evm.nasa.gov/handbooks.html>. With an electronic submittal the report can be downloaded into Empower within minutes and charts, graphs and reports produced with a couple of mouse clicks on your computer that will assist with the monthly analysis.

3.12.4.2.5 Earned Value Management (EVM) Analysis Charts

The bottom line with monthly analysis is to highlight issues, trends, etc. of any problem areas within the project. If the problems are identified early enough in the project then corrective action or mitigation plans can be put into place to minimize the impact.

Below are some examples of EVM reports and charts that can be produced and used in the analysis process each month. Figure 72 shows the Schedule Variance (SV), Cost Variance (CV), and Variance at Complete (VAC) by pre-determined thresholds. The variances are also displayed in both dollars and %.

WBS	Description	% CMP	ET	SV	CV	VAC	BCWS	BCWP	ACWP	SV	SV %	SPI	CV	CV %	CPI	BAC	EAC	VAC
1000	MOH-2	32.94		↓	↓	↓	7,278,600	6,850,800	7,349,800	-427,800	-5.88	0.941	-499,000	-7.28	0.932	20,796,200	20,761,000	35,200
2000	PROJ MANAGEMENT	62.79		↓	↓	---	882,600	869,400	930,600	-13,200	-1.50	0.985	-61,200	-7.04	0.934	1,384,600	1,418,600	-34,000
2100	PROJ MANAGEMENT	45.70		↓	---	---	294,600	282,600	300,000	-12,000	-4.07	0.959	-17,400	-6.16	0.942	618,400	621,600	-3,200
2200	SYS ENGINEERING	85.04		↑	↑	---	234,600	241,000	267,400	6,400	2.73	1.027	-26,400	-10.95	0.901	283,400	283,400	0
2300	FUNC INTEGRA	71.62		↓	↓	---	353,400	345,800	363,200	-7,600	-2.15	0.978	-17,400	-5.03	0.952	482,800	513,600	-30,800
3000	PRIME EQUIP	30.29		↓	↓	↑	4,809,200	4,424,400	4,792,000	-384,800	-8.00	0.920	-367,600	-8.31	0.923	14,606,400	14,915,400	-309,000
3100	SENSORS	20.87		↑	↑	---	397,400	360,800	371,400	-36,600	-9.21	0.908	-10,600	-2.94	0.971	1,728,400	1,750,000	-21,600
3200	COMMUNICATIONS	34.63		↑	↓	---	910,600	707,400	838,200	-203,200	-22.31	0.777	-130,800	-18.49	0.844	2,043,000	2,130,000	-87,000
3300	AUX EQUIP	27.57		↑	↓	↓	759,800	666,600	588,400	-93,200	-12.27	0.877	78,200	11.73	1.133	2,418,200	2,409,800	8,400
3400	ADPE	41.89		↑	↓	---	261,200	251,000	238,400	-10,200	-3.91	0.961	12,600	5.02	1.053	599,200	594,600	4,600
3500	COMP PROGRAMS	46.46		↑	↑	---	88,000	87,800	84,400	-200	-0.23	0.998	3,400	3.87	1.040	189,000	190,400	-1,400
3600	PCC	28.99		↑	↑	---	1,692,800	1,681,400	1,977,600	-11,400	-0.67	0.993	-296,200	-17.62	0.850	5,800,600	5,987,800	-187,200
3700	DATA DISPLAY	41.13		↑	↑	---	272,600	159,600	159,600	-113,000	-41.45	0.585	0	0.00	1.000	388,000	388,000	0
3800	I & A	35.40		↓	↓	---	426,800	509,800	534,000	83,000	19.45	1.194	-24,200	-4.75	0.955	1,440,000	1,464,800	-24,800
4000	SPARES	17.87		↑	↑	---	133,800	135,000	142,800	1,200	0.90	1.009	-7,800	-5.78	0.945	755,600	761,800	-6,200
5000	DATA	72.60		↑	↑	---	98,800	92,200	110,000	-6,600	-6.68	0.933	-17,800	-19.31	0.838	127,000	143,000	-16,000
5100	ENG DATA	38.51		↑	↓	---	19,000	12,400	17,000	-6,600	-34.74	0.653	-4,600	-37.10	0.729	32,200	32,200	0
5200	MANAGEMENT DATA	84.18		↑	↓	↑	79,800	79,800	93,000	0	0.00	1.000	-13,200	-16.54	0.858	94,800	110,800	-16,000
6000	TEST & EVAL	43.28		↑	↑	---	692,200	706,800	706,200	14,600	2.11	1.021	600	0.08	1.001	1,633,000	1,635,000	-2,000
6100	TEST FACILITIES	100.00		↑	↑	---	101,600	101,000	99,000	-600	-0.59	0.994	2,000	1.98	1.020	101,000	101,000	0
6200	SYSTEM TEST	60.82		↑	↑	---	393,800	405,800	411,400	12,000	3.05	1.030	-5,600	-1.38	0.986	667,200	669,200	-2,000
6300	PCC TEST	23.13		↑	↓	---	196,800	200,000	195,800	3,200	1.63	1.016	4,200	2.10	1.021	864,800	864,800	0
[G&A]	GEN & ADMIN	33.67		↓	↓	---	662,000	623,000	668,200	-39,000	-5.89	0.941	-45,200	-7.26	0.932	1,850,400	1,887,200	-36,800
[PMB]	PERF MEASURE BL	33.65		↑	↓	↑	7,278,600	6,850,800	7,349,800	-427,800	-5.88	0.941	-499,000	-7.28	0.932	20,357,000	20,761,000	-404,000
[MR]	MGT RESERVE	0.00		↑	↑	---	0	0	0	0	0.00	0.000	0	0.00	0.000	439,200	0	439,200

FIGURE 72. CV, SV and VAC

Figure 73 is a six period summary report. This report shows all of the EVM metrics in both current period and cum-to-date (cumulative-to-date). This report can be used to assess the project performance on a monthly basis, and also to do trend analysis over a period of time, in this case 6 months. It also indicates the % complete of the project, and provides independent forecasts for the project's Estimate at Completion (EAC).

**MSFC Technical Standard
CS40**

**Title: Project Planning and Control
Handbook**

**Document No.: MSFC-HDBK-3684
Effective Date: September 25, 2017**

**Revision: A
Page 141 of 230**

Six Period Summary Report						
MOH-2 01/31/08 WBS Dollars [1000 : MOH-2] Six Period Summary						
ITEM	08/31/07	09/30/07	10/31/07	11/30/07	12/31/07	01/31/08
BCWS_c	429,000	816,000	286,000	1,677,000	1,439,200	1,645,400
BCWP_c	443,000	840,000	526,000	1,042,000	1,557,600	1,509,200
ACWP_c	540,000	706,000	836,000	1,220,000	1,395,800	1,707,000
SCH VAR_c	14,000	24,000	240,000	-635,000	118,400	-136,200
SCH VAR %_c	3.26	2.94	83.92	-37.87	8.23	-8.28
SPI_c	1.033	1.029	1.839	0.621	1.082	0.917
COST VAR_c	-97,000	134,000	-310,000	-178,000	161,800	-197,800
COST VAR %_c	-21.90	15.95	-58.94	-17.08	10.39	-13.11
CPI_c	0.820	1.190	0.629	0.854	1.116	0.884
BCWS	1,415,000	2,231,000	2,517,000	4,194,000	5,633,200	7,278,600
BCWP	1,376,000	2,216,000	2,742,000	3,784,000	5,341,600	6,850,800
ACWP	1,485,000	2,191,000	3,027,000	4,247,000	5,642,800	7,349,800
SCH VAR	-39,000	-15,000	225,000	-410,000	-291,600	-427,800
SCH VAR %	-2.76	-0.67	8.94	-9.78	-5.18	-5.88
SPI	0.972	0.993	1.089	0.902	0.948	0.941
COST VAR	-109,000	25,000	-285,000	-463,000	-301,200	-499,000
COST VAR %	-7.92	1.13	-10.39	-12.24	-5.64	-7.28
CPI	0.927	1.011	0.906	0.891	0.947	0.932
TCPI-BAC	1.007	0.998	1.020	1.034	1.021	1.037
TCPI-EAC	1.016	1.008	1.030	1.078	1.072	1.040
BAC	17,205,000	17,205,000	17,205,000	17,802,000	20,076,400	20,796,200
EAC	17,067,000	17,067,000	17,067,000	17,252,000	19,393,800	20,761,000
VAC	138,000	138,000	138,000	550,000	682,600	35,200
VAC %	0.80	0.80	0.80	3.09	3.40	0.17
% SCHED	8.22	12.97	14.63	23.56	28.06	35.00
% COMP	8.00	12.88	15.94	21.26	26.61	32.94
% SPENT	8.63	12.73	17.59	23.86	28.11	35.34
CUR CPI Fcst	20,779,944	14,788,898	26,013,821	20,659,630	18,846,982	23,122,923
3 PER AVG Fcst	19,010,465	16,939,963	19,672,642	20,325,786	21,915,382	22,021,523
6 PER AVG Fcst	18,893,110	17,115,547	19,152,223	20,147,542	21,293,855	22,442,824
CUM CPI Fcst	18,567,896	17,010,900	18,993,266	19,980,205	21,208,460	22,310,958
CPI*SPI Fcst	19,052,077	17,111,215	17,683,124	21,684,912	22,058,195	23,245,211
MICOM Fcst	19,386,509	17,216,570	17,829,038	21,870,381	22,148,252	23,385,312
COST & SCH Fcst	18,400,534	17,064,233	18,371,441	19,940,540	21,203,156	22,281,745
PERF FACTOR Fcst	17,314,000	17,180,000	17,490,000	18,265,000	20,377,600	21,295,200
User Entered EAC	0	0	0	0	0	0
PO Entered EAC	19,000,000	18,000,000	19,000,000	20,000,000	20,000,000	23,069,000
Weighted VAR: Cost = 80.0%, Schedule = 20.0, Performance Factor = 1.00 Forecasts are generated independently for each level.						

FIGURE 73. 6-Month EVM Metrics Summary

In Figure 74, analysts can quickly identify the top schedule and CVs from the Integrated Project Management Report (IPMR) to determine where the project may need to focus its corrective actions. Again, with the Empower data analysis tool, this information can be obtained in just a few minutes.

Top Cost Variances

1/08 WBS Dollars :: Empower																		
WBS	Description	% CMP	ET	SV	CV	VAC	BCWS	BCWP	ACWP	SV	SV %	SPI	CV	CV %	CPI	BAC	EAC	VAC
3600	PCC	28.99		↓	↑	++	1,692,800	1,681,400	1,977,600	-11,400	-0.67	0.993	-296,200	-17.62	0.850	5,800,600	5,987,800	-187,200
3200	COMMUNICATIONS	34.63		↑	↓	++	910,600	707,400	838,200	-203,200	-22.31	0.777	-130,800	-18.49	0.844	2,043,000	2,130,000	-87,000
[G&A]	GEN & ADMIN	33.67		↓	↓	++	662,000	623,000	668,200	-39,000	-5.89	0.941	-45,200	-7.26	0.932	1,850,400	1,887,200	-36,800

Top Schedule Variances

1/08 WBS Dollars :: Empower																		
WBS	Description	% CMP	ET	SV	CV	VAC	BCWS	BCWP	ACWP	SV	SV %	SPI	CV	CV %	CPI	BAC	EAC	VAC
3200	COMMUNICATIONS	34.63		↑	↓	++	910,600	707,400	838,200	-203,200	-22.31	0.777	-130,800	-18.49	0.844	2,043,000	2,130,000	-87,000
3700	DATA DISPLAY	41.13		↑	++	++	272,600	159,600	159,600	-113,000	-41.45	0.585	0	0.00	1.000	388,000	388,000	0
3300	AUX EQUIP	27.57		↓	↓	↓	759,800	666,600	588,400	-93,200	-12.27	0.877	78,200	11.73	1.133	2,418,200	2,409,800	8,400

Top Variances at Complete

1/08 WBS Dollars :: Empower																		
WBS	Description	% CMP	ET	SV	CV	VAC	BCWS	BCWP	ACWP	SV	SV %	SPI	CV	CV %	CPI	BAC	EAC	VAC
3600	PCC	28.99		↓	↑	++	1,692,800	1,681,400	1,977,600	-11,400	-0.67	0.993	-296,200	-17.62	0.850	5,800,600	5,987,800	-187,200
3200	COMMUNICATIONS	34.63		↑	↓	++	910,600	707,400	838,200	-203,200	-22.31	0.777	-130,800	-18.49	0.844	2,043,000	2,130,000	-87,000
[G&A]	GEN & ADMIN	33.67		↓	↓	++	662,000	623,000	668,200	-39,000	-5.89	0.941	-45,200	-7.26	0.932	1,850,400	1,887,200	-36,800

FIGURE 74. Top Variances in Empower

The bottom line is that the analyst job is to analyze the data to assess the project performance. EVM data, along with the associated trend charts, can help analysts quickly identify the areas that need to be addressed. The ultimate goal is to try to predict the outcome of the project in terms of cost and schedule. In the following paragraphs, the discussion will transition to the EAC.

3.12.5 Estimate at Completion (EAC)

When the management of the project believes the cost of the project will be different than originally planned, a new Comprehensive EAC should be prepared. The EAC will be determined on any project regardless of whether Earned Value Management (EVM) is required, but an evaluation should be made to verify the best estimate for completion. This new forecast of funding requirements is developed by adding the cumulative actual costs plus the estimate of the remaining unaccomplished and planned work. It is important to note that the EAC is not the same as the Budget at Complete (BAC). The EAC can be greater than or less than the

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 143 of 230

BAC. The BAC represents the planned value of the work to be performed, while the EAC represents the actual or expected cost to perform that work. The EAC reflects the project's current best estimate of what the actual cost will be when completed for all the authorized work. EACs should be developed at the lowest level that insight is needed, and summarized up to the project level. The classical definition of EAC is as follows:

Estimate Cost of Work Performed (ECWP)-to-date + Estimate to Complete (ETC) of the remaining work = EAC

It should be noted that the ETC, a term frequently confused with EAC, is the "to go" cost expected to be incurred in order to complete the effort.

3.12.5.1 Estimate at Completion (EAC) Revision

The EAC should be revised whenever it is no longer valid. Given the dynamic nature of project operations, the actual timing of EAC updates can be very fluid. In practice, two types of EAC have emerged: comprehensive EAC and routine EAC.

3.12.5.2 Comprehensive Estimate at Completion (EAC)

When there is a significant and permanent variance that will impact the final EAC then the project team should provide an update to its EAC. The comprehensive EAC is to re-estimate the Estimate to Complete (ETC) for each Control Account (CA). This ETC, added to the actual costs to-date for each CA, will provide a new EAC at the CA levels. The CA EACs can be summarized up for a project EAC. The comprehensive EAC should be done periodically, as needed, but at a minimal, on an annual basis. However, the frequency will be driven by the quality of the initial cost estimates underlying the baseline, and the quality of subsequent revisions or updates to the EAC. In addition, changes in the scope of work, changes in labor or overhead rates, and anticipated problems may require revisions to the EAC.

3.12.5.3 Routine Estimate at Completion (EAC)

When one Control Account (CA) experiences a significant and permanent Variance at Complete (VAC), the Control Account Manager (CAM) should develop a new cost estimate for all unaccomplished work within the CA. The result is the updated Estimate to Complete (ETC), when added to the actual costs to date provides the revised EAC at the CA level.

3.12.5.4 Developing the new Estimate at Completion (EAC)

The EAC should be developed at the Control Account (CA) or Work Package (WP) level. The EAC forecast should be supported by a Basis of Estimate (BOE) that outlines the assumptions used in developing the EAC. It should reflect a range of estimates for three different cases: best case, worst case, and most likely case. The most likely EAC should be included in the project reporting.

There are several factors that should be considered when developing an updated EAC. Some suggested considerations while updating the EAC are listed below:

- a. Historical performance
- b. Schedule Status
- c. Risks
- d. Threats/Liens/Opportunities
- e. Burn Rates

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 144 of 230

3.12.5.5 Estimate at Completion (EAC) Analysis without Earned Value Management (EVM) Data

3.12.5.5.1 NASA Form (NF) 533-Based Estimate at Completion (EAC)

One example of analysis without Earned Value Management (EVM) data is to use the NF 533 costs and compare it to the schedule status to generate an EAC. For example, assume that the schedule is one month behind the schedule plan. Analysts should determine the cost impact resulting from this schedule condition. One way to do that is to use the burn rate of the project over the past few months. An average burn rate can be derived by adding the last 6 months (or whatever period is appropriate) of cost and dividing by six. The average burn rate can then be used to forecast that if the schedule slip remains at 1 month, then it will cost the project an estimated one month of additional cost using the burn rate.

3.12.5.5.2 Development of an Integrated Cost/Schedule/Metric System (ICSMS) That Works in a Dynamic Development Environment

[Note: This process is quite complex and may require execution under the guidance of an experienced practitioner to understand and become proficient. This technique was developed and this section was written by Vision Analytics, Inc., a human exploration support contractor from Houston, TX.]

The ICSMS system must be summarized enough to allow for quick updating, and simple enough in appearance to easily depict cost/schedule plans and progress against plans. As will be demonstrated later, statistical calculations can be added to the system; however, the emphasis is on painting a picture that demonstrates the cost/schedule plan and attendant risks. The steps to building the ICSMS are described below.

Step 1 - Select the major drivers to be highlighted.

Management attention should be focused on major drivers; minor products and processes should be reviewed on an exception basis only. Primary candidates are those items which represent definitive end products and exhibit one or more of the following characteristics:

- a. high cost
- b. high technical risk
- c. high schedule risk
- d. key integration intersection

High cost is the easiest characteristic to observe as high cost generally denotes a complex item. Please note that key functions where complex assemblies are integrated together into complex subsystems should always be evaluated as potential critical drivers. Management might meet the cost criteria, but does not satisfy the definitive end product characteristic. Weeding out less important items is an extremely difficult process. Every engineer tends to think his/her system, subsystem, or component is very important. In general, people are a little afraid of tossing something out. You must overcome these strong human tendencies or become inundated with data.

Note, who builds the component is not a criteria for whether an item makes the focus list. Do not accept the premise that it is the prime contractor's job to worry about subcontractors, so data is unnecessary for subcontracted items. The contractor may try to convince you differently; your colleagues may bend under contractor pressure. Do not back down. The most common problem for Project Managers (PMs) is growth of subcontractor estimates. The government is responsible for long-range planning. Do not rely on the contractor to provide this function.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 145 of 230

The process has been most successful when analysts build a hardware tree (see Figure 75), usually available from data in a document entitled Master Equipment List, and perform a preliminary selection of the critical components. Insight to facilitate the selection process can be extracted from technical review documentation such as that produced for the Preliminary Design Review (PDR). Don't be intimidated with the voluminous technical data. It's not hard to find information such as the Technology Readiness Level (TRL), unresolved requirements issues, etc., for the components. The analyst then takes the product to the responsible subsystem manager for review and coordination. Historically, the preliminary list has been in 90% agreement with the subsystem manager, and the same items remain on the list for long periods of time.

Figure 75 illustrates how the selection process might work. In this case, high TRL, high design heritage S-Band and video systems will be employed. Systems with similar requirements have successfully performed on recent crewed missions. The data rate, reliability, and latency requirements for the Ku-band system present development challenges. Thus the Ku-band system is spotlighted. More specifically, the antenna and high rate mux are the risky components.

**Illustration of Hardware Tree with Critical Assemblies
Crew Vehicle - Comm**

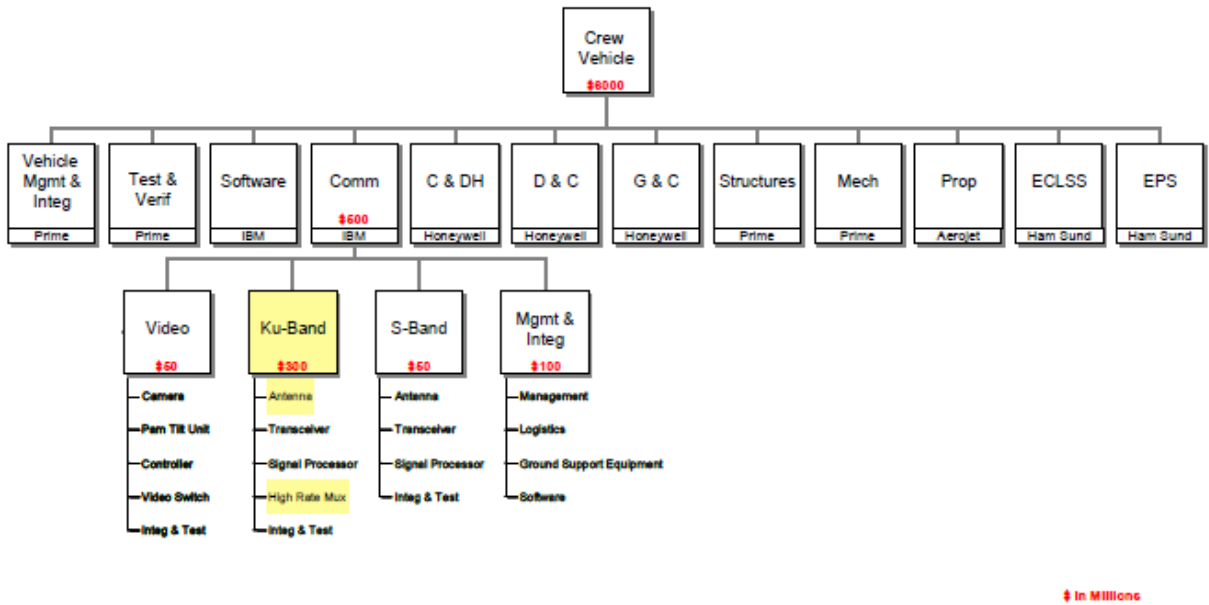


FIGURE 75. Hardware Tree Selection Process

Step 2 - Select a schedule template.

All crewed space projects follow the same general development template from System Requirements Review through first flight. Figure 76 illustrates the interplay between the designers, who represent the crewed space system through analytical models and drawings, and the builders/testers, which construct test articles consistent with the drawings flowing out of the design cycle (DC) and test them. The test results are played back against the design models from DC 1, which in turn feeds DC 2, and so on. This design it/test it iteration process continues until the design is certified.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684 Effective Date: September 25, 2017	Revision: A Page 146 of 230

The Development Project Template

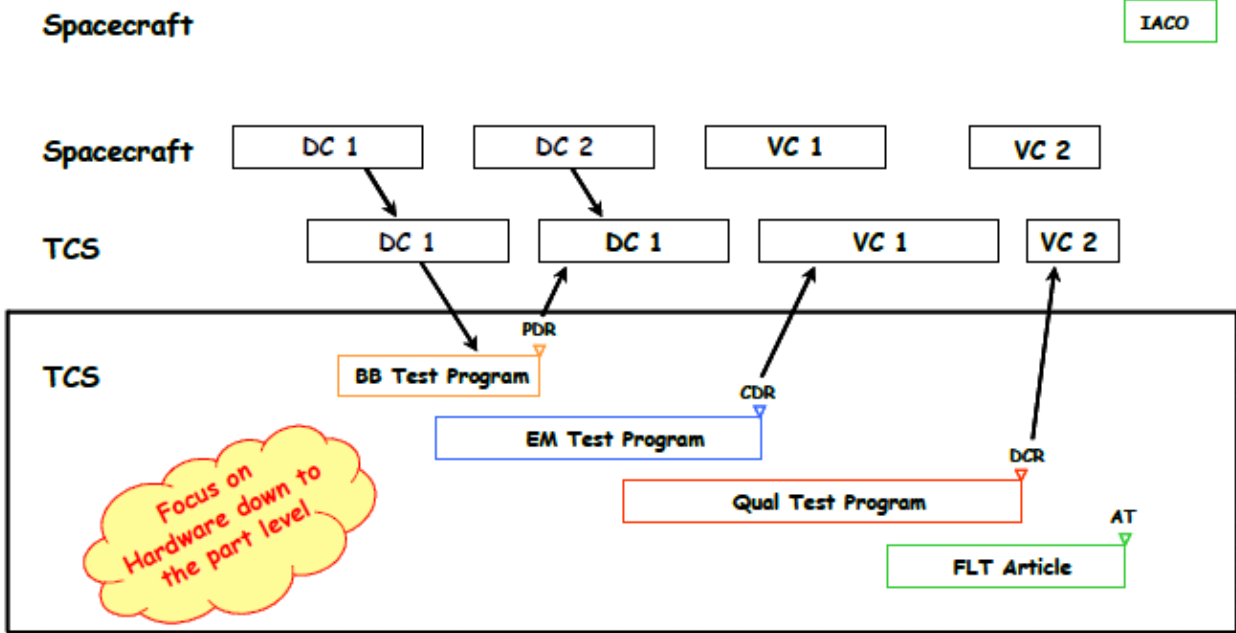
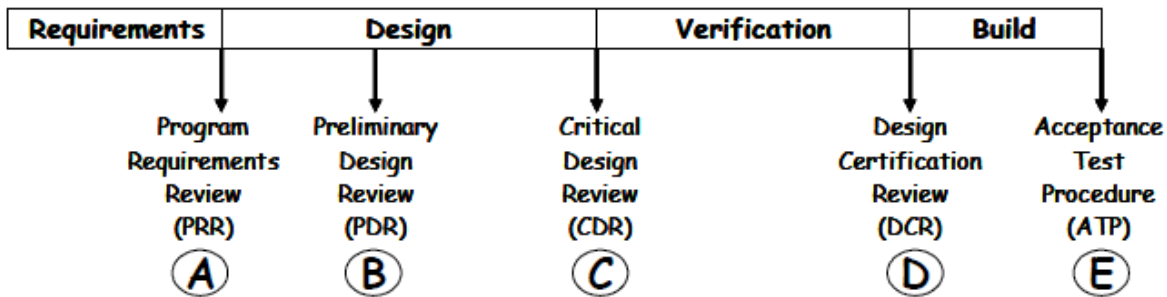


FIGURE 76. Development Project Template

The recommended ICSMS template highlights the hardware build and test programs with the major design reviews shown as a backdrop. The major design reviews are described in Figure 77. Each of these reviews can be thought of as clash points as each subsystem lead describes which requirements have been demonstrated via analysis and test, and which issues remain to be worked in the next iteration. This process continues all the way through the Design Certification Review (sometimes issues are worked after the Design Certification Review).

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 147 of 230

Design & Development Process Major Milestones



- A - Verify that project objectives have been translated into statements of requirements.

- B - Establish the "design - to" baseline and insure that it meets the program, project system and subsystem baseline requirements.
 - Demonstrate ability of selected design to meet technical and operability requirements
 - Demonstrate compatibility of interface relationships between subsystems (10% of drawings)
 - Provide project status
 - Very limited test data is utilized

- C - Verify suitability of detailed design to meet specified requirements and establish "build - to" and "code - to" baseline. The integrity of the design is verified through review of both analytical and test data (90% drawing release).
 - Significant form/fit/function test data is utilized

- D - Verify that each "as-built" subsystem satisfies functional and performance requirements. Four methods of verifications - test, analysis, demonstration and inspection. Heavy reliance on tests at the component/subsystem level. More reliance on analysis at the system/spacecraft level.

- E- Verify that the as built subsystem to be used as a flight article is the same as the qualification subsystem, e.g., no manufacturing problems. More limited testing than qual testing. Spacecraft level functional end to end tests.

FIGURE 77. Design & Development Process Major Milestones

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 148 of 230

Figure 78 illustrates how each of the four test phases usually employed in crewed space projects relates to the major program reviews. Note the color code, which denotes fidelity of the hardware, with yellow representing the lowest fidelity and green the flight fidelity, is a good aid in communicating the schedule. In this particular example breadboard tests will be conducted at the component level; engineering model tests at the system level; and qualification/acceptance testing at the subsystem level. This is within the norm. The level of testing will vary by program and compromises will be made as budget constraints dictate. There are no absolutes with regard to which requirements must be demonstrated by test versus analysis.

Typical System Hardware Test Article Template

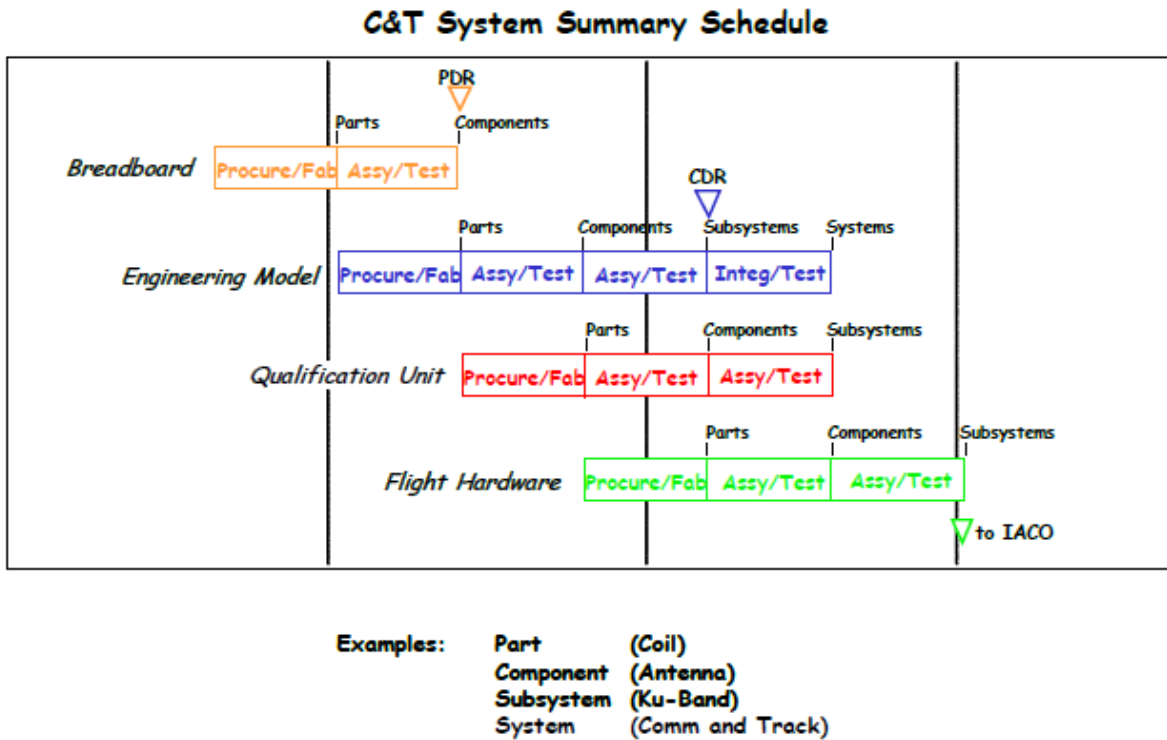


FIGURE 78. Typical System Hardware Test Article Template

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 149 of 230

Figure 79 provides the definition for each test phase.

Test Article Definitions

The **Breadboard Model (BB)** is built to support the preliminary design of a system. If certain system components require a complex design or new technology, proof-of-concept components may be built and tested. These are often crude versions of what the actual flight components will look like, but they are adequate to demonstrate that the components can provide the intended function. Breadboard models are often function-only models. Breadboard test programs are normally very low cost items. A **Brassboard** is a similar, but somewhat higher fidelity model.

The **Engineering Model (EM)** is best described as a flight model look-alike. Components conform to actual flight volume, shape and weight constraints, power utilization limitations, etc. Engineering models are often called form-fit-and-function articles. Another term used for this fidelity is **Development Verification Test Model (DVTM)**. Both performance and environmental tests are conducted on these units, however, space-rated parts are not used and less test process rigor is followed than in the qual program. DVTM test programs are normally moderate cost items.

The **qualification unit** is the first unit built to flight specification requirements. Extensive tests are conducted on this unit. In human crew space-flight programs, this unit is not usually flown. The qualification unit is the most expensive unit built.

Flight hardware is the actual unit(s) flown. The unit(s) meets form, fit, and function requirements and is made with space-rated parts. In non-crewed programs the qualification unit is often refurbished and flown, and production of a flight unit is avoided. This is called **protoflighting**. The flight hardware is similar in cost to the qualification unit.

Although not a hardware fidelity term, **Installation, Assembly, and Check-out (IACO)** is included on the schedule. The IACO activity includes all labor and material required to assemble the multiple systems (e.g., communications and tracking and thermal control) into the flight packages and check them out.

FIGURE 79. Test Article Definitions

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 150 of 230

Figure 80 lists the types of tests conducted in both the EM and qualification phases. The type of breadboard tests varies. Acceptance tests are limited to more simple functional tests.

Typical Tests Performed on Both DVTM and Qualification Units

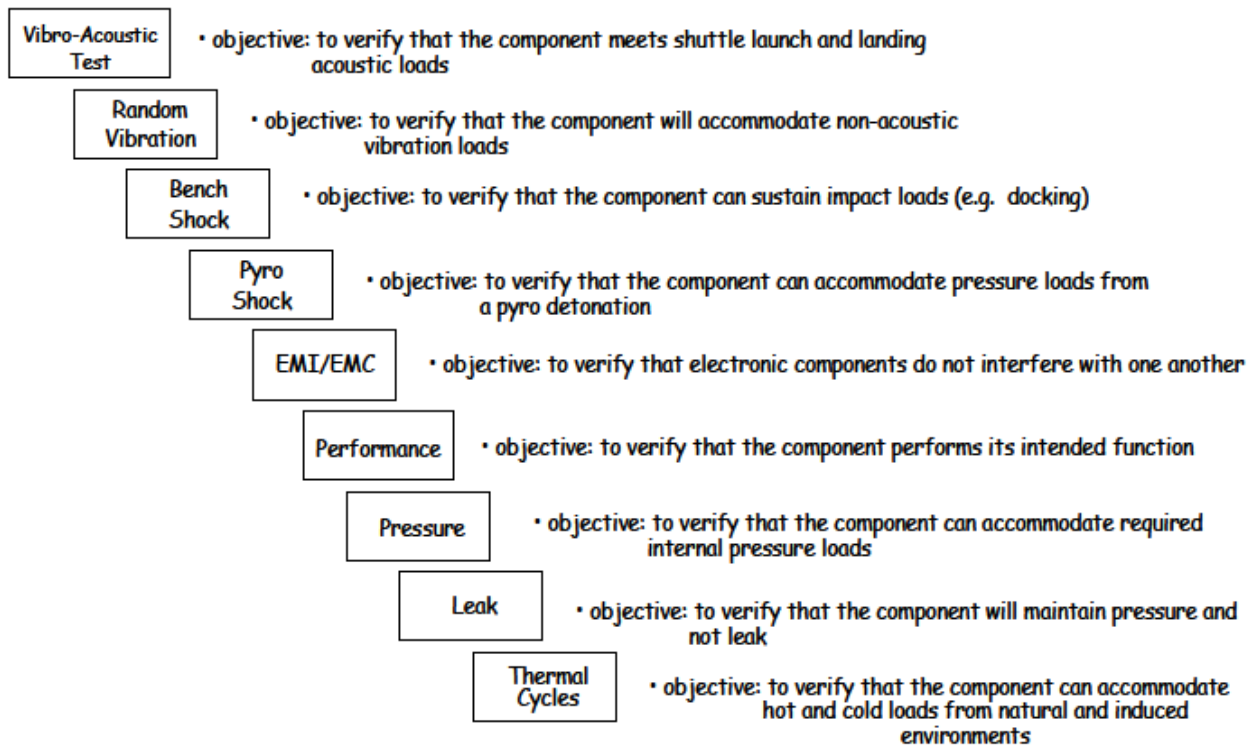


FIGURE 80. Tests Conducted During the EM and Qualification Phases

Ku-Band Example

A schedule for the Ku-band subsystem might look like the one in Figure 81.

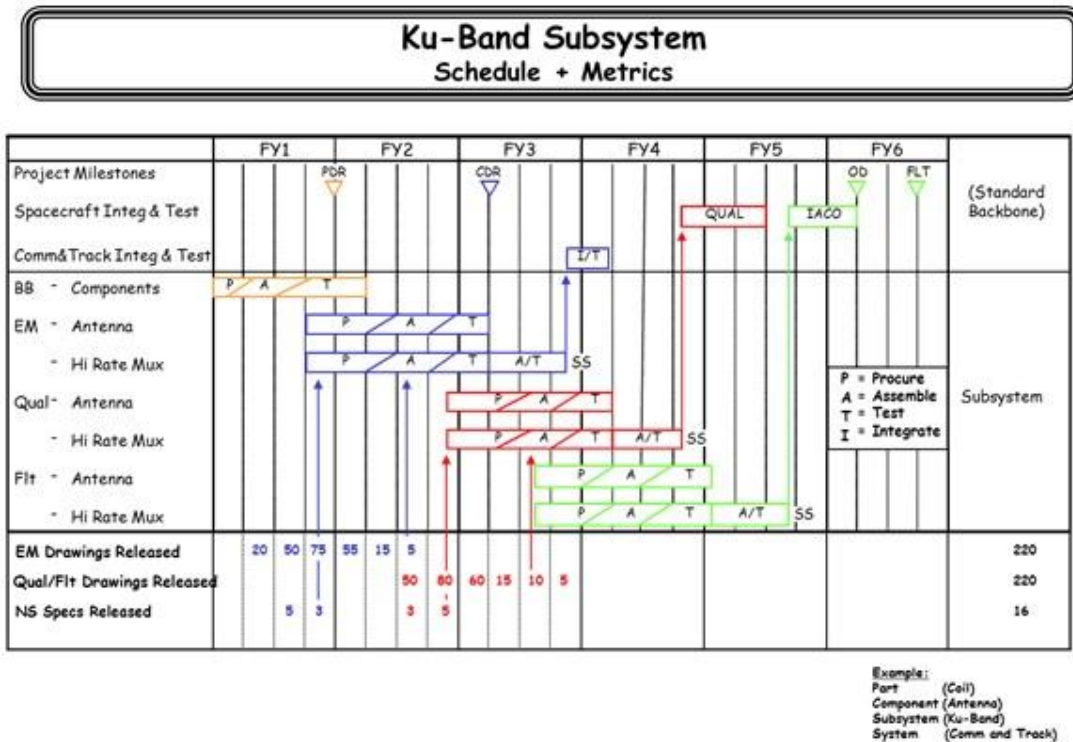


FIGURE 81. Example Ku-band Subsystem Milestone Schedule

A quick examination of the plan yields the following observations and potential issues to discuss with owner of schedule.

- Breadboard tests partially complete at PDR—potential problem if proof of concept tests fail.
- 18 month span from start of parts procurement to antenna/hi rate mux completion for the EM, Qual, and Flight Units nominal.
- Moderate overlap between start of EM parts procurement and completion of breadboard tests. Moderate risk that parts specifications could change.
- 6 month span for Ku-band level integration and test for EM. Qual and Flight units nominal.
- Ku-band Subsystem test completion before Critical Design Review (CDR) allows for incorporation of test results into the CDR process. As a minimum, component level test results should be available to confirm the detail design at CDR. Subsystem test result exceeds the minimum. Possible flexibility here if downstream cost/schedule problems surface.
- 3 month span for integration and test at the communication system level nominal. This test will explore interaction of C&T system with the S-band, Ku-band, and Video subsystems in an integrated setting. Not unusual to be scheduled post CDR.
- Procurement of qualification parts starts after EM assembly completion. This is not ideal, though not unusual in the NASA culture; we sometimes start earlier. There is obvious risk for procurement if problems are found in component tests.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 152 of 230

- h. The 15 month span from PDR to CDR is tight and consistent with a project that incurs no unexpected design problems and no externally imposed requirement/cost availability changes.
- i. The 36 month from CDR to Flight Article On-Dock is comfortable. Note that the schedule includes a full up spacecraft level qual article. The requirement to verify the design with an expensive/time consuming full up qualification article exceeds what many would argue as the minimum required to verify the design. Possible flexibility here if downstream cost/schedule problems surface.

Overall the schedule appears to reflect a reasonable baseline with the knowledge that the front end is a little tight and the back end loaded with a conservative verification approach.

Step 3 - Augment the schedule with selected engineering and manufacturing metrics.

One line of metrics can substitute for many pages of schedule. Drawing releases and nonstandard specification releases shown on Figure 82 are two that should always be included. 90% of the parts in a development program are standard (can be ordered from a catalog) since an identical part meeting all performance and environmental requirements has flown on previous crewed programs, and is thus qualified. 10% are nonstandard in that changes must be made to existing parts to meet additional performance and/or environmental requirements. These parts require a mini development program, and are often the cause for schedule and cost problems. Other candidates include nonstandard parts deliveries, standard part deliveries, and open requirement discrepancy burndown. These metrics are readily available within the prime/subcontractor organizations. The metric plan appears reasonable. A preliminary drawing release cycle supports EM assembly. The final release cycle supports qual model assembly. Likewise there are two releases of nonstandard parts specifications, one for EM procurement and one for qual article procurement.

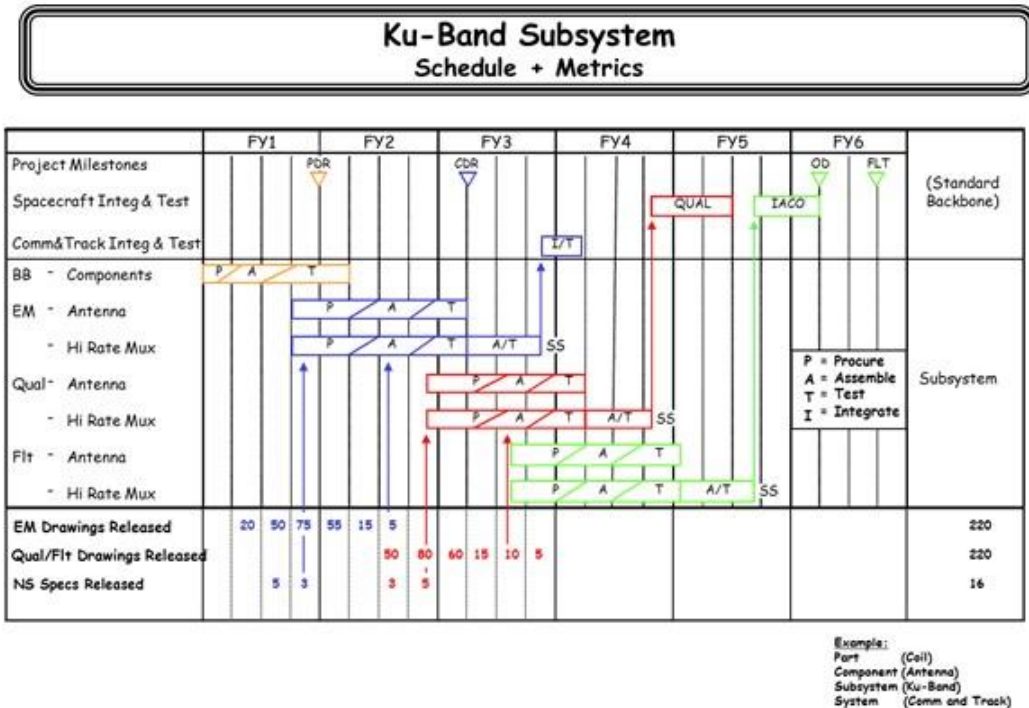


FIGURE 82. Example Drawing Releases and Nonstandard Specification Releases

Step 4 - Overlay the phased cost plan over the schedule/metrics display. (See Figure 83)

As a general rule, about 15% of the total development cost (all cost from start of preliminary design through delivery of the first flight article) should be spent through PDR and 50% through CDR.

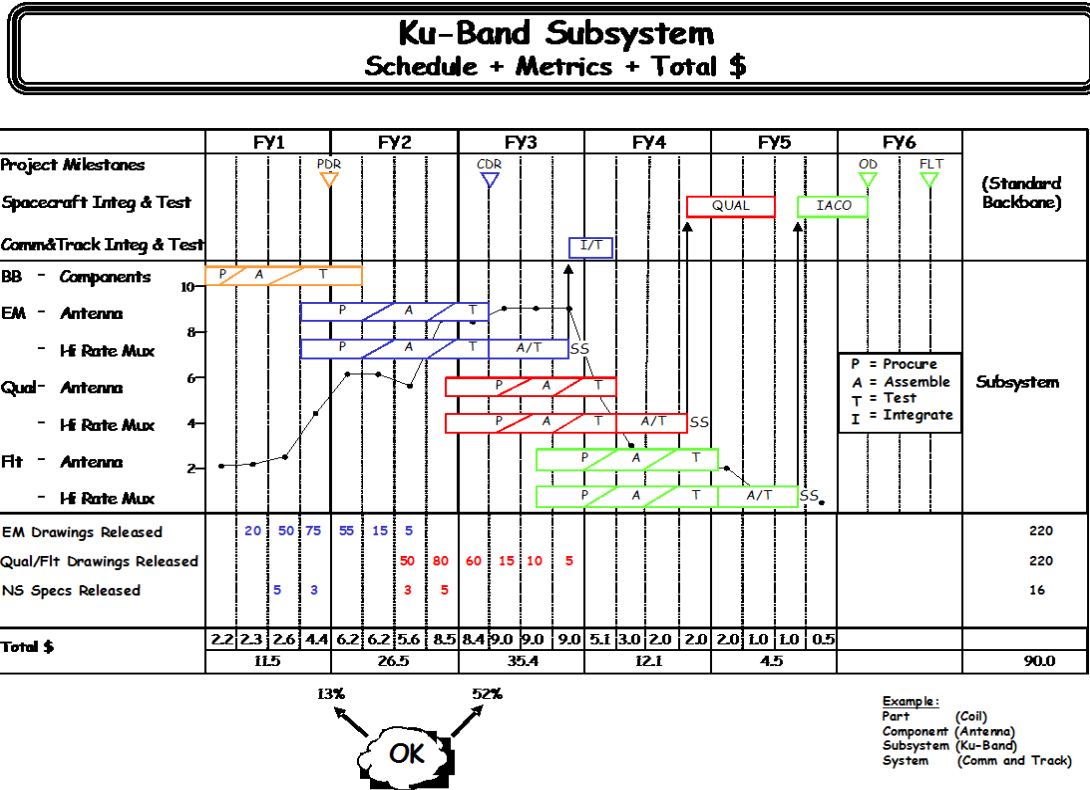


FIGURE 83. Cost Plan Overlaid with Schedule/Metrics

From a functional viewpoint cost phasing should follow the profiles summarized in Figures 84 and 85.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 154 of 230

Engineering Expected Cost/Schedule Relationships

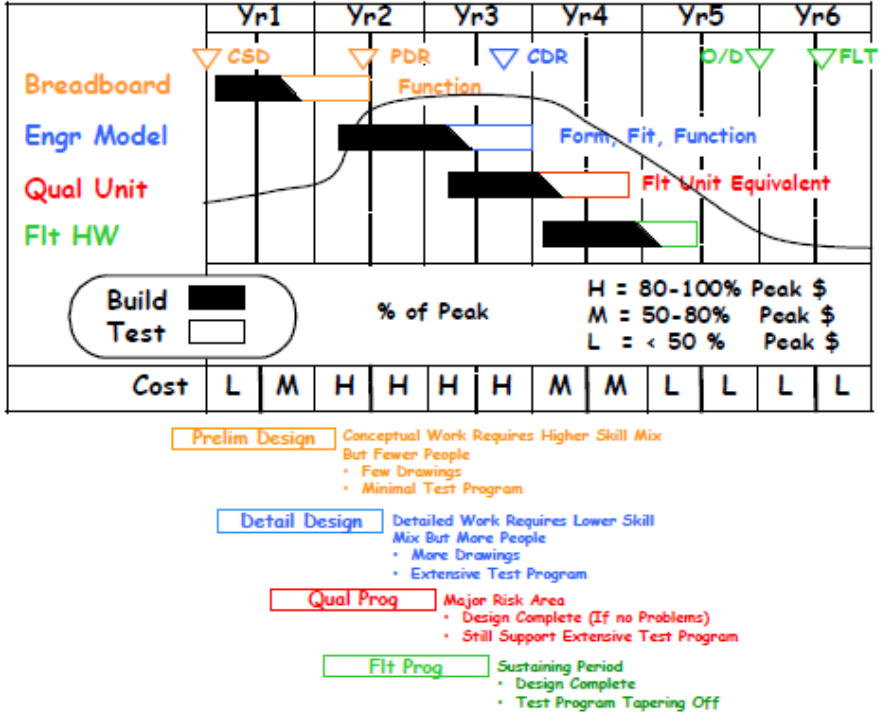


FIGURE 84. Engineering Expected Cost/Schedule Relationships

Manufacturing/Purchases Expected Cost/Schedule Relationships

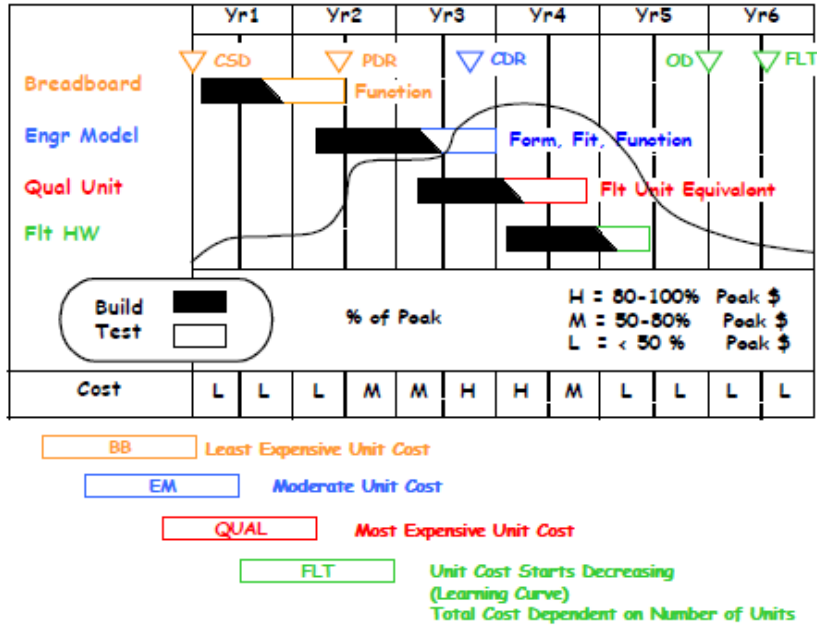


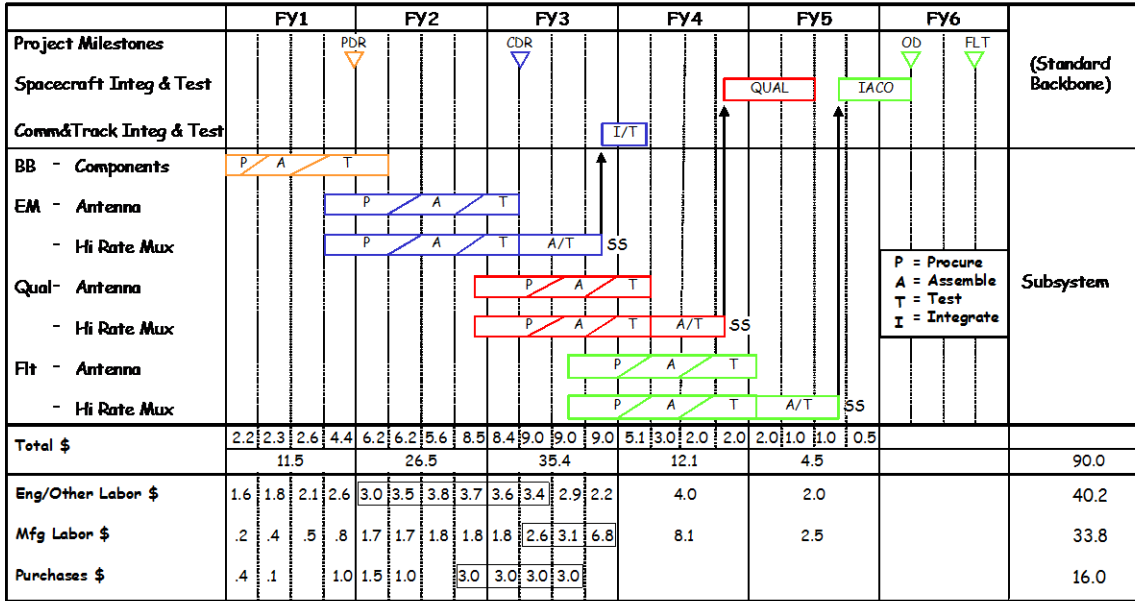
FIGURE 85. Manufacturing/Purchases Expected Cost/Schedule Relationships

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 156 of 230

The functional cost phasing plan is depicted on Figure 86. Engineering costs peak first and continue at a high level through CDR. Manufacturing and procurement costs begin to climb in the EM phase and peak in the qualification article phase.

Ku-Band Subsystem

Schedule + Total \$ + Functional \$



Engineering Labor - Peak between PDR & a little past CDR

MFG Labor - Peak with Assembly/Test of Qual & Flight units

Purchases - Feeds Qual/Flight Assembly bars

Example:
Part (Coil)
Component (Antenna)
Subsystem (Ku-Band)
System (Comm and Track)

FIGURE 86. Functional Costing Plan

Step 5 - Assessing progress against cost/schedule/metrics plan.

Contractor plans are often rebaselined frequently. For ICSMS purpose, plans should be updated infrequently to enable examination of trends. In this example, we are measuring progress during a 15 month window. The baseline plan was the one in effect at the beginning of the 15 month period and the current plan is the one in effect at the end of the 15th month. Note there may have been several plan updates during the 15 month window. The steps to follow in determining progress against the baseline plan are:

Step 5A: Overlay current plan against the baseline plan (see Figure 87).

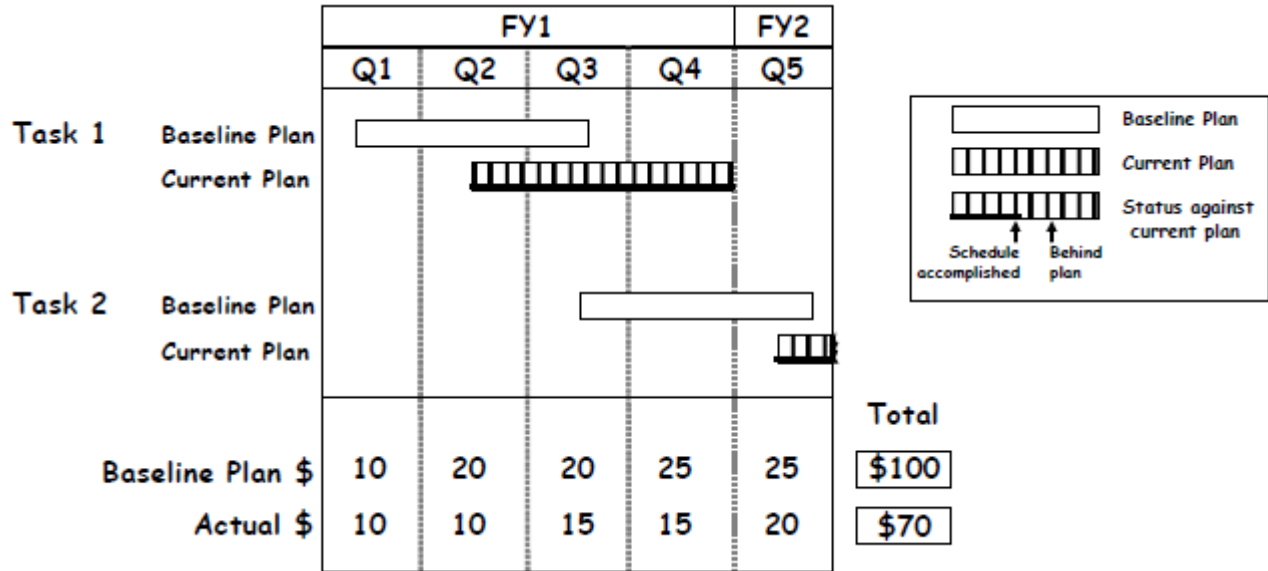


FIGURE 87. Current Cost/Schedule Plan versus Baseline Plan

In this example, Task 1 was completed at the end of Q4, approximately 4 ½ months later than the baseline plan. The baseline plan called for completion of Task 2 during the window, however, only about 6 weeks of Task 2 was accomplished during the window.

Step 5B: Color in the schedule completed against the Baseline Plan during the 15 month window and draw a vertical line at the point best representing schedule accomplished against the baseline (see Figure 88).

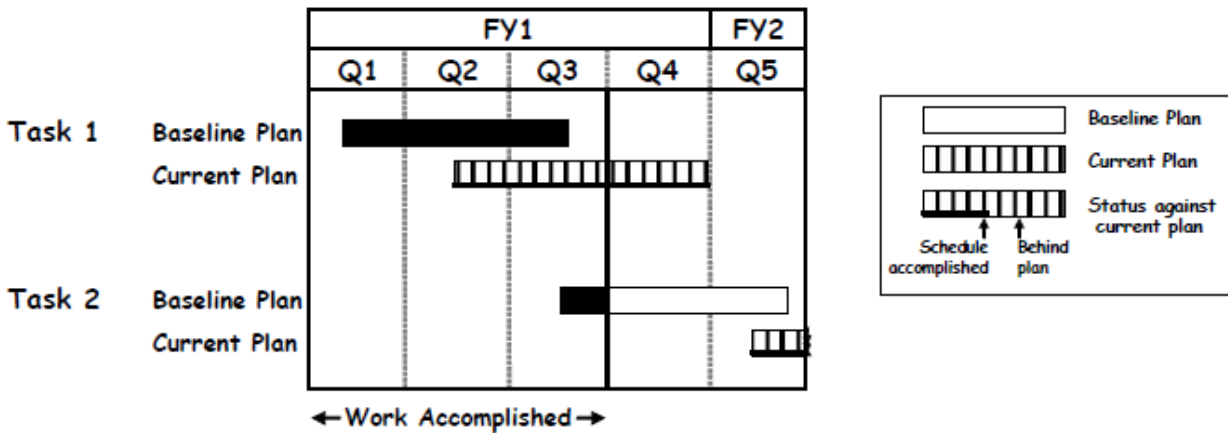


FIGURE 88. Actual Work Accomplished per Baseline Plan

In this example, the vertical line indicates 9 months of the 15 months planned in the baseline were completed.

Step 5C: Determine the Schedule Performance Index (SPI) by extending the line through the Baseline Plan \$ part of the chart. (See Figure 89).

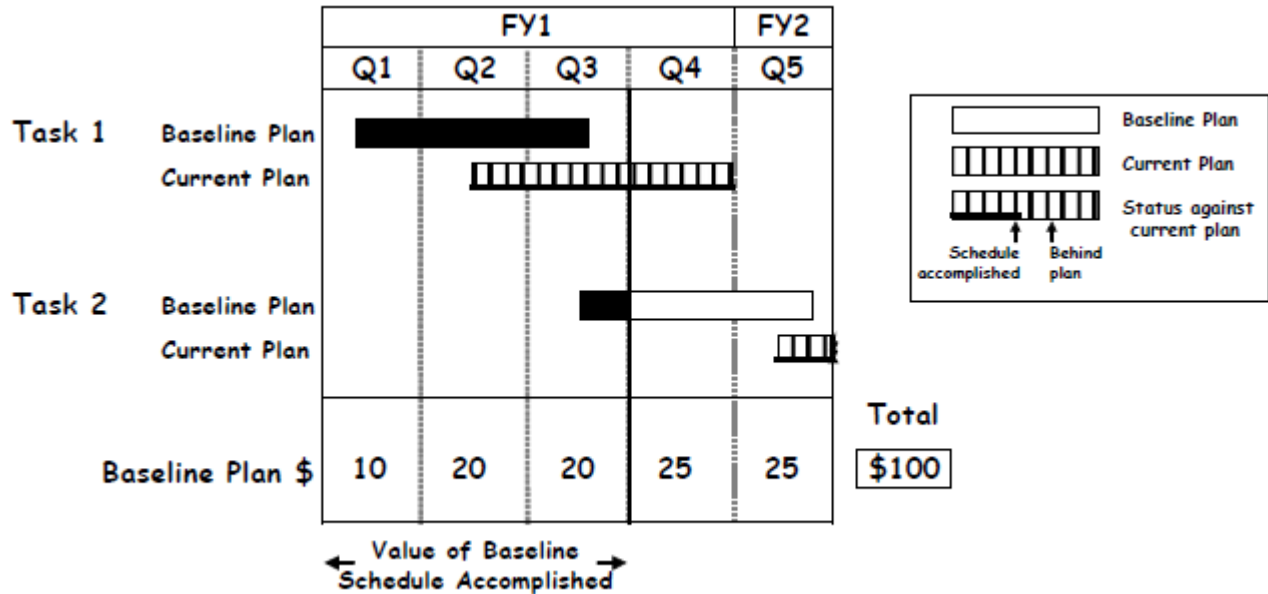


FIGURE 89. Determining SPI

The baseline planned schedule for the window was \$100. The value of baseline schedule accomplished was \$50. The SPI is:

$$\frac{\$ \text{ Value of Baseline Schedule Accomplished } \$50}{\$ \text{ Value of Baseline Plan Schedule } \$100} = 50\%$$

Step 5D: Determine the Cost Performance Index (CPI) by comparing the \$ value of baseline schedule accomplished against the actual \$ spent during the 15 month window (see Figure 90).

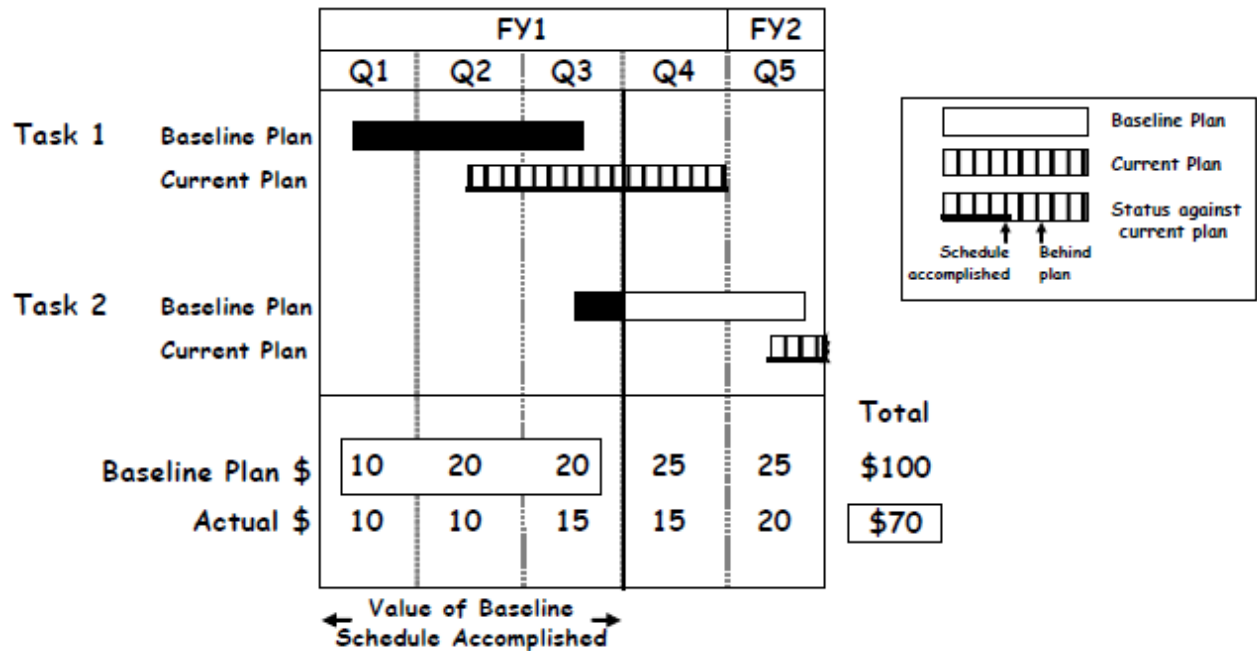


FIGURE 90. Determining CPI

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 159 of 230

The value of baseline schedule accomplished was \$50. The actual \$ spent during the 15 month window was \$70. The CPI is:

$$\frac{\text{\$ Value of Baseline Schedule Accomplished } \$50}{\text{Actual \$ Spent During the 15 month Window } \$70} = 71\%$$

In summary, the contractor completed only 50% of the work during the 15 month window partly due to the fact that he failed to spend the planned \$ and partly because of less than planned efficiency. The CPI suggests a 71% efficiency factor (71¢ accomplished for every \$1 spent). The low efficiency factor may have been due to government changes or contractor performance problems. The purpose of the measurement is not to assign blame or determine performance efficiency against the contract, but rather to provide insight into how I am progressing toward completing the project. In my career, a 71% factor suggests probable out year cost and schedule growth. When assessing plans, consider whether historical performance has been incorporated.

Ku-Band Example (cont'd)

Our examination of the Ku-Band example (Figure 91) indicates an SPI of 40% – 50% and a CPI of 50% – 67% depending on the weight assigned to test hardware vs. the Preliminary Design milestone. Normally, more weight is given to test hardware as a better indicator of true progress.

- a. We have pushed \$10M +/- into the future
- b. If we keep performing at a rate of 50¢ on the \$1, future cost could grow significantly

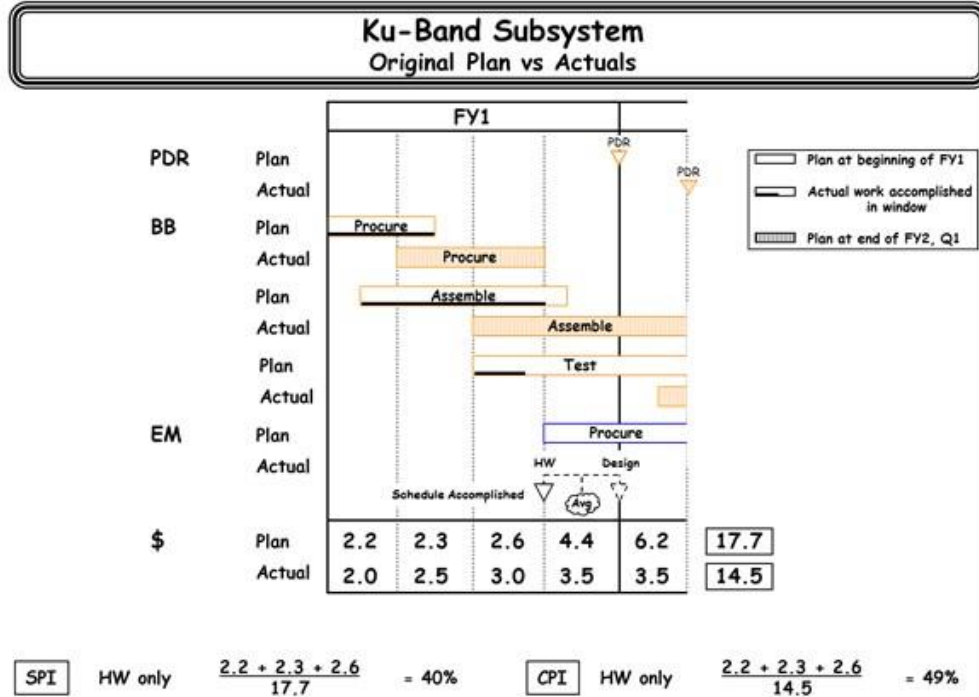


FIGURE 91. Ku-Band Example

Likely interpretation of Ku-Band status from the Prime

- 3 months behind on PDR
- Under running cost
- Cause of design instability solved
- Working to assess / mitigate schedule
- 90% + EV

Step 5 (and its subparts) addresses the full blown approach to measuring progress against the cost/schedule/metric plans at the key subsystem level. This level of analysis assures that the government meets the smart buyer test. Good analysis is half the job; communicating your findings concisely to a busy PM inundated with information overload is equally important. You must be able to get his/her attention if your analysis is to be utilized. Drift charts, as illustrated in Figure 92, have proven to be good eye catcher charts which are useful to get the right topics on the project/contractor meeting agendas.

Ku-Band Subsystem Drift Chart

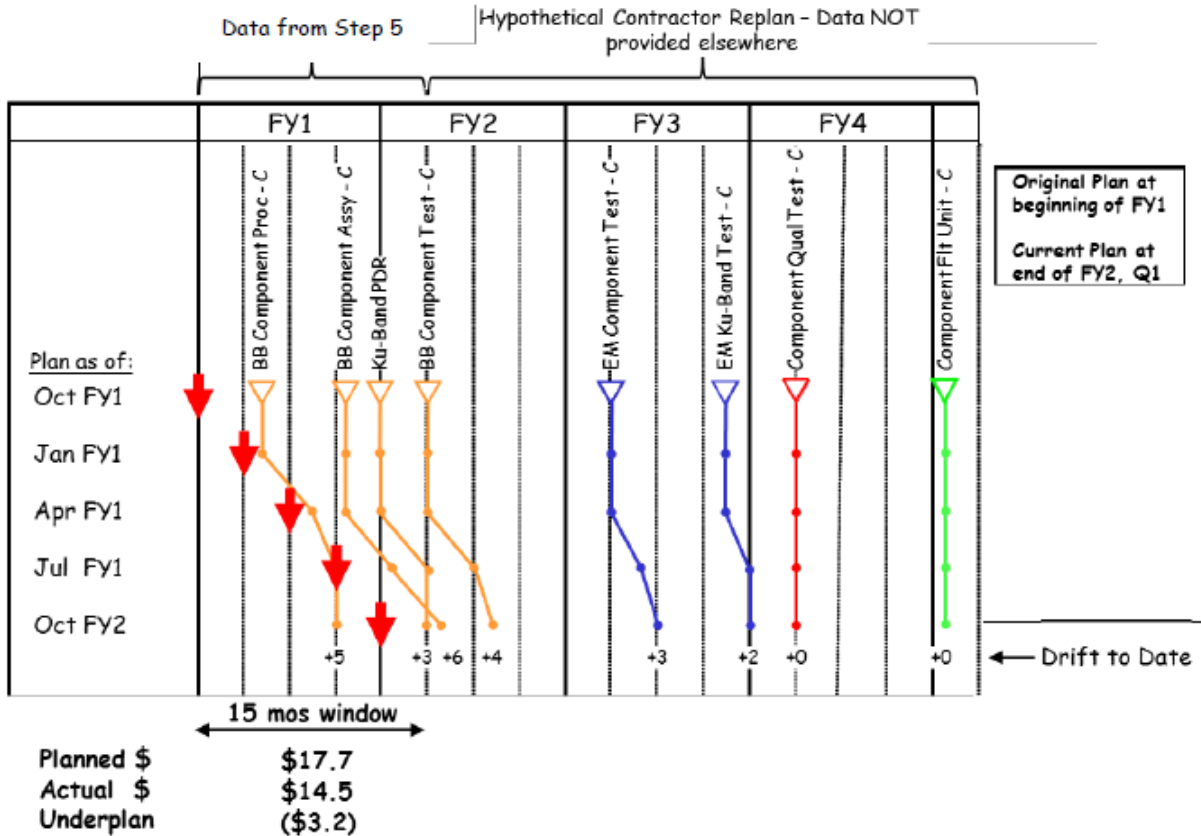


FIGURE 92. Drift Charts

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 161 of 230

Topics which should be a part of project/contractor discussions include the following:

- Performance during the first 15 months of contract indicates significant slippage of work—at least 6 months work pushed out in first 15 months of contract.
- Your plan indicates that you will recover schedule and complete Ku-Band qual and flight article delivery on time. Please discuss how you will accomplish this recovery including a discussion of risk/confidence in achieving recovery.

NOTE! The Drift chart approach may be employed at a more summary project (vs. subsystem) level to highlight changing risk/logic profiles.

As described on the previous page, the reason for the poor performance should be investigated to determine the risk inherent to the \$90M Estimate at Completion (EAC) (see Figure 87) and 3rd quarter FY5 Flight Article delivery.

Possible Ku-Band schedule mitigation candidates include:

- Utilization of EM hardware in the early spacecraft qual activities, and substitution of real qual hardware later (see Figure 93).

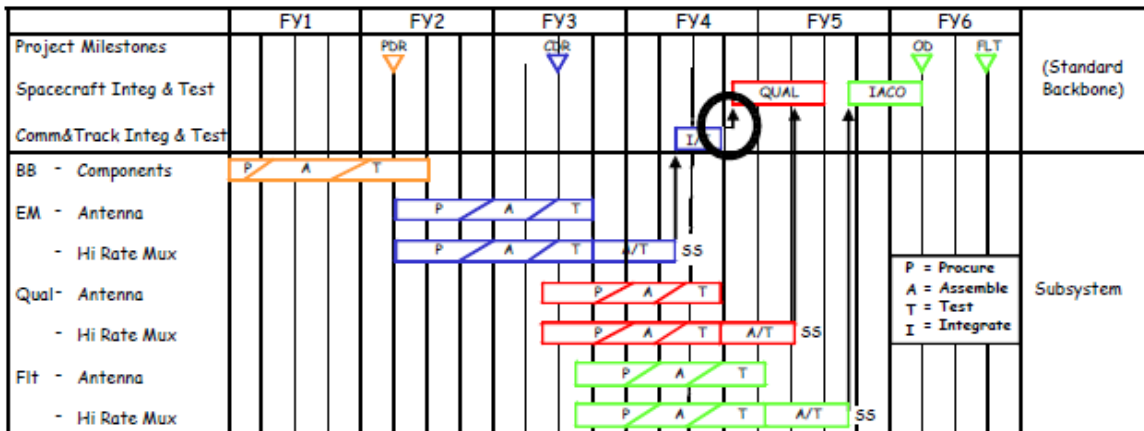


FIGURE 93. Mitigation Option: Use of EM for Early Qual Testing

- Accept more parallelism between EM and qual programs (i.e., move out with qual procurements as soon as EM procurements complete – see Figure 94).

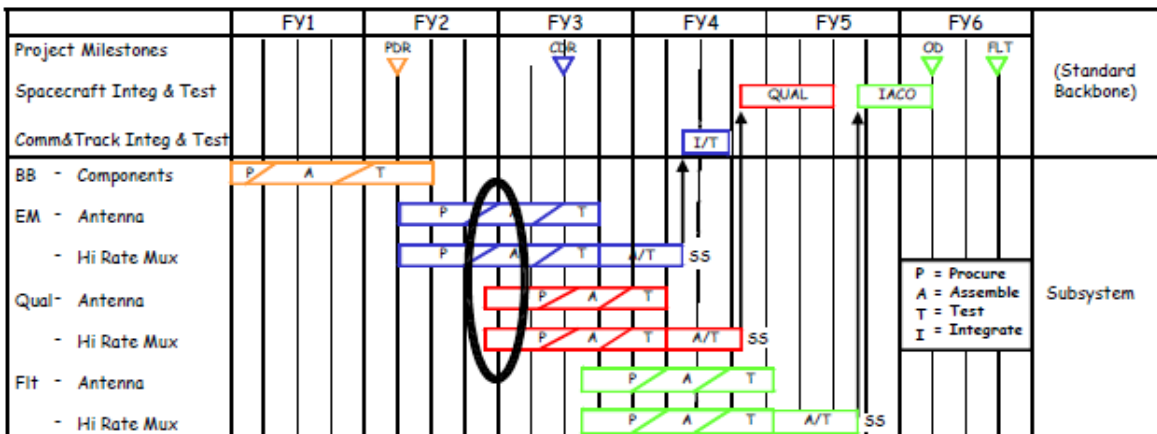


FIGURE 94. Mitigation Option: Early Build of Qual Article

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Possible Ku-Band cost mitigation candidates include:

- c. Use protoflight approach for Ku-Band subsystem, thus saving the cost of a flight hardware set (see Figure 95).

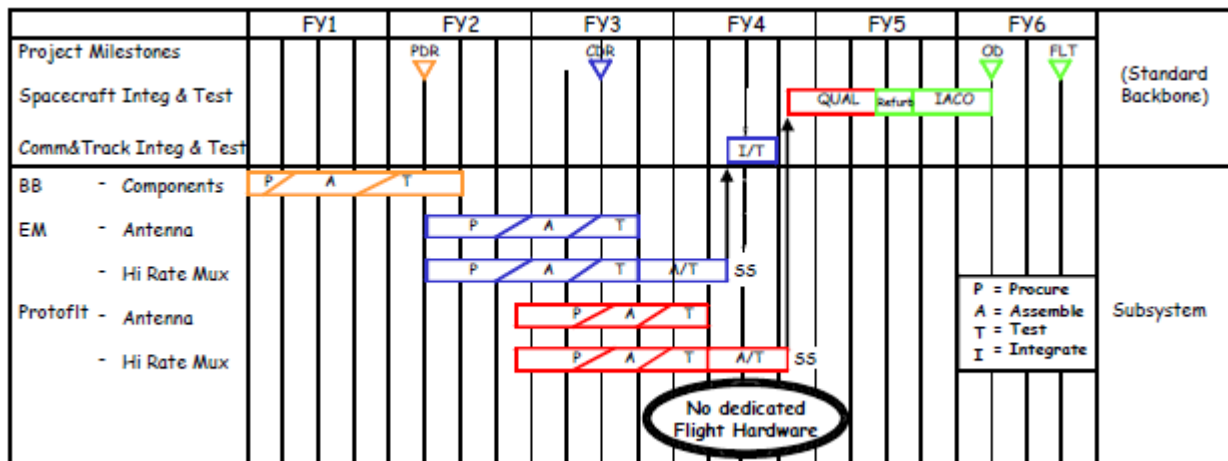


FIGURE 95. Mitigation Option: Early Build and Use of Protoflight Article

- d. Investigate possible deferral of requirements (e.g., early flights might not require full radiation protected hardware).

You are not presented with enough information to determine whether Ku-Band is an isolated problem within the project, or representative of a more generic problem across multiple subsystems. If the latter is true, the project may choose to pursue such mitigation approaches as:

- a. Use cost and schedule reserve if available
- b. Slip schedule
- c. Reduce or eliminate spacecraft level qualification testing (see Figure 96)

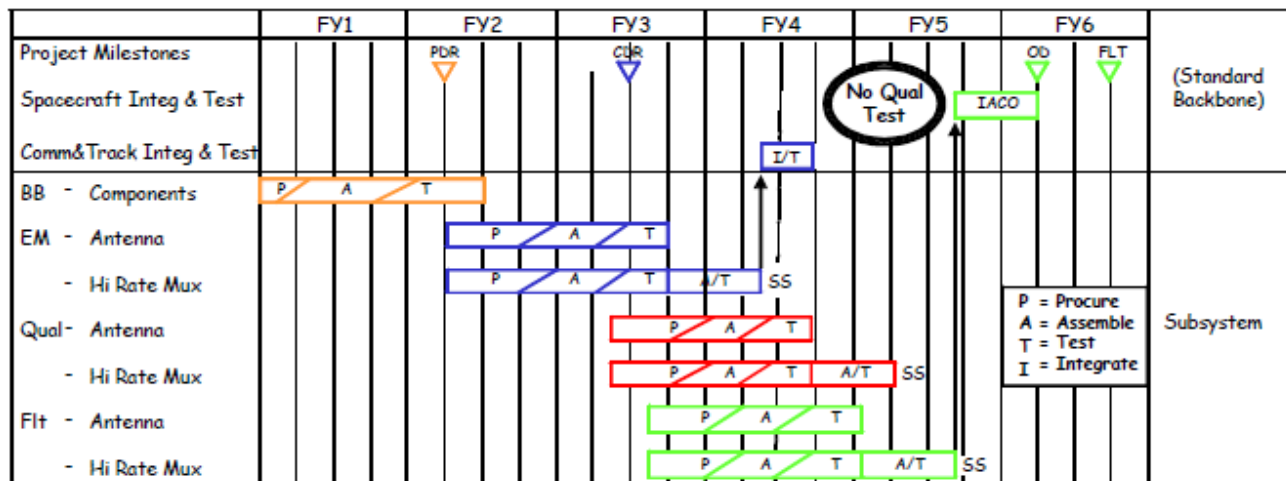


FIGURE 96. Mitigation Option: Reduce or Eliminate Qual Test

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 163 of 230

Step 6 – Working Reduced Funding “What If’s”.

Answering “What-If’s” concerning the cost and schedule impact of constrained budget scenarios is a common task for Project Planning & Control (PP&C). Often the answer is needed quickly. It is helpful to think of the total development cost as having two major components, time related (fixed) cost and variable cost, as illustrated in Figure 97.

Fixed vs. Variable Cost

1. Certain costs are related to time (fixed) rather than the shape of the development contract funding curve. These are:
 - Configuration Management
 - Business/Subcontract Management
 - Engineering skill base
 - Information Management
 - Etc.

2. The lower the total cost the higher the ratio! Early start up items are:
 - Configuration Management
 - Information Management
 - Project Management
 - SE&I
 - Etc.

3. Prior experience indicates fixed cost of ~30% at cost peak; higher percentage of total cost on either side of peak.

4. Certain fixed costs controllable up front but not after turn on (e.g., manufacturing group)

5. There is optimum shape for a development program. Flattening the program with funding constraints will stretch schedule, carry fixed/plateau cost for longer periods and may lead to inefficient utilization of variable cost. Note: Fixed cost at peak on optimum development contract will be higher if contract peak is artificially flattened.

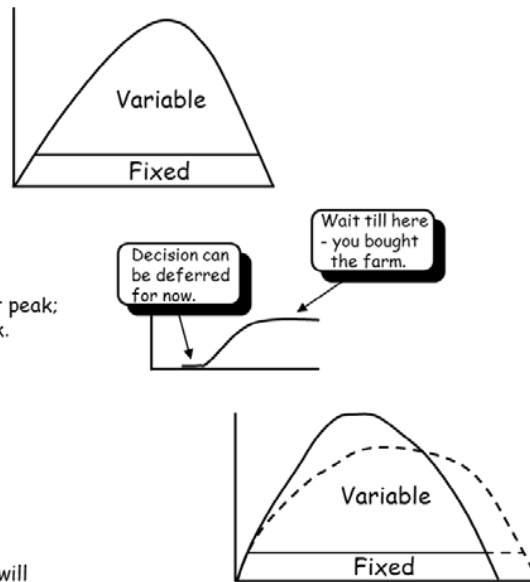


FIGURE 97. Impact of Constrained Funding on Fixed and Variable Costs

Ku-Band Example (cont'd)

The Ku-Band subsystem cost and schedule is stated in Figure 98.

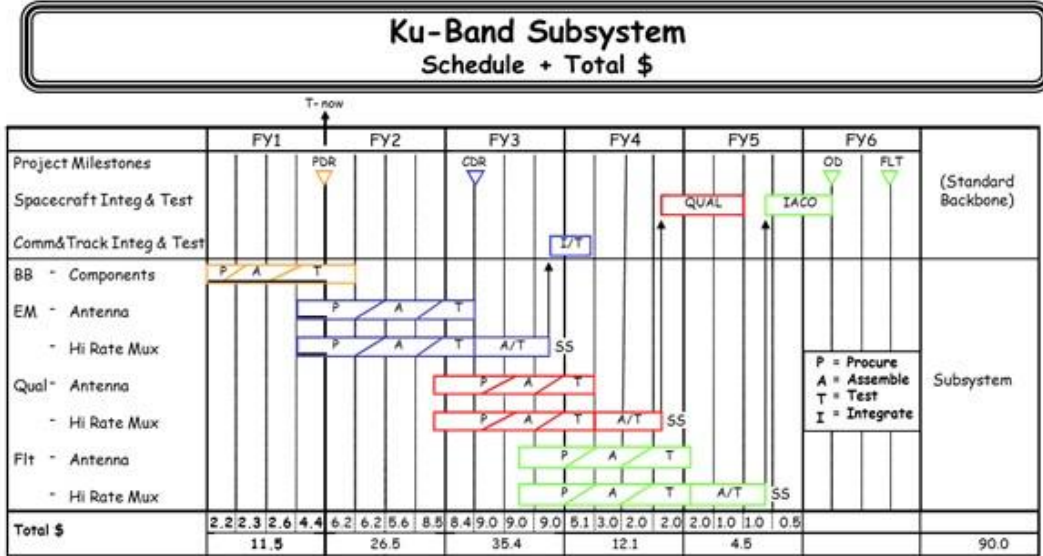


FIGURE 98. Status of Ku-Band Subsystem Cost and Schedule

The project actually incurred the \$11.5 million cost in FY1, however, headquarters has asked for the schedule impact of constraining the FY2 and out budget to a ceiling of \$16 million per year. The steps below illustrate a quick sizing approach to answering the question.

Step 6A: Convert the baseline cost plan from Real Year \$ to Constant Year (FY1) \$ (see Figure 99).

	FY1	FY2	FY3	FY4	FY5	Total
RYS	11.5	26.5	35.4	12.1	4.5	90
Conversion Factor	1	1.03	1.0609	1.0927	1.1255	
CY\$	11.5	25.7	33.4	11.1	4.0	85.7

(Assume 3% annual inflation in this example)

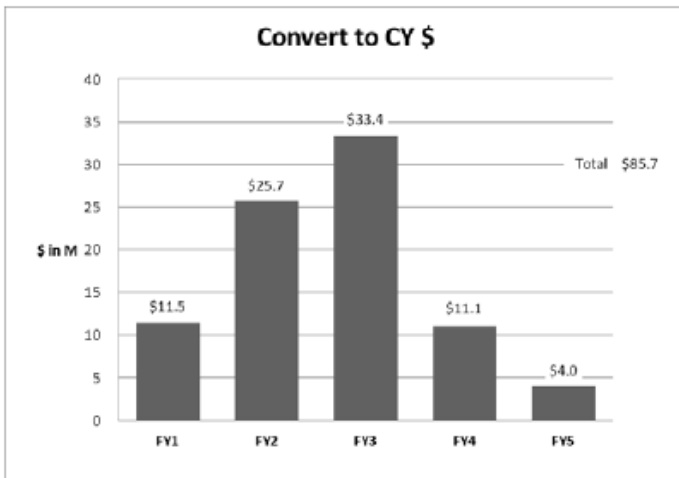


FIGURE 99. Baseline Cost Plan in Constant Year Dollars

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 165 of 230

Step 6B: Split the converted baseline plan \$ into fixed/variable costs (see Figure 100).

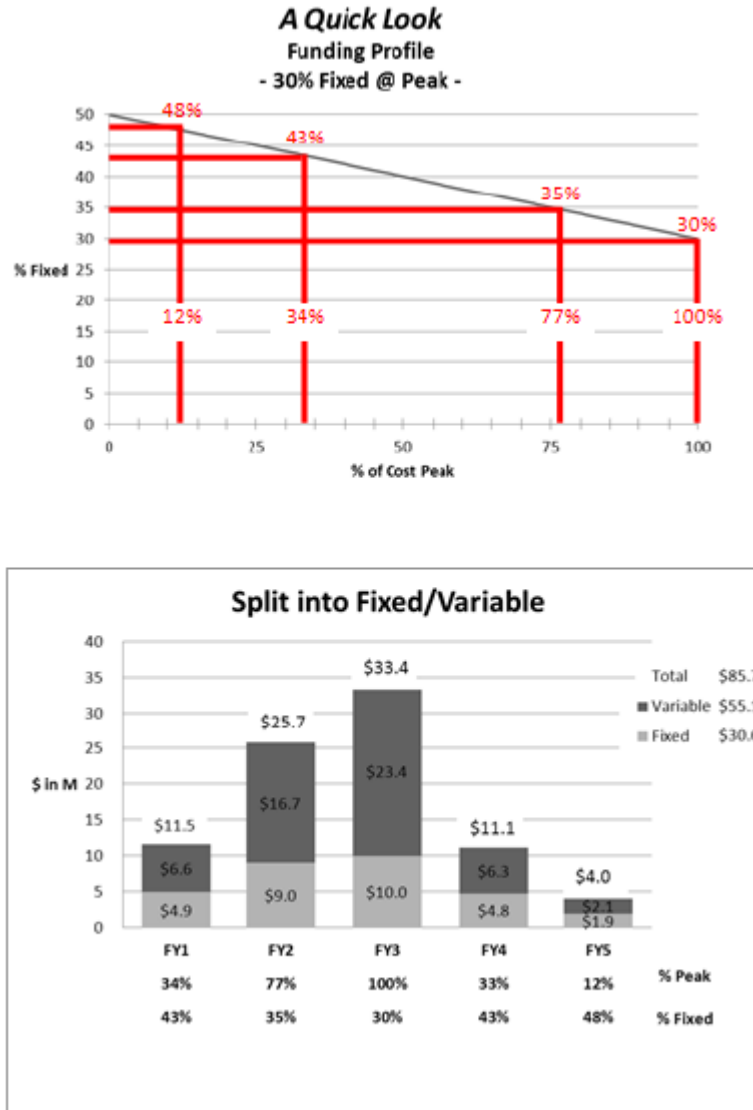
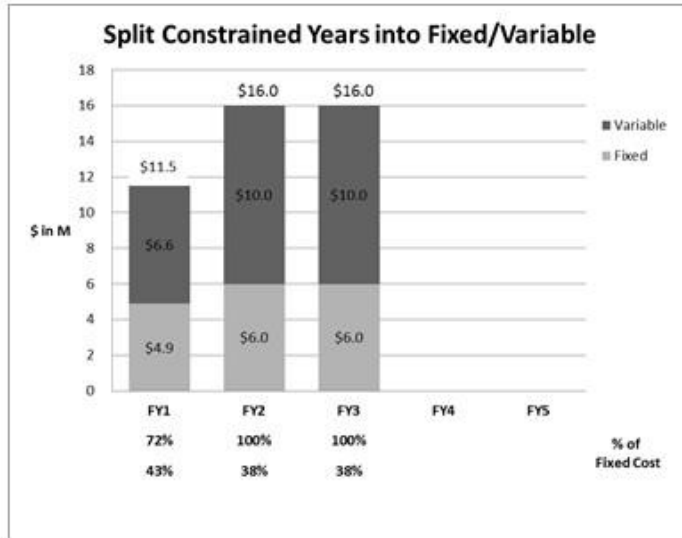


FIGURE 100. Baseline Plan in Fixed and Variable Costs

Step 6C: Determine the fixed and variable cost during the constrained years (see Figure 101).



(Derive % fixed from Quick Look Table on prior page.)

Note, do not achieve the 30% fixed cost ratio in the baseline plan due to reduced peak.

FIGURE 101. Constrained Years' Fixed and Variable Costs

Step 6D: Compute schedule loss due to variable cost constraint. Note, the capped peak effects FY2 and FY3; we need to determine how far down we are due to the constraint of the years (see Figure 102).

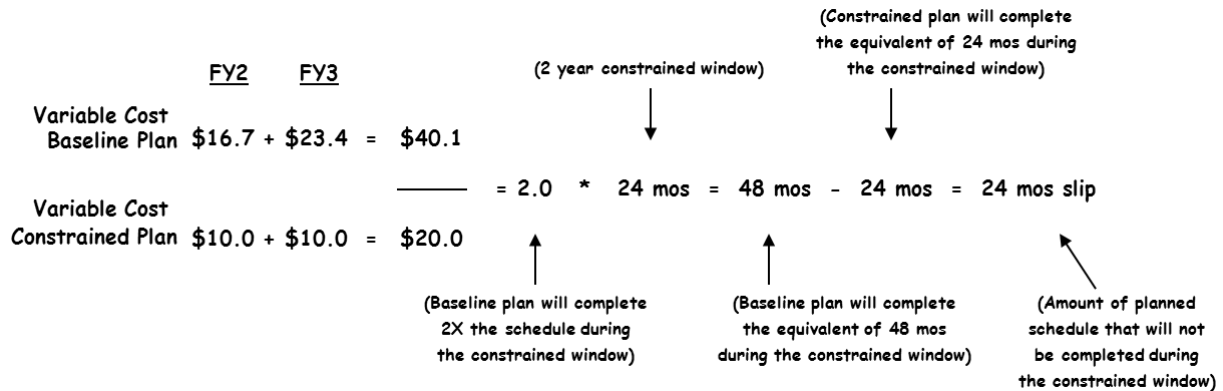


FIGURE 102. Computing Schedule Loss

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 167 of 230

Step 6E: Fill in the back end. Note, the amount you can spend is constrained by the tasks remaining as we near the end of the development phase (see Figure 103).

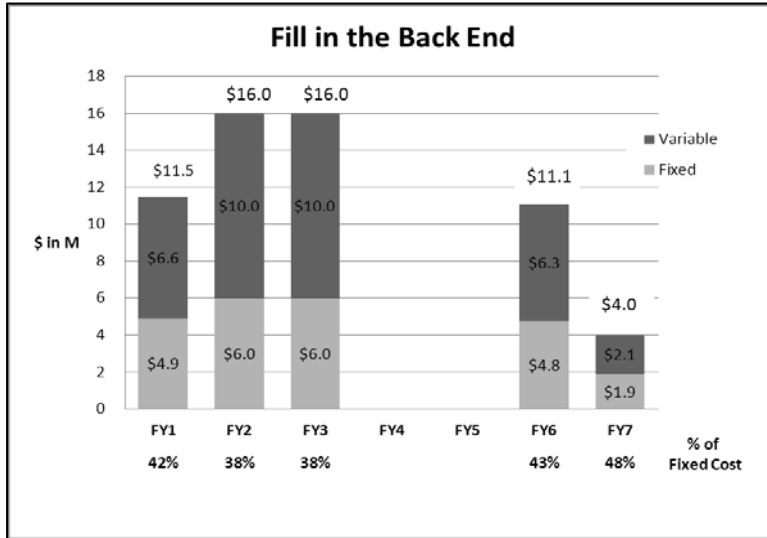
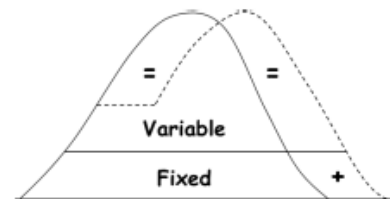
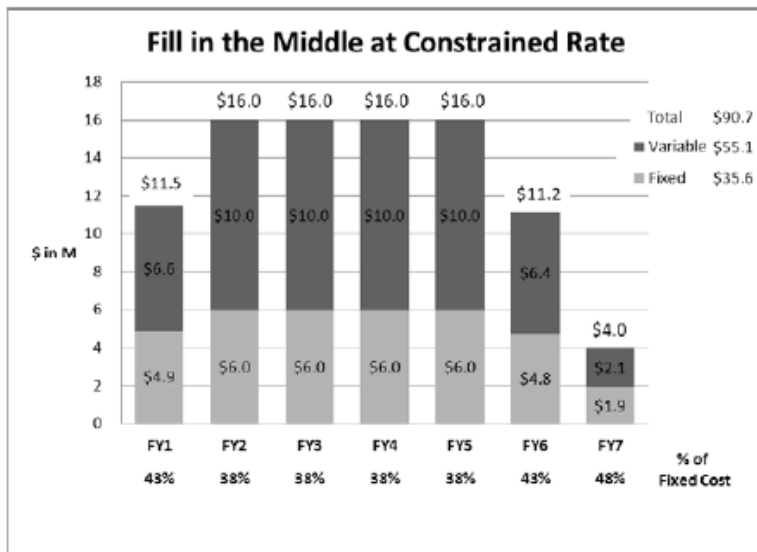


FIGURE 103. Filled in Back End

Step 6F: Fill in the middle by extending the fixed cost of \$6 million per year and allocating the remaining \$20.1 million variable cost which were constrained in FY2 and FY3 (see Figure 104).



Slip Schedule w/out
Fire and Rehire



Fixed Cost Increases
Variable Cost Rephased, but does not Increase

FIGURE 104. Filled in Middle

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Step 6G: Convert constrained plan back to Real Year \$ (see Figure 105).

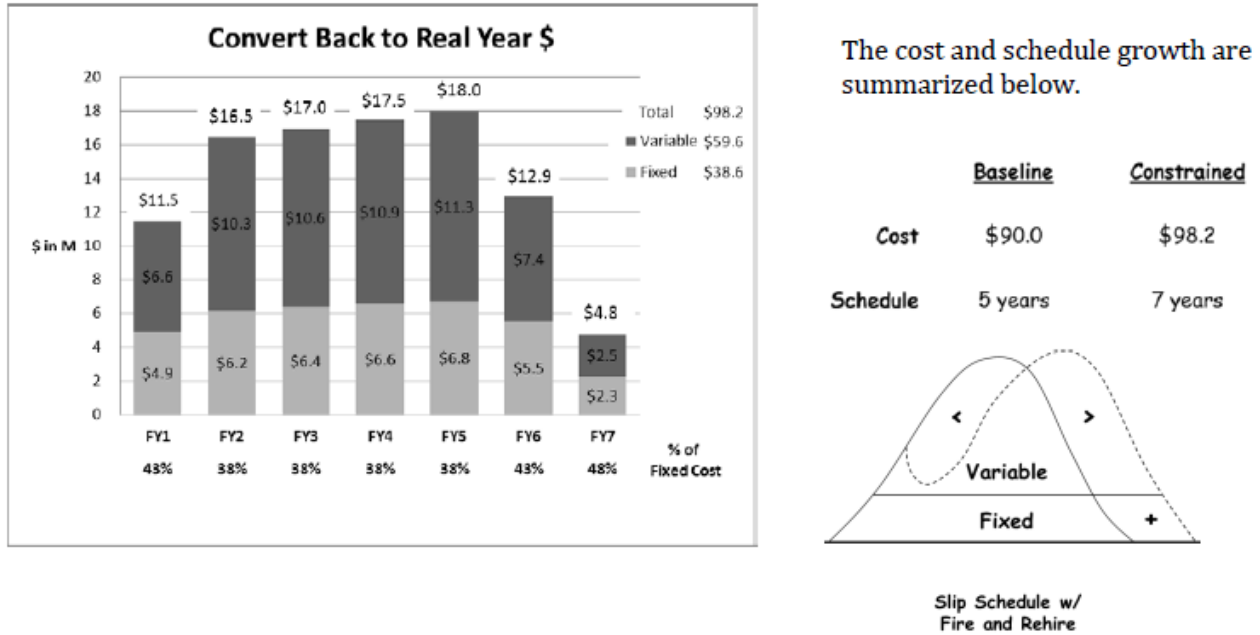


FIGURE 105. Conversion to Real Year Dollars

The cost growth is moderate in that the constraint did not require layoffs or termination costs; however, there is risk in the estimate due to potential vendor/prime gapping as illustrated below in Figure 106. The actual penalty will depend on how much flexibility the prime/vendors have to transfer skills back and forth to this contract.

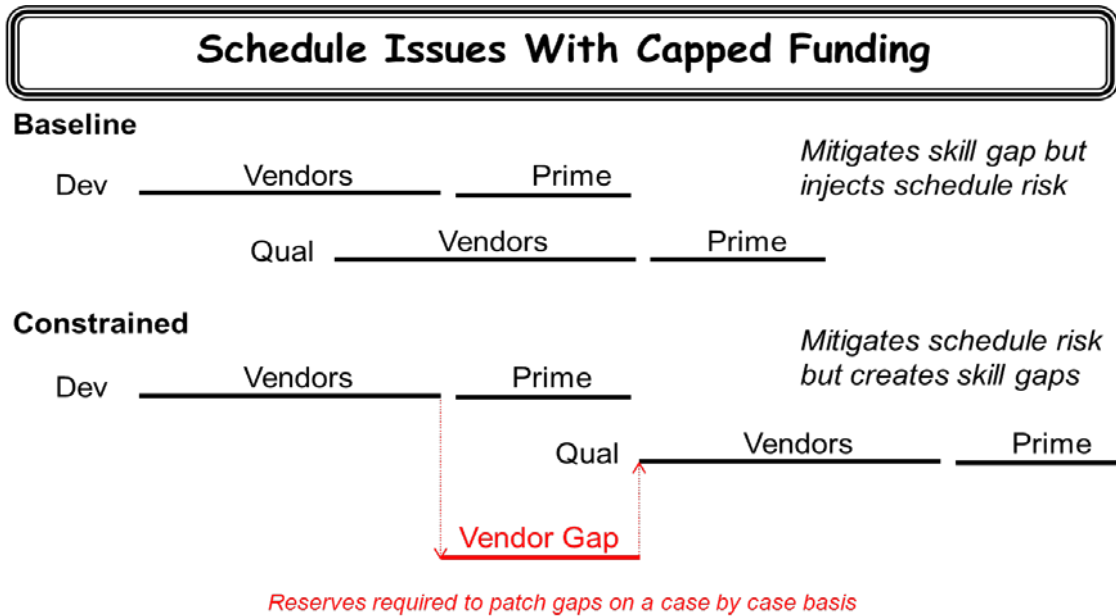


FIGURE 106. Schedule Issues with Capped Funding

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 169 of 230

Step 7 – Loaded Cost per Equivalent Person (EP).

The annual loaded cost to procure one contractor-provided EP varies from the \$100k to the \$300k range. Developing a set of expectations as to what cost to expect for a particular procurement, and the factors which can impact the cost from year to year will be discussed in this step. See the example illustrated in Figure 107 below.

**Administrative Support vs. Aerospace Manufacturing
Loaded Cost per Equivalent Person (EP)**

	Administrative ^(b)		Manufacturing ^(b)	
1. Direct Labor Hours in EP ^(c)	1840 hrs		1800 hrs	
2. Direct Labor Cost Per Hour ^(d)	\$30		\$40	
3. Overhead ^(e)	\$15	50%	\$80	200%
Fringes	\$9	30%	\$20	50%
Indirect Labor	\$3	10%	\$20	50%
Facility Related	\$3	10%	\$40	100%
4. Direct Labor + Overhead	\$45		\$120	
5. General and Administrative ^(f)	\$5	10%	\$18	15%
6. Total Cost w/out Fee	\$50		\$138	
7. Fee ^(g)	\$5	10%	\$13	10%
8. Total Cost + Fee	\$55		\$151	
9. Total Cost + Fee per Year ^(a)	\$101,200		\$271,800	

FIGURE 107. Variations in Full (Loaded) Cost for Different Labor Categories

- a. The difference in loaded cost for an administrative support contractor EP vs. the average cost of an EP in a development contractor manufacturing organization is illustrated. Note both the direct labor and overhead costs are higher for the manufacturing type. Direct labor cost is higher for the manufacturing type due to the training and skill level required; however, the difference in total loaded cost is compounded by the facility related/indirect labor cost required for design, test, and production of development hardware. A good rule of thumb for the cost of development contractors is 4 EP per million dollars vs. 8-10 EP per million dollars for administrative type contractors (offsite personnel will be a little more expensive than onsite personnel). In those instances where the development contractor operates out of government-owned facilities (e.g., external tank contractor), the rates will be lower as the government bears much of the facility related cost.
- b. In this example the administrative support person works in a government facility with government provided Information Technology (IT). The manufacturing type person represents a composite technician/manufacturing engineer who works in a contractor provided facility using contractor provided tools/support equipment/IT.
- c. The annual hours in an EP (Administrative support illustrated below) are determined by subtracting all leave from the total available work hours. If overtime is worked it is added to the hours in an EP; subsequently, any indirect hours worked are subtracted.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 170 of 230

Total Annual Available Work hours	2080
Less Leave hours	-160
Less Holiday hours	- 80

Hours in an EP	1840

- d. Direct labor cost per hour is determined by dividing the total annual salary by the annual available work hours. In the administrative type example the employee’s annual salary is \$62,400 ($\30×2080); the direct labor cost portion is \$55,200 ($\30×1840) with the remaining \$7,200 ($\30×240) charged to overhead.
- e. When conducting an overhead review always force the presenter to address overhead in the context of 3 categories (fringes, indirect labor, facility related), then drill down in each category until you are satisfied that the estimates are credible. Note, overhead percentages are expressed here as a percentage of direct labor base and represent the rate for a particular organizational entity at the division level of a corporation (see Figure 108).

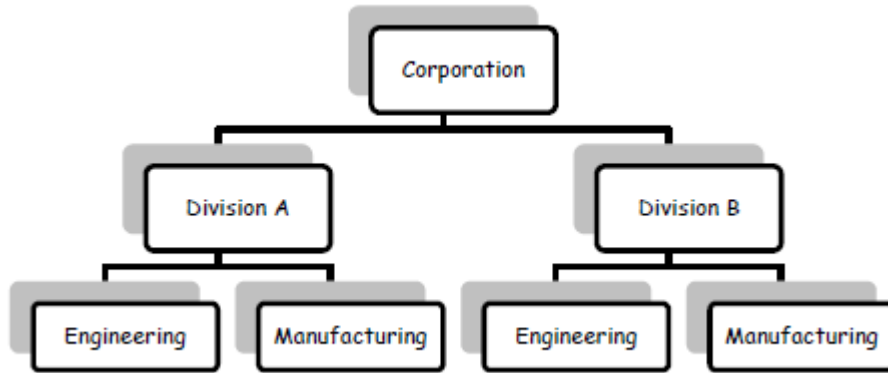


FIGURE 108. Overhead Rates Vary Between Corporate Divisions

When credibility checking a plan covering multiple years, be sure to force a discussion of planned business base projections vs. current year experience. In general, overhead rates go up when division business base declines and down when business base increases. Remember, division business base is the driver; your contract might or might not be a major driver in the contractor's overall division business base. Contractor's business base forecasts often contain questionable ground rules and assumptions which can be the source of sizeable budget uncertainty. NASA pays Defense Control Management Agency (DCMA) to oversee contractor’s rate forecast; however, don’t assume that it is unnecessary for you to be familiar with how the forward pricing rates were developed and the attendant risks/opportunities imbedded therein. You have the right to talk to both DCMA and your contractor about this subject.

- f. General & Administrative (G&A) expense includes three major components which are flowed down on a prorata basis to the divisions. The components are corporate management and services, bid and proposal (B&P), and independent research and development (IR&D) costs. Examples of corporate management and services are the President's staff, legal, and IT. B&P costs for all divisions and discretionary costs spent for advancing technology are pooled here.
- g. This represents prime contractor fee. In major development contracts, NASA normally uses cost-plus-award-fee (CPAF) type contracts. Maximum earnable fee ranges from 12-15%. Fee is normally accrued at a lesser rate with adjustments made periodically depending on the rate which has been earned by the contractor to date.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 171 of 230

In summary step, loaded cost for contractor labor can be a major source of budget uncertainty and should receive appropriate attention.

SOME PERCEIVED AND REAL PROBLEMS WITH IMPLEMENTING AN INTEGRATED COST/SCHEDULE/METRIC SYSTEM (ICSMS)

1. Problem — A costly set of cost/schedule/metric reporting requirements, especially at the subcontractor level, will be required.

Answer — This one is mostly perceived. 90% of the data needed to populate the ICSMS exists within the prime engineering and manufacturing organizations and respective subcontractors. They do not have to reformat the data, but rather provide it in the existing condition. It's not uncommon to take 30 pages of detailed schedule and convert to a one page summary, but the contractor is not the one doing the conversion.

2. Problem — The supporting data you need is not adequately managed and controlled. There may be a lag between the official plan and the one included in the organization and/or subcontractor cost/schedule/metric plans due to lag in flowing down contractual change direction.

Answer — This is real; however, these inconsistencies usually do not unduly distort the story.

3. Problem — The functional data on the 533 excludes large undistributed costs since the work is authorized but not negotiated. You are asking us to refine the estimate by breaking the cost into functional pieces.

Answer — Yes, we need your best guess; if you don't do it, we will guess. A plan does not have to await full contractual documentation.

3. Problem — You took our data and put it in another format. That is one more requirement on us to understand.

Answer — We are trying to set the right agendas and talk only about real issues. This process will make our communications more, not less efficient.

4. Problem — We should keep the focus on all areas. The one component you don't select may bite you.

Answer — This one is also perceived. We pay special attention to the drivers; however, we can still review a commonly produced contractor product such as the Hardware Utilization List to keep up with other components. For non-driver items we rely on the contractor to identify any forecast that does not meet need dates (see Figure 109 below).

Non-Critical Subsystem Matrix
Comm & Track - Video

Component Milestones			Engineering Model				Qual Model				Fit Unit - 1								
PDR	CDR	Qual	PO Release	PO Release	Promise Date to Lab	HW/SW Need	PO Release	PO Release	Promise Date to Lab	HW/SW Need	Qual AIP/Test	PO Release	PO Release	Promise Date to Lab	Fit - 1 AIP/Test				
			Promise	Need	Qty	Lab	Date			Qty	Lab	Date	AIP/Test	Date					
03/15/09	11/15/10	07/01/12	10/15/09	10/15/09	1	04/15/11	05/01/11	08/01/10	07/01/10	2	01/15/12	02/15/12	01/15/12	02/15/12	05/15/11	06/15/11	1	01/01/13	01/15/13

FIGURE 109. Non-critical Subsystem Matrix

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 172 of 230

5. Problem — We, the government, are too busy to keep up with another task. Our folks are swamped with classic contract/budget management tasks.

Answer - This approach does require effort; however, it will help focus us on the real problems and deflect effort from inconsequential ones.

6. Problem — This approach requires personnel with an engineering/technical background and I have a shortage of technical talent.

Answer — Technical background not required. Someone who is quantitative and curious about space systems and development processes fits the bill.

7. Problem — There will be resistance within NASA, as well as the contractor, to this or any other change. This is a difficult and sometimes confrontational task.

Answer — If there is strong leadership, mentoring, and commitment from the top, early warning /what if products will dramatically improve.

3.12.5.6 Estimate at Completion (EAC) Analysis Using Earned Value Management (EVM) Data

There are several EAC calculations that are used in the EVM analysis that are listed as follows:

$$EAC = \text{Actuals to Date} + \text{Work Remaining} \div \text{Efficiency Factor}$$

$$EAC_{\text{Composite}} = ACWP_{\text{CUM}} + (BAC - BCWP_{\text{CUM}}) \div (CPI_{\text{CUM}} * SPI_{\text{CUM}})$$

$$EAC_{\text{CPI}} = ACWP_{\text{CUM}} + (BAC - BCWP_{\text{CUM}}) \div CPI_{\text{CUM}}$$

ACWP – Actual Cost of Work Performed

BAC – Budget at Complete

BCWP – Budgeted Cost of Work Performed

CPI – Cost Performance Index

SPI – Schedule Performance Index

3.12.5.6.1 Estimate at Completion (EAC) Validity

Analysts should always test the validity of the EAC. A couple of ways to check the reasonableness of the EAC; 1) use a common sense approach, and 2) statistical analysis. In using the common sense approach the key question is does the revised EAC make sense? Using the chart below in Figure 110, let's determine if the EAC for the Work Breakdown Structure (WBS) 3200, Communication makes sense. The current EAC is 2,130, while the Budget at Complete (BAC) is 2,043, which is a difference of 87 and a projected overrun of approximately - 4.3%. The current Cost Variance (CV) is -30.8 or -18.49%, and the Schedule Variance (SV) is -203.2 or -22.31%. Analysts can also determine that the communications WBS element is approximately 35% percent complete by dividing the Budgeted Cost of Work Performed (BCWP) (work accomplished) of 707.4 by the original BAC of 2043.

**MSFC Technical Standard
CS40**

Title: Project Planning and Control Handbook

**Document No.: MSFC-HDBK-3684
Effective Date: September 25, 2017**

**Revision: A
Page 173 of 230**

/08 WBS Dollars :: Empower																			
WBS	Description	% CMP	ET	SV	CV	VAC	BCWS	BCWP	ACWP	SV	SV %	SPI	CV	CV %	CPI	BAC	EAC	VAC	
1000	MOH-2	32.94		↓	↓	→	7,278,600	6,850,800	7,349,800	-427,800	-5.88	0.941	-499,000	-7.28	0.932	20,796,200	20,761,000	35,200	
2000	PROJ MANAGEMENT	62.79		↓	↓	→	882,600	869,400	930,600	-13,200	-1.50	0.985	-61,200	-7.04	0.934	1,384,600	1,418,600	-34,000	
2100	PROJ MANAGEMENT	45.70		↓	↓	→	294,600	282,200	300,000	-12,000	-4.07	0.959	-17,400	-6.16	0.942	618,400	621,600	-3,200	
2200	SYS ENGINEERING	85.04		→	→	→	234,600	241,000	267,400	6,400	2.73	1.027	-26,400	-10.95	0.901	283,400	283,400	0	
2300	FUNC INTEGRA	71.62		↓	↓	→	353,400	345,800	363,200	-7,600	-2.15	0.978	-17,400	-5.03	0.952	482,800	513,600	-30,800	
3000	PRIME EQUIP	30.29		↓	↓	↑	4,809,200	4,424,400	4,792,000	-384,800	-8.00	0.920	-367,600	-8.31	0.923	14,606,400	14,915,400	-309,000	
3100	SENSORS	20.87		↑	→	→	397,400	360,800	371,400	-36,600	-9.21	0.908	-10,600	-2.94	0.971	1,728,400	1,750,000	-21,600	
3200	COMMUNICATIONS	34.63		↑	↓	→	910,600	707,400	838,200	-203,200	-22.31	0.777	-130,800	-18.49	0.844	2,043,000	2,130,000	-87,000	
3300	AUX EQUIP	27.57		↓	↓	→	759,800	666,600	588,400	-93,200	-12.27	0.877	78,200	11.73	1.133	2,418,200	2,409,800	8,400	
3400	ADPE	41.89		↓	↓	→	261,200	251,000	238,400	-10,200	-3.91	0.961	12,600	5.02	1.053	599,200	594,600	4,600	
3500	COMP PROGRAMS	46.46		→	→	→	88,000	87,800	84,400	-200	-0.23	0.998	3,400	3.87	1.040	189,000	190,400	-1,400	
3600	PCC	28.99		↓	↓	→	1,692,800	1,681,400	1,977,600	-11,400	-0.67	0.993	-296,200	-17.62	0.850	5,800,600	5,987,800	-187,200	
3700	DATA DISPLAY	41.13		↑	→	→	272,600	159,600	159,600	-113,000	-41.45	0.585	0	0.00	1.000	388,000	388,000	0	
3800	I & A	35.40		↓	↓	→	426,800	509,800	534,000	83,000	19.45	1.194	-24,200	-4.75	0.955	1,440,000	1,464,800	-24,800	
4000	SPARES	17.87		↓	↓	→	133,800	135,000	142,800	1,200	0.90	1.009	-7,800	-5.78	0.945	755,600	761,800	-6,200	
5000	DATA	72.60		→	↓	→	98,800	92,200	110,000	-6,600	-6.68	0.933	-17,800	-19.31	0.838	127,000	143,000	-16,000	
5100	ENG DATA	38.51		↓	↓	→	19,000	12,400	17,000	-6,600	-34.74	0.653	-4,600	-37.10	0.729	32,200	32,200	0	

FIGURE 110. EAC Comparison

Most analysts would conclude based on the data that it is unlikely this work will be completed with only a -4.3% cost overrun that is currently being reported. The conclusion is based on the current overruns for cost and schedule of -18.49 and -22.31, respectively. It is not impossible, however, so let us do another validity test using Earned Value Management (EVM) statistical data.

In Figure 111 is a portion of the six-period summary for the communications WBS that can be used to do a logic test of the current EAC.

ITEM	08/31/07	09/30/07	10/31/07	11/30/07	12/31/07	01/31/08
TCPI-BAC	1.007	0.999	1.020	1.066	1.065	1.109
TCPI-EAC	1.002	0.993	1.014	1.009	1.000	1.034
BAC	1,936,000	1,936,000	1,936,000	1,963,000	1,962,800	2,043,000
EAC	1,946,000	1,946,000	1,946,000	2,050,000	2,049,800	2,130,000
VAC	-10,000	-10,000	-10,000	-87,000	-87,000	-87,000
VAC %	-0.52	-0.52	-0.52	-4.43	-4.43	-4.26
% SCHED	9.61	15.13	17.05	27.66	36.23	44.57
% COMP	7.70	12.45	15.39	17.12	27.46	34.63
% SPENT	8.37	12.35	17.05	22.26	31.91	41.03
CUR CPI Fcst	2,358,521	1,657,641	2,945,053	5,018,290	1,954,812	2,518,011
3 PER AVG Fcst	2,154,066	1,924,687	2,217,442	2,829,647	2,477,340	2,496,119
6 PER AVG Fcst	2,132,956	1,926,566	2,157,663	2,601,068	2,312,417	2,457,483
CUM CPI Fcst	2,104,913	1,919,934	2,143,893	2,553,069	2,281,072	2,420,756
CPI*SPI Fcst	2,587,381	2,282,625	2,338,673	3,856,718	2,809,708	2,875,343
MICOM Fcst	2,622,388	2,290,688	2,353,922	3,934,288	2,851,066	2,922,620
COST & SCH Fcst	2,156,381	1,984,264	2,143,893	2,639,041	2,321,495	2,446,328
PERF FACTOR Fcst	1,949,000	1,934,000	1,968,000	2,064,000	2,050,200	2,173,800
User Entered EAC	0	0	0	0	0	0

FIGURE 111. EAC Using EVM Statistical Data

In this example, analysts should review the To-Complete Performance Index (TCPI), which is a mathematical formula used to calculate the future performance efficiency needed to complete the work using the BAC or EAC numbers. The TCPI-EAC in the last month of the report is 1.034. Remember with EVM anything less than 1 is assumed to be less efficient than planned and more than 1.0 more efficient. The 1.034 TCPI means

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 174 of 230

that for this work to be completed within the current EAC of 2.130 that the project will have to perform at an efficiency rate of 103.4% of the original plan. The current CPI is .844 and SPI is .777, which indicates poor performance with both cost and schedule up to this point. A rule of thumb is to compare the TCPI 1.034 versus the CPI .844, and if the difference between the two numbers are greater than .05 than the EAC is not reasonable. In this example, the difference is .19 so statistically the EAC for WBS 3200 is unreasonable and needs to be updated.

Using both the common sense approach and the statistical approach analysts can assume in this example that the EAC does not appear reasonable. This approach can be used in both developing an EAC and analyzing a project or contractor's EAC. In addition, the graphs and charts used in this example are available to analysts that have a project with the EVM requirement. To get access to Empower, see the *NASA EVM Implementation Handbook*, <http://evm.nasa.gov.handbook.html>.

In this discussion of the EAC the conversation has focused heavily on EVM analysis. The reason is that EVM integrates the technical work with the cost and schedule data and provides information that can easily be used for analysis. The use of these three components (technical, cost, and schedule) is very important in the analysis process, so using EVM data makes sense when it is present. When EVM reports are not available, however, then there are other techniques that analysts can use to develop an EAC. A key point is that all analysis should consider not only cost data, but also schedule status and what has been planned and accomplished to date.

3.12.6 Performance Reporting at Center Governing Councils and Related Committees

Governance is an integrated system of policies, process, accountability and implementation to ensure that organizational work and resources are aligned with the strategic goals of the Agency and Center to achieve mission success. MSFC uses governance to strategically plan and execute its program/project work and mission enabling functions in a manner that meets the goals and objectives of the Agency and Center. All components of the governance system operate in an integrated way to ensure alignment to the Agency and Center goals. Effective governance includes the following components:

- a. Executives and leadership who determine strategic direction and priorities and oversee the management system.
- b. Clear definitions of the level and scope of decision-making.
- c. A management system consisting of organizations and their charters, governing policies, procedures, standards, and tools supporting the analysis and management of resources.
- d. Mechanisms for monitoring and control; including audits (external and internal), performance objectives, plans and reviews, governing bodies, benchmarks, and special assessments or evaluations.

As illustrated in Figure 112, MSFC governs with three bodies with distinct charters and responsibilities — the Strategic Planning Council (SPC), the Center Management Council (CMC), and the Integrated Management System Council (IMSC). These governing bodies provide discussion forums for Center-level topics. The chairing executive of each council holds the ultimate decision-making authority for each council. Members of each council provide input for their area of expertise and advise the chairing executive during council discussions. Governing bodies provide transparency of activities and decisions across organizations and establish and communicate direction and priorities so that appropriate action is taken. Topics covered by governing bodies are those that generally require a high degree of visibility, integration, and approval to align the activities of organizations. Agendas are planned to focus executive attention of topics concerning strategic direction, technical execution and excellence, risk, and institutional health and effectiveness.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 175 of 230

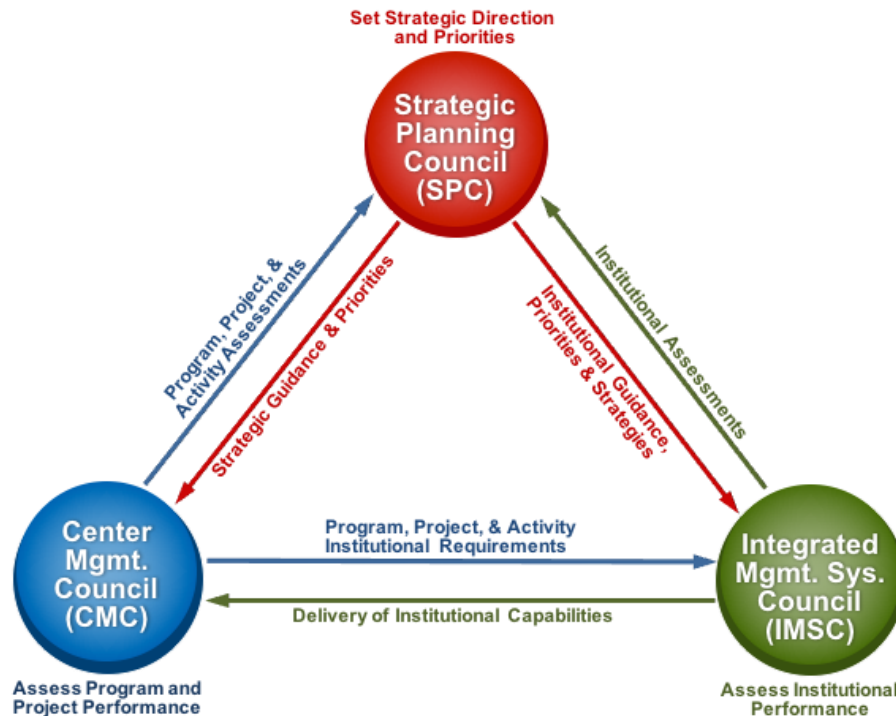


FIGURE 112. Center Governance Framework

Across MSFC, decisions are generally made at the lowest possible level. Line organization or project managers make decisions concerning budget, schedule, human resources, and infrastructure in order to support their assignments. Decisions that involve an organization’s internal alignment or execution to accomplish its charter and assignments are made by its executive. Decisions that concern an organization’s alignment or executive relative to the overall strategic direction are made between the Direct Report and the Center Director (or Deputy Director, and Associate Director by delegation). Decisions rendered by the chairing executive during a governing body meeting are generally only made as a last resort in the event that two organizations’ views conflict on the subject.

3.12.6.1 Strategic Planning Council (SPC)

The SPC provides a forum to establish Center strategic direction and priorities. The SPC responsibilities are defined in MPD 1150.1, *Establishment of Councils, Boards, and Committees*, and in Charter MC-25. *MSFC Strategic Planning Council*. The SPC considers topics such as (1) the Center’s business base and portfolio, (2) changes in organizational structure and management model(s), (3) strategic planning guidance, (4) strategic investments, (5) strategic make/buy acquisition policies and decisions, (6) product lines and priorities, (7) new business/ partnering activities, and (8) stakeholder and customer feedback and management. There are three committees that report to the SPC: The Technology Investment Advisory Committee (TIAC), the Innovation and Technology Advisory Committee (ITAC), and the Center Strategic Development Steering Group (CSDSG). The charters for these committees are online in the MSFC Integrated Document Library (MIDL).

3.12.6.2 Center Management Council (CMC)

The CMC provides a Center-level forum to evaluate technical performance of program and project work, and to ensure adequate technical resources are applied to meet program/project requirements and schedules. The operation of the CMC is described in MPR 7120.4, *MSFC Center Management Council Process*, and in Charter MC-08,

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 176 of 230

MSFC Center Management Council. The CMC evaluation focuses on whether management, engineering, SMA, and health and medical best practices are being followed by the program or project under review, and whether Center resources properly support program/project requirements. The CMC also assesses program/project risk, and evaluates the status and progress of activities to identify and report trends and provide guidance to the Agency and affected programs and projects. The CMC provides feedback and recommendations to the program/project and to the appropriate Agency Program Management Councils (APMCs) (when applicable) regarding the performance and technical viability of the program/project prior to Key Decision Points.

The CMC has four committees that report to it: the Engineering Management Council (EMC), SMA Council (SMAC), Technical Standards Document Control Board, and the Program/Project Management Advisory Council (PPMAC). The charters for these are online in the MSFC Integrated Document Library (MIDL). Relative to Project Planning & Control (PP&C), the committee of primary importance is the PPMAC, which provides a Center forum to address the integration of disciplines that are necessary to effectively execute its programs and projects. Specifically the PPMAC:

- a. Serves as the senior advisory body for all matters related to cross-cutting program and project management policy, including integration, assessment, initiatives, strategies, studies, improvements, and tailoring of program/project management processes, development of policy and requirements documents, and support to Agency-level activities.
- b. Provides a Center forum for developing and defining the Center’s approach to implementing programs and projects. The Council identifies the best management and organizational practices and lessons learned from across the Agency to improve Center program/project execution. The PPMAC assesses Agency program/project management policies, requirements, and guidance in the context of the Center culture to provide recommendations on compliant, integrated, Center-unique approaches to formulating and implementing programs and projects.
- c. Recommends approaches to continually develop the Center’s program/project management workforce. The PPMAC serves as the Center’s Program/Program Manager (PM) Certification Review Panel and Lessons Learned Committee.

3.12.6.3 Integrated Management Systems Council (IMSC)

The IMSC provides a forum to address institutional effectiveness and efficiency through on-going review and assessment of the overall health of the Center’s management system by providing a forum to discuss and assess strategies, plans, policies, and risk, especially as they impact the Center’s ability to support NASA’s strategic goals. The IMSC discusses issues and reviews topics related to the management system components that influence the Center’s delivery of products and services.

IMSC responsibilities are defined in Charter MC-21, *MSFC Integrated Management Systems Council*. The IMSC shall discuss and provide continual review of the Center’s management system components in the context of how they impact the Center’s ability to support NASA’s strategic goals and other federal initiatives and mandates. Components and elements appropriate for discussion and/or presentation include but are not limited to:

- (1). Structure and Organization: Organizational Components and Charters; Workforce Distribution and Management; Funds Management; and Sourcing Strategies.
- (2). People: Performance Management (includes behaviors); Development and Training; Workforce Alignment; Employee Welfare and Assistance; Recognition and Awards; Equal Employment Opportunity; and Cultural Assessment and Feedback.
- (3). Real Assets: Master Planning; Construction, Environmental, Compliance, and Restoration (CECR); and Maintenance and Repair.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 177 of 230

- (4). Monitoring and control: Internal Controls Identification and Assessment; Risk Identification and Mitigation; Compliance and Performance Audits; and Corrective Action/Continual Improvement.
- (5). Policies/Requirements/Processes/Systems: Agency/Center Policies and Processes; Agency/Center Directives System; Agency/Center Systems--other.

There are 10 committees that report to the IMSC: the Personnel Management Advisory Committee (PMAC), MSFC Facility Utilization Review Committee (FURC), MSFC Management Directives Control Board (DCB), MSFC Safety, Health, and Environmental (SHE) Committee, MSFC Information Systems Change Board, MSFC Business Management Committee (BMC), MSFC High Grade Position Review Committee, Center Events Management Board (CEMB), MSFC Information Technology Strategic Investments Board (ITSIB), and the Quality Management System (QMS) Steering Committee.

Relative to Project Planning & Control (PP&C), the main committee of focus is the BMC. The BMC provides a forum for addressing a wide range of business and financial management issues, planning schedules, Agency and Center business systems requirements, and policy guidance. The Office of Chief Financial Officer (OCFO) and Office of Strategic Analysis and Communication (OSAC) provide a means for sharing information, discussing issues, and developing recommendations to help ensure a common, integrated approach to business and financial management activities across the Center, consistent with Agency and Center policies and procedures. Discussions and assessments include the potential for continuous improvement implementations associated with business and financial management processes and practices to include integration of PP&C improvements, in conjunction with the Program/Project Management Advisory Council (PPMAC), as it relates to business management processes and practices, and provides MSFC with a forum to address the integration of disciplines that are necessary to effectively execute its programs and projects.

3.12.6.4 Other Center Reporting

The Center uses a variety of other forums, processes, and products to manage and ensure the successful implementation of programs, projects, and Center institutional capabilities. These range from regular program and project reviews and organizational status briefings to specific product reviews that are integrated and assessed to ensure the knowledge is disseminated properly.

3.12.6.4.1 Monthly Performance Reviews (MPRs)

Monthly Performance Reviews are conducted by each of the major program/project organizations at the Center, and these reviews are used to assess the technical performance of the programs and projects managed by these organizations. Program/project assessments of cost, schedule, workforce, risk, and management are also made, in addition to the integrated portfolio of the organization. Outcomes from the MPRs are sometimes brought to the Center Management Council (CMC) or Integrated Management Systems Council (IMSC), depending on the severity of the issue or ramification of the corrective action required.

3.12.6.4.2 Institutional Performance Review (IPR) Executive Presentation

The IPR Executive presentation was implemented to provide a more in-depth quarterly look at the Accomplishments, Issues, Risks, Goals/Initiative Progress, Workforce, Agency functional impacts, and Functional activities. Additionally, a quarterly Resources-IPR was implemented for the Functional Business managers to discuss functional performance to workforce and phasing plans on a quarterly basis. The integration of these processes allows for an on-going “health-assessment”. The sub-goals of the IPR presentation are for:

**MSFC Technical Standard
CS40**

Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 178 of 230

- To provide an Institutional Health Assessment on a quarterly basis regarding functional areas within the MSFC Center Management Operations (CMO) and Agency Management Operations (AMO) funding areas.
- For the continued communication of the overall Institutional performance to all managers and Center-level direct reports in a timely manner to create an actionable environment for meaningful decision making.
- To impart both a higher quality of data analysis and assessment regarding both Center and Agency-level activities to illustrate dependencies and connectivities not readily apparent within a performance dataset.
- To document on a regular basis Center risks, activities, goals, (Center & Agency), financial performance, and workforce planning for future analysis and insight.
- For the integration of all functional area performance to improve the efficiency in collecting he information, the integration of the data analysis, and the communication and utilization of functional management by the Center's organizational managers.

January – Unfunded Mandates by Functional Area

**note – these goals are draft and not necessarily actual*

Functional Area	Objective	Measure	Target	Current Status	Comments
ASST President Research & Dev	Research & Development (R&D) Program	Reduce R&D program and total R&D program	100%	100%	ASST President Research & Dev (ASST PR&D) is currently 100% funded. ASST PR&D is currently 100% funded. ASST PR&D is currently 100% funded.
ASST President Research & Dev	Research & Development (R&D) Program	Reduce R&D program and total R&D program	100%	100%	ASST President Research & Dev (ASST PR&D) is currently 100% funded. ASST PR&D is currently 100% funded. ASST PR&D is currently 100% funded.

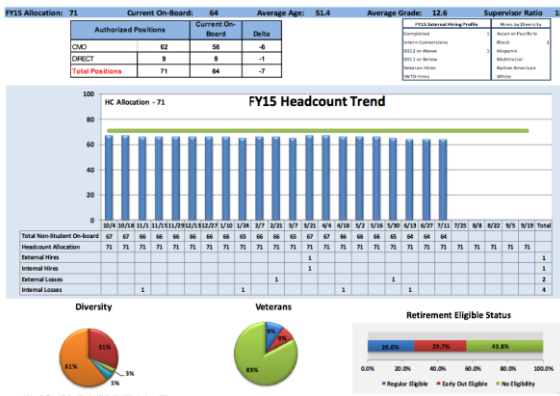
Draft, pre-decisional for NASA use only |

January – Performance Goals

**note – these goals are draft and not necessarily actual*

Goals and Initiatives	Reference Number	Scorecard Indicator	2014	2015	2016	Comments
ASST President Research & Dev (ASST PR&D) is currently 100% funded. ASST PR&D is currently 100% funded. ASST PR&D is currently 100% funded.	ASST PR&D	ASST PR&D	C	C	C	
ASST President Research & Dev (ASST PR&D) is currently 100% funded. ASST PR&D is currently 100% funded. ASST PR&D is currently 100% funded.	ASST PR&D	ASST PR&D	C	C	C	

Workforce Status (Representative Example)



**Executive Level Summary
Budget Received, Commitments, Obligations and Cost**

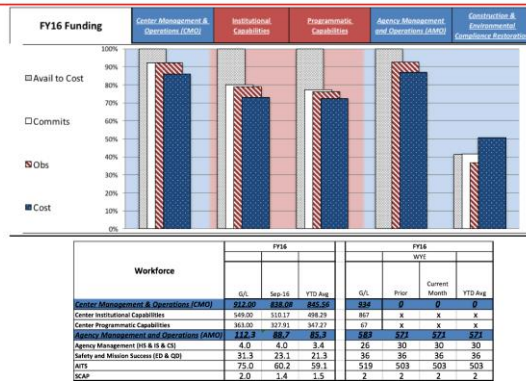


FIGURE 113 IPR Reports

3.12.6.4.3 Smartbooks

MSFC uses integrated monthly summaries (aka Smartbooks) to integrate and analyze detailed data and metrics from the programs/projects, mission support organizations, and committees. These integrated monthly snapshots are designed to provide integrated Center insight, promote more actionable information, provide a more systematic process for analyzing and reporting data, and influence both programmatic and mission support decision-making to maximize benefit to Center and Agency missions.

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 179 of 230

The Integrated Management Systems Council (IMSC) Smartbook was created to promote more actionable information, a more systematic process for analyzing and reporting data, and to influence mission support organizations' decision-making to maximize benefit to Center and Agency missions. The sub-goals of the Smartbook are for:

- a. Workforce Planning and Development - Size, shape, and cultivate the workforce to accomplish our present & anticipated missions.
- b. Infrastructure/Information Technology (IT) Management - Plan, operate, and sustain the infrastructure that provides program/projects with the facilities, capabilities, tools, and services required for mission success.
- c. Center Operational Processes, Practices & Systems -produce and integrate reliable timely information for efficient and effective resource management to benefit programs/projects and steward the public trust.
- d. Provide an integrated monthly snapshot of mission support performance and alignment to facilitate IMSC discussions.

Figure 114 displays a representation of the type of material displayed in the IMSC Smartbook.

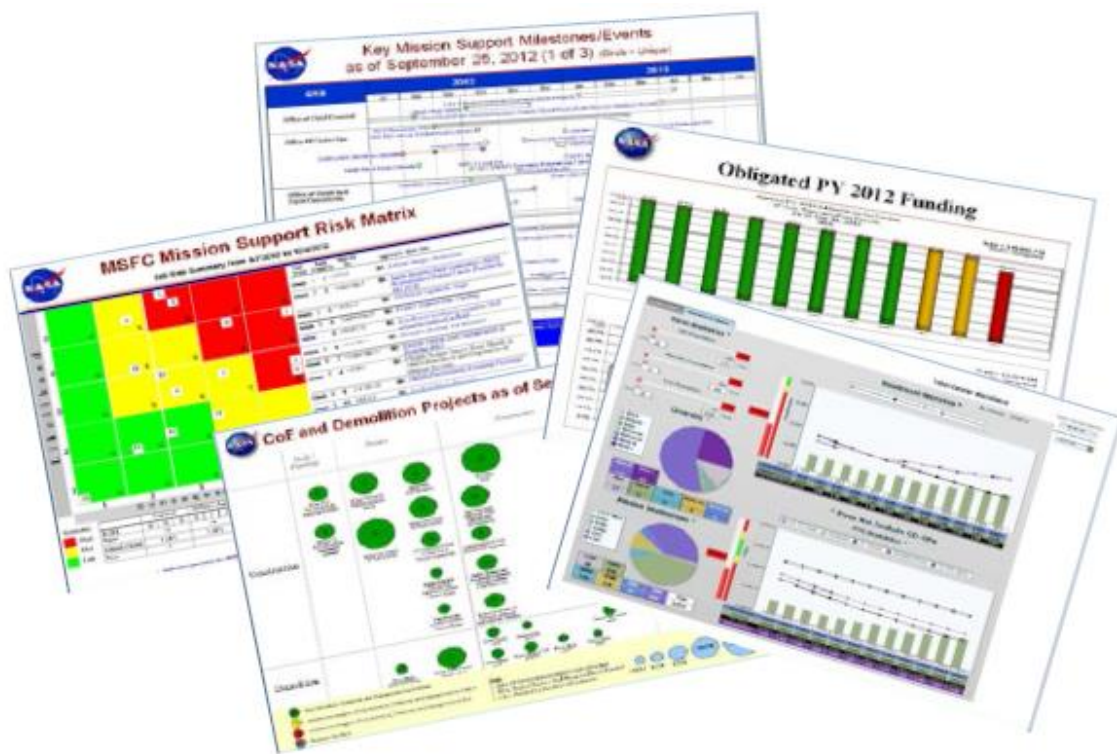


FIGURE 114. IMSC Smartbook Examples

3.12.6.5 Agency Governance

As illustrated in Figure 115, NASA governs with three Agency-level councils, each with distinct charters and responsibilities: the Executive Council (EC), the Agency Program Management Council (APMC), and the Mission Support Council (MSC). Each council has a unique focus. The EC focuses on major Agency-wide decisions; the APMC focuses on program and mission decisions, with emphasis on managing performance as programs reach Key Decision Points (KDPs), and the MSC focuses on mission-enabling decisions.

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 180 of 230

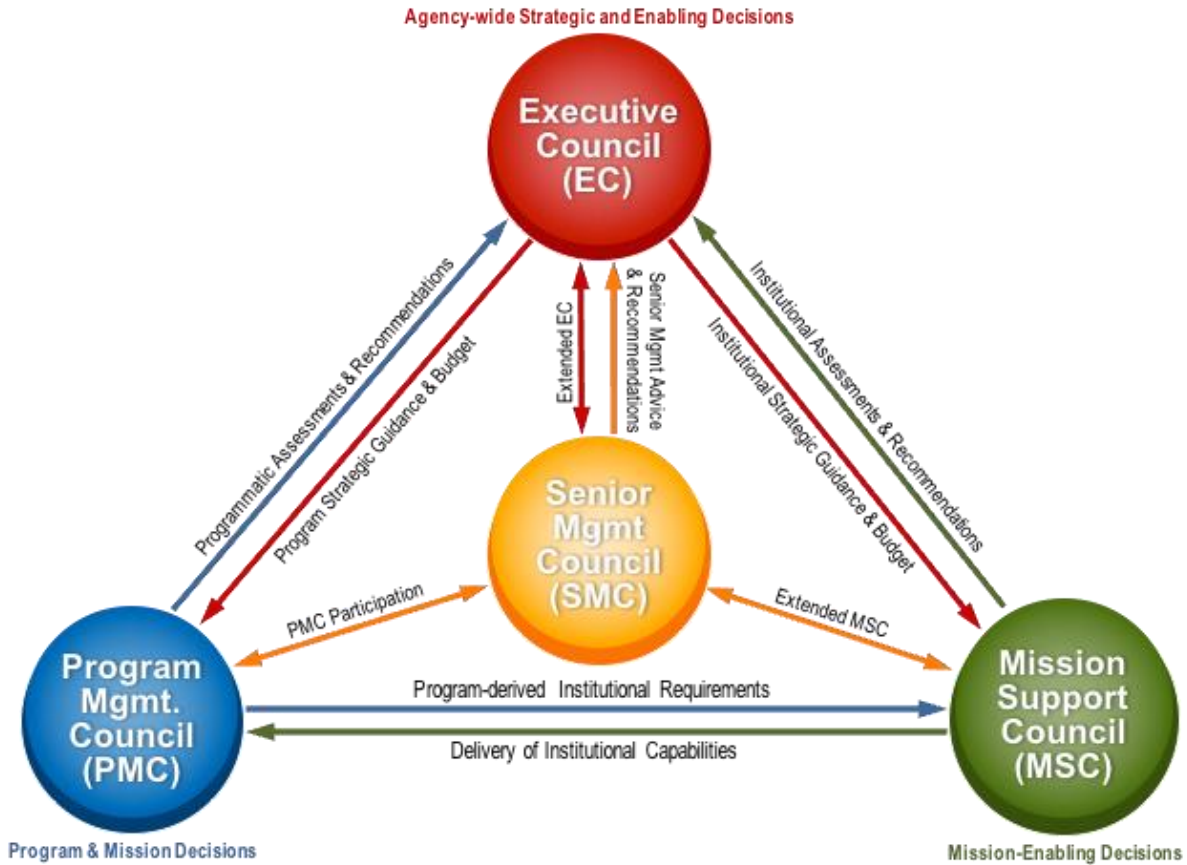


FIGURE 115. NASA Governance Framework

3.12.6.5.1 Executive Council (EC)

The EC determines NASA’s strategic direction, assesses Agency progress towards achieving the NASA vision, and serves as the Agency’s senior decision-making body for Agency-wide decisions. For topics dealing with Agency strategic direction and planning, the EC Chair may call a meeting of the Senior Management Council (SMC), which acts in the “extended EC” mode. Members of both Councils advise the Administrator in the Administrator’s capacity as Council Chair and decision authority.

3.12.6.5.2 Agency Program Management Council (APMC)

The APMC serves as the Agency’s senior decision-making body regarding the integrated Agency mission portfolio. The APMC baselines and assess performance of NASA projects, programs, Mission Directorate portfolios, and the integrated Agency mission portfolio to ensure achievement of NASA strategic goals. Council members serve as advisors to the Associated Administrator, who chairs the APMC and serves as the decision authority.

3.12.6.5.3 Mission Support Council (MSC)

The MSC serves as the Agency’s senior decision-making body regarding the integrated Agency mission support portfolio, and mission support plans and implementation strategies (including facility, infrastructure, technical capabilities and associated investments). The MSC determines and assess mission

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 181 of 230

support requirements to enable the successful accomplishment of the Agency’s mission. Council members serve as advisors to the Associate Deputy Administrator, who chairs the MSC and serves as the decision authority.

3.12.6.6 Other Agency Governance Forums

In addition to the three Agency management councils, other senior leadership forums are used to assess specific topics, and coordinate with the management councils on their findings and decisions where applicable.

3.12.6.6.1 Senior Management Council (SMC)

The SMC provides advice and recommendations to Agency senior leadership on key issues of the Agency. The SMC serves as an advisory body and provides a mechanism for discussion, clarification, and buy-in on key issues affecting the Agency. The SMC is convened by the Agency Chief of Staff and is chaired by the Administrator.

3.12.6.6.2 Partnership Council (PC)

The PC provides awareness and coordination of partnership issues to senior leadership before Agency commitments are made. The PC serves as a decisional body for partnerships that require a high degree of integration, are highly visible, or require an Agency-level affirmation of strategy. The PC is also tasked with improving and streamlining the Agency’s partnership approval process. The PC is chaired by the Administrator.

3.12.6.6.3 Directorate Program Management Council (DPMC)

Each Mission Directorate (HEOMD, SMD, and STMD) hosts its own Directorate Program Management Council (DPMC) which serves as the senior decision-making body regarding the integrated Directorate mission portfolio. Where authority is delegated by the APMC, each DPMC baselines and assesses performance on the Directorate programs, projects and missions to achieve Agency goals. Each DPMC is chaired by the Associate Administrator of the respective Directorate.

3.12.6.6.4 Agency Baseline Performance Review (BPR)

The BPR originated as a monthly topic in the Agency Program Management Council (APMC) called “State of the Agency,” and was expanded to include Mission Support activities after becoming a separate review from the APMC. The BPR serves as an informational body to manage the performance of Programs and Projects and is the culmination of all of the Agency’s regular business rhythm monitoring activities, providing ongoing performance assessment between Key Decision Points (KDPs). The BPR serves as the Agency’s monthly senior management review of performance integrating vertical and horizontal Agency-wide communication of performance metrics, analysis, and independent assessments. The BPR is chaired by the Associate Administrator, with the Deputy Associate Administrator as the co-chair.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 182 of 230

4. Project Planning & Control (PP&C) Training

4.1 Training Overview

MSFC has a tradition as a learning organization and of excellence in project management and program control. It is the intent of Center management that effective PP&C training and work experience will further the excellence of PP&C at the Center.

Professional development is a shared responsibility of the employee and supervisor. In order to design a successful career, employees need to take responsibility to create a career development plan and initiate actions that will lead them to their career goals. To optimize current and future employee contributions, supervisors and managers should be actively involved with their employees in developing their knowledge and experience. This assessment then leads to the generation of an individual development plan identifying work assignments and training that promote both MSFC and employees goals.

Professional development for an individual contributes to improved organizational performance. Establishing a program control experience workforce enables personnel to share tools that will provide an efficient and effective approach to the management of programs to ensure that the overall objectives of MSFC are accomplished.

Table II is a listing of MSFC PP&C courses for those who are new to the discipline or those wanting to enhance their PP&C knowledge and skills. It is not an all-inclusive listing of PP&C courses, SATERN and APPEL have additional courses that relate to the PP&C discipline as well. MSFC PP&C employees can register for these courses through SATERN, https://satern.nasa.gov/customcontent/splash_page/.

4.2 Training Courses

In an effort to provide robust training, the training below and additional training through Academy of Program/Project Engineering Leadership (APPEL), Defense Acquisition University (DAU), Chief Financial Officer (CFO) University, and other tailored training are being evaluated, and this portion of the document will be improved in another release of this handbook.

Table II. Training Courses at MSFC

Name	Description	Length	Responsible Org
Work Breakdown Structure (WBS)	This course will provide students with an overview of how WBSs are developed, their value and use. WBS types and techniques are emphasized, as well as the importance of the involvement of both technical and business personnel who support the project. This class will benefit anyone requiring a greater understanding of the WBS process, especially support team members for projects that are in the formulation phase.	4 hrs.	Office of Strategic Analysis and Communication (OSAC/CS40)

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 183 of 230

Planning & Scheduling	This course covers all aspects of planning & scheduling from A to Z. The students get an understanding of planning & scheduling, and then focus on specific areas like: Control Account Plan (CAP), Schedule Development, Resources, Critical Performance Measurement (CPM), Schedule Risk, Baselineing, Statusing, and Schedule Assessment. The course has several class exercises and acronyms/ terminology for student reference.	4 hrs.	OSAC (CS40)
Schedule Assessment & Analysis	The objective of this course is to provide a methodology for determining a schedule's credibility and usability for managing a project. To that end, this course will provide guidance in determining if a schedule is complete, has the correct basis and structure, determine schedule validity, and provide guidance in schedule analysis. The course is for both scheduler and non-scheduler personnel.	4 hrs.	OSAC (CS40)
Overview of Earned Value Management (EVM)	This course will cover the fundamental concepts of EVM. How work is planned (organized, budgeted, scheduled, Earned Value (EV) methods, etc.), and progress assessed will be covered. The importance and value of the Integrated Baseline Review (IBR) process will also be address. How EVM data analysis can improve project management will also be covered. EVM data analysis for addressing ongoing problems, as well as its usefulness for accurate forecasting of cost and schedule at completion of a project will also be taught.	4 hrs.	OSAC (CS40)
Integrated Baseline Review (IBR)	This presentation will cover what exactly is an IBR, and what it is not. We will discuss the NASA requirements for conducting an IBR and when it occurs based on the contract award date; training the NASA IBR team; assigning roles and responsibilities; information requirements, data gathering, and preliminary assessments; conducting a mock IBR and Project Control Account Managers (P-CAM) interviews; all the way to actually conducting the on-site IBR at the contractor facility; as well as follow-on activities. In addition, we will review example NFs, reports, and other documents.	1 hrs.	OSAC (CS40)

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 184 of 230

Project Performance Analysis	This course is intended to provide participants with an overview of “Project Performance Analysis” with an emphasis on detailed programmatic analysis and communication of results to project managers and other stakeholders responsible for making project decisions. Through lecture, individual exercises, team exercises, and a team case study, participants will gain knowledge of these specific focus areas: analyst responsibilities; understanding stakeholder expectations and requirements; performance analysis guidance, tools and techniques; recognizing various types of performance metrics.	12 hrs.	OSAC (CS40)
Earned Value Management (EVM) for Technical Managers/Project Control Account Managers (P-CAMs)	The course is designed to provide technical managers with information concerning: EVM concepts; Integration of cost and schedule; Means to quantitatively measure the performance of contracts and projects; Better independent projections of Estimate at Completion (EAC) costs; and the identification of risks. This course is meant for technical personnel who have not taken any of the other EVM courses offered at MSFC.	4 hrs.	OSAC (CS40)
Contract Administration	This is an introduction to the fundamentals of pre- and post-award processes, with a focus on project interfaces with the Contracting Officer (CO). The class will benefit anyone requiring a greater understanding of the contract administration process.	4 hrs.	Office of Procurement (PS)
Contract Costs	This course provides information on procedures used to analyze contractor’s cost proposals by discussing and describing the differences in direct costs and indirect costs.	4 hrs.	PS
Risk Management	The objective of the course is to provide an understanding of the concepts and principles of Continuous Risk Management (CRM), and to understand the considerations involved in planning and implementing CRM. The class will benefit anyone requiring a greater understanding of the CRM process.	1.5 hrs.	Office of Safety and Mission Assurance (OSMA/QD)
NASA / MSFC Budget Overview	NASA/MSFC Budget Overview will provide participants with an overview of the Agency's budget structure, key terminology, and budget formulation process. The class will benefit anyone requiring a greater understanding of the budget process.	4 hrs.	Office of Chief Financial Officer (OCFO/RS50)

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 185 of 230

Configuration and Data Management	<p>This course is one of the PP&C series and is an overview course that provides the participants with an introduction to the data management and configuration process performed at MSFC. Included in this course are data types, data management life-cycle, data manager's responsibilities, and MSFC requirements and processes. The class will benefit anyone requiring a greater understanding of the MSFC configuration and data management requirements and processes.</p>	4 hrs.	EE12
Introduction to MS Project 2010	<p>Students will get hands-on experience using the tool by learning how to navigate through the main features, and developing a simple schedule using proven scheduling techniques. The course covers the fundamentals of project management to set the stage for using the tool. Then the students will learn how to navigate through the menu, toolbar, and shortcut features, before developing a simple schedule from a task list, linking task/milestones, assigning resources, baselining, statusing, etc. The course is intended to provide a basic understanding of the tool (for non-schedulers) with the understanding that more advanced courses will be offered in the future to cover the many other features and functionality.</p>	4 hrs.	OSAC (CS40)
Intermediate MS Project 2010	<p>The students will receive hands-on experience using Microsoft Project 2010 and building on what they learned in the Introduction course. This course discusses more detail about resource loading and leveling schedules; customizing the schedules; more analysis - particularly critical path identification; determining the schedule drivers; and schedule maintenance and reporting.</p>	4 hrs.	OSAC (CS40)

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 186 of 230

4.3 Project Planning & Control (PP&C) Training Topics

As demonstrated by Figure 1, the PP&C discipline requires knowledge of many subjects (practically any function that could impact cost or schedule). Well-rounded PP&C analysts should have knowledge and an appreciation of all functions that interface or impact an activity or project's cost and/or schedule baseline. The following list of training subject areas is by no means complete. The intent is to stimulate analysts (and their supervisor) to consider functional areas where they might have limited knowledge and therefore be an area to explore in more depth through training courses. Training, by itself, has limited value unless it can be applied in an actual work situation, and therefore developmental assignments are critical in the development and retention of PP&C-related skills and techniques.

PP&C-Related Training Topics:

Organization

- a. Program/Project Plans, requirements, etc.
- b. Work Breakdown Structure (WBS) Development
- c. WBS Dictionary Purpose and Content Development
- d. Establishing a Dollarized Responsibility Assignment Matrix (RAM)
- e. Understanding the technical design process and how technical and programmatic requirements must be integrated to meet project objectives
- f. Program/Project Management, Systems Engineering, Configuration and Data Management, SMA, etc. Overviews

Accounting

- a. Federal Accounting Principles
- b. Understanding the NASA Accounting System
- c. Funds Control

Budget Development and Execution

- a. WA
- b. Principles of Budget Development
- c. Budget Validation
- d. Budget and Schedule Integration Techniques
- e. Techniques for Baseline Budget Control
- f. Best Practices for Managing the Budget
- g. Budget Analysis Techniques
- h. Workforce/Resource Planning
- i. "In-house" labor (contractor and civil servant) budgeting via the Collaborative Work Plan (CWP) process and tools

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 187 of 230

Acquisition & Contract Management

- a. Contract Acquisition Strategy, Planning, and Support
- b. Contract Administration
- c. Contract Rates
- d. Contract Change
- e. Contractor Reporting

Cost Estimating

- a. Developing the Basis of Estimate (BOE)
- b. The Bottoms-Up Estimate
- c. Parametric Estimating
- d. Cost Estimating Tools

Performance Measurement

- a. Assigning Performance Measurement Techniques
- b. Performance Measurement Baseline (PMB) Development
- c. Principles of Earned Value Management (EVM) Analysis
- d. EVM Practices for the Project Control Account Manager (P-CAM)
- e. EVM Reporting (Guidelines and Formats)

Schedule Management

- a. Scheduling Fundamentals
- b. Critical Performance Measurement (CPM) & Logic Network Scheduling Techniques
- c. Schedule Updates and Maintenance
- d. Grouping Tasks for Control Accounts (CAs), Work Packages (WPs), and Planning Packages (PPs)
- e. Critical Path Identification
- f. Schedule Resource Loading and Leveling
- g. Schedule Reporting (Guidelines and Formats)
- h. Schedule Baseline Maintenance and Control
- i. Structuring and Coding of Schedule Data
- j. Establishing and Managing Schedule Margin

Risk Management

- a. Risk Management
- b. Technical, Schedule, & Cost Risk Identification, Tracking, Mitigation
- c. Cost and Schedule Risk Assessment (C/SRA)

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 188 of 230

Configuration & Data Management

- a. Plans, requirements, Data Requirements Descriptions (DRDs), etc.
- b. Baseline Requirements (Identification, Control, Accounting, Verification)
- c. Baseline Change Management
- d. Information Systems (Hardware, Software, Databases, etc.)

Performance Analysis

- a. Cost, Schedule, & Technical Baseline Variance Analysis
- b. Schedule Trend Analysis
- c. Critical Path Analysis
- d. Schedule Analysis with EV Data
- e. Management Reserve and Schedule Margin usage Analysis
- f. EVM Analysis (Integrated Project Management Report (IPMR) Formats 1-7, Cost Performance Index (CPI)/Schedule Performance Index (SPI), Cost Variance (CV), Schedule Variance (SV), To-Complete Performance Index (TCPI)(Budget at Complete (BAC))
- g. Financial Analysis (NF 533)
- h. Workforce/Resource Analysis
- i. Reporting

Major Project Reviews

- a. Understanding and Development of Programmatic Review Documentation (Required Pre- and Post-Review)
- b. Preliminary Analysis and Programmatic Assessment of Review Findings to Support Project Management (PM) Decisions

Leadership

- a. Team-building and Motivation, Personnel Leadership and Performance Evaluation, and Delegation of Authority/Responsibility Skills
- b. Work Planning, Problem Assessment and Solving, Skills
- c. Mentoring, Training, and Career Development of Subordinates
- d. Managing Conflict in the Workplace
- e. Presentation Skills

Employees desiring training in any of these or other PP&C-related topics should contact their supervisor; who can then contact their assigned training consultant from the OHC Training and Incentives Office, HS40. Employees may register for courses related to many of these topics through the NASA System for Administration, Training, and Educational Resources for NASA (SATERN) training tool.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 189 of 230

5. Project Planning & Control (PP&C) Points of Contact

This chapter contains an incomplete list of reference websites cited in this handbook and various MSFC organizations that have expertise in one or more of the “PP&C disciplines,” as well as other disciplines that relate and interface with PP&C. This is not a complete or exhaustive list, but it is intended to provide users of this handbook with contacts to obtain assistance, guidance, and/or knowledge on a particular subject that they may be dealing with at any given time. This list will change handbook updates, as Center organizational changes occur. Figure 116 below revisits some of the many disciplines that interface with or make up or interface with the PP&C discipline.



FIGURE 116. Business Management Functions Utilized by MSFC Projects

5.1 Organizational References

PP&C Training: OHC Training and Incentives Office, HS40

Project Budgets: OCFO Budget Integration & Analysis Office, RS50

Funding/Accounting and Pricing: OCFO Accounting and Operations Office, RS20

Project Analysis: OSAC Performance and Capabilities Office, CS40; SLS PP&C Office, XP03

Mission Support Budgets: OCFO Mission Support and Integration Office, RS40; and Engineering Directorate Business Office, ED02.

EVM, Scheduling, and WBS: OSAC Performance and Capabilities Office, CS40; and SLS PP&C Office, XP03.

Parametric Cost Estimating: OSAC Engineering Cost Office, CS50

Risk Management: SMA Assessment and Assurance Branch, QD21; ED Spacecraft & Vehicle Systems Department, Technical Management Branch, EV71; and OSAC Performance and Capabilities Office, CS40

Procurement: Office of the Director of Procurement, PS01

Change Management: Engineering Directorate, Configuration and Data Management Office, EE12

Lessons Learned: Engineering Directorate, Systems Engineering Management Office, EE11

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 190 of 230

5.2 Electronic links to reference materials

The following websites were referenced in the body of this handbook, and are repeated here as a quick reference for the reader. These site references will likely change with each revision of this handbook, and additional information will be added as it is identified.

<http://evm.nasa.gov> (publicly accessible) or <https://nen.nasa.gov/web/pm/evm> (internal NASA; NASA Engineering Network) – access to EVM and scheduling tools such as “Cobra” and “STAT,” and access to handbooks (see below) and other related information.

<http://evm.nasa.gov/handbooks.html> (publically accessible) - The following documents are available through this site:

- *NASA Schedule Management Handbook*
- *NASA IBR Handbook*
- *NASA Work Breakdown Structure (WBS) Handbook*
- *NASA EVM Implementation Handbook*

<https://nen.nasa.gov/web/pm/evm> - Program and Project Management Community of Practice (various references), and the *NASA EVM System Description*

<http://www.ceh.nasa.gov> - *The 2008 NASA Cost Estimating Handbook*

<https://aim.msfc.nasa.gov/Dashboard/draw/> - Many accounting tools can be found in the Applications Inventory Module. Access to these systems can be requested through IdMAX at <https://idmax.nasa.gov/idm/user/dashboard/home.jsp>.

<http://cfo.msfc.nasa.gov/documents/RS01-OI-006.pdf> - MSFC-HDBK-RS01-01-006, *Collaborative Work Plan (CWP) Process and Requirements Handbook*

https://masterlist.msfc.nasa.gov/drm/drd_masterlist.taf - Listing of PP&C related DRDs (within the MSFC Integrated Library)

<https://cmstool.nasa.gov/> - NASA Competency Management System (CMS): a collection of business processes, data, and tools that are used to categorize, identify, measure, and forecast the Center’s corporate knowledge base. This web application allows the Center to collect, manage, and report on the workforce competencies as they relate to people, positions, and projects.

<http://llis.nasa.gov/llis/search/home.jsp>, and <https://nen.nasa.gov/web/ll/msfc> - access to the NASA LLIS search capability and MSFC lessons learned points of contact.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 191 of 230

Appendix A Acronyms

ACWP	Actual Cost of Work Performed
ANSI/EIA	American National Standards Institute /Electronics Industries Alliance
APMC	Agency Program Management Council
ARM	Active Risk Manager
ARS	Accounting Resources System
B&P	Bid and Proposal
BAC	Budget at Completion
BB	Breadboard Model
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
BCR	Baseline Change Request
BEI	Baseline Execution Index
BFAS	Budget and Funds Allocation System
BMC	Business Management Committee
BOE	Basis of Estimate
BPR	Baseline Performance Review
BURLS	Bottoms-up Resource Loaded Schedule
BW	Business Warehouse
CA	Control Account
CADRe	Cost Analysis Data Requirement
CAM	Control Account Manager
CAP	Control Account Plan
CBO	Congressional Budget Office
CDR	Critical Design Review
CERR	Critical Event Readiness Review
CES	Cost Element Structure
CFO	Chief Financial Officer
CGE	Concur Government Edition
CI	Contract Item
CM	Configuration Management
CMC	Center Management Council
CMM	Contract Management Module
CMO	Center Management and Operations
CMP	Configuration Management Plan
CMS	Competency Management System
CO	Contracting Officer
COR	Contracting Officer's Representative
COTS	Commercial-Off-The-Shelf
CPAF	Cost-Plus-Award-Fee
CPFF	Cost-Plus-Fixed-Fee
CPI	Cost Performance Index
CPIF	Cost-Plus-Incentive-Fee
CPM	Critical Path Method
CPR	Contract Performance Report
CR	Change Request
CRM	Continuous Risk Management
CS	MSFC Org Code for OSAC
CV	Cost Variance

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 192 of 230

CWP	Collaborative Work Plan
DA	Decision Authority
DCMA	Defense Contract Management Agency
DM	Data Management
DR	Decommissioning Review
DRD	Data Requirements Description
DRR	Disposal Readiness Review
DC	Design Cycle
DVTM	Development Verification Test Model
EAC	Estimate at Completion
eBud	MSFC Electronic Budgeting Tool
ECO	Engineering Cost Office
ECR	Engineering Change Request
ED	Engineering Directorate (MSFC Org Code)
EM	Element Manager
EM	Engineering Model (Section 3.12.5.5.2 only)
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
eMRPT	electronic Marshall Resource Planning Tool
EP	Equivalent Person (same as WYE)
ePORT	electronic Project Online Risk Tool
EPO	Education and Public Outreach
EPSS	Enterprise Performance Support System
ETC	Estimate to Complete
EUL	Enhanced Use Lease
EV	Earned Value
EVM	Earned Value Management
EVMS	Earned Value Management System
FAD	Formulation Authorization Document
FAR	Federal Acquisition Regulation
FOIA	Freedom of Information Act
FP	Fixed-Price
FPAF	Fixed-Price-Award-Fee
FPI	Fixed-Price-Incentive
FFP	Firm-Fixed-Price
FRR	Flight Readiness Review
FTE	Full Time Equivalent
FY	Fiscal Year
G&A	General and Administrative
GAO	Government Accountability Office
GPMC	Governing Project Management Council
GSE	Ground Support Equipment
HEOMD	Human Exploration and Operations Mission Directorate
HR	Human Resources
IA	Independent Assessment
IACO	Installation, Assembly, and Check-out
IAWA	Intra-Agency Work Agreement
IBR	Integrated Baseline Review
ICE	Independent Cost Estimate
ICSMS	Integrated Cost/Schedule/Metric System

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 193 of 230

IEM	Integrated Enterprise Management
IEMP	Integrated Enterprise Management Program
IMS	Integrated Master Schedule
IMSC	Integrated Management System Council
IPMR	Integrated Program Management Report
IPT	Integrated Product Team
IR&D	Independent Research and Development
IRMA	Integrated Risk Management Application (tool)
ISS	International Space Station
IT	Information Technology
I&T	Integration and Testing
JCL	Joint Cost and Schedule Confidence Level
KDP	Key Decision Point
LCC	Life-Cycle Cost
LLIS	Lessons Learned Information System
LOE	Level-of-effort
LRE	Latest Revised Estimate
MAF	Michoud Assembly Facility
MCR	Mission Concept Review
MDAA	Mission Directorate Associate Administrator
MdM	Metadata Manager
MDR	Mission Definition Review
MOP	Missions Operations Plan
MOU	Memorandum of Understanding
MPD	Marshall Policy Directive
MPR	Marshall Procedural Requirements
MR	Management Reserve
MRR	Mission Readiness Review
MS	Microsoft® (Software brand; e.g., <i>MS Project</i>)
MSFC	Marshall Space Flight Center
MWI	Marshall Work Instruction
N2	NASA Budget System
NAFCOM	NASA Air Force Cost Model
NASA	National Aeronautics and Space Administration
NDIA	National Defense Industrial Association
NEACC	NASA Enterprise Applications Competency Center
NF	NASA Form
NF533M	NASA Form 533 - Monthly
NF533Q	NASA Form 533 – Quarterly
NFS	NASA FAR Supplement
NOA	New Obligation Authority
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
NSM	NASA Structure Management
OBS	Organization Breakdown Structure
OCE	Office of the Chief Engineer
OCFO	Office of the Chief Financial Officer
OCIO	Office of the Chief Information Officer
ODC	Other Direct Costs
ODEO	Office of Diversity and Equal Opportunity
OHC	Office of Human Capital

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

**MSFC Technical Standard
CS40**

Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 194 of 230

OMB	Office of Management and Budget (Executive Office of the White House)
OP	Office of Procurement
OPR	Office of Primary Responsibility
ORR	Operational Readiness Review
OSAC	Office of Strategic Analysis and Communications
PAA	Program, Analysis and Alignment
PAIG	Programmatic and Institutional Guidance
PBB	Project Budget Base
PCA	Program Commitment Agreement
PCB	Project Control Board
P-CAM	Project Control Account Manager
P-Card	Purchase Card
PDLM	Product Data and Life-cycle Management
PDM	Program Decision Memorandum
PDR	Preliminary Design Review
PFAR	Post-Flight Assessment Review
PIMS	Program Integrated Master Schedule
PIR	Program Implementation Review
PLAR	Post-Launch Assessment Review
PM	Program/Project Manager
PMB	Performance Measurement Baseline
PO	Performing Organization (Purchase Order in Section 3.12.5.5 only)
PP&C	Program/Project Planning and Control
PP	Planning Package
PPBE	Planning, Programming, Budgeting, and Execution
PPMAC	Program/Project Management Advisory Committee
PR	Procurement Requisition
PRG	Program and Resource Guidance
PRR	Program/Project Requirements Review
P/S	Planner/Scheduler
PSM	Procurement Strategy Meeting
QMS	Quality Management System
R&D	Research and Development
R&T	Research and Technology
RAM	Responsibility Assignment Matrix
REDSTAR	Resource Data Storage and Retrieval
RFP	Request for Proposal
RIDM	Risk-Informed Decision Making
RMP	Risk Management Plan
ROM	Rough Order of Magnitude
SMA	Safety and Mission Assurance
SAA	Space Act Agreement
SAP	System Application Products (NASA Accounting System software package)
SAR	System Acceptance Review
SDR	System Definition Review
SEB	Source Evaluation Board
SEC	Source Evaluation Committee
SHE	Safety, Health, and Environmental
SIR	System Integration Review
SIRMA	Shuttle Integrated Risk Management Application (tool)
SMD	Science Mission Directorate

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 195 of 230

SME	Subject Matter Expert
SO	Sponsoring Organization
SOW	Statement of Work
SPC	Strategic Planning Council
SPI	Schedule Performance Index
SRA	Schedule Risk Assessment
SRB	Standing Review Board
SRR	System Requirements Review
STAT	Schedule Test and Assessment Tool
SV	Schedule Variance
SWP	Strategic Workforce Planning
TCPI	To-Complete Performance Index
TCS	Thermal Control System
TD	Technology Development
TM	Task Manager
TPM	Technical Performance Measure
TRL	Technology Readiness Level
UFE	Unallocated Future Expenditures
VAC	Variance at Completion
VS	Verification Cycle
WA	Work Authorization
WAD	Work Authorization Document
WBS	Work Breakdown Structure
WebTADS	Web-based Time and Attendance System
WIMS	Workforce Integrated Management System
WP	Work Package
WYE	Work-Year Equivalent

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 196 of 230

Appendix B Glossary of Terms

Acceptable Risk: The risk that is understood and agreed to by the project, Governing Project Management Council (GPMC), Mission Directorate, and other customer(s) such that no further specific mitigating action is required. (Some mitigating actions might have already occurred.)

Accrual Basis: Revenues are recorded in the accounts when earned and expenses are recorded when incurred, even though disbursements and collections are not recorded until funds are paid and collected. Use of accrual accounting enables MSFC's management to more accurately measure the Center's performance and financial position using the financial data available

Acquisition: The acquiring by contract, with appropriated funds, supplies or services (including construction) by and for the use of the Federal Government through purchase or lease, whether the supplies or services are already in existence or must be created, developed, demonstrated, and evaluated. Acquisition begins at the point when Center needs are established, and includes the description of requirements to satisfy Center needs, solicitation and selection of sources, award of contracts, contract financing, contract performance, contract administration, and those technical and management functions directly related to the process of fulfilling Center needs by contract.

Acquisition Planning: The process by which the efforts of all personnel responsible for an acquisition are coordinated and integrated through a comprehensive plan for fulfilling the Center need in a timely manner and at a reasonable cost. It includes developing the overall strategy for managing the acquisition.

Activity: Efforts that support MPR 7120.1-defined programs or projects that meet any one of the following conditions: multi-mission directorate collaborative efforts, greater than \$1 million budget in any one year, greater than \$10 million Life Cycle Cost (LCC), or high priority to the Center.

Agency Program Management Council (APMC): The senior management group, chaired by the NASA Associate Administrator or designee, responsible for reviewing formulation performance, recommending approval, and overseeing implementation of programs and Category 1 projects according to Agency commitments, priorities, and policies.

Approval: Authorization by a required management official to proceed with a proposed course of action. Approvals must be documented.

Appropriations: Congressional bill which provides budget authority to agencies (how much and for what). Allows an agency to incur obligations.

Authorization: Congressional bill which provides the authority for NASA to expend resources. Authorization laws have two basic purposes: (1) establish, continue, or modify federal programs and (2) prerequisite under House and Senate rules (sometimes statute) for Congress to appropriate budget authority for programs/projects.

Baseline: See “Integrated Baseline”.

Budget: A **financial plan** that provides a summary of intended expenditures along with proposals for how to meet them; a **political instrument** that allocates scarce public resources among the social & economic needs of the jurisdiction; a **managerial/administrative instrument** that ensures all projects/activities will be reviewed at least once a year; an economic instrument that can direct a nation’s economic growth & development; and an **accounting instrument** that holds government officials responsible for the funds with which they have been entrusted.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 197 of 230

Budget Execution: The implementation of funds based on appropriations/funds release from Agency.

Budget Formulation: The process of developing budget run-out estimates.

Budget Justification: The process of advocating budget to Office of Management and Budget (OMB)/Congress.

Center Management Council (CMC): The council at MSFC that performs oversight of projects by evaluating all project work executed at that Center.

Change Request (CR): The format used to document a proposed engineering change. It is used to submit documentation for initial baselining or to process changes to the baseline for evaluation and disposition by the appropriate Project Control Board (PCB).

Collaborative Work Plan (CWP): Documentation of definition of work to be performed, the resources necessary to accomplish the defined work, and the commitments of the Sponsoring Organization (SO) and Performing Organization (PO) to provide the resources to perform the work. Work is defined in a CWP between the PO CWP owner and the SO Task Manager (TM). Depending on the task complexity, the Task Manager may choose to decompose the CWP into subtasks. Subtasks can be used as a means of clarifying the task content.

Configuration: The functional and physical characteristics of a product (i.e., hardware, firmware, software, or a combination thereof) as defined in technical documentation and achieved in a product.

Configuration Management (CM): A management discipline applied over the product's life-cycle to provide visibility into and to control changes to performance, functional, and physical characteristics.

Continuous Risk Management (CRM): A systematic and iterative process that efficiently identifies, analyzes, plans, tracks, controls, and communicates and documents risks associated with implementation of designs, plans, and processes.

Contract: A mutually binding legal relationship obligating the seller to furnish the supplies or services (including construction), and the buyer to pay for them. It includes all types of commitments that obligate the Government to an expenditure of appropriated funds. In addition to bilateral instruments, contracts include (but are not limited to) awards and notices of awards; job orders or task letters issued under basic ordering agreements; letter contracts; orders, such as purchase orders, under which the contract becomes effective by written acceptance or performance; and bilateral contract modifications. Contracts do not include grants and cooperative agreements.

Contract Clause or “**Clause**”: A term or condition used in contracts or in both solicitations and contracts, and applying after contract award or both before and after award.

Contract Modification: Written change(s) in the terms of a contract.

Contracting Officer (CO): Person with the authority to enter into, administer, and/or terminate contracts, and make related determinations and findings. The term includes certain authorized representatives of the CO acting within the limits of their authority as delegated by the CO.

Contracting Officer’s Representative (COR): A certified Government employee appointed by the CO to act as their representative in managing the technical aspects of a particular contract.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 198 of 230

Cooperative Agreement: A legal instrument to reflect a relationship between MSFC and a recipient whenever the principal purpose of a transaction is to accomplish a public purpose of support or stimulation authorized by law of the United States; and substantial involvement of MSFC is expected in carrying out the activity contemplated in the agreement.

Cost: The dollar value of projected and utilized resources in accomplishing MSFC’s mission (including contractor fee).

Cost Analysis Data Requirement (CADRe): A formal document designed to help managers understand the cost and cost risk of space flight projects.

Cost Sharing: An explicit arrangement under which the contractor bears some of the burden of reasonable, allocable, and allowable contract cost.

Data Management: The timely and economical identification/definition, preparation, control, and disposition of documents and data required by a program, project, or activity.

Data Requirements: Required data items applicable to a specific MSFC activity or contract.

Data Requirements Description (DRD): A detailed description of a required data item, including purpose, contents, format, maintenance requirements, and submittal requirements.

Decision Authority (DA): The Agency's responsible individual who authorizes the transition of a program/project to the next life-cycle phase.

Deviation: A specific written authorization, granted prior to the manufacture of a Contract Item (CI), to depart from a particular requirement of a CI’s current approved configuration for a specific number of units or a specified period of time.

Direct Cost: Any cost that is identified specifically with a particular final cost objective. Direct costs are not limited to items that are incorporated in the end product as material or labor. Costs identified specifically with a contract are direct costs of that contract. All costs identified specifically with other final cost objectives of the contractor are direct costs of those cost objectives.

Direct Materials: Materials that enter directly into the end-product, or that are used or consumed directly in connection with the furnishing of the end product or service.

Earned Value Management (EVM): A tool for measuring and assessing project performance through the integration of technical scope with schedule and cost objectives during the execution of the project. EVM provides quantification of technical progress, enabling management to gain insight into project status and project completion costs and schedules. Two essential characteristics of successful EVM and EVMS data integrity, and carefully targeted monthly EVM data analyses (i.e., risky Work Breakdown Structure (WBS) elements).

EVM Focal Point: A member of the Agency-wide EVM Working Group who is selected to represent each Center, each Mission Directorate, and each of the Headquarters Mission Support Offices. The EVM Focal Points assist in the development, review, assessment, and maintenance of Agency-level EVM policy, processes, guidance, requirements, tools, handbooks and toolkits, and makes recommendations for improvement. The EVM Focal Points also serve as the Process Owner for EVM for their respective Center, Mission Directorate, and Mission Support Office by providing leadership, direction, and proactively addressing EVM needs, requirements and issues.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 199 of 230

Enterprise Performance Support System (EPSS): website maintained by the NASA Enterprise Applications Competency Center (NEACC), which houses the end-user procedures and job aids related to the integrated enterprise management (IEM) project systems.

Evaluation: The continual, independent (i.e., outside the advocacy chain of the project) evaluation of the performance of a project, and incorporation of the evaluation findings to ensure adequacy of planning and execution according to plan.

Formulation: The identification of how the project supports the Center's strategic needs, goals, and objectives; the assessment of feasibility, technology and concepts; risk assessment, team building, and development of operations concepts and acquisition strategies; establishment of high-level requirements and success criteria; the preparation of plans, budgets, and schedules essential to the success of a project; and the establishment of control systems to ensure performance to those plans and alignment with current Center strategies.

Formulation Authorization Document (FAD): The document issued by the Mission Directorate Associate Administrator (MDAA) to authorize the formulation of a project whose goals will fulfill part of the Agency's Strategic Plan, Mission Directorate Strategies, or Mission Support Office Functional Leadership Plans. In addition, a FAD or equivalent is used to authorize the formulation of a project.

Forward pricing rate agreement: A written agreement negotiated between a contractor and the Government to make certain rates available during a specified period for use in pricing contracts or modifications. These rates represent reasonable projections of specific costs that are not easily estimated for, identified with, or generated by a specific contract, contract end item, or task. These projections may include rates for such things as labor, indirect costs, material obsolescence and usage, spare parts provisioning, and material handling.

Full and open competition: When used with respect to a contract action, means that all responsible sources are permitted to compete.

Full Time Equivalent: Term used to refer to civil service workforce, which is equivalent to a civil service employee working one year.

General and administrative (G&A) expense: Any management, financial, and other expense which is incurred by or allocated to a business unit, and which is for the general management and administration of the business unit as a whole. G&A expense does not include those management expenses whose beneficial or causal relationship to cost objectives can be more directly measured by a base other than a cost input base representing the total activity of a business unit during a cost accounting period.

Government-wide Commercial Purchase Card: The method of payment used at MSFC to pay for supplies and services not exceeding \$3,500 per single purchase and construction services not exceeding \$2,000 per requirement, except for supplies and services (including construction) up to \$5,000 under a Blanket Purchase Agreement. Sometimes referred to as a "purchase card" and/or "P-card".

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 200 of 230

Grant: A legal instrument to reflect a relationship between MSFC and a recipient whenever the principal purpose of a transaction is to accomplish a public purpose of support or stipulation authorized by law of the United States, and substantial involvement of MSFC is not expected in carrying out the activity contemplated in the agreement.

Implementation: The execution of approved plans for the development and operation of the project, and the use of control systems to ensure performance to approved plans and continued alignment with the Center's strategic needs, goals, and objectives.

Incurred Cost: The value of expended resources for which disbursements have not been made.

Independent Assessment (IA): The general term referring to an evaluation of a project conducted by experts outside the advocacy chain. The evaluation results in an assessment of the project's readiness (i.e., technical, schedule, cost, and risk) to proceed to the next phase in the life-cycle that is reported to a CMC.

Independent Cost Estimate (ICE): An independent project cost estimate prepared by an office or other entity that is not under the supervision, direction, advocacy, or control of the project (or its chain of command) that is responsible for carrying out the development or acquisition of the project. An ICE is bounded by the project scope (total life-cycle through all phases), schedule, technical content, risk, ground rules, and assumptions, and is conducted with objectivity and the preservation of integrity of the cost estimate. ICEs are generally developed using parametric approaches that are tailored to reflect the design, development state, difficulty, and expertise of team members.

Independent Evaluations: Reviews conducted by a primarily non-advocate team for the purpose of providing external assessment and recommendations within its established scope. Independent evaluations include reviews by the Standing Review Board.

Indirect cost: Any cost not directly identified with a single final cost objective, but identified with two or more final cost objectives or with at least one intermediate cost objective.

Indirect cost rate: The percentage or dollar factor that expresses the ratio of indirect expense incurred in a given period to direct labor cost, manufacturing cost, or another appropriate base for the same period.

Information Technology (IT): Any equipment, or interconnected system(s) of subsystem(s) of equipment, that is used in the automatic acquisition, storage, analysis, evaluation, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information by the Center.

Institutional Requirements: Infrastructure and workforce needed to support projects. Specifically, the Human Resources (HR), real property, facilities, aircraft, personal property, equipment, Information Technology (IT) resources, and administrative and project support services (e.g., environmental management) required to support projects.

Integrated Baseline: The projects' technical performance baseline/mission content, technology application, and schedule milestones. The integrated baseline also includes the Work Breakdown Structure (WBS), WBS dictionary, Integrated Master Schedule (IMS), Life Cycle Cost (LCC), and workforce estimates that are consistent with the project requirements on the project, the projects' Cost Analysis Data Requirement (CADRe) (if applicable), and the technical performance baseline/mission content.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 201 of 230

Integrated Baseline Review (IBR): A joint assessment by the offeror/contractor and the Government to verify the technical content and the realism of the related performance budgets, resources, and schedules. The IBR should provide a mutual understanding of the inherent risks in offerors’/ contractors’ performance plans and the underlying management control systems, and it should formulate a plan to handle these risks.

Integrated Management System Council (IMSC): Addresses institutional performance, effectiveness, health, efficiency and risk. Made up of twelve committees (e.g., SHE, MSFC Exchange Council, Personnel Management Advisory Committee, etc.), the IMSC focuses on topics like: performance of Cross Agency Support (CAS) products and services; workforce allocations, sizing, and skill mix; infrastructure availability, readiness and efficiency; Center-level institutional risks; Center-level Cross-cutting activities; policy, processes, and systems compliance and performance; workforce recruitment, retention, development, diversity, performance management, succession management and culture; SHE compliance and performance.

Integrated Master Schedule (IMS): An integrated set of schedule data that reflects the total project scope of work as discrete and measurable tasks/milestones that are time-phased through the use of task durations, interdependencies, and date constraints, and is traceable to the WBS.

Interface: Physical or functional interaction at the boundary between Contract Items (CIs).

Invoice: A contractor’s bill or written request for payment under the contract for supplies delivered or services performed.

Joint Cost and Schedule Confidence Level (JCL): (1) The probability that cost will be equal to or less than the targeted cost and schedule will be equal to or less than the targeted schedule date; (2) A process and product that helps inform management of the likelihood of a project’s programmatic success; and (3) A process that combines a project’s cost, schedule, and risk into a complete picture. JCL is not a specific methodology (e.g., resource-loaded schedule) or a product from a specific tool. The JCL calculation includes consideration of the risk associated with all elements, regardless of whether or not they are funded from appropriations or managed outside of the project.

Key Decision Point (KDP): The event at which the Decision Authority (DA) determines the readiness of a project to progress to the next phase of the life-cycle (or to the next Key Decision Point (KDP)).

Life-cycle Cost (LCC): The total of the direct, indirect, recurring, nonrecurring, and other related expenses incurred, or estimated to be incurred, in the design, development, verification, production, operation, maintenance, support, and disposal of a project. The LCC of a project or system can also be defined as the total cost of ownership over the project or systems' life-cycle from formulation through implementation. It includes all design, development, deployment, operation and maintenance, and disposal costs.

Margin: The allowances carried in budget, projected schedules, and technical performance parameters (e.g., weight, power, or memory) to account for uncertainties and risks. Margin allocations are baselined in the formulation process, based on assessments of risks, and are consumed as the project proceeds through the life-cycle.

Metric: A measurement taken over a period of time that communicates vital information about the status or performance of a system, process, or activity.

Mission: A major activity required to accomplish an Agency goal or to effectively pursue a scientific, technological, or engineering opportunity directly related to an Agency goal.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 202 of 230

New Obligation Authority (NOA): Authority to obligate current year funds. See “Obligation authority”.

Nonconformance: The failure of a unit or product to conform to specified requirements. Non-conformances are defined as critical, major, or minor departures from a baseline.

Obligation authority: Authority to incur obligations granted by a Resource Authority Warrant (NF 506) or a “citation of funds” authorization. An appropriation authorizing the incurrence of obligations within a specified amount without further recourse to the office which granted the authority. Also known as NOA in budget planning.

Obligations: The contractual commitment of funds for a product or service.

Office of Primary Responsibility (OPR): The MSFC organization with primary responsibility for the content of specific data items, or the organization responsible for the process represented by the document.

Operating Plan (OP): The Execution Plan for the Year.

Option: A unilateral right in a contract by which, for a specified time, the Government may elect to purchase additional supplies or services called for by the contract, or may elect to extend the term of the contract.

Organizational Unit: An organization (such as a program, project, Center, Mission Directorate, or Mission Support Office) that is responsible for carrying out a particular activity.

Passback: After Office of Management and Budget (OMB) review of NASA’s budget submission, OMB notifies the Agency of budget changes through the “Passback” process (occurs in late November).

Past performance: An offeror’s or contractor’s performance on active and physically completed contracts.

Performance Measure: A metric used to measure the extent to which a system, process, or activity fulfills its intended objectives.

Performing Organization (PO): The organization that performs the tasks defined in a Collaborative Work Plan (CWP) in support of the Sponsoring Organization (SO).

Phasing Plan: The Monthly Phased Plan of Obligations/Cost, Commitments, and Workforce.

Planning, Programming, Budgeting and Execution (PPBE): The NASA Budget Process.

Pricing: The process of establishing a reasonable amount(s) to be paid for supplies or services.

Primary Risks: Those undesirable events having both high probability and high impact/severity.

Probabilistic Risk Assessment (PRA): A comprehensive, structured, and logical analysis method aimed at identifying and assessing risks in complex technological systems for the purpose of cost-effectively improving their safety and performance in the face of uncertainties. PRA assesses risk metrics and associated uncertainties relating to the likelihood and severity of events adverse to safety or the mission.

Procurement: See “acquisition”.

Procurement Strategy Meeting (PSM): A meeting in which the Project Manager (PM), supported by the Contracting Officer (CO), seeks Agency approval of the procurement approach (e.g., competition approach, small business goals, and government furnished property). The PSM is normally contract-specific, but may

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 203 of 230

address all contracts within a project. PSMs can occur multiple times over the project life-cycle, are held prior to release of a solicitation, and are conducted in accordance with the NASA FAR Supplement (NFS).

Program: A strategic investment by a Mission Directorate or Mission Support Office that has a defined architecture and/or technical approach, requirements, funding level, and a management structure that initiates and directs one or more projects. A program defines a strategic direction that the Agency has identified as critical.

Program Commitment Agreement (PCA): The contract between the Associate Administrator and the cognizant MDAA that authorizes transition from formulation to implementation of a program.

Program Plan: The document that establishes the Programs' baseline for implementation, signed by the Mission Directorate Associate Administrator (MDAA), Center Director(s), and Program Manager (PM).

Program/Project Planning and Control (PP&C): Responsible for supporting the Program/Project Manager (PM) in the overall programmatic implementation and management of a Program or Project.

Programmatic Requirements: Requirements set by the Mission Directorate, program, project, and Principle Investigator (PI), if applicable. These include strategic scientific and exploration requirements, system performance requirements, and schedule, cost, and similar non-technical constraints.

Project: A specific investment identified in a *Program Plan* (or other sponsoring documentation) having defined requirements, a LCC, a beginning, and an end. A project yields new or revised products that directly address NASA's and MSFC's strategic needs.

Project Control Board (PCB): The functional body responsible for establishing project baselines and reviewing and dispositioning all changes, deviations, and waivers to these baselines.

Project Plan: The document that establishes the Project's baseline for implementation, signed by the cognizant Project Manager (PM) (or other sponsoring official), Center Director, Program Manager (PM), and the Mission Directorate Associate Administrator (MDAA), if required.

Purchase Order: When issued by the Government, means an offer by the Government to buy supplies or services, including construction and Research & Development (R&D), upon specified terms and conditions, using simplified acquisition procedures. A Purchase Order generally is not a bi-lateral agreement and, therefore, does meet the definition of a contract until after the goods or services are received.

Procurement Requisition (PR): An electronic form generated by Systems, Applications, and Products (SAP) used to initiate the procurement of supplies and services, recommend changes thereto, and request modifications of existing contracts and purchase orders.

Resources: The services and supplies required to accomplish MSFC's mission, such as labor, material, facilities, equipment, and funds.

Reference Document: A document used as guidance.

Reimbursable Project: A project executed at MSFC for a sponsor other than NASA.

Requisitioner: The person who prepares or is otherwise responsible for initiating the Procurement Requisition (PR) for supplies or services required by their respective organizations, including the furnishing of appropriate

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 204 of 230

Specifications or Statement of Work (SOW), recommended sources, market research, Data Requirements, special approvals as required, evaluation criteria and any other required documentation in accordance with this instruction.

Risk: The combination of the probability that a project will experience an undesired event, and the consequences, impact, or severity of the undesired event were it to occur. The undesired event may come from technical or programmatic sources (e.g., a cost overrun, schedule slippage, safety mishap, health problem, malicious activities, environmental impact, failure to achieve a needed scientific or technological objective, or success criterion). Both the probability and consequences may have associated uncertainties.

Risk Assessment: An evaluation of a risk item that determines: what can go wrong, how likely is it to occur, what the consequences are, and what are the uncertainties associated with the likelihood and consequences.

Risk Management: An organized, systematic decision-making process that efficiently identifies, analyzes, plans, tracks, controls, communicates, and documents risk, and establishes mitigation approaches and plans to increase the likelihood of achieving project goals.

Risk Mitigation: The process of applying methods, tools, and resources aimed at eliminating the risk or reducing the likelihood and/or consequence of a risk. This may be accomplished through engineering changes to design, processes, or procedures; schedule realignment; budget adjustments; or alternate paths and approaches.

Schedule Risk Assessment (SRA): A quantitative analysis of a project’s scheduled task durations that provides a range of probable completion dates with the associated probabilities for each. If the schedule is resource loaded, a quantitative cost analysis may also be performed using the schedule data. This cost analysis would provide a range of probable project costs with probabilities for each cost. The SRA could provide the basis for project schedule margin and recommended budgetary reserves.

Sole Source Acquisition: A contract for the purchase of supplies or services that is entered into or proposed to be entered into by the Center after soliciting and negotiating with only one source.

Solicitation: Any request to submit offers or quotations to the Government. Solicitations under sealed bid procedures are called “invitations for bids.” Solicitations under negotiated procedures are called “requests for proposals.” Solicitations under simplified acquisition procedures may require submission of either a quotation or an offer.

Source Evaluation Board: A board established to provide for an equitable and comprehensive evaluation of offerors’ proposals, for a specific competitive acquisition, to assist a Source Selection Authority in selecting the proposal which is most advantageous to MSFC. An SEB is used for competitive negotiated actions of \$50 million or more unless formally waived by the NASA Assistant Administrator for Procurement.

Sponsoring Organization (SO): The organization initiating the Collaborative Work Plan (CWP) and providing funding for the requested tasks. This individual supports the Project Manager (PM).

Stakeholder: An individual or organization having an interest (or stake) in the outcome or deliverable of a project.

Standing Review Board: The entity responsible for conducting independent reviews of the project per the life-cycle requirements. The Standing Review Board is advisory, and is chartered to objectively assess the material presented by the project at a specific review.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 205 of 230

Statement of Work (SOW): A document that establishes and defines all technical and programmatic requirements that the contractor is obligated to fulfill during performance of the contract.

Strategic Planning Council (SPC): The MSFC SPC is one of three MSFC governance councils. The SPC provides a forum to set strategic direction through discussion and assessment of strategies, plans, and policies that have broad impact on the Center’s future and ability to contribute to NASA’s strategic goals. By setting strategic direction and priorities, the SPC considers organizational structure and management models, business base, business development activities, procurement strategies and goals, product lines, investment priorities, and stakeholder and customer relationships as related to strategy. The SPC also has three committees: Technology Investment Advisory Committee, Innovation and Technology Advisory Committee, and the Center Strategic Development Steering Group.

Success Criteria: That portion of the top-level requirements that defines what must be achieved to successfully satisfy NASA Strategic Plan objectives addressed by the project.

Supplemental agreement: A contract modification that is accomplished by the mutual action of the parties.

Supplies: All property except land or interest in land.

System: The combination of elements that function together to produce the capability required to meet a need. The elements include all hardware, software, equipment, facilities, personnel, processes, and procedures needed for this purpose.

System Application Products (SAP): NASA Accounting System software package implemented by the NEACC. SAP is part of the Core Financial Module of the NASA Accounting System within the NEACC. It is the official record for all commitments and obligations. Core Financial is the NEACC backbone providing management and technical leadership for Agency-wide implementation of standard systems and processes necessary to support MSFC’s financial management activities.

Task order contract: A contract for services that does not procure or specify a firm quantity of services (other than a minimum or maximum quantity), and that provides for the issuance of orders for the performance of tasks during the period of the contract.

Task Manager (TM): The Task Manager is the Performing Organization (PO) technical lead in support of the Collaborative Work Plan (CWP), and is in continual communication with the Sponsoring Organization (SO) CWP owner. The TM coordinates with all parties to define, clarify, and negotiate CWP task content, schedule, and resources. The TM is responsible and accountable for the management of established resources to support the technical performance of the task described in the CWP, and any CWP subtasks within the defined schedule and technical aspects. The TM is assigned by the PO at the lowest appropriate level in the organization, and is responsible for working with PO implementing groups as necessary to manage the resources to accomplish the task(s) described in the CWP.

Termination for convenience: The exercise of the Government’s right to completely or partially terminate performance of work under a contract when it is in the Government’s interest.

Termination for default: The exercise of the Government’s right to completely or partially terminate a contract because of the contractor’s actual or anticipated failure to perform its contractual obligations.

Termination Review: A review initiated by the DA for the purpose of securing a recommendation as to whether to continue or terminate a project. Failing to stay within the parameters or levels specified in

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 206 of 230

controlling documents will result in consideration of a termination review.

Unallowable cost: Any cost that, under the provisions of any pertinent law, regulation, or contract, cannot be included in prices, cost-reimbursements, or settlements under a Government contract to which it is allowable.

Unsolicited proposal: A written proposal for a new or innovative idea that is submitted to MSFC on the initiative of the offeror for the purpose of obtaining a contract with the Government, and that is not in response to a Request for Proposal (RFP) or any other Government-initiated solicitation or project.

Waiver: A documented authorization intentionally releasing a project from meeting a requirement.

Work Agreement: The Center form (or equivalent), prepared for each project Control Account (CA) and used to document agreements and commitments for the work to be performed, including scope of work, receivables/deliverables, schedule, budget, and assumptions.

Work Breakdown Structure (WBS): A product-oriented hierarchical division of the hardware, software, services, and data required to produce the project's end product(s), structured according to the way the work will be performed, and reflective of the way in which project costs, schedule, technical and risk data are to be accumulated, summarized, and reported.

Work-Year Equivalent (WYE): Term used to refer to support contractor workforce, which is equivalent to a contractor employee working one year.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 207 of 230

Appendix C Contract Types and Agreements

Introduction

The selection of contract type involves the consideration of several factors. These include (among others): the certainty of the work description, adequacy of price competition, degree of risk involved, contract dollar value, availability of the cost/pricing data, cost experience in the production of similar or identical items, and the degree of control desired over the contractor. The intended result of the contract type selection is to provide a means for successful performance at a reasonable price/cost with an appropriate apportionment of risk. For complete details on contract types, refer to Federal Acquisition Requirements (FAR) Part 16, “Types of Contracts”.

Fixed-Price (FP) Contracts

FP types of contracts provide for a firm price or, in appropriate cases, an adjustable price. FP contracts providing for an adjustable price may include a ceiling price, a target price, or both. Unless otherwise specified in the contract, the ceiling price or target price is subject to adjustment only by operation of contract clauses providing for equitable adjustment or other revision of the contract price under stated circumstances. Since it is usually to the Government’s advantage for the contractor to assume substantial cost responsibility and an appropriate share of the cost risk, FP contracts are preferred when contract costs and performance requirements are reasonably certain.

Firm Fixed Price (FFP) contracts: provides for a price that is not subject to any adjustment on the basis of the contractor’s cost experience in performing the contract. This contract type places the contractor at maximum risk and full responsibility for all costs and resulting profit (or loss). It provides maximum incentive for the contractor to control costs and perform effectively, and imposes a minimum administrative burden upon the contracting parties. A FFP contract is suitable for acquiring commercial items or for acquiring other supplies or services on the basis of reasonably definite functional or detailed specifications when a fair and reasonable price can be established.

FP contracts with economic price adjustment: provides for upward and downward revision of the stated contract price based on the occurrence of specified contingencies. Economic price adjustments are of general: adjustments based on established prices; adjustments based on actual costs of labor or material; and adjustments based on cost indexes of labor or material. This type contract is used when there is serious doubt in the stability of market or labor conditions that will exist during an extended period of contract performance.

Fixed-price incentive (FPI) contracts: provides for adjusting profit and establishing the final contract price by application of a formula based on the relationship of total final negotiated cost to total target cost. The final price is subject to a price ceiling, negotiated at the outset. There are two forms of FPI contracts: firm target and successive targets.

FPI (firm target) contracts: specifies a target cost, a target profit, a price ceiling (but not a profit ceiling or floor), and a profit adjustment formula. These elements are all negotiated at the outset. The price ceiling is the maximum paid to the contractor, except for any adjustment under other contract clauses. When the contractor completes performance, the parties negotiate the final cost, and the final price is established by applying the formula. When the final cost is less than the target cost, application of the formula results in a final profit greater than the target profit. When the final cost is more than target cost, application of the formula results in a final profit less than the target profit (or even a net loss). If the final negotiated cost exceeds the price ceiling, the contractor absorbs the difference as a loss. Because the profit varies inversely with the cost, this contract type provides a positive, calculable profit incentive for the contractor to control costs.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 208 of 230

FPI (successive targets) contracts: appropriate when available cost or pricing information is not sufficient to permit the negotiation of a realistic firm target cost and profit before award; sufficient information is available to permit negotiation of initial targets; and there is reasonable assurance that additional reliable information will be available at an early point in the contract performance so as to permit negotiation of either: a FFP or a firm target.

FP contracts with prospective price redetermination: provides for a FFP for an initial period of contract deliveries or performance, and prospective redetermination, at a stated time or times during performance, of the price for subsequent periods of performance. This contract type is used in acquisitions of quantity production or services for which it is possible to negotiate a fair and reasonable FFP for an initial period, but not for subsequent periods of contract performance.

Fixed-ceiling-price contracts with retroactive price redetermination: provides for a fixed ceiling price, and retroactive price redetermination within the ceiling after completion of the contract. This contract type is appropriate for R&D contracts estimated at \$150,000 or less when a reasonable FFP cannot be negotiated, and a short performance period make the use of any other FP contract type impracticable.

FFP, Level of Effort (LOE) term contracts: requires the contractor to provide a specified LOE, over a stated period of time, on work that can be stated only in general terms; and the Government to pay the contractor a fixed dollar amount. This type contract is suitable for investigation or study in a specific R&D area. The product of the contract is usually a report showing the results achieved through application of the required LOE. Payment is based on the effort expended rather than on the results achieved.

Fixed-price-award-fee (FPAF) contract: uses award fee provisions in Fixed Price (FP) contracts when the Government wishes to motivate a contractor, and other incentives cannot be used because contractor performance cannot be measured objectively. Such contracts establish a FP (including normal profit) for the effort that will be paid for satisfactory contract performance. Award fee earned (if any) will be paid in addition to that FP.

Cost-Reimbursement Contracts

Cost-reimbursement contracts provide for payment of allowable incurred costs to the extent prescribed in the contract, and establish an estimate of total cost for the purpose of obligating funds and establishing a ceiling that the contractor may not exceed (except at their own risk) without the approval of the Contracting Officer (CO). Cost-reimbursement contracts are used when: circumstances do not allow the Center to define its requirements sufficiently to allow for a Fixed Price (FP) type contract, or uncertainties involved in contract performance do not permit costs to be estimated with sufficient accuracy to use any type of FP contract.

Cost contracts: a cost-reimbursement contract in which the contractor receives no fee. This contract type may be appropriate for Research & Development (R&D) work, particularly with nonprofit educational institutions or other nonprofit organizations.

Cost-sharing contracts: a cost-reimbursement contract in which the contractor receives no fee and is reimbursed only for an agreed-upon portion of their allowable costs. This contract type may be used when the contractor agrees to absorb a portion of the costs, in the expectation of substantial compensating benefits.

Cost-plus-incentive-fee (CPIF) contracts: a cost-reimbursement contract that provides for the initially negotiated fee to be adjusted later by a formula based on the relationship of total allowable costs to total target costs. This contract type specifies a target cost, a target fee, minimum and maximum fees, and a fee adjustment formula. After contract performance, the fee payable to the contractor is determined in accordance with the formula. The fee adjustment formula should provide an incentive that will be effective over the full

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 209 of 230

range of reasonably foreseeable variations from target cost. When total allowable cost is greater than or less than the range of costs within which the fee-adjustment formula operates, the contractor is paid total allowable costs plus the minimum or maximum fee. This contract type is appropriate for services or development and test projects when: a cost-reimbursement contract is necessary, and a target cost and a fee adjustment formula can be negotiated that are likely to motivate the contractor to manage effectively.

Cost-plus-award-fee (CPAF) contracts: a cost-reimbursement contract that provides for a fee consisting: of a base amount (which may be zero) fixed at inception of the contract, and an award amount, based upon a judgmental evaluation by the Government that is sufficient to provide motivation for excellence in contract performance. Award-fee contracts are a type of incentive contract that is suitable for use when: the work is neither feasible nor effective to devise predetermined objective incentive performance targets; the likelihood of meeting acquisition objectives will be enhanced by motivating the contractor and providing the Government with the flexibility to evaluate performance; and any additional administrative effort and cost required to monitor and evaluate performance are justified by the expected benefits.

Cost-plus-fixed-fee (CPFF) contracts: a cost-reimbursement contract that provides for payment to the contractor of a negotiated fee that is fixed at the inception of the contract. The fixed fee does not vary with actual cost, but may be adjusted as a result of changes in the work to be performed under the contract. This contract type permits contracting for efforts that might otherwise present too great a risk to contractors, but it provides the contractor only a minimum incentive to control costs. This contract type is suitable for use when: the contract is for the performance of research or preliminary exploration or study, and the Level of Effort (LOE) required is unknown; or the contract is for development and test, and using a CPIF contract is not practical.

A CPFF contract may take one of two basic forms: completion or term. Because of the differences in obligation assumed by the contractor, the completion form is preferred over the term form whenever the work can be defined well enough to permit development of estimates within which the contractor can be expected to complete the work.

The completion form of the CPFF contract describes the scope of work by stating a definite goal or target, and specifying an end product. It normally requires the contractor to complete and deliver the specified end product within the estimated cost as a condition for payment of the entire fixed fee. In the event the work cannot be completed within the estimated cost, the Government may require more effort without increase in fee, provided the Government increases the estimated cost.

The term form of the CPFF contract describes the scope of work in general terms and obligates the contractor to devote a specified LOE for a stated time period. If the performance is considered satisfactory by the Government, the fixed fee is payable at the expiration of the agreed-upon period, upon contractor statement that the LOE specified in the contract has been expended in performing the contract work.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 210 of 230

Indefinite-Delivery Contracts

There are three types of indefinite-delivery contracts: definite-quantity contracts; requirements contracts, and indefinite-quantity contracts. The appropriate type of indefinite delivery contract may be used to acquire supplies and/or services when the exact times and/or exact quantities of future deliveries are not known at the time of contract award.

Definite-quantity contracts: provides for delivery of a definite quantity of specific supplies or services for a fixed period, with deliveries or performance to be scheduled at designated locations. This contract type is used when it can be determined in advance that: a definite quantity of supplies or services will be required during the contract period, and the supplies or services are regularly available or will be available after a short lead time.

Requirements contracts: provides for filling all actual purchase requirements of designated Government activities for supplies or services during a specified contract period (from one contractor), with deliveries or performance to be scheduled by placing orders with the contractor. This contract type is appropriate for acquiring any supplies or services when the Government anticipates recurring requirements, but cannot predetermine the precise quantities of supplies or services that designated Government activities will need during a definite period.

Indefinite-quantity contracts: provides for an indefinite quantity, within stated limits, of supplies or services during a fixed period. The quantity limits may be stated as number of units or as dollar values. This contract type is used when the Government cannot predetermine, above a specified minimum, the precise quantities of supplies or services that the Government will require during the contract period, and it is inadvisable for the Government to commit itself for more than a minimum quantity.

Time-and-Materials, Labor-Hour, and Letter Contracts

Time-and-materials contracts and labor-hour contracts are not Fixed Price (FP) contracts. A letter contract is a written, preliminary contractual instrument that authorizes the contractor to begin work immediately.

Time-and-materials contracts: may be used only when it is not possible at the time of placing the contract to estimate accurately the extent or duration of the work, or to anticipate costs with any reasonable degree of confidence. This contract type provides no positive profit incentive to the contractor for cost control or labor efficiency. Therefore, appropriate Government surveillance of contractor performance is required to give reasonable assurance that efficient methods and effective cost controls are being used. The contract specifies separate fixed hourly rates that include wages, overhead, General & Administrative (G&A) expenses, and profit for each category of labor.

Labor-hour contracts: A labor-hour contract is a variation of the time-and-materials contract, differing only in that materials are not supplied by the contractor.

Letter contracts: A letter contract is a written preliminary contractual instrument that authorizes the contractor to begin immediately manufacturing supplies or performing services. This contract type is used when: the Government’s interests demand that the contractor be given a binding commitment so that work can start immediately, and negotiating a definitive contract is not possible in sufficient time to meet the requirement. The letter contract should be as complete and definite as feasible under the circumstances.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 211 of 230

Agreements

Two types of agreements (basic agreement and basic ordering agreement) are discussed below. Both agreements are not contracts.

Basic agreements: a written instrument of understanding, negotiated between a Center or contracting activity and a contractor, that: contains contract clauses applying to future contracts between the parties during its term, and contemplates future contract(s) that will incorporate by reference or attachment the required and applicable clauses agreed upon in the basic agreement. A basic agreement is used when a substantial number of separate contracts may be awarded to a contractor during a particular period and significant recurring negotiating problems have been experienced with the contractor.

Basic ordering agreements: a written instrument of understanding, negotiated between a Center, contracting activity, or contracting office and a contractor, that contains: terms and clauses applying to future contracts (orders) between the parties during its term; a description, as specific as practicable, of supplies or services to be provided; and methods for pricing, issuing, and delivering future orders under the basic ordering agreement. A basic ordering agreement is used to expedite contracting for uncertain requirements for supplies or services when specific items, quantities, and prices are not known at the time the agreement is executed. Under proper circumstances, the use of these procedures can result in economies in ordering parts for equipment support by reducing administrative lead time, inventory investment, and inventory obsolescence due to design changes.

Commercial Customer Agreements

The National Aeronautics and Space Act of 1958, provides NASA with the unique authority to enter into a wide range of “contracts or other transactions”, commonly referred to as Space Act Agreements (SAAs). MSFC enters into SAAs with various partners to advance MSFC mission and project objectives, including the handling of international cooperative space activities. Commercial customer funded activity must be performed on a “non-interference basis” with other MSFC activities and resources.

As MSFC looks for additional funding resources, especially from commercial customers, the management of SAAs and Enhanced Use Leases (EUL) are starting to require some new areas of responsibility. These areas (usually performed by Project Planning & Control (PP&C)) include:

- a. Support the development of Statement of Work (SOW)
- b. Support the development of requirements
- c. Management of the commercial customer funded effort
- d. Detail cost collection and reporting for each user
- e. Payment schedule development
- f. Billing process
- g. Collection process
- h. Rate development

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 212 of 230

Space Act Agreement (SAA): The PP&C team should work closely with the technical personnel and/or Performing Organizations (POs) to support the development and control of SAA’s resources. The SAA will be prepared in accordance with NASA Advisory Implementing Instruction (NAII 1050-1, “Space Act Agreements Guide”), which provides detail SAA guidance of various SAAs. NAII 1050-1 identifies the responsibilities of the SAA Manager, who should work closely with the PP&C team in preparation of the SAA. Each NASA signing official is responsible for determining that the SAA has been properly reviewed consistent with NPD 1050.1, *Authority to Enter into Space Act Agreements*. All SAAs are subject to the provisions of NASA financial management policy for determining, allocating, and billing costs. Before a SAA is executed, and in accordance with NPD 1050.1, a cost estimate must be prepared and reviewed by the NASA Director for Headquarters Operations (for Headquarters Agreements) or Center’s Chief Financial Officer (CFO) (for Center Agreements) so that the NASA signing officials have a basis for determining whether MSFC’s proposed contribution is fair and reasonable.

SAAs are categorized according to the partner (e.g., a public or private entity), whether U.S. or international law applies, and by the parties’ financial obligations (Reimbursable, Non-Reimbursable, or Funded SAA). The funding of the agreement depends on which partner pays. The majority of the SAA are reimbursable.

- a. Reimbursable SAA - the partner pays for work MSFC conducts for the partner’s benefit. A reimbursable SAA permits the partner to use MSFC facilities, personnel, expertise, or equipment to advance the partner’s own interests. MSFC undertakes reimbursable SAAs when it has unique goods, services, or facilities, which can be made available to another party on a non-interference basis, and is consistent with MSFC’s mission requirements. See NASA Interim Directive 9090.1, *Reimbursable Agreements*, for additional information on Reimbursable SAAs.
- b. Non-reimbursable SAA - each party assumes responsibility for its own costs, and both MSFC and the partner(s) receive mutual benefits from the agreement. The Non-reimbursable SAA permits MSFC to offer time and effort of personnel, support services, equipment, expertise, information, and/or facilities. Non-reimbursable SAAs are used when MSFC and its partner(s) are performing activities collaboratively for which each is particularly suited and for which the end results are of interest to MSFC. Since Non-reimbursable SAAs involve the commitment of MSFC resources, the respective contributions of each partner must be fair and reasonable. Before executing a Non-reimbursable SAA, the MSFC signing official is responsible for determining that the partner’s contribution is comparable to MSFC’s contribution.
- c. Funded SAA - MSFC provides funding to a domestic partner to accomplish a Center mission. Funded SAAs should only be used when the Center objectives cannot be achieved through any other agreement instrument, such as a Federal Procurement Contract, a Grant, a Cooperative Agreement, a Reimbursable SAA, or a Non-reimbursable SAA. Prior to using a Funded SAA, the Center Director or MDAA must determine, in consultation with the Office of the General Counsel or Chief Counsel, as appropriate, and the CFO, that a Funded SAA is the appropriate legal instrument for the activity.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 213 of 230

Enhanced Use Leases (EUL) Agreements: The EUL authority allows federal agencies to enter into real estate agreements that grant, by lease to others, the use of underutilized real Government property including land, buildings, and other structures. EUL allows the Center to retain and use the proceeds derived from the lease. EUL agreements will be prepared in accordance with NPR 8800.15, *Real Estate Management Program*, which provides guidance as to the collection and utilization of funds; development of information and reports regarding their priorities, market, cost structure, business cases, Life Cycle Cost (LCC), and rate development. Under this authority, all NASA Centers may enter EUL agreements. The PP&C team should work with technical personnel and/or POs to insure that the EUL financial requirements are satisfied.

A summary of this EUL authority includes:

- a. Agreements may only be for cash consideration at fair market value determined by the Administrator;
- b. No in-kind consideration is allowed for leases under the expanded authority; leases executed before December 31, 2008 may continue to include in-kind consideration;
- c. The amounts of cash consideration received may be used to cover the full costs to MSFC in connection with the lease;
- d. Of any amounts of cash consideration received that is not utilized to cover the full costs of the lease to MSFC:
 1. 35 percent is deposited in a capital asset account established by the Administrator, and made available for maintenance, capital revitalization, and improvements of the real property assets and related personal property under the jurisdiction of the Administrator, until expended;
 2. The remaining 65 percent is deposited in a capital asset account and made available to the respective Center or component facility engaged in the lease of non-excess real property until expended for maintenance, capital revitalization, and improvements of the real property assets and related personal property at the respective Center or facility subject to the concurrence of the Administrator;
- e. Funds may be used on any real property at the Centers including collateral equipment, and does not have to be spent on facilities or infrastructure that are leased out under EUL;
- f. Funds may not be utilized for daily operations costs.

Appendix D Schedule Assessment Checklist

SCHEDULE ASSESSMENT CHECKLIST		
Yes	No	Criterion Description
1. <input type="checkbox"/>	<input type="checkbox"/>	Does the IMS reflect the total scope of work?
2. <input type="checkbox"/>	<input type="checkbox"/>	Is the correct WBS element identified for each task and milestone in the IMS?
3. <input type="checkbox"/>	<input type="checkbox"/>	Is the IMS used by all levels of management for project implementation and control?
4. <input type="checkbox"/>	<input type="checkbox"/>	Do all tasks/milestones have interdependencies identified to reflect a credible logical sequence?
5. <input type="checkbox"/>	<input type="checkbox"/>	Are task durations reasonable, measureable, and at appropriate level of detail for effective management?
6. <input type="checkbox"/>	<input type="checkbox"/>	Does the IMS include all contract and/or designated management control milestones?
7. <input type="checkbox"/>	<input type="checkbox"/>	Does IMS reflect accurate current status & credible start/finish forecasts for all to-go tasks and milestones?
8. <input type="checkbox"/>	<input type="checkbox"/>	Has the IMS been resource loaded and are assigned resources reasonable and available?
9. <input type="checkbox"/>	<input type="checkbox"/>	Is the critical path identifiable and determined by the calculated IMS logic network?
10. <input type="checkbox"/>	<input type="checkbox"/>	Is the critical path credible?
11. <input type="checkbox"/>	<input type="checkbox"/>	Has a Schedule Risk Assessment (SRA) been conducted on the IMS within the last three months?
12. <input type="checkbox"/>	<input type="checkbox"/>	Has adequate schedule margin been included and clearly defined within the IMS?
13. <input type="checkbox"/>	<input type="checkbox"/>	Has the IMS content been baselined and is it adequately controlled?
14. <input type="checkbox"/>	<input type="checkbox"/>	Is there an excessive & invalid use of task constraints and relationship leads/lags?
15. <input type="checkbox"/>	<input type="checkbox"/>	Are right task & resource calendars used in the IMS?

FIGURE 117. Schedule Assessment Checklist

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 215 of 230

Appendix E Earned Value Management (EVM) Guidelines

Below is a list of the 32 EIA-748 EVMS guidelines, grouped into the five EIA categories. The term “program” also refers to the project.

Organization

1. Define the authorized work elements for the program. A Work Breakdown Structure (WBS), tailored for effective internal management control, is commonly used in this process (2.1.a – Note: These are reference paragraphs within EIA-748).
2. Identify the program organizational structure, including the major subcontractors responsible for accomplishing the authorized work, and define the organizational elements in which work will be planned and controlled (2.1.b).
3. Provide for the integration of the company’s planning, scheduling, budgeting, Work Authorization (WA), and cost accumulation processes, and as appropriate, the program WBS and the program organizational structure (2.1.c).
4. Identify the company organization or function responsible for controlling overhead (indirect costs) - (2.1.d).
5. Provide for integration of the program WBS and the program organizational structure in a manner that permits cost and schedule performance measurement by elements of either or both structures as needed (2.1.e).

Planning, Scheduling, and Budgeting

6. Schedule the authorized work in a manner which describes the sequence of work and identifies significant task interdependencies required to meet the requirements of the program (2.2.a).
7. Identify physical products, milestones, technical performance goals, or other indicators that will be used to measure progress (2.2.b).
8. Establish and maintain a time-phased budget baseline, at the Control Account (CA) level, against which program performance can be measured. Initial budgets established for performance measurement will be based on either internal management goals or the external customer negotiated target cost including estimates for authorized but undefinitized work. Budget for far-term efforts may be held in higher level accounts until an appropriate time for allocation at the CA level. If an over-target baseline is used for performance measurement reporting purposes, prior notification must be provided to the customer (2.2.c).
9. Establish budgets for authorized work with identification of significant cost elements (labor, material, etc.) as needed for internal management and for control of subcontractors (2.2.d).
10. To the extent it is practical to identify the authorized work in discrete Work Packages (WPs), establish budgets for this work in terms of dollars, hours, or other measurable units. Where the entire CA is not subdivided into WPs, identify the far-term effort in larger Planning Packages (PPs) for budget and scheduling purposes (2.2.e).
11. Ensure that the sum of all WP budgets plus PP budgets within a CA equals the CA budget (2.2.f).
12. Identify and control Level of Effort (LOE) activity by time-phased budgets established for this purpose. Only that effort which is not measurable or for which measurement is impractical may be classified as LOE (2.2.g).
13. Establish overhead budgets for each significant organizational component for expenses that will become

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 216 of 230

indirect costs. Reflect in the program budgets, at the appropriate level, the amounts in overhead pools that are planned to be allocated to the program as indirect costs (2.2.h).

14. Identify Management Reserve (MR) and undistributed budget (2.2.i).
15. Provide that the program target cost goal is reconciled with the sum of all internal program budgets and MR (2.2.j).

Accounting Considerations

16. Record direct costs in a manner consistent with the budgets in a formal system controlled by the general books of account (2.3.a).
17. When a Work Breakdown Structure (WBS) is used, summarize direct costs from CAs into the WBS without allocation of a single CA to two or more WBS elements (2.3.b).
18. Summarize direct costs from the CAs into the organizational elements without allocation of a single CA into two or more organizational elements (2.3.c).
19. Record all indirect costs that will be allocated to the program consistent with the overhead budgets (2.3.d).
20. Identify unit costs, equivalent unit costs, or lot costs when needed (2.3.e).
21. For Earned Value Management System (EVMS), the material accounting system will provide for:
 - a. Accurate cost accumulation and assignment of costs to CAs in a manner consistent with the budgets using recognized, acceptable costing techniques.
 - b. Cost recorded for accomplishing work performed in the same period that earned value is measured and at the point in time most suitable for the category of material involved, but no earlier than the time of actual receipt of material.
 - c. Full accountability of all material purchased for the program including the residual inventory (2.3.f).

Analysis and Management Reports

22. At least on a monthly basis, generate the following information at the CA and other levels as necessary for management control using actual cost data from, or reconcilable with, the accounting system:
 - a. Comparison of the amount of planned budget and the amount of budget earned for work accomplished. This comparison provides the Schedule Variance (SV).
 - b. Comparison of the amount of the budget earned and the actual (applied where appropriate) direct costs for the same work. This comparison provides the Cost Variance (CV) (2.4.a).
23. Identify, at least monthly, the significant differences between both planned and actual schedule performance and planned and actual cost performance, and provide the reasons for the variances in the detail needed by program management (2.4.b).
24. Identify budgeted and applied (or actual) indirect costs at the level and frequency needed by management for effective control, along with the reasons for any significant variances (2.4.c).
25. Summarize the data elements and associated variances through the program organization and/or WBS to support management needs and any customer reporting specified in the contract (2.4.d).
26. Implement managerial actions taken as the result of earned value information (2.4.e).
27. Develop revised estimates of cost at completion based on performance to date, commitment values for
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MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 217 of 230

material, and estimates of future conditions. Compare this information with the Performance Measurement Baseline (PMB) to identify variances at completion that are important to company management and any applicable customer reporting requirements including statements of funding requirements (2.4.f).

Revisions and Data Maintenance

- 28. Incorporate authorized changes in a timely manner, recording the effects of such changes in budgets and schedules. In the directed effort prior to negotiation of a change, base such revisions on the amount estimated and budgeted to the program organizations (2.5.a).
- 29. Reconcile current budgets to prior budgets in terms of changes to the authorized work and internal replanning in the detail needed by management for effective control (2.5.b).
- 30. Control retroactive changes to records pertaining to work performed that would change previously reported amounts for actual costs, earned value, or budgets. Adjustments should be made only for correction of errors, routine accounting adjustments, effects of customer or management directed changes, or to improve the baseline integrity and accuracy of performance measurement data (2.5.c).
- 31. Prevent revisions to the program budget except for authorized changes (2.5.d).
- 32. Document changes to the PMB (2.5.e).

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 218 of 230

Appendix F NASA Standard Level 2 Work Breakdown Structure (WBS)

SPACE FLIGHT PROJECT WBS Standard Level 2 Elements (see NPR 7120.5, Appendix G): Standard Level 2 WBS elements for space flight projects are shown in Figure 118. The standard WBS template assumes a spacecraft flight development project with relatively minor ground or mission operations elements. For major launch or mission operations ground-development activities which are viewed as projects unto themselves, the WBS may be modified. For example, the spacecraft element may be changed to reflect the ground project major deliverable (such as a facility). The elements such as payload, launch vehicle/services, ground system(s), and mission operations (system) that are not applicable may be deleted.

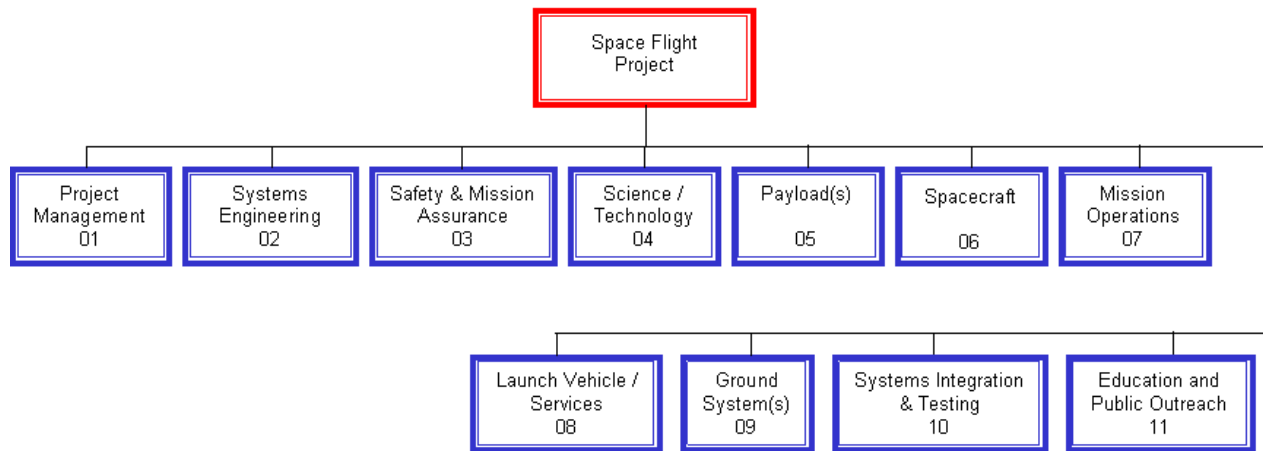


FIGURE 118. Space Flight Project Standard WBS

Following is the Space Flight Project Standard WBS Dictionary:

Element 01 - Project Management: The business and administrative planning, organizing, directing, coordinating, analyzing, controlling, and approval processes used to accomplish overall project objectives, which are not associated with specific hardware or software elements. This element includes project reviews and documentation, non-project owned facilities, and project reserves. It excludes costs associated with technical planning and management and delivery of engineering, hardware and software.

Element 02 - Systems Engineering: The technical and management efforts of directing and controlling an integrated engineering effort for the project. This element includes the efforts to define the project space flight vehicle(s) and ground system, conducting trade studies, the integrated planning and control of the technical program efforts of design engineering, software engineering, specialty engineering, system architecture development and integrated test planning, system requirements writing, configuration and technical data management, technical oversight, control and monitoring of the technical program, and technical risk management activities.

Element 03 – SMA: The technical and management efforts of directing and controlling the SMA elements of the project. This element includes design, development, review, and verification of practices, procedures, and mission success criteria intended to assure that the delivered spacecraft, ground systems, mission operations, and payload(s) meet performance requirements and function for their intended lifetimes. This element excludes mission and product assurance efforts directed at partners and subcontractors other than a review/oversight function.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 219 of 230

Element 04 - Science/Technology: This element includes the managing, directing, and controlling of the science investigation aspects, as well as leading, managing, and performing the technology demonstration elements of the Project. The costs incurred to cover the Principal Investigator, Project Scientist, science team members, and equivalent personnel for technology demonstrations are included. Specific responsibilities include defining the science or demonstration requirements; ensuring the integration of these requirements with the payloads, spacecraft, ground systems, and mission operations; providing the algorithms for data processing and analyses; and performing data analysis and archiving. This element excludes hardware and software for onboard science investigative instruments/payloads.

Element 05 - Payload: This element includes the special-purpose equipment and normal equipment [e.g., Ground Support Equipment (GSE)] integral to the spacecraft. This includes managing and implementing the hardware and software payloads that perform the scientific experimental and data-gathering functions on board the spacecraft, as well as the technology demonstration for the mission.

Element 06 - Spacecraft(s): The spacecraft that serves as the platform for carrying payload(s), instrument(s), humans, and other mission-oriented equipment in space to the mission destination(s) to achieve the mission objectives. The spacecraft may be a single spacecraft or multiple spacecraft/ modules (i.e., cruise stage, orbiter, lander, or rover modules). Each spacecraft/module of the system includes the following subsystems, as appropriate: Crew, Power, Command & Data Handling, Telecommunications, Mechanical, Thermal, Propulsion, Guidance Navigation and Control, Wiring Harness, and Flight Software. This element also includes all design, development, production, assembly, test efforts, and associated GSE to deliver the completed system for integration with the launch vehicle and payload. This element does not include integration and test with payloads and other project systems.

Element 07 - Mission Operations System: The management of the development and implementation of personnel, procedures, documentation, and training required to conduct mission operations. This element includes tracking, commanding, receiving/processing telemetry, analyses of system status, trajectory analysis, orbit determination, maneuver analysis, target body orbit/ephemeris updates, and disposal of remaining end-of-mission resources. The same WBS structure is used for Phase E Mission Operation Systems, but with inactive elements defined as "not applicable." However, different accounts must be used for Phase E due to NASA cost reporting requirements. This element does not include integration and test with the other project systems.

Element 08 - Launch Vehicle/Services: The management and implementation of activities required to place the spacecraft directly into its operational environment, or on a trajectory towards its intended target. This element includes launch vehicle, launch vehicle integration, launch operations, any other associated launch services, and associated GSE. This element does not include the integration and test with the other project systems.

Element 09 - Ground System(s): The complex of equipment, hardware, software, networks, and mission-unique facilities required to conduct mission operations of the spacecraft systems and payloads. This complex includes the computers, communications, operating systems, and networking equipment needed to interconnect and host the Mission Operations software. This element includes the design, development, implementation, integration, test, and the associated support equipment of the ground system, including the hardware and software needed for processing, archiving, and distributing telemetry and radiometric data, and for commanding the spacecraft. Also includes the use and maintenance of the project test beds and project-owned facilities. This element does not include integration and test with the other project systems and conducting mission operations.

Element 10 - Systems Integration and Testing (I&T): This element includes the hardware, software, procedures, and project-owned facilities required to perform the integration and testing of the project's systems, payloads, spacecraft, launch vehicle/services, and mission operations.

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MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 220 of 230

Element 11 - Education and Public Outreach (EPO): Provide for the EPO responsibilities of NASA's missions, projects, and programs in alignment with the Strategic Plan for Education. This element includes management and coordinated activities, formal education, informal education, public outreach, media support, and website development.

TECHNOLOGY DEVELOPMENT PROJECT Work Breakdown Structure (WBS) Standard Level 2 Elements

From NPR 7120.8, Appendix K (Formerly Advanced Technology Development Project):

Standard Level 2 WBS elements for technology development projects are shown in Figure 119 below. The standard WBS template assumes a technology development project with no flight elements. For technology development projects, additional WBS elements may be added horizontally (i.e., at Level 2) as long as their content does not fit into the content of any existing standard WBS elements. The elements that are not applicable do not need to be used (entered into Metadata Manager (MdM)). For technology development projects managed as Space Flight Projects in accordance with NPR 7120.5, the Space Flight Project WBS will be used.

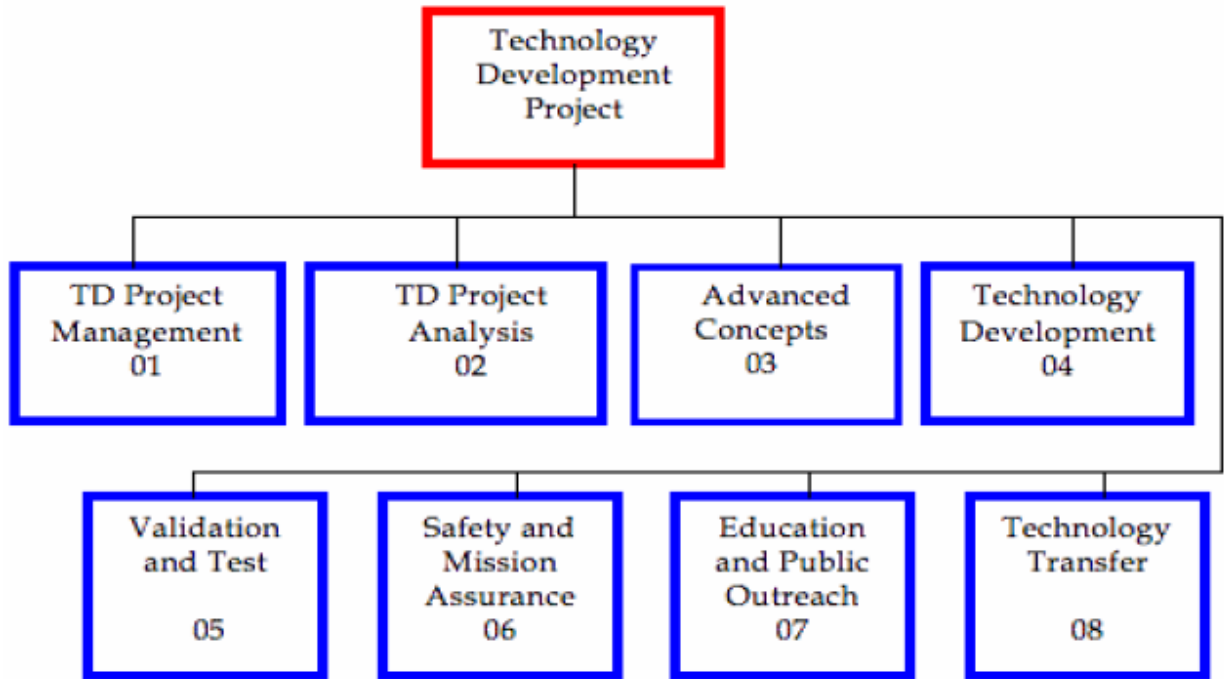


FIGURE 119. Technology Development Project Standard WBS Following is the **Technology Development Project Standard WBS Dictionary:**

Element 01 – Technology Development Project Management: The business and administrative planning, organizing, directing, coordinating, controlling, and approval processes used to accomplish overall project objectives, which are not associated with specific hardware or software elements. This element includes project reviews and documentation, non-project owned facilities, and project reserves. It excludes costs associated with technical planning and management and costs associated with delivering specific engineering, hardware, and software products.

Element 02 – Technology Development Project Analysis: System and Portfolio Analysis includes the process of developing qualitative and quantitative understanding of key technical issues and drivers, including current

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 221 of 230

limitations and challenges. These analyses are the foundations that support development and assessment of: goals, requirements, scope, risk/feasibilities, costs, design, integration, and operations. Based on the systems analysis, the process further identifies and tracks the investment trade spaces and supports the project's ability to optimize its resources to maximize the return on investment within acceptable risk exposure, budget, schedule, and performance requirements.

Element 03 -- Advanced Concepts: This WBS element encompasses low-level studies (possibly including laboratory experiments) intended to explore the feasibility of new ideas or approaches to accomplish programmatic or technical objectives. Often they are inspired by new scientific or technical breakthroughs that open up new avenues for technological investigation. Advanced concept activities can be an integral part of a specific technology project, or they can be separate technology activities focused on broad topics. Advanced concept activities are tied to long-term objects, though this is not required, and due to their speculative nature, are generally considered high-risk. Also, they tend to be managed in a looser manner than technology development. Advanced concept studies are a principal means for identifying promising new opportunities for high payoff technology development.

Element 04 -- Technology Development: This WBS element encompasses the execution phase of implementing a technology development project plan. Most of the lower level (Level 3 and below) WBS elements associated with achieving the technical objectives (e.g., performance metrics) of the project are contained within this element. Technology Development projects span the gap from advanced concepts to engineering or advanced development (Technology Readiness Level (TRL) 2/3 to TRL 6/7), and can begin and end anywhere within this range. Once a project has started, technology development will include the continual assessment of progress, redistribution of resources, and schedule updates necessary to meet key milestones within budget and schedule. When the intended outcome cannot be met within plan, re-planning at the project level falls within Project Management. The primary deliverables, including technical progress reports and documenting technical accomplishments, are part of this WBS element.

Element 05 -- Validation and Test: This element provides for specific activities to test and validate products of technology development when those activities represent a critical aspect of the overall technology development plan. A separate test and validation element will be part of the project that intends to achieve TRL 6/7. The element encompasses the development hardware/software test validation articles; development or acquisition of special test or validation equipment; scheduling and staffing facilities or ranges; as well as the development and execution of the test or validation plan. Often the full context of test and validation may not be known at the beginning of the project, and will be developed as required. In some cases, if extensive use of large-scale facilities is required, or the test/ validation takes on the characteristics of a space flight project, it will be conducted as a flight project (e.g., space-flight project) within the WBS element or transferred to a space flight project in accordance with NPR 7120.5.

Element 06 – SMA: Provides for directing and controlling the SMA elements of the project. This element includes design, development, review, and verification of practices, procedures, and success criteria intended to assure that the delivered product meets performance requirements and function for their intended lifetimes. This element excludes mission and product assurance efforts at partners/ subcontractors other than a review/oversight function.

Element 07 – Education and Public Outreach (EPO): Provide for EPO responsibilities of NASA's missions, projects, and programs in alignment with the Strategic Plan for Education, including formal and informal education, public outreach, media support, and website development.

Element 08 -- Technology Transfer: This WBS focuses principally on three types of activities: (1) Transferring knowledge and technology development products developed within the project to non-NASA entities that are not part of the project either as direct participants or as direct beneficiaries of the project; (2)

CHECK THE MASTER LIST – VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 222 of 230

Acting on behalf of the project to identify and transfer into the project knowledge or technology from sources not directly participating in the project or benefiting from the project; and (3) Providing supporting expertise to transfer knowledge and technology products between NASA and non-NASA entities, including project participants. Technology transfer requires special expertise not associated with any specific project or required to accomplish primary technical objectives/milestones/metrics. Also, technology transfer activities are often an integral part of the overall project plan, but not necessarily an integral part of the technology development process. As such, it is often appropriate to fund, implement, and manage technology transfer as a distinct element of a technology development project.

**RESEARCH & TECHNOLOGY (R&T) PORTFOLIO PROJECTS WORKBEAK DOWN
STRUCTURE (WBS) STANDARD LEVEL 2 ELEMENTS**

From NPR 7120.8, Appendix K (Formerly Basic and Applied Research Portfolio WBS):

Standard Level 2 WBS elements for R&T Portfolio Projects are shown in Figure 120 below. The template is used to specify the integrated budget within the R&T Portfolio Project Plan. For R&T Portfolio Projects, additional WBS elements may be added horizontally (i.e., at Level 2) as long as their content does not fit into any existing WBS elements. The elements that are not applicable need not be used. For R&T Portfolio Projects managed as Space Flight Projects in accordance with NPR 7120.5, the Space Flight Systems Project WBS will be used.

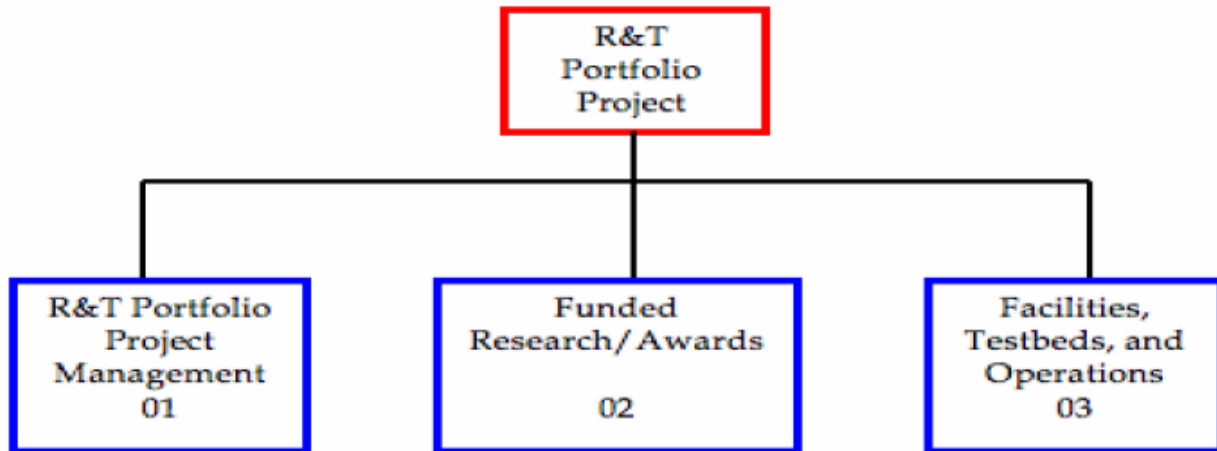


FIGURE 120. Research and Technology Standard WBS

Following is the R&T Portfolio Project Standard WBS Dictionary (from NPR 7120.8, Appendix K, formerly Basic and Applied Research Portfolio Standard WBS Dictionary):

Element 01 -- R&T Portfolio Project Management: The management activity is paid for with R&T Portfolio Project dollars. This includes salaries and travel (e.g., civil service personnel, Intergovernmental Personnel Act assignees, detailees), peer review management (contractor support, travel, and honoraria), and meetings and conferences.

Element 02 -- Funded Research/Awards: The awards from either competed or directed elements of the R&T Portfolio Project. This includes grants, Independent Assessment Teams, R&T Objectives, Plans Summaries, and contracts. It may also include awards for Education and Public Outreach (EPO).

Element 03 -- Facilities, Test beds, and Operations: The non-award infrastructure costs that support the R&T Portfolio Projects.

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MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 223 of 230

Appendix G Project Planning & Control (PP&C) Key Questions

The following are recommended questions related to PP&C:

Planning

1. Is your Work Breakdown Structure (WBS) product oriented and compliant with MPR 7120.1?
2. Has the entire scope of work been incorporated into the WBS? Is there any scope not included?
3. Are all WBS elements and deliverables/milestones contained in the Integration Master Schedule (IMS)?
4. Is there cost and schedule integration? How do you ensure reconciliation of the two?
5. Does the level of cost collection in Integrated Enterprise Management Program (IEMP) provide you the visibility needed to manage your project?

Technical Performance

1. What technical performance requirements have changed since the last Center Management Council (CMC) meeting, and when were these changes incorporated into the cost and schedule baseline? (e.g., if you're not meeting your technical objectives, you might see cost growth, schedule slips, added scope, etc. If a change is needed, you'd expect to see a change in your baseline.)
2. How well do your technical metrics agree with your cost and schedule metrics? (e.g., if there are technical difficulties or breakthroughs, you'd expect to see an impact (good or bad) to your cost and schedule metrics).

Risk Performance

1. Which of the major risks have been included in the current cost and schedule baseline and which have not been? [i.e., Risk mitigation steps with dates should become tasks in the Integrated Master Schedule (IMS), and since work is being performed (resources are expended to step down the risk to an acceptable level), there should be a cost associated with that work].
2. Describe the adequacy of schedule, cost, and technical reserves/margins based on the current burn rate?
3. Assuming "most problems occur at the interfaces," what are the key interfaces associated with this project?
4. Has a Schedule Risk Assessment (SRA) been performed?

Performance toward Goals/Objectives

1. Is the project at risk of not fully meeting any Level 1 requirements?
2. How many times has the project re-baselined since Key Decision Point (KDP) C?
3. If Earned Value Management (EVM) is required, was an Integrated Baseline Review (IBR) conducted? If so, when? What were the results?

Cost/Financial Performance

1. What is the cause of major Cost Variances (CVs) that have occurred since the last CMC? What actions have been taken in response to these variances?
2. Is the current year funding per the approved baseline plan (funds vs. budget)? Has the project received all the required spend authority?

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 224 of 230

3. Does your project have EVM requirements? Is the baseline stable enough for EVM data to be useful? If so, what is the current Cost Performance Index (CPI)? (Note: for every dollar spent, how much work was accomplished?) If not, what would it take to maintain the baseline? If elements of the project are not using EVM, how is cost performance being measured?
4. Is there still confidence in the Performance Measurement Baseline (PMB) being achievable?
5. What is the current Estimate at Completion (EAC) versus the Budget at Complete (BAC) and what is the trend versus time of these metrics? Does this EAC reflect a cost probability of identified risks? Does this project have sufficient reserves to meet this predicted EAC? How has the EAC been reflected in the Project Planning, Programming, Budgeting & Execution (PPBE) process? Are there sufficient funds (both total and time-phased) to meet this EAC? If not, what actions are required?
6. What is the To-Complete Performance Index (TCPI) to meet the BAC and EAC? (Note: A TCPI-BAC of 1.10 means that the remaining work must be accomplished at 110% cost efficiency to meet the BAC, or in order to meet the BAC, for every dollar of work, you must perform a \$1.10 worth of work, and likewise for the EAC formula.)

Schedule Performance

1. What is the cause of major Schedule Variances (SVs) that have occurred since the last CMC? What actions have been taken in response to these variances?
2. What is the float value on the critical path? Do you have adequate float and/or schedule margin/reserve? What is it?
3. What deliverables in the project's top critical paths (the critical path and near critical paths) are you most worried about?
4. What is the projected completion date? Does the projected slip include schedule probability of identified risks? Is this impact reflected in your EAC?
5. Are any deliverables dependents on new technology/technology development?
6. What correctives actions are being done to bring the schedule back on track? (Note: Crashing the schedule (reducing task durations), Fast tracking the schedule (re-sequencing more tasks to be done in parallel), etc.)
7. For projects with EVM requirements, what is the current SPI? (Note: for every dollar planned, how much work was accomplished?) If EVM is not required, how is schedule performance being measured?
8. How much Level of Effort (LOE) work is there? (Note: LOE tasks should be held to the lowest practical level, 20% or less)
9. If applicable, how are subcontractor(s) schedules developed and integrated into the IMS?
10. How often is the IMS updated?

External Agreements

1. What is the status of all external agreements in relation to the approved baseline plan? Are there any issues?

Partnerships

1. What is the status of key partner commitments in relation to the approved baseline plan? Are there any issues?

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 225 of 230

Contracts

1. What type of contracts do you have (cost plus, Fixed Price (FP), other)?
2. What contracts have not been awarded? Which ones have an EVM requirement?
3. What are your major contract issues and challenges?
4. For those that did get awarded, is EVM required? If so, did the IBRs verify that the contractors fully understand the contract scope, and do we have confidence that their baseline plan is achievable?
5. What are the status of undefinitized contract actions and the estimated impact of those actions on the cost and schedule baseline?
6. If you are receiving EVM reporting, how are you managing with it? What is the contractor's cumulative Cost Performance Index (CPI) & Schedule Performance Index (SPI)?
7. If EVM is not required, what performance information is the contractor providing?
8. Have you authorized the contractor to perform any scope of work that has not yet been formally incorporated into the contract?

Facilities

1. Describe the adequacy of required facilities to support project activities and any facility requirements that are not currently identified in the IMS?
2. Describe the mechanism in place to negotiate facility impacts as a result of project or facility baseline changes.

Change Control

1. Is there a change control process? How are cost/schedule/technical changes managed?
2. Are there any pending cost/schedule/technical changes that have not been incorporated into the baseline?

Workforce

1. What changes have occurred in critical staff and skills availability or forecast since the last CMC? What support staff or skills are lacking?
2. Is the IMS resource loaded to ensure cost and schedule integration? If not, how are you determining resource requirements and ensuring cost and schedule integration?
3. For in-house work, what process is used for Work Authorization (WA), and how are changes to work agreements communicated and formally resolved? How responsive have both parties been concerning changes that have occurred since the last CMC?
4. What is the estimated overall insight/penetration level of major contracts? What lower Work Breakdown Structure (WBS) level penetration/insight changes have occurred since the previous CMC?

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 226 of 230

Appendix H Earned Value Management (EVM) for Small Cat 3 Projects

INTRODUCTION

NASA has prepared this Earned Value Management (EVM) guidance for Category 3, Class D projects with a Life Cycle Cost (LCC) estimate of \$150 million or less. This approach was developed recognizing that smaller projects may not require the full rigor of an EVM System (EVMS) when compared with major acquisitions, such as much larger development projects. Note that this approach was developed for in-house work and that contracts that are part of these projects must meet the requirements of NFS 1834.201.

The NASA EVM capability has been scaled using the Seven Principles of an EVMS cited in the TechAmerica – formally American National Standards Institute (ANSI) – Standard/Electronic Industry Association (EIA-748). When followed, these principles will provide necessary best practices and enable insight into performance for less complex projects. This approach allows flexibility in implementing EVM, while meeting the intent of the principles of project management. For more detail, go to the NASA EVM Capability System Description.

Each of the Seven Principles is discussed and examples of objective evidence (required products) have been identified that are necessary to achieve project requirements and meet the intent of the EVM principles. Although the Seven Principles offer less rigor in the implementation of an EVMS, it is necessary for NASA projects to demonstrate that fundamental management processes and products are in place for effective project management. As part of the Project Plan as described in NPR 7120.5E, the project will define the implementation of EVM in the Project Control Plan. See Appendix J-1 of the NASA EVM Implementation Handbook for assistance in developing a plan.

Principle 1: Plan all work scope for the program to completion

The Project Plan will be created and is a narrative description of the authorized project work scope and deliverables for in-house efforts as well as contracted efforts. As part of the planning effort, a Work Breakdown Structure (WBS) will be developed and used as the foundation for planning all authorized work required to complete the project. The WBS is a foundation for planning all authorized work required to complete the project. The WBS is a product-oriented hierarchical division of hardware, software, services, and data required to produce the project's end product(s), structured according to the way the work will be performed and reflecting the way in which product costs and schedule, technical, and risk data are to be accumulated, summarized, and reported. For space flight projects, the Level 2 WBS found in *NASA Procedural Requirements (NPR) 7120.5* should be used, and tailored as necessary. For research and technology projects, the Level 2 WBS found in *NPR 7120.8* should be used. In addition, a WBS Dictionary should be developed which describes in detail, including deliverables, work effort in each WBS element. The NASA WBS Handbook (NASA SP-2010-3404) provides guidance on developing a WBS.

Objective Evidence:

- Project Plan, which includes the Project Control Plans where EVM is described
- WBS
- WBS Dictionary

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 227 of 230

Principle 2: Break down the program work scope into finite pieces that are assigned to a responsible person or organization for control of technical, schedule and cost objectives

The control accounts (CAs) and work packages (WPs), will be created to support the WBS and are the main juncture for the planning and control of authorized work. All aspects of the system including budgets, schedules, work assignments, cost collection, progress assessment, problem identification, and corrective actions come together at that point. Also, a project Acquisition Plan will be created identifying all major proposed acquisitions in relation to the project WBS.

The project will create and maintain an Integrated Master Schedule (IMS) to provide a time-phased plan for performing the project’s approved total scope of work and for achieving the project’s goals and objectives within a determined timeframe. The IMS will be a core tool for the integration, control, and analysis of all project work scope. The IMS will be structured based on the WBS, and CAs/WPs will be identified at meaningful levels to provide visibility into performance. Milestones and interdependencies will be developed using industry and NASA scheduling best practices (NASA/SP-2010-3403) to provide a logic network that accurately models the approved project scope. The IMS will provide the time-phasing utilized in the Performance Measurement Baseline (PMB).

Objective Evidence:

- Integrated Master Schedule (IMS)
- Make/Buy list
- Acquisition Plan

Principle 3: Integrate program work scope, schedule, and cost objectives into a performance measurement baseline against which accomplishments are measured. Control changes to the baseline.

Based on the WBS and CAs/WPs, the project will integrate project work scope, schedule, budget, and funding requirements into a PMB against which accomplishments can be measured. The objective is to create a comprehensive plan that links the project scope with the resources required in a time-phased manner, also known as Budgeted Cost for Work Schedule (BCWS). BCWS is established for each month of the plan, for as far out into the future as the work packages are defined. Ideally, this monthly plan would be established through the end of the project, but in reality there often are activities that are not defined well enough at the Key Decision Point (KDP)-C (confirmation gate review) to enable projection through the end of development, let alone the end of the project. In those cases, quarterly or annual budgets for those undefined elements linked to a few measurable technical milestones will have to suffice until that point when the work is further defined, and a detailed BCWS can be created. Project management should work to minimize those undefined elements prior to or at KDP-C, and to define the detailed BCWS as early as feasible in the project, as the work packages that are not well defined carry a significant risk to completion of the project on time, within budget.

The project will provide a comprehensive Basis of Estimate (BoE) for all elements of the BCWS, down to at least the WP level.

While not included in the PMB, the establishment of reserves is a critical part of the project planning process. The Project’s reserve posture and management plans, including Management Reserves held by either the Project or contractors, will be established via a rigorous and thorough process that identifies and characterizes all known risks to executing the plan, while also assessing the level of uncertainty in the Project’s ability to execute the plan. The cost and schedule impacts of the risk and uncertainty will be assessed and documented in a comprehensive BoE for the recommended reserve posture. The plan for managing, allocating and tracking and reporting reserve usage at all levels of the Project (HQ/Program,

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 228 of 230

Project, Contractor, CA, and WP) will also be fully documented. The Project’s reserves, BoE, and management plan will be presented to Center and HQ management to enable management to make informed decisions regarding: (1) required funding and schedule reserve levels for the project above and beyond the PMB; and (2) where (contractor, control account, project top level, HQ) and when those reserves are to be held. Note that this planning and risk assessment process might take several iterations to enable the project to execute the final agreed project scope per an agreed schedule within the available budget.

PMB changes should, in principle, be limited to only approved changes in work scope or externally induced changes to schedules or budgets. It is recognized that additional changes might be desired, particularly if the project’s performance varies so significantly from the baseline. However, changes to the baseline based on anything other than scope or external changes (e.g., resets based on large variances to date) severely limit the PMB as a management tool, and are to be avoided if possible. All rebaselines or replans should be approved by the project sponsor at the HQ level. The purpose of the program control processes is to provide an accurate picture of progress against the plan agreed to at KDP-C and to facilitate management actions and decisions in response to that performance to date. The PMB must be stable in order to achieve that purpose.

Objective Evidence:

- Technical Baseline
- Schedule Baseline
- Budget Baseline
- Integrated PMB with monthly BCWS established for as many work packages as possible for as far into the future as possible
- Comprehensive Basis of Estimate (BoE) for the PMB as well as for the reserve posture
- Change Management Process
- Control Account Plan
- Risk Management Process and Assessment
- Funding/schedule reserve (MR) plan

Principle 4: Use actual costs incurred and recorded in accomplishing the work performed

Actual costs recorded in the NASA accounting system will be obtained and used. It is essential that all costs be identified down to at least the CA level as work progresses and that the actual costs align to the authorized project budgets. All costs will be recorded in NASA’s Core Financial Systems including SAP, Business Warehouse (BW), the Contract Management Module (CMM) and Agency Labor Distribution System (ALDS). Actual project costs should be used for month-end management reporting. The actual cost at contractors and within the NASA accounting system should include accruals in accordance with federal accounting standards, not just paid invoices. On occasion where actual cost is not recorded in the same time period as work accomplishment, alternate methods or reporting the actual cost needs to be implemented. A process of using estimated actuals will need to be considered to avoid artificial variances. Information on estimated actuals can be found in the *NASA/SP-2013-3704, NASA EVM System Description*.

Objective Evidence:

Note that the reports should provide data for the entire project down to at least the control account level.

- Systems, Applications, and Products (SAP) Actual Cost Reports
- Contract Performance Report (CPR) or Integrated Program Management Report (IPMR) for both prime and subcontractors when applicable
- NF533 Reports

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 229 of 230

Principle 5: Objectively assess accomplishments at the work performance level

All work will be scheduled by WBS, and CAs/WPs, using measureable units or milestones to enable the objective assessment of accomplishments and to obtain earned value (also referred to as Budgeted Cost for Work Performed or BCWP).

The most appropriate Performance Management Technique (PMT) will be selected in order for EVM indicators to provide accurate and meaningful insight. The task types are Discrete, Level of Effort (LOE), and Apportioned. Projects should seek to plan as much work as possible as discrete tasks, using measureable completion units or milestones to enable accomplishments to be demonstrated objectively. Where a task truly has a direct, supporting relationship to a separate discrete task (e.g., Mission Assurance), that task should be planned as apportioned work. LOE should be limited to those activities (e.g., project management) that absolutely cannot be planned as, or linked to, a measureable completion unit or milestone.

Special attention should be paid to PMTs for discrete tasks that are relatively long in duration (>3 months). The number of such tasks should be minimized (by breaking them into measurable sub-tasks) where possible. Where longer duration tasks cannot be avoided, the PMT should be selected to ensure that progress can be measured and recorded accurately so that the performance measurement metrics will provide an accurate picture of project status.

The one common characteristic for all PMTs for all task types is that earned value (EV) is ultimately determined by the product of percent of accomplishment and the Budget Cost for Work Scheduled (BCWS). Once a PMT is selected, it will be documented and reviewed by management and during the Integrated Baseline Review (IBR) to ensure that the above guidance has been followed.

Objective Evidence:

- Integrated Master Schedule (master, intermediate, detailed, as applicable)
- Budget Baseline with PMTs defined

Principle 6: Analyze significant variances from the plan, forecast impacts, and prepare an estimate at completion based on performance to date and the remaining work to be performed

The project will analyze significant variances to the plan to ensure that cost and schedule performance is analyzed and reported. The project will, at a minimum, calculate the following EVM metrics for both monthly and cumulative data at the control account (CA) level:

- Cost Variance (CV)
- Cost Performance Index (CPI)
- Schedule Variance (SV)

Projects are encouraged to go beyond this minimum set of metrics, to track trends using 3-month, 6-month, 1-year, etc., Cost Performance Indexes (CPIs) and SPIs, because important trends are often hidden within the cumulative metrics and distorted in the monthly indices. Projects will include EVM metrics in monthly management reviews and discuss cause, impact, and corrective actions for cost and schedule performance that breaches established thresholds.

The project will prepare and maintain an Estimate at Complete (EAC) based on performance to date, actuals to date, and the estimate of the cost of the work remaining to be performed. The project will calculate an EAC monthly, update the official EAC at least annually. An EAC should also be updated when it is significantly different from the previously reported EAC.

MSFC Technical Standard CS40		
Title: Project Planning and Control Handbook	Document No.: MSFC-HDBK-3684	Revision: A
	Effective Date: September 25, 2017	Page 230 of 230

Objective Evidence:

- Estimate at Complete (EAC)
- Contract Performance Report
- Cost Variance (CV) with explanations for all variances exceeding thresholds
- Cost Performance Index (CPI)
- Schedule Performance Index (SPI)
- To-Complete Performance Index (TCPI)

Principle 7: Use the EVMS information in the organization’s management processes

The project will use the EV in conjunction with other program control data at all management levels: Mission Directorate, program, project, system, subsystem, etc. in its decision-making process to gain an understanding of the performance to date and where the project is likely headed in the future based on trending data.

Objective Evidence:

- Monthly EVM reports, and other monthly cost, technical, risk, and schedule reports
- Metrics included in the project’s monthly management reviews
- Timely, accurate, and reliable EV data to facilitate effective management decisions
- Up to date EAC calculations

EVM References

NASA EVM website: <http://evm.nasa.gov>

NASA Engineering Network (NEN) EVM Community of Practice (CoP):
<https://nen.nasa.gov/web/evm/documents>