

# Continuous Cost-Risk Management & EVM Links to Risk Management for NASA Projects

NASA Risk Management Conference 2004  
(RMC V) - October 26-29

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# Topics



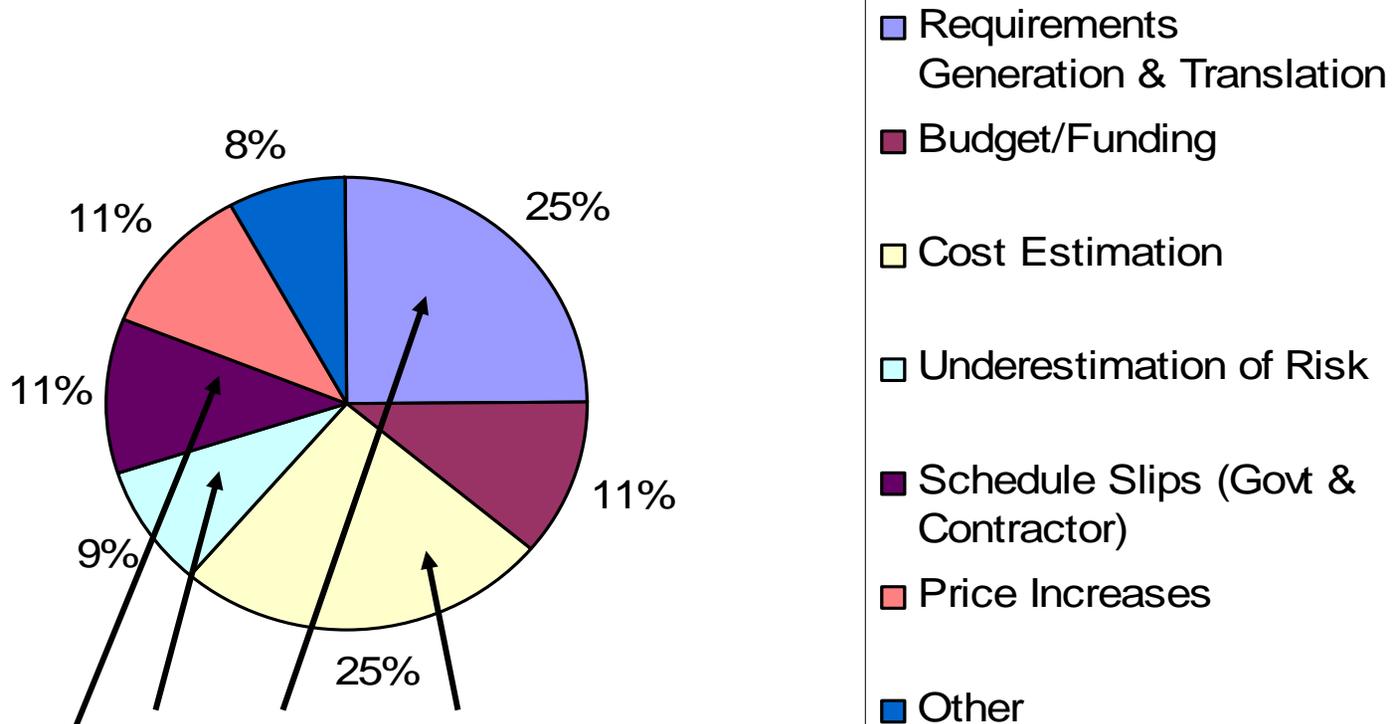
- Why Continuous Cost-Risk Management (CCRM) & EVM for risk management?
  - **NASA Administrator/Comptroller initiatives**
  - **GAO and Aldridge Reports**
- NPR 7120.5C: NASA Project Management
- Continuous Cost Risk Management
  - **Stage 1: Preparation**
  - **Stage 2: Development**
  - **Stage 3: Application**
    - **Earned Value Management**
- CCRM Implementation



# Total Cost Growth for Two Space Programs<sup>1</sup>



## Development Growth Causes



Addressed by CCRM: 70%

## Quantitative Framework

<sup>1</sup>“The Success Triangle of Cost, Schedule, and Performance: A Blueprint for Development of Large-Scale Systems in an Increasingly Complex Environment” - (Booz|Allen|Hamilton, 2003)



# Why Continuous Cost-Risk Management (CCRM)?

- 2002: NASA Administrator and Comptroller charged with improving budget credibility
  - Created HQ Cost Analysis Division
- **Began working on cost initiative improvements: CAIV, CADRe, Cost-Risk, LCCE, EVM, Data Collection etc.**
- **Developed CCRM process**
- 2004 GAO recommendations
  - Develop an integrated plan including
    - Guidance for rebaselining
    - – Enforced use of EVM
    - – Staff and support for cost-estimating and EVM
  - Establish a standard framework for LCCEs
    - Based on a full LCC
    - Using a WBS encompassing both in-house and contractor efforts
    - – Using CARDS (NASA CADRe)
    - – With ICEs at each milestone
    - – Using cost risk assessments
  - Prohibit projects from proceeding through the review and approval process without above

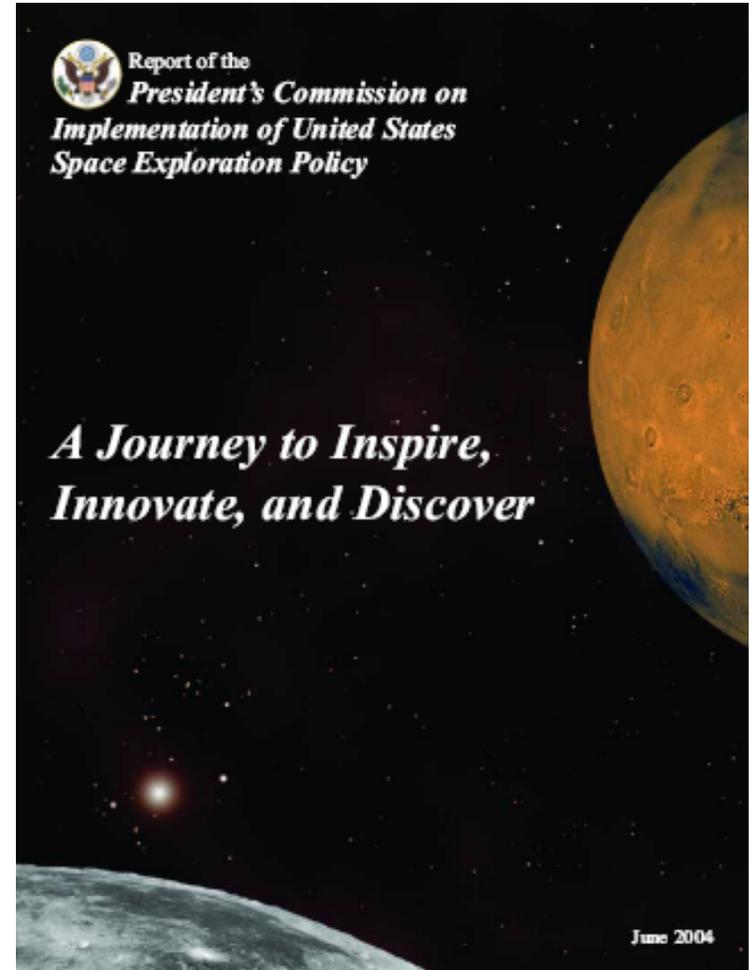
GAO	United States General Accounting Office Report to the Subcommittee on Space and Aeronautics, Committee on Science, House of Representatives
May 2004	NASA
DRAFT	Lack of Disciplined Cost-Estimating Processes Undermines NASA's Ability to Effectively Manage Its Programs
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GAO-04-642	



# Aldridge Commission Recommendations On NASA Cost Estimating



- **Recommended an independent cost analysis organization similar to the OSD CAIG (Cost Analysis Improvement Group)**
  - Independent cost estimating organization
  - Maintains corporate data base of historical project cost information
  - Generally uses parametric cost estimating procedures
  - Recommends final cost position to approving bodies
- ♦ **NASA responding in 7120.5C with a NASA Cost Position development process**





# NPR 7120.5 “C”:



## Program and Project Management Requirement

- Requirements cover all aspects of program and project management at NASA, including....
  - Cost, Risk and Performance Management Integration
- Context is Continuous Cost-Risk Management (CCRM)
  - A cost discipline architecture designed for maximizing the quality of cost management information **for the Project Manager** that:
    - Is a “system of cost systems”
    - Removes the “stove piped” nature of cost disciplines
    - Focuses on **same risks** with which all cost disciplines have to deal
    - Produces **cost-risk feedback** for successful project and risk management
- NPR 7120.5C will replace NPR 9501.3 as governing document for EVM at NASA



# Continuous Cost-Risk Management (CCRM)



- A cost management architecture providing:
  1. **Identification** of medium and high risk WBS elements, their assessment & translation of risk into cost-risk in LCCEs
    - Supports adequate budget for project
  2. **Communication** of identified medium and high risk WBS elements to project managers (contractor or NASA)
  3. **Post-cost estimate tracking** of medium and high risk WBS element cost and schedule performance using EVM system
    - Produces early warning of potential cost and schedule problems
    - Enables actionable intelligence for timely mitigation/management
  4. **Updates** of technical and cost data (including annual LCCEs)
  5. **History** of cost and technical data for use in updating cost models

# Continuous Cost-Risk Management

A System of Cost Systems *linked together in sequence by the same risks*

Incorporated in  
NPR 7120.5C

## Preparation

Cost-Risk  
Feedback:  
Steps 1-5



## Development

Cost-Risk  
Feedback:  
Steps 6-8

## Application

Cost-Risk  
Feedback:  
Steps 9-12



# Continuous Cost -

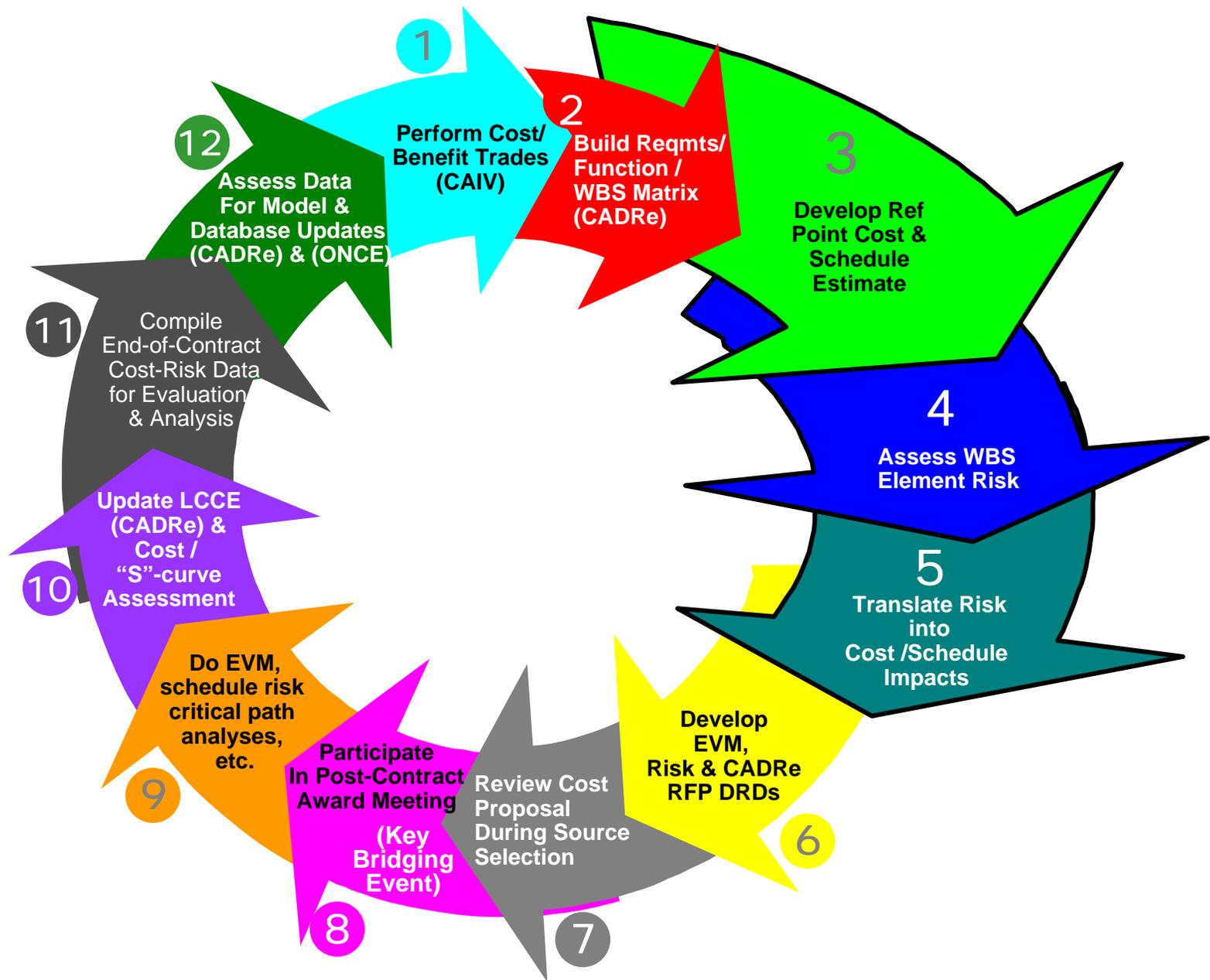
# Risk Management



# Continuous Cost-Risk Management



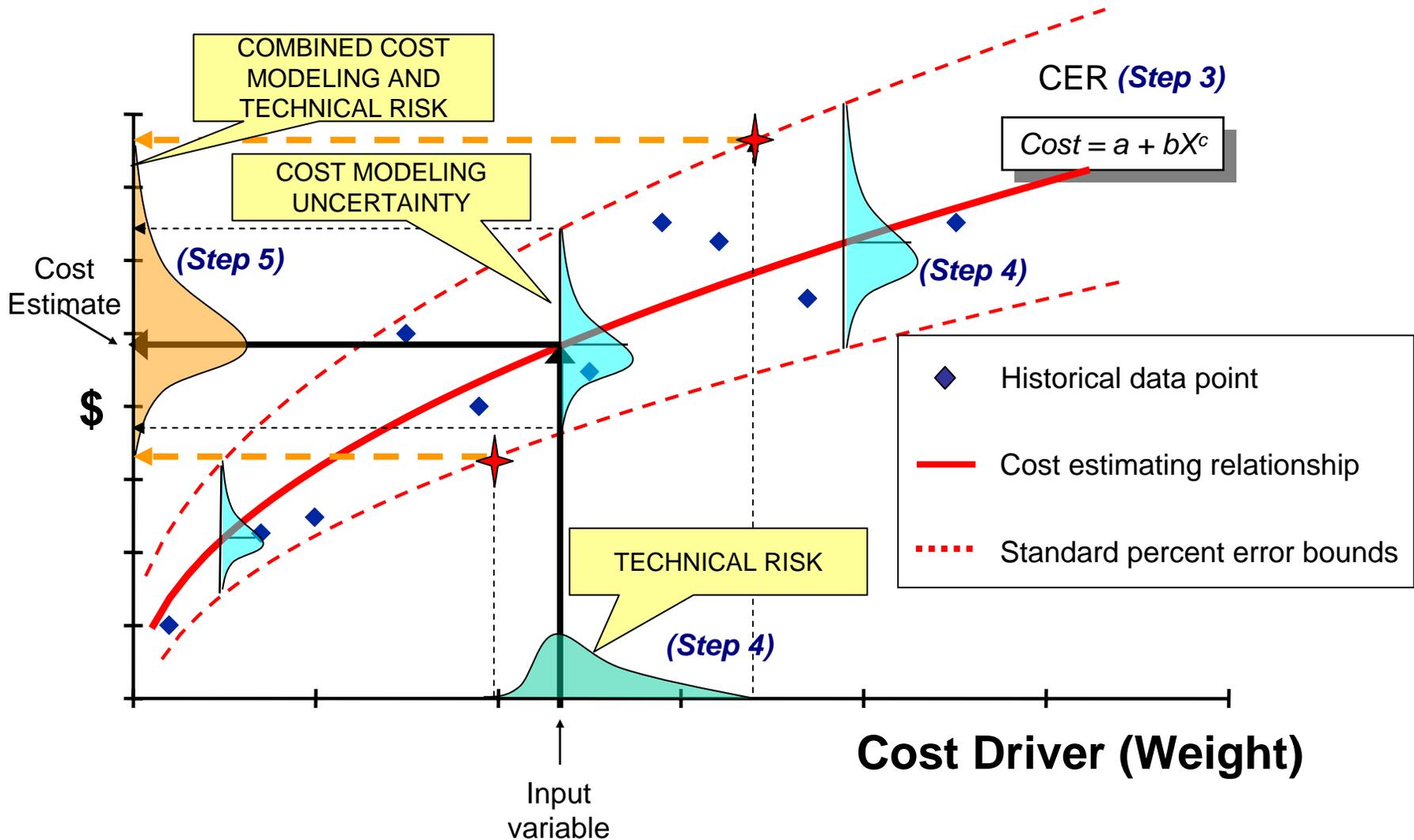
# Continuous Cost-Risk Management





# Translating Risk to Cost Impacts

## e.g., Wavefront Sensor





# SUM WBS COST DISTRIBUTIONS

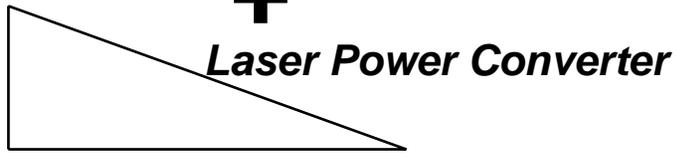


## CORRELATED WBS COST DISTRIBUTIONS:



RPE

+



RPE

+

⋮

+



RPE

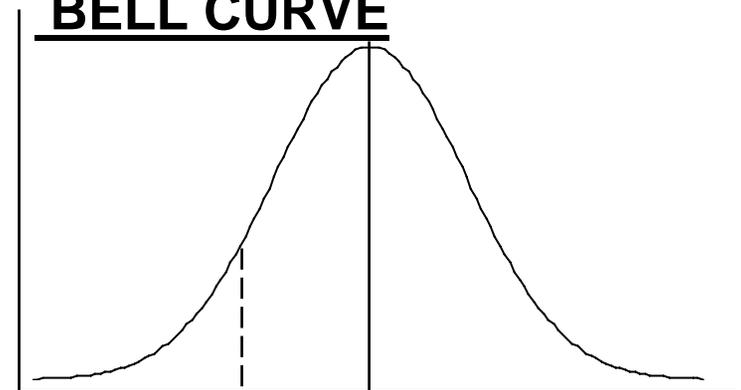
PROBABILITY DENSITY

=

CONFIDENCE LEVEL

## SUMMARY COST DISTRIBUTION:

### BELL CURVE

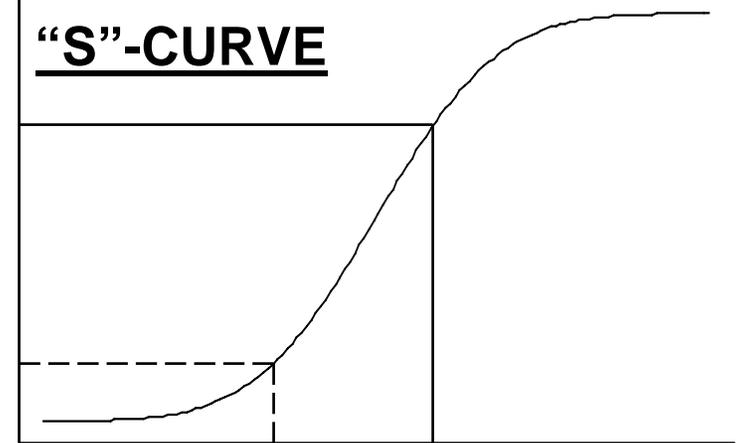


$\Sigma$ RPE

COST

100

### "S"-CURVE



100

85

70

50

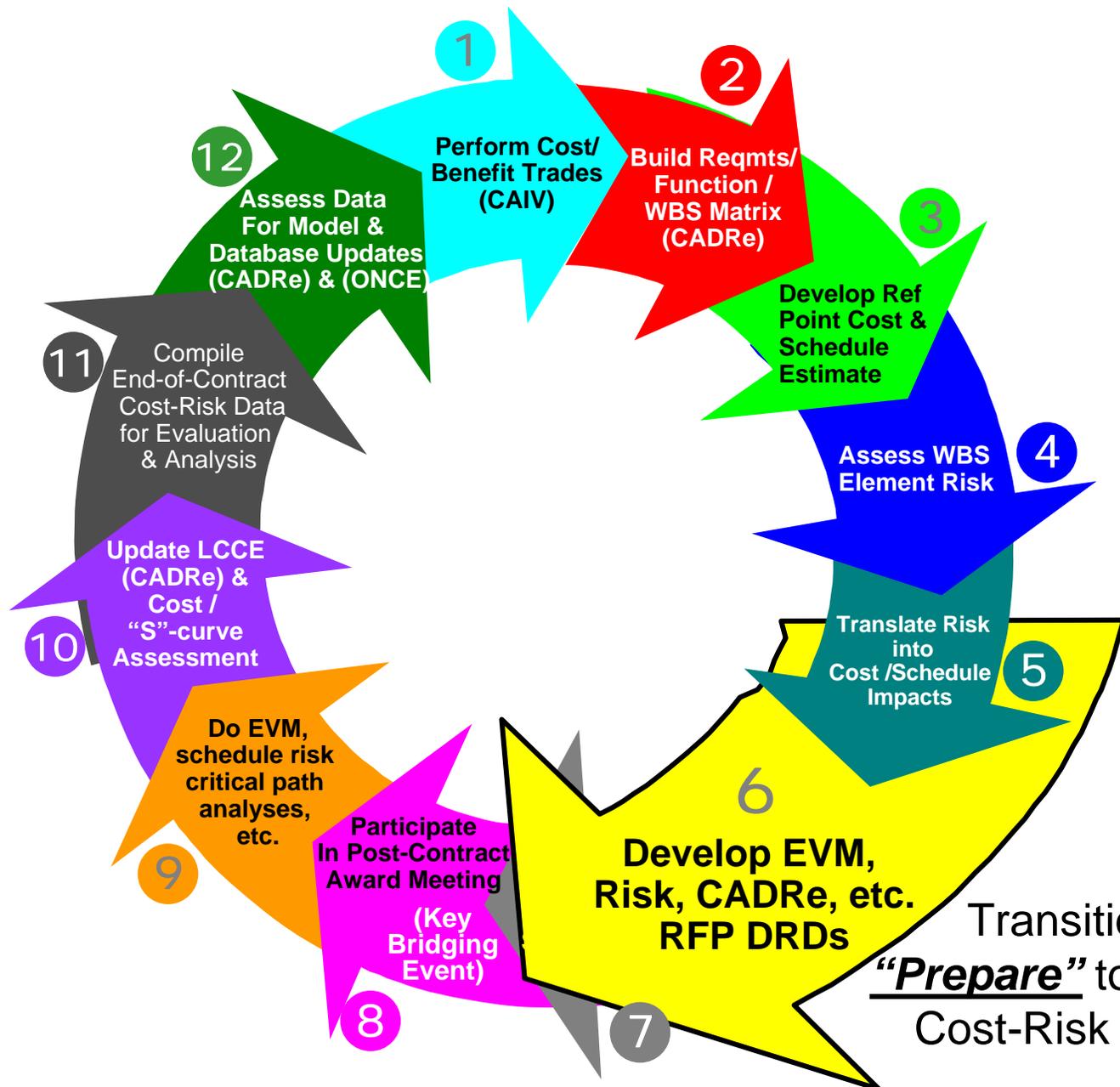
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$\Sigma$ RPE

COST

← Range 1 →

# Continuous Cost-Risk Management





# Develop RFP Cost-Risk DRDs



## *(DRDs Addressed & Interrelated)*

- **EVM Report (Cost Performance Report)**
    - *Identify high and medium risk WBS elements for monthly reporting*
  - **Standardized Work Breakdown Structure (WBS)**
  - **Financial Management Reporting (533M&Q)**
  - **Risk Management Plan & Reports**
  - **PRA Plan and Reports**
  - **Project Integrated Master Schedule**
- Interrelated*
- **Cost Analysis Data Requirement (CADRe)**
    - Equivalent to a combination of the Cost Analysis Requirements Description (CARD); Life Cycle Cost Estimate (LCCE); and, Cost Estimating Data Collection DRDs



# Suggested Earned Value DR Instructions

## Paragraph 1: High Risk WBS List & Reporting Criteria

1. Earned value insight (BCWS, BCWP, ACWP on Format 1 and narrative status on Format 5) for the following high risk WBS elements shall be provided every month regardless of variance percentage levels until the system program office (SPO) informs the contractor otherwise:

(List High Risk WBS Elements here)

If WBS elements, other than those identified here, begin to experience variances exceeding 10% due to technical risk for two consecutive months, the contractor will inform the Program Manager and a consensus reached on adding them to the group of high risk WBS elements identified for monthly cost performance reporting and analysis purposes.

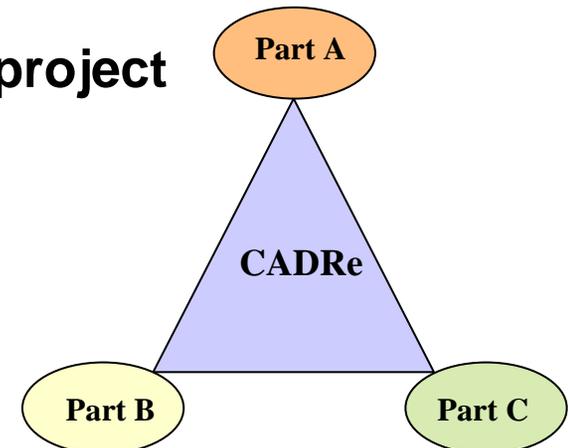
All other WBS elements shall have earned value (BCWS, BCWP, ACWP) reported at level 3 of the WBS to satisfy observing and monitoring requirements according to acquisition reform guidelines.



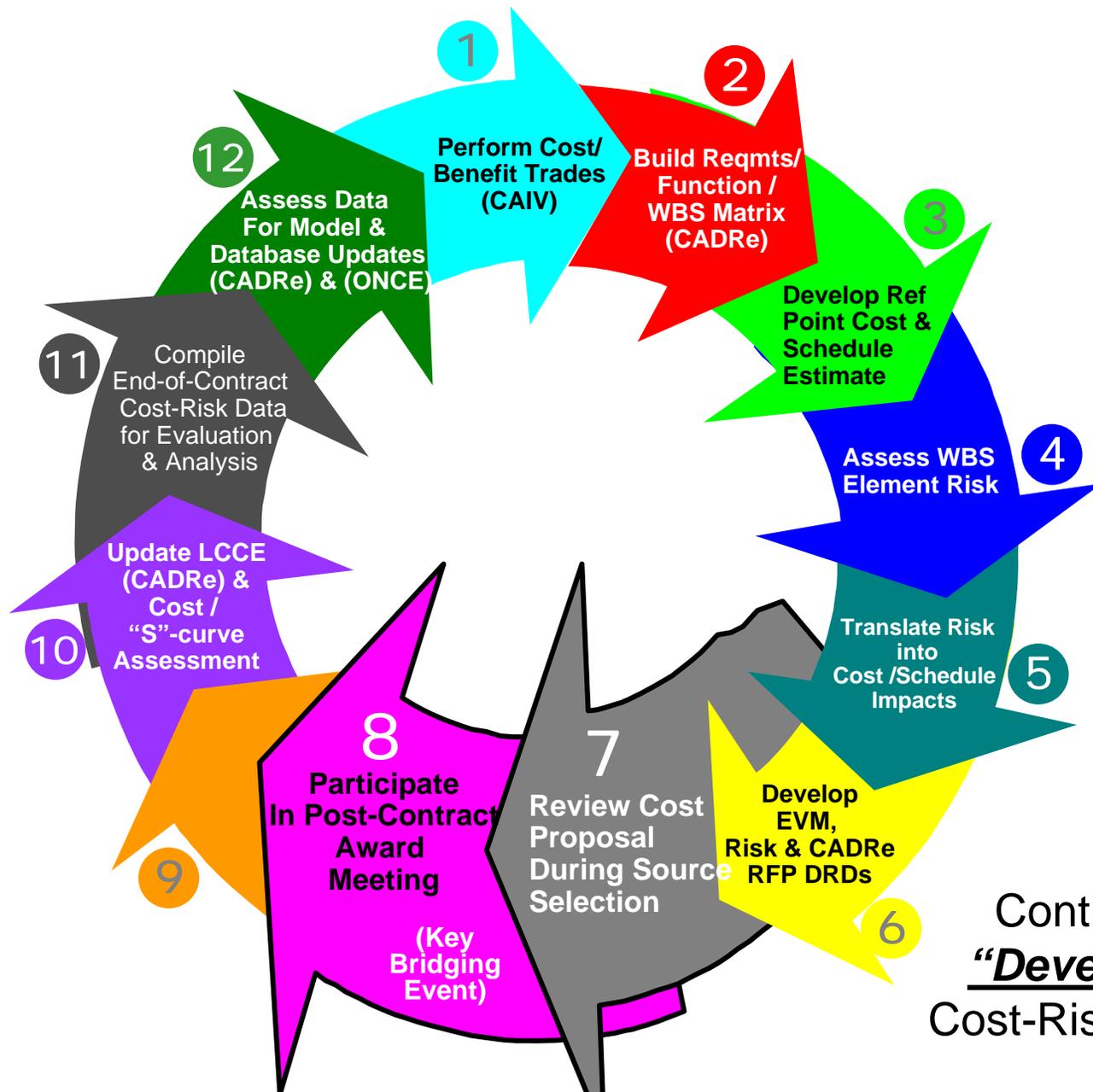
# What's Contained in the CADRe ?



- Part A
  - Includes some traditional CARD information, (streamlined due to NASA product lines)
  - *Includes identification of where risks may affect costs*
- Part B
  - Contains technical cost driver and programmatic data in tabular form
- Part C
  - Integrates the Life Cycle Cost Estimate (detachable)
  - *LCCE Includes impact of risk on cost by WBS element*
- Updated periodically through the life of the project



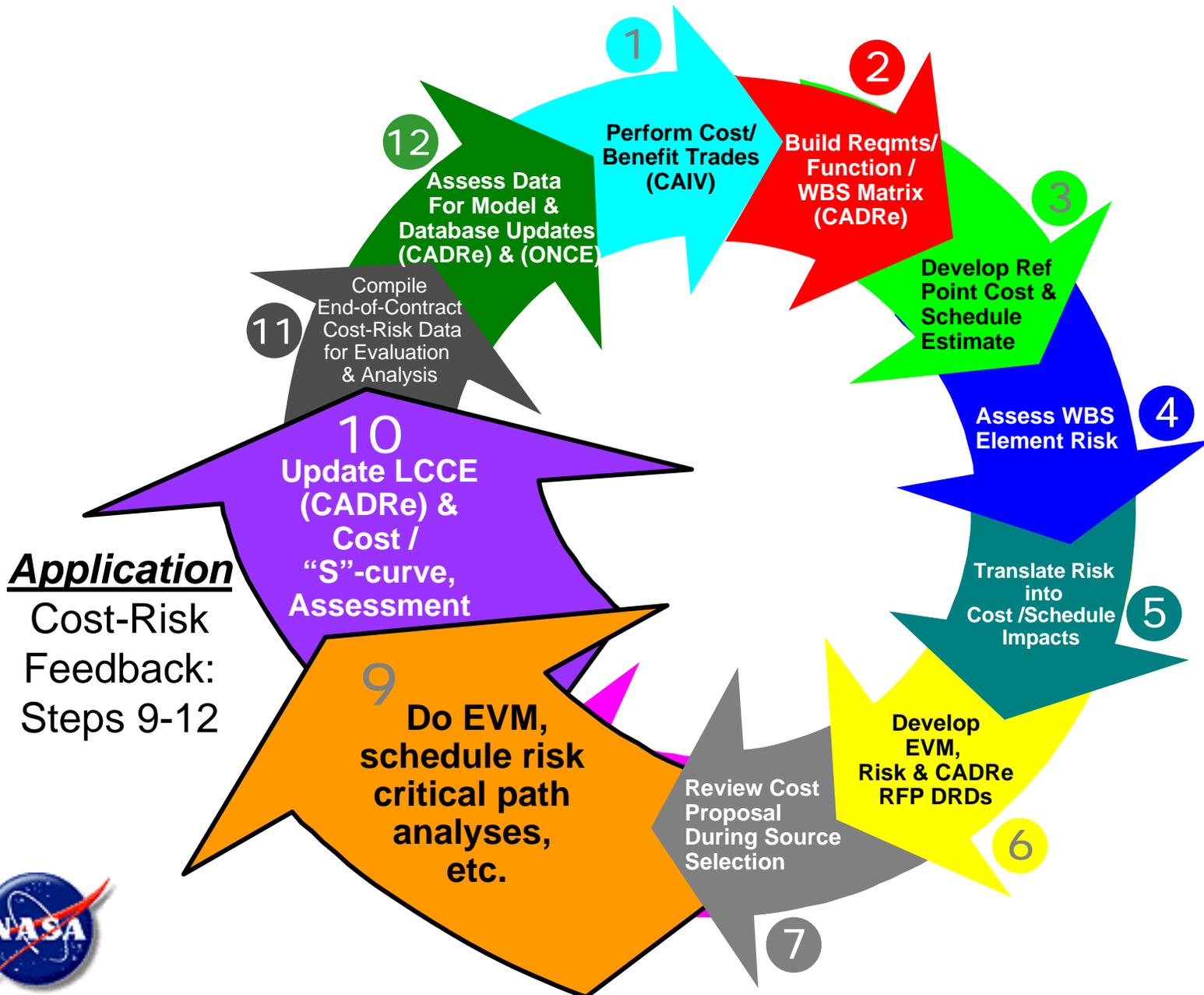
# Continuous Cost-Risk Management



Continue with  
**“Development”**  
Cost-Risk Feedback



# Continuous Cost-Risk Management



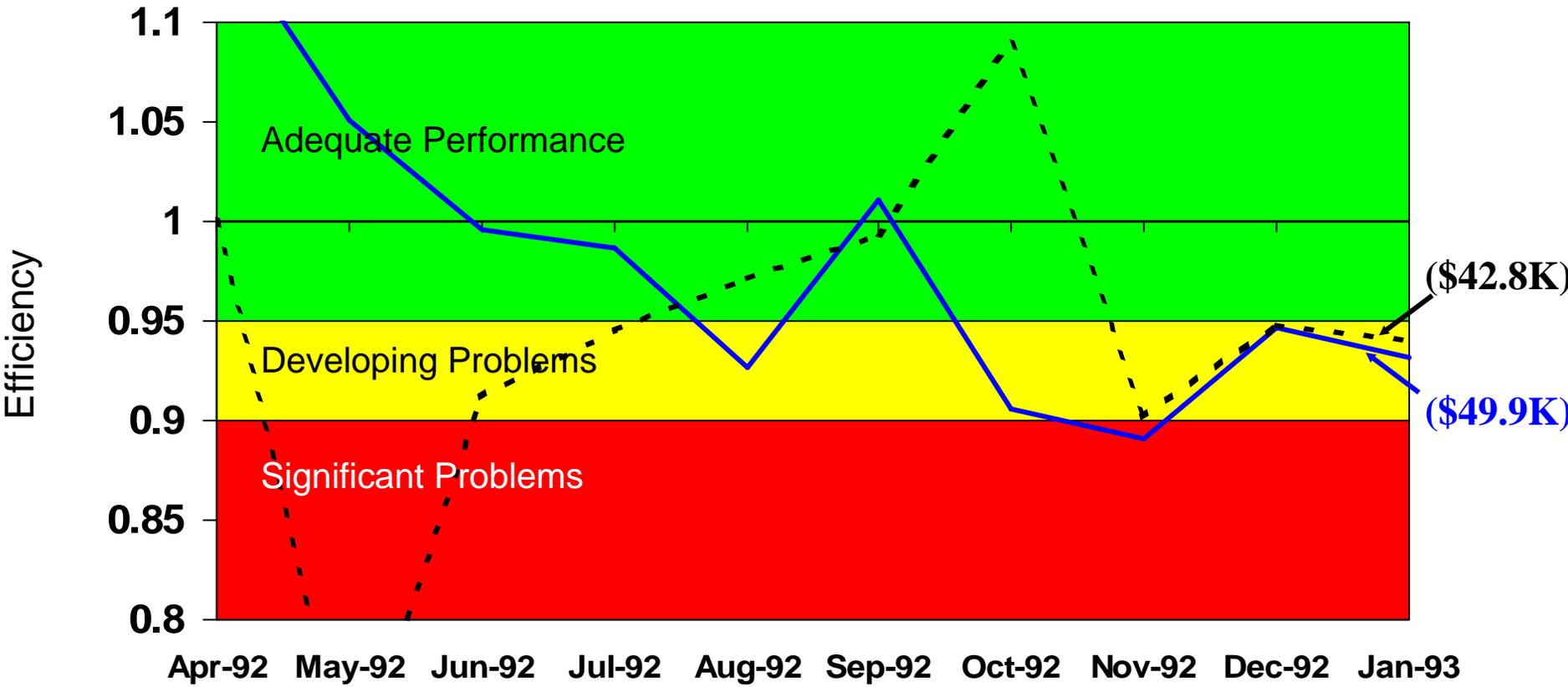


# High Risk WBS Element Focus (EVM Analysis)

Cost and schedule efficiency (Compared to plan)

Baseline: \$2,079.6K (w/out fee)  
 Completion Estimate: \$2,076.1K  
 % Complete: 33 % Spent: 35

— Cost    - - - - - Schedule



Contract: MOH-2      Ktr: Mega Hertz (CPAF) as of June 2004



# NPR 9501.3 Earned Value Management Implementation on NASA Contracts



In Accordance With (IAW), NPR 9501.3 Earned Value Management Implementation on NASA Contracts, CHAPTER 4. Earned Value Management Pre-contract Activities, Paragraph 4.6 **EVM Links to Risk Management** states the following:

*“Throughout the execution of the contract, the Project Manager shall ensure that the results of all analysis based on EVM are linked to the Risk Management Plan of the Project (as applicable). Any cost and/or schedule **risks** being managed by the Project Manger should rely on the results of EVM analysis to track, manage, and mitigate the **risks**.”*



**RISK**: A measure of the potential inability to achieve overall program success within defined cost, schedule and technical constraints. Risk consists of two components: (1) The probability (or likelihood) of failing to achieve a particular outcome; and (2) The consequences (or impact) if failing to achieve that outcome.



## Concepts of Earned Value Management (EVM)

- Earned Value Management is a tool that allows both government and contractor program managers to have visibility into technical, cost, and schedule progress on their contracts.
- The implementation of an Earned Value Management System (EVMS) is a recognized function of program management.
- EVM ensures that cost, schedule and technical aspects of the contract are truly integrated.
- EVM facilitates the Continuous Risk Management (CRM) Process.
- EVM can be implemented on in-house projects as well as prime contractor projects.



## Management Needs

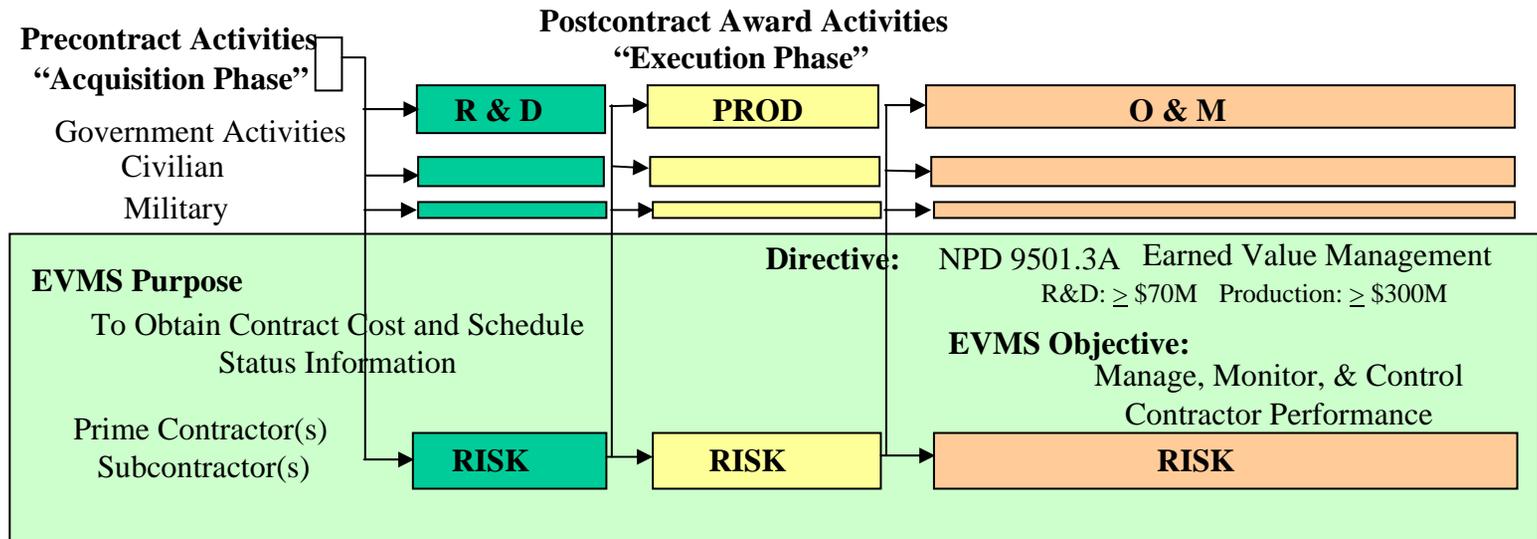
- ❑ A fundamental requirement of the acquisition and/or modifications of major systems is **insight** into the program/project's progress for program management purposes.
  
- ❑ The implementation of an Earned Value Management System (EVMS) on selected contracts within applicable government programs ensures the program manager is provided with program/project cost and schedule performance data which:
  - (1) Relate time-phased budgets to specific contract tasks and/or statements of work (SOW)
  - (2) Indicate work progress
  - (3) Properly relate cost, schedule and technical accomplishment
  - (4) Are valid, timely, and auditable
  - (5) Supply managers with information at a practical level of summarization
  - (6) Are derived from the same internal earned value management systems used by the government/contractor to manage the contract.



# Contract Management Overview



## Can We Meet Program Requirements With Existing Resources?



## Where Are the Risks?

### Type of Data Required to Answer Fundamental Questions?

- Gov't Statement of Work (RFP)
- Contractor's Proposal
- Organization Breakdown Structure (OBS)
- Contract Work Breakdown Structure (CWBS)
- Work Packages/Planning Packages (WPDs)
  - Scope of Work (Technical Content)
  - Budget (Cost) CAM's Estimate Methodology
  - Time Phased (Resources Scheduled Over Time)
- Control Account Plans (EVM Milestones)
- Schedules (Logic Network/Gantt Charts)
- Other Program Documents (WBS Dictionary, Milestone Dictionary, etc.)



# WBS 3.0 TEST & EVALUATION

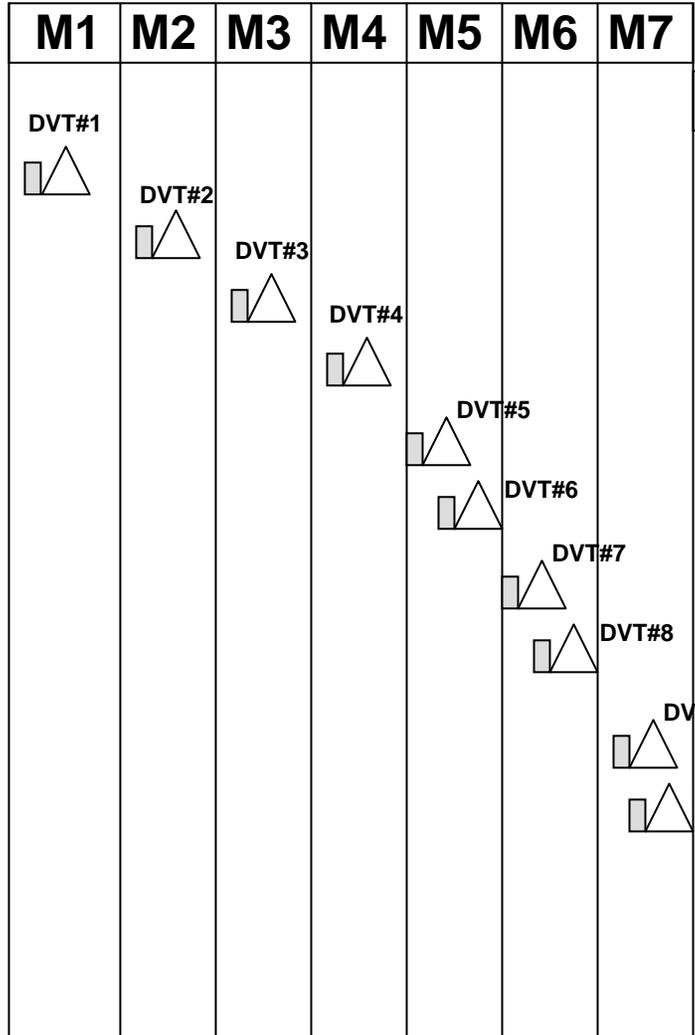


Can We Meet Program Requirements  
With Existing Resources?

## WBS 3.1 Tests

WBS 3.1.1 Design Verification Test

### DVT



WBS 3.1.2 Contractor Developmental Test

### CDT

- DOCUMENTS REVIEWED**
- EDTP
  - Milestone Dictionary
  - Statement of Work
  - Work Packages
  - Scope of Work
  - Cost Estimates
  - Time Phased Budget
  - Logic Networks/Schedules
  - WBS Dictionary

- FINDINGS**
- WPD Indicated 10 Tasks ea.
  - Each Test Had Different Objectives
  - 5 Tests Introduced Special Circumstances
  - ATI/FDR
  - IR Seeker
  - Warhead
  - etc.
  - Each WP Cost Identical

Where Are the Risks?



# ORGANIZATION CONSIDERATIONS



## Integrated Program Management/Earned Value Management Roles & Responsibilities



- EVM Implementation
- EVM Training
- EVM Tools (i.e., Winsight)
- EVM Metrics (CPR Metric)
- Performance Monitoring & Oversight Reporting
- CPR & C/SSR Trend Analysis
- CAM Roles & Responsibilities
- CAM Training – Fundamentals of EVM
- Work Packages & Planning Packages (WP/PP)
- Work Package Documentation (WPDs)
- Control Account Plans (CAP Sheets)
- Earned Value Milestones (EV)
- “What If’s”
- Coordination with Schedule & Risk Management
- Other

- Logic Networks/Scheduling Implementation
- Scheduling PMTs Training
- Scheduling Tools (i.e., MS Project or Open Plan)
- Schedule Metrics
- Performance Monitoring & Oversight Reporting
- Logic Networks/Schedules Status (Monthly)
- Critical Path Method (CPM) Analysis
- Work Around Plans
- Coordinate (WP/PP)
- Coordinate Work Package Documentation
- Coordinate Control Account Plans (CAP Sheets)
- Coordinate Earned Value Milestones (EV)
- “What If’s”
- Coordination with Cost & Risk Management
- Other

- OSP Risk Management Plan Implementation
- OSP Risk Interrelationship Documentation
- CST Risk Management Tools (i.e., IRMA)
- IRMA Metrics (5x5 & Risk Stepdown/Waterfall)
- Performance Monitoring & Oversight Reporting
- CST Risk Trend Analysis
- Integrated Baseline Review (IBR) Focal Point
- IRMA & CRM Training
- Coordinate (WP/PP)
- Coordinate Work Package Documentation
- Coordinate Control Account Plans (CAP Sheets)
- Coordinate Earned Value Milestones (EV)
- Coordination with Cost & Schedule Management
- CST Integration
- Other





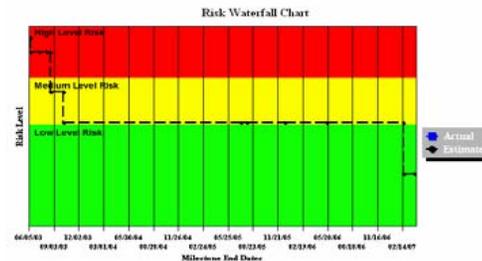
# Risk Management Metrics



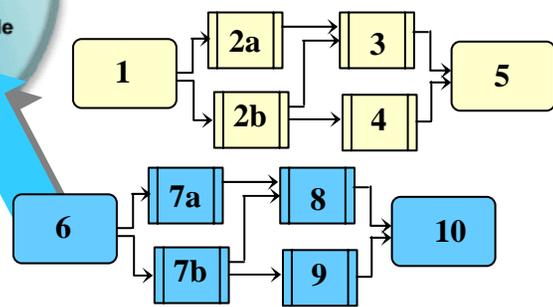
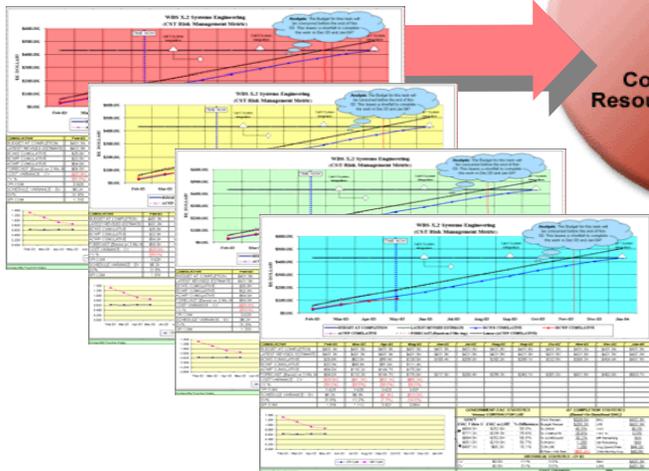
**CONSEQUENCE**

	NEGLIGIBLE	MINOR	MAJOR	SERIOUS	CRITICAL
91 - 100%					
61 - 90%					
41 - 60%					
11 - 40%					
0 - 10%					

**PROBABILITY**



Risk ID: 1000 has 11 task(s) that have been identified and charted

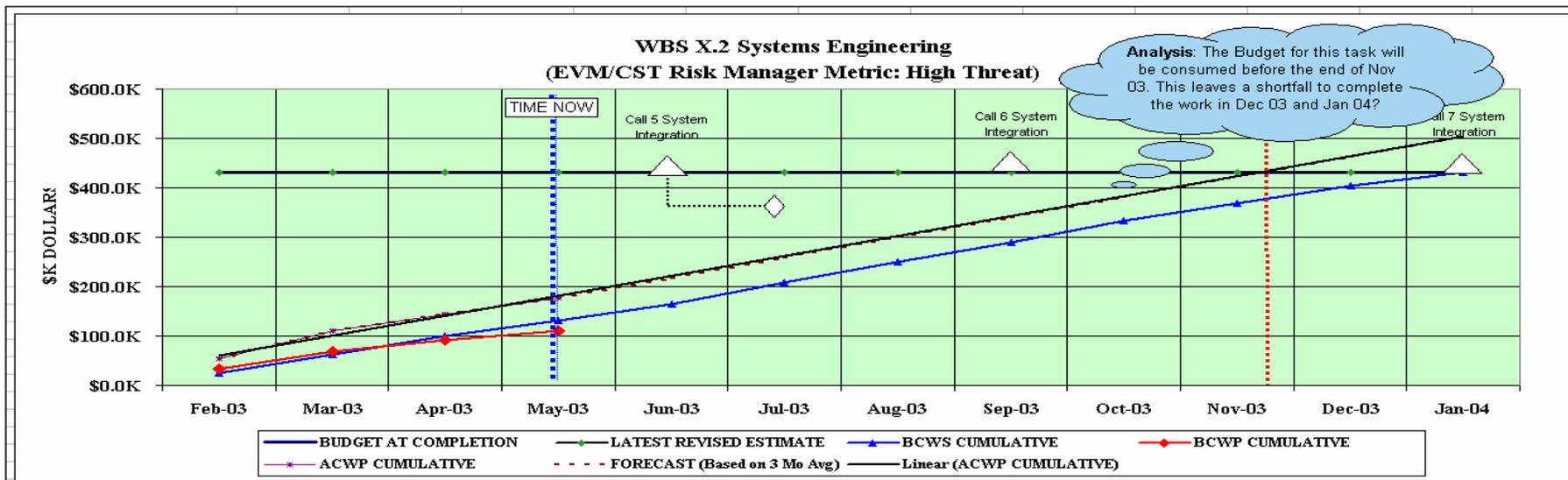




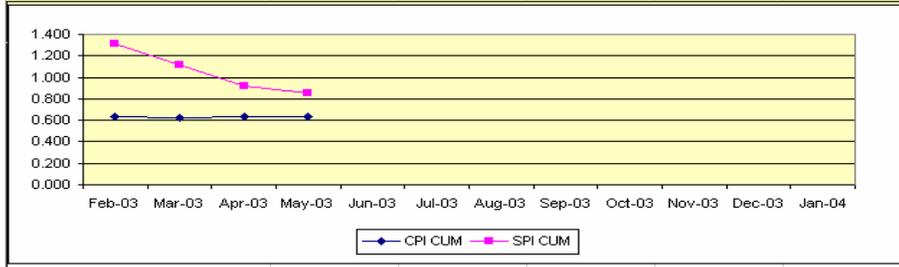
# Risk Management Metrics



## Can We Meet Program Requirements



CUMULATIVE	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03	Nov-03	Dec-03	Jan-04
BUDGET AT COMPLETION	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K
LATEST REVISED ESTIMATE	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K	\$431.9K
BCWS CUMULATIVE	\$25.8K	\$62.0K	\$99.4K	\$130.5K	\$165.4K	\$209.0K	\$250.2K	\$289.1K	\$332.9K	\$369.3K	\$404.4K	\$431.9K
BCWP CUMULATIVE	\$33.9K	\$68.9K	\$91.6K	\$111.4K								
ACWP CUMULATIVE	\$54.0K	\$110.2K	\$144.7K	\$176.6K								
FORECAST (Based on 3 Mo Avg)	\$54.0K	\$110.2K	\$144.7K	\$176.6K	\$217.5K	\$258.4K	\$299.3K	\$340.1K	\$381.0K	\$421.9K	\$462.8K	\$503.7K
COST VARIANCE - CV	(\$20.0K)	(\$41.3K)	(\$53.1K)	(\$65.2K)								
CV %	(59.0%)	(59.9%)	(58.0%)	(58.5%)								
CPI CUM	0.629	0.625	0.633	0.631								
SCHEDULE VARIANCE - SV	\$8.2K	\$6.9K	(\$7.8K)	(\$19.0K)								
SV%	31.8%	11.2%	(7.9%)	(14.6%)								
SPI CUM	1.318	1.112	0.921	0.854								



GOVERNMENT EAC STATISTICS Versus CONTRACTOR LRE			AT COMPLETION STATISTICS (Based On Baseline BAC)			
GOVT			Work Remain	\$320.5K	BAC	\$431.9K
EAC 1 thru 5	EAC vs LRE	% Difference	Budget Remain	\$255.3K	LRE	\$431.9K
\$684.5K	\$252.6K	58.5%	% SPENT	40.9%	VAC	\$0.0K
\$771.2K	\$339.3K	78.6%	% COMPLETE	25.8%	VAC %	0.0%
\$684.5K	\$252.6K	58.5%	% SCHEDULED	30.2%	MR Remaining	N/A
\$651.0K	\$219.0K	50.7%	TCPI BAC	1.255	UB Remaining	N/A
\$497.1K	\$65.2K	15.1%	TCPI LRE	1.255	Avg Spend Rate	\$44.2K
			B Rem v Wk Rem	(\$65.2K)	3 Mo Moving Avg	\$40.9K
HISTORICAL STATISTICS - CY 03						
CV		CV%			BAC	
SV		SV%			LRE	
<b>COST GROWTH</b>					<b>\$432K</b>	

Developed By: Tracy Kent Wrigley

# Identifying & Managing Program Level CST Risk Drivers

## STEP 2: Rate Top 10 Program Level Risk Drivers Threat Level

CST RISK DRIVERS

**5**  
LOW THREAT

**3**  
MEDIUM THREAT

**2**  
HIGH THREAT

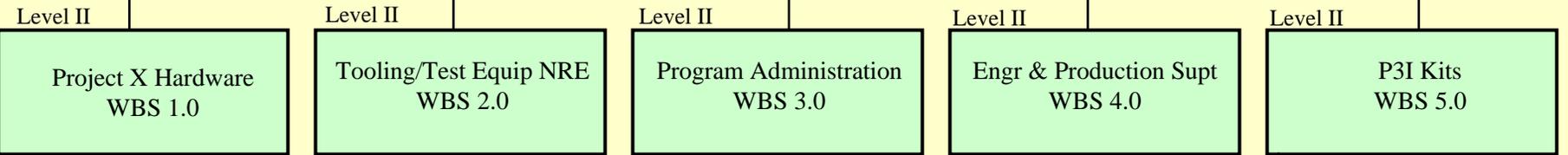
ACCEPTABLE

24

Level I

Project X  
WBS 0.0  
BAC: \$76,142K / 100.0%

Indirect Costs



Level III

- 1.1 Fwd Assembly  
BAC: \$50K / 0.07%
- 1.2 Wing & Probe Assy  
BAC: \$92K / 0.12%
- 1.3 Acoustic Assembly  
BAC: \$374K / 0.49%
- 1.4 Rear Assembly  
BAC: \$45K / 0.06%
- 1.5 Submunition Assy  
BAC: \$3,336K / 4.38%
- 1.6 Subcontracts HW  
BAC: \$24,994K / 32.83%
- 1.7 FDR Assembly  
BAC: \$207K / 0.27%
- 1.8 DSS Assembly  
BAC: \$207K / 0.27%
- 1.9 P...  
BAC: ...

Level III

- 2.1 NG Tool/Test Equip  
BAC: \$876K / 1.15%
- 2.2 Subcontractor Tool/TF  
BAC: \$3,393K / 4.46%
- 2.3 NG Non-Recurring  
BAC: \$496K / 0.65%
- 2.4 Subcontractor N/R  
BAC: \$8,621K / 11.32%
- 2.5 Reserved  
BAC: \$0K / 0.00%
- 2.6 Engr Support FAT  
BAC: \$299K / 0.39%
- 2.7 Engr Support N/R Dsr  
BAC: \$247K / 0.32%
- 2.8 Qual Flight Support  
BAC: ...

Level III

- 3.1 Program Mgmt  
BAC: \$2,471K / 3.25%
- 3.2 Reserved  
BAC: \$0K / 0.00%
- 3.3 CM/DM  
BAC: \$131K / 0.17%
- 3.4 Integr Log Supt (ILS)  
BAC: \$0K / 0.00%
- 3.5 Quality  
BAC: \$415K / 0.55%
- 3.6 Warranty  
BAC: \$0K / 0.00%

Level III

- 4.1 Mfg & Mat'l Support  
BAC: \$182K / 0.24%
- 4.2 Prod Mfg Engr Supt  
BAC: \$207K / 0.27%
- 4.3 Engr Dsn Prod Supt  
BAC: \$1.037K / 1.36%
- 4.4 Reserved  
BAC: \$0K / 0.00%

Level III

- 5.1 P3I Kits Mat'l & Sub  
BAC: \$2,542K / 3.34%
- 5.2 P3I Kits Assy/Integr  
BAC: \$53K / 0.07%
- 5.3 P3I Kits Prgm Mgmt  
BAC: \$10K / 0.01%
- 5.4 Reserved  
BAC: \$0K / 0.00%

Indirect Costs

- 2 Overhead (O/H)  
BAC: \$11,152 / 14.65%
- Cost of Money (COM)  
BAC: \$448K / 0.59%
- 3 Gen & Admin (G&A)  
BAC: \$8,830K / 11.60%

Mgmt Reserve (MR)  
BAC: \$3,163K / 4.15%

Undistr Budget (UB)  
BAC: \$2,044K / 2.68%

Schedule Variances tend to pose a greater degree of risk because their impact is typically horizontal across multiple WBS elements. Cost Variances are more vertical and impact primarily the same leg of the WBS for which it belongs.

The Top 10 CST Risk Drivers illustrate that Project X has 5 Low CST Risks, 3 Medium CST Risks, and 2 High CST Risks. These are the areas the RMT would focus their attention and in preparation of an IBR, the PM/RM should request in advance, program documentation for these elements.

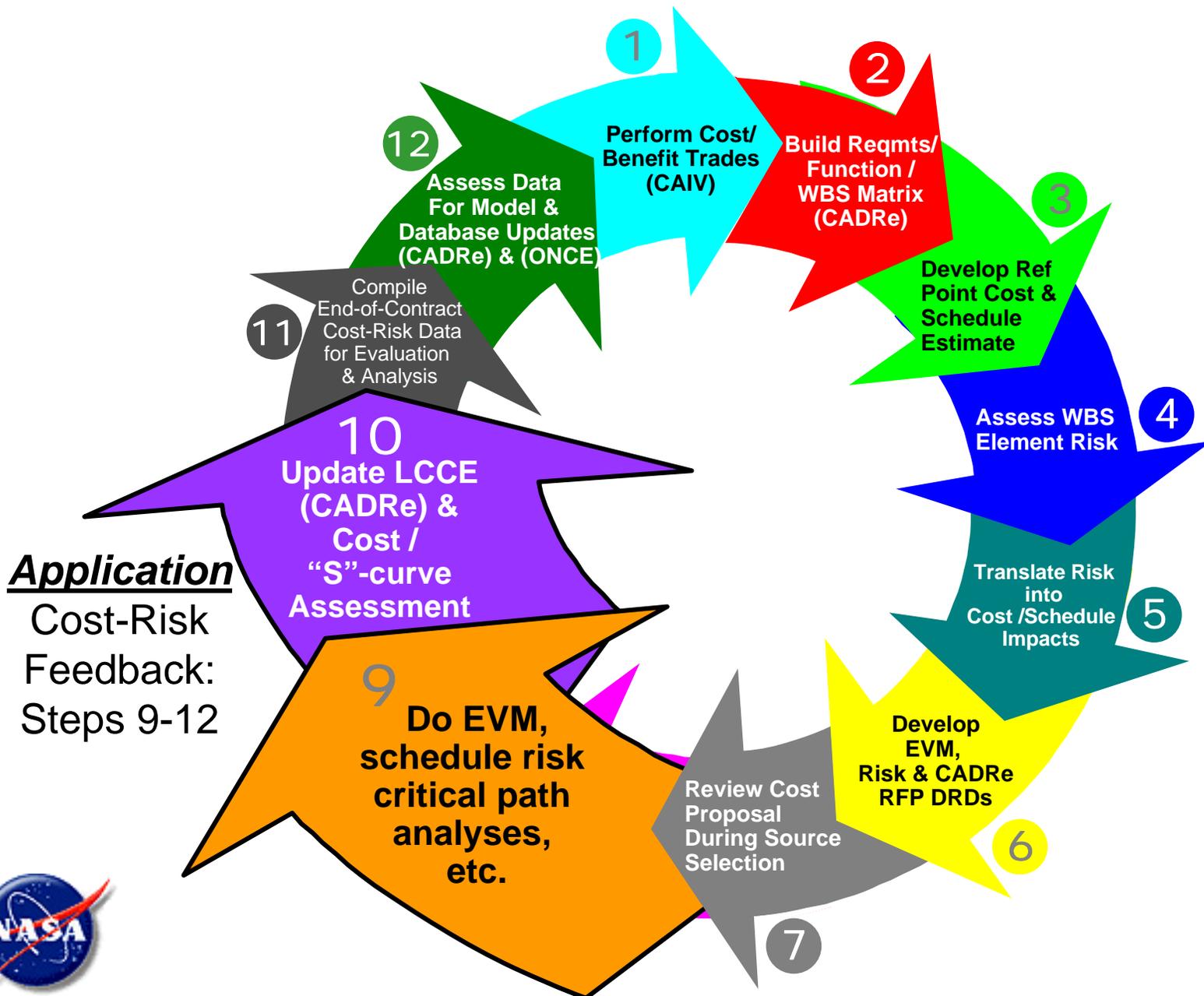


# WHY IMPLEMENT EVM?



- ❑ EVM instills a disciplined approach to cost, schedule, and technical development via the Work Breakdown Structure (WBS).
- ❑ EVM ensures that cost, schedule and technical aspects of the contract are truly integrated.
- ❑ Data derived from EVMS provides **insight and visibility** into contractor's progress for program management purposes (trend analysis, forecasting, early warning signs, trigger mechanism, etc.).
- ❑ EVM is a Risk Mitigation Step at the Program Level designed to reduce risk on complex programs.
- ❑ EVM is a sound business practice.

# Continuous Cost-Risk Management



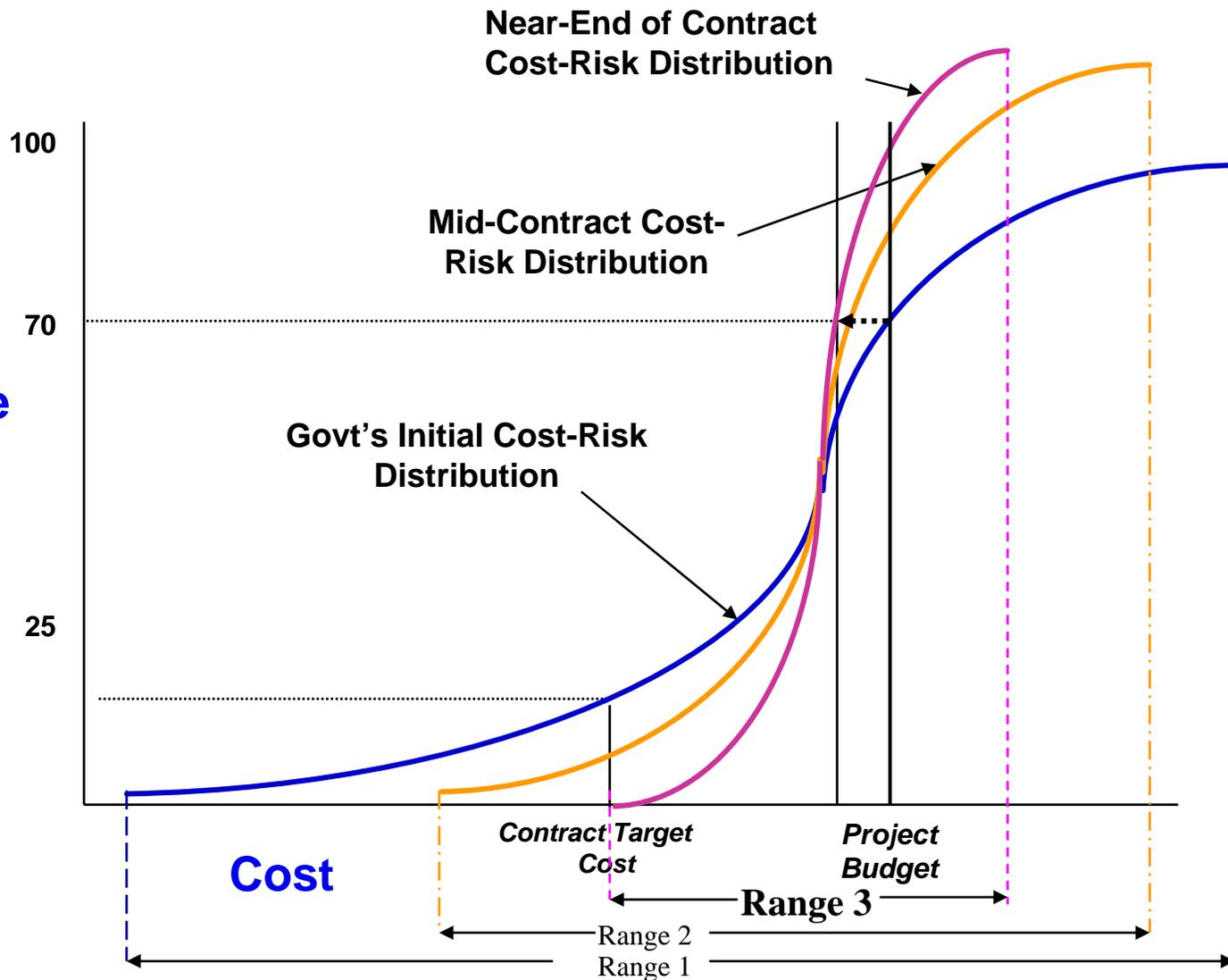


# Measuring Range Change

## Update Contract "S"-Curve Over Time

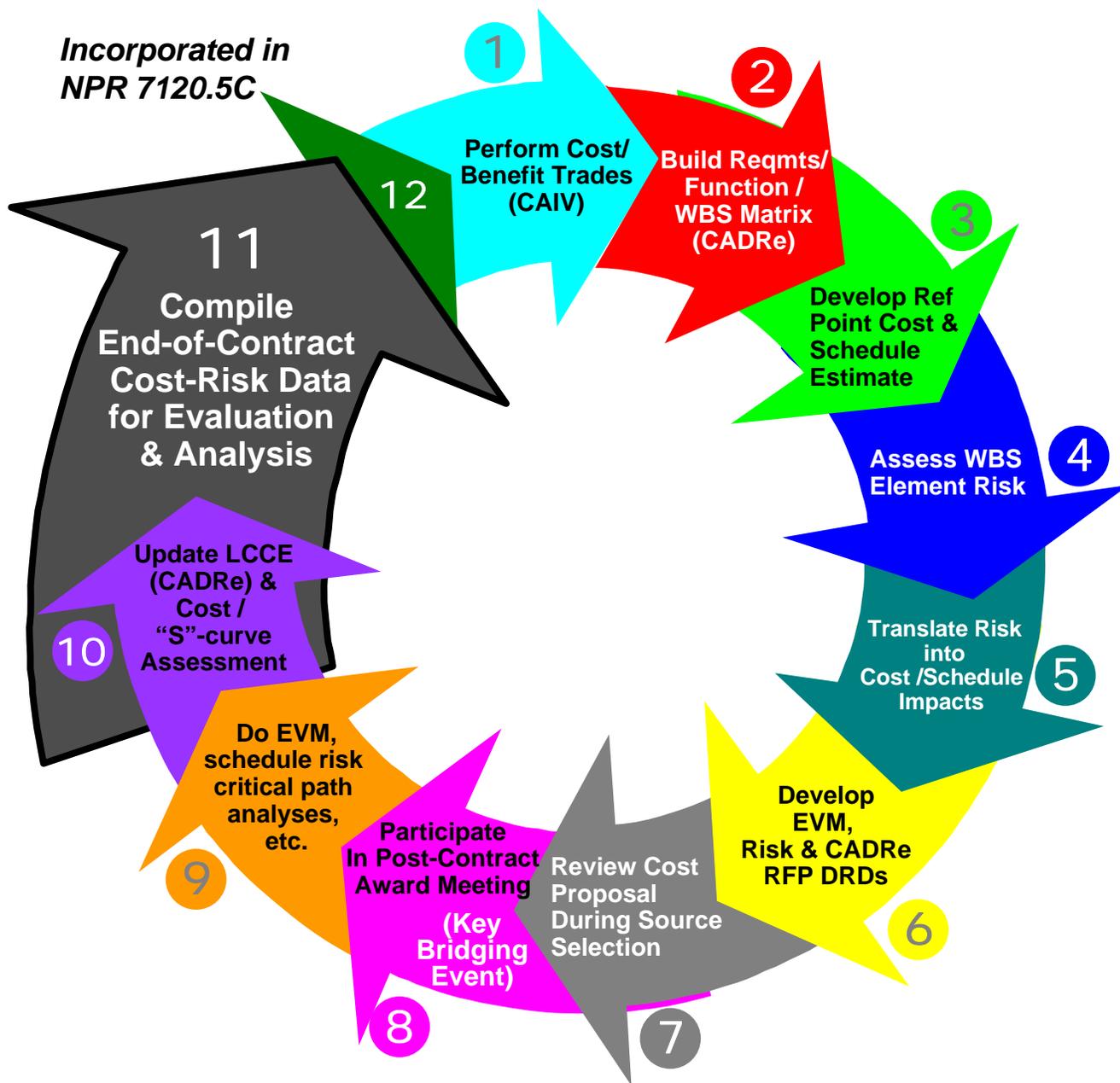


Confidence Level

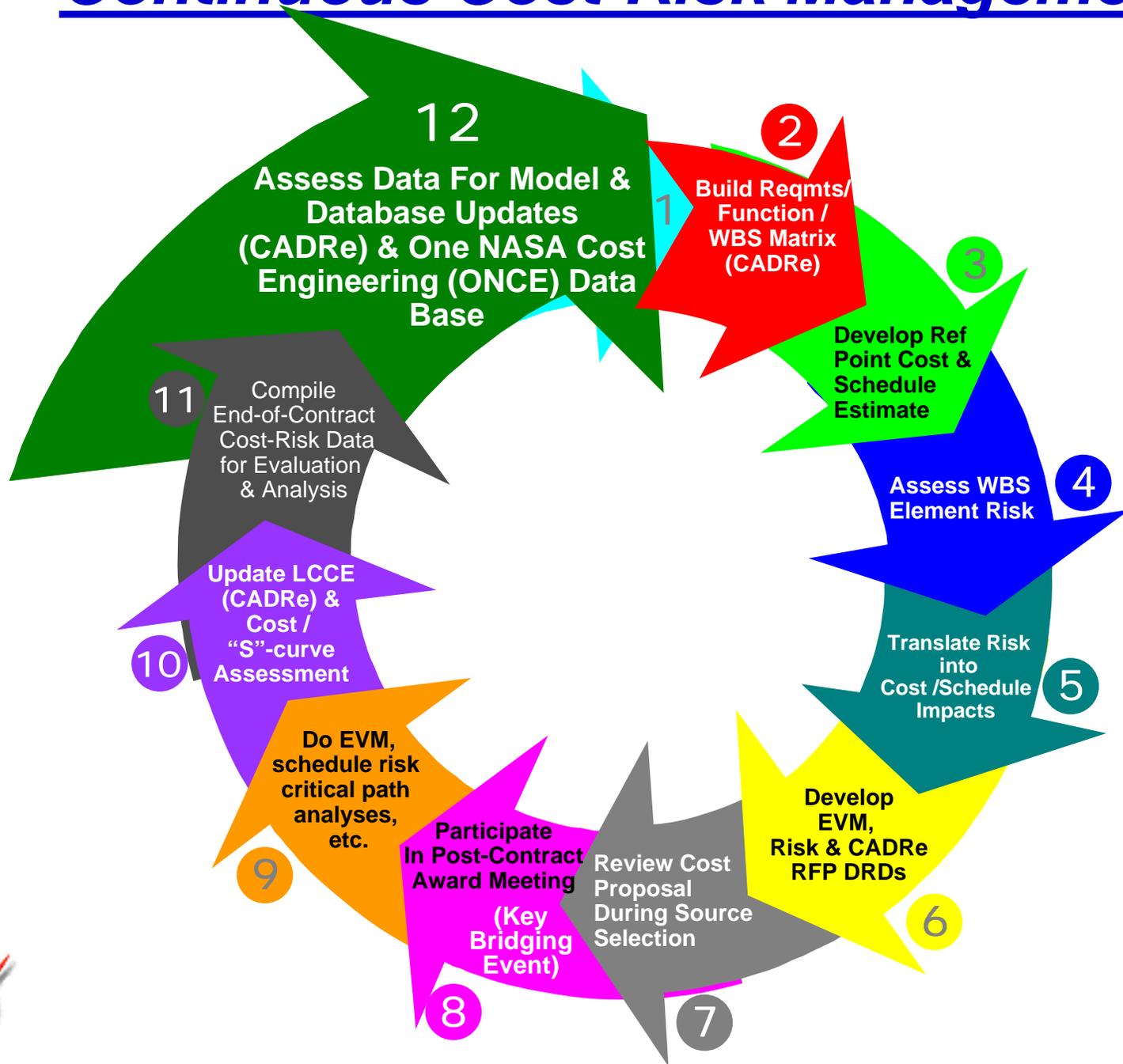


# Continuous Cost-Risk Management

A System of Cost Systems *linked together in sequence by the same risks*



# Continuous Cost-Risk Management





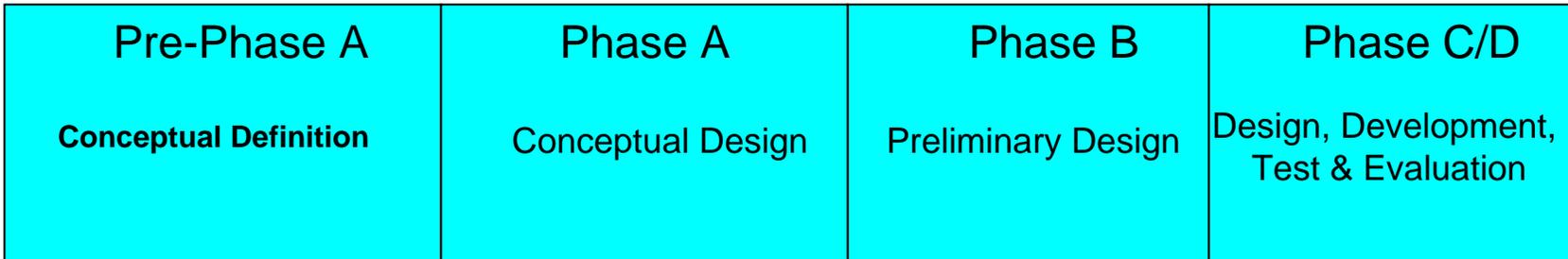
# CCRM Repeats in Each Project Phase



ATP



IOC



Pre-NAR



NAR



Preliminary Design Review



Critical Design Review

Initial CADRe

Updated CADRe

CADRe Updates as Necessary



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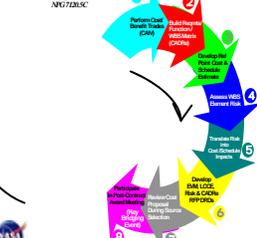
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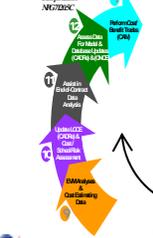
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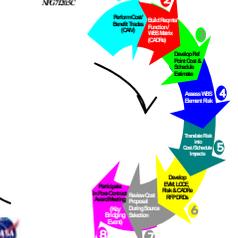
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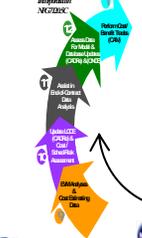
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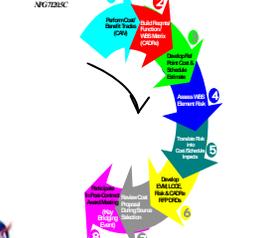
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# ***How Do We Implement the CCRM and the CADRe?***



# Implementing CCRM and the CADRe



- ✓ **Brief the NASA Mission Directorates and Agency PMC**
- ✓ **Institutionalize CCRM into the draft NPR 7120.5C**
- ✓ **Expand on “how to’s” in the Cost Estimating Handbook**
  - ✓ [www.ceh.nasa.gov](http://www.ceh.nasa.gov)
- **Brief to NASA Center leadership, S&MA project managers and cost analysts**
- **Establish “Center CCRM/CADRe Champions”**
  - **Recommend/provide tools (e.g., NAFCOM; ACEIT; Crystal Ball; @RISK)**
- **Put CADRe, EVM, PRA, Risk Management, Technical Performance Measurement, Schedule Risk DRDs in RFPs and assist in drafting them**
- **Directly assist project offices in implementing each step of the CCRM**
- *Hire a SETA/FFRDC to augment NASA personnel for training, DRD writing and implementing on projects*
- **Benchmark project management teams in their CCRM capability**
  - **Rate against CCRM criteria**
  - **NAR teams could implement**
- **Contact at HQ: David R. Graham (202) 358-1002; david.graham-1@nasa.gov**