NAVSEA WARFARE CENTERS DAHLGREN

Fully Integrated Cost and Schedule Method (FICSM) Analysis Schedule Implementation

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Dahlgren Cost Engineering & Analysis

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Please silence or turn off all electronic devices and hold your questions until the discussion period at the end of the presentation.

Thank you

Agenda

1. *Background*
2. *Analysis Schedule*
3. *Mapping Cost, Duration, and Risk Uncertainty to Analysis Schedule*
4. *FICSM Results of Study*
5. *Summary and Q&A*

How To Make Better Buying Power Better

By Bryan Clark and Mark Gunzinger on March 01, 2016 at 11:38 AM

"According to a recent study by the Institute for Defense Analysis, growth in the Cost of DoD's Major Defense Acquisition Programs since 1970 ranged between 20 percent to more than 60 percent. By DoD's own calculations, new weapon systems are fielded about 20 percent later than originally planned."

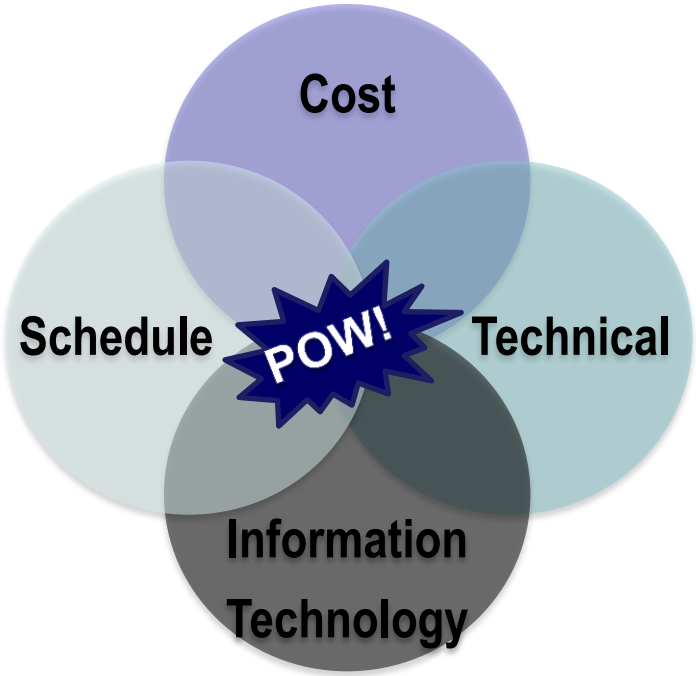
http://breakingdefense.com/2016/03/how-to-make-better-buying-power-better/

Background

"*The 98 MDAPs from FY2010 collectively ran $402 billion over budget and were an average of 22 months behind Schedule* since their first full estimate."

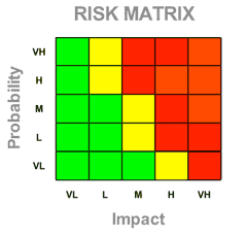
Center for Strategic and International Studies; *Cost and Time Overruns for Major Defense Acquisition Programs (2011)*

1. ***Recent studies have shown a clear correlation between Cost and Schedule***
2. ***2014 Joint Agency Cost, Schedule Risk and Uncertainty Handbook (JA CSRUH) outlined two methods for bringing together Cost and Schedule***
   - ❑ Cost Informed by Schedule Method (CSIM)
   - ❑ Fully Integrated Cost and Schedule Method (FICSM)
3. ***2016 Naval Surface Warfare Center Dahlgren conducted a Naval Innovative Science and Engineering (NISE) pilot project***
   - ❑ Perform FICSM on a major US Navy software intensive development program
4. ***This presentation focuses on developing an Analysis Schedule and the process used***



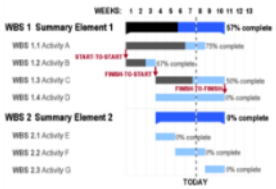
Status Quo: Cost, Schedule and Risk Method

Risk



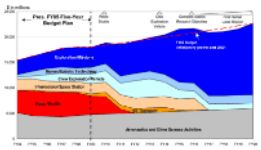
Collect Risk Data → Assess Event Cost and Duration Uncertainty → Validate File → Run Analysis

Schedule



Collect Schedule Data → Assess Duration Uncertainty

Cost

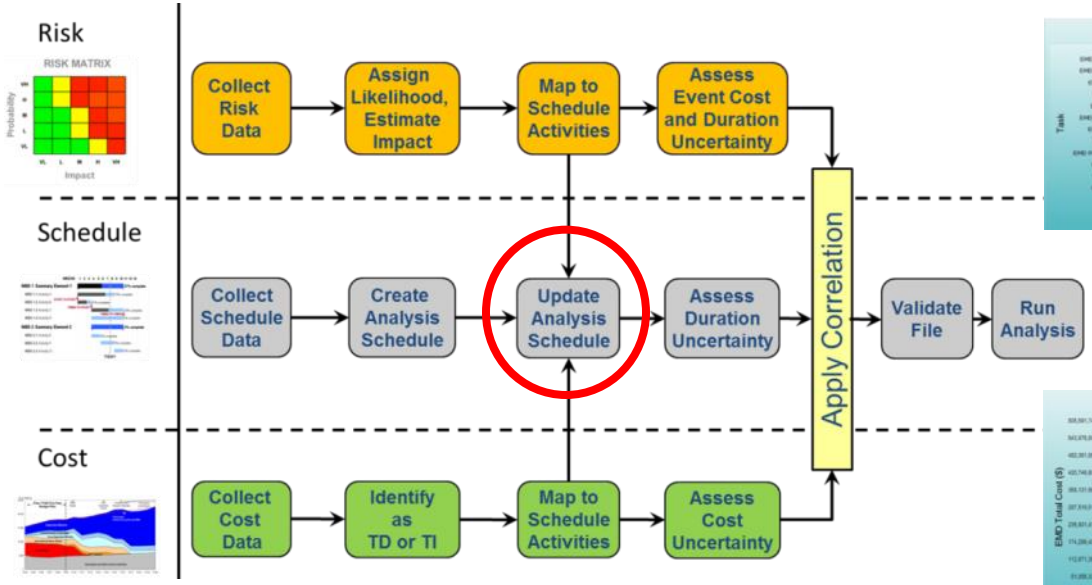


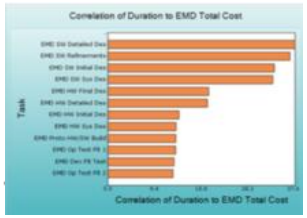
Collect Cost Data → Assess Cost Uncertainty → Validate File → Run Analysis

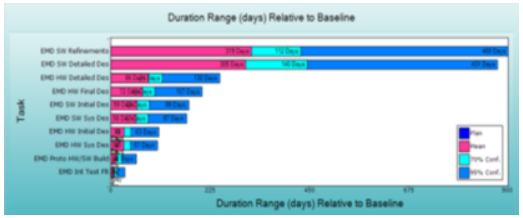
Fully Integrated Cost and Schedule Method (FICSM)

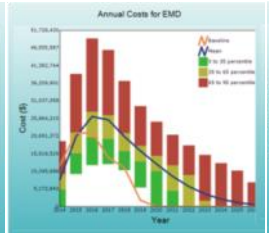
- *Brings together an existing Cost Estimate, Integrated Master Schedule, and Risk Register into one comprehensive and predictive model*

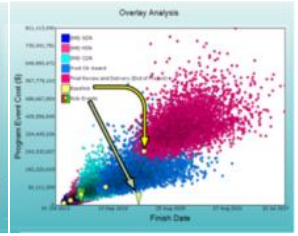
- *Enables dynamic, quantitative and integrated assessment of Cost, Schedule and Risk or Uncertainty*



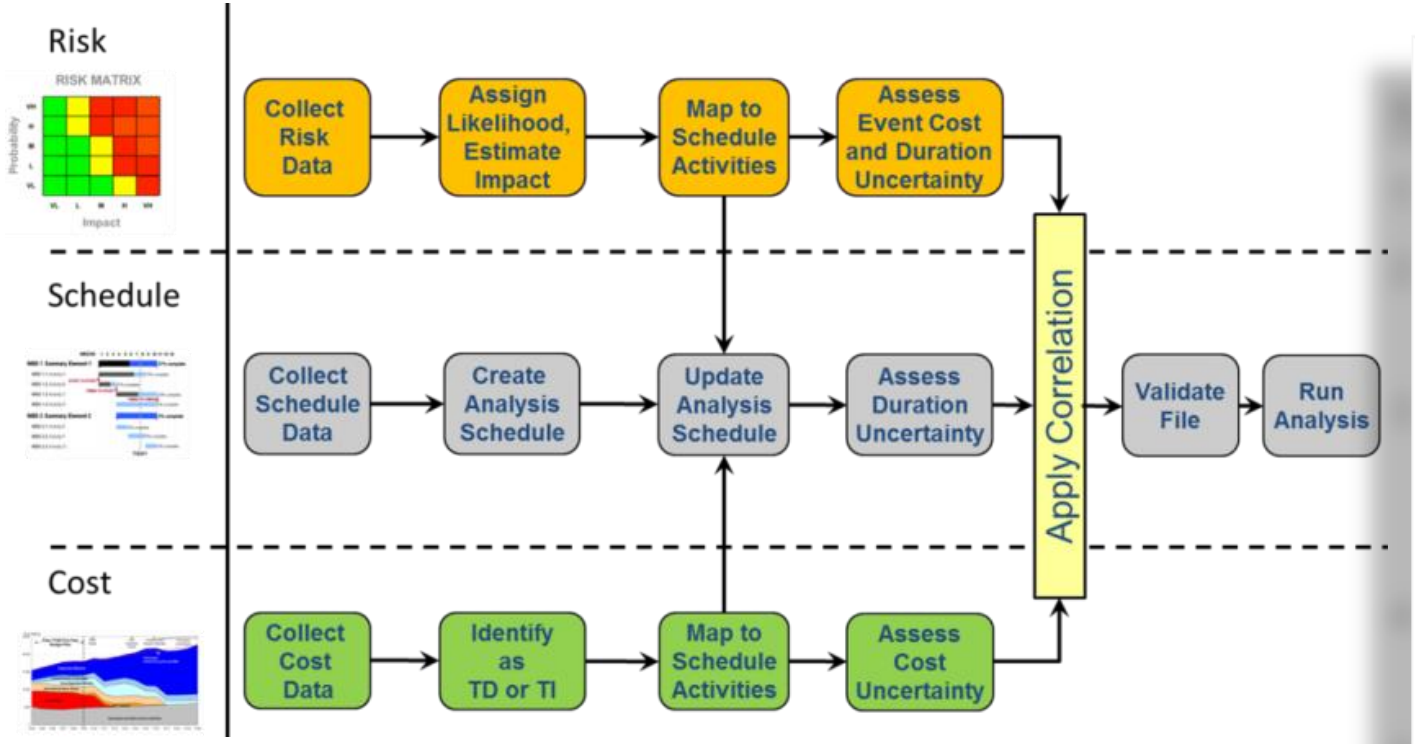








FICSM Process

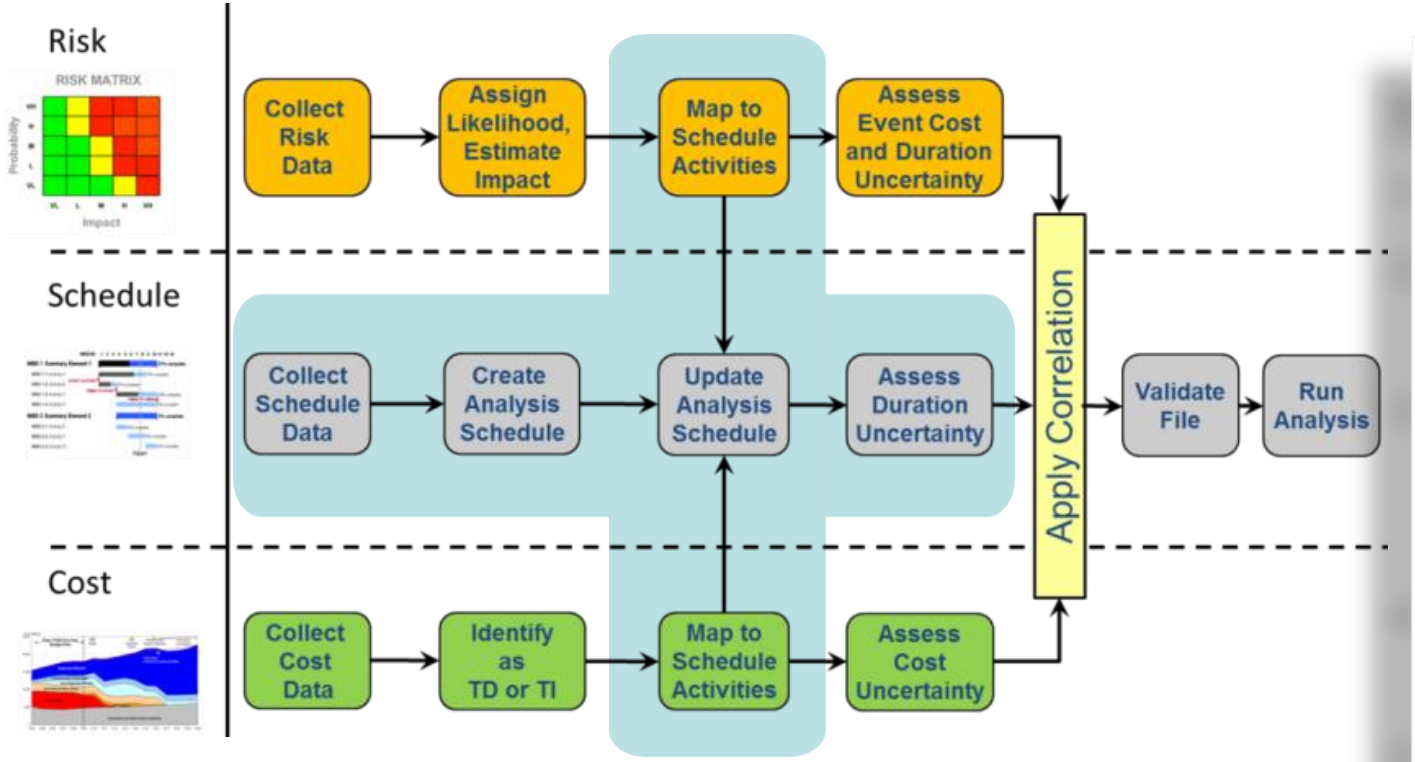


Graphic source: Joint Agency Cost Schedule Risk Uncertainty Handbook (JA CSRUH)-April 2014

Key Steps to FICSM

1. *Collect Data*
2. *Develop Analysis Schedule*
3. *Divide Costs into Time Independent/ Time Dependent*
4. *Map costs to Schedule*
5. *Map Risks to Schedule*
6. *Assign Uncertainty*
7. *Run and Assess Model*

FICSM Process



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This presentation focuses on the Analysis Schedule implementation highlighted by the blue area

Analysis Schedule Process Used

- ***Assess Schedule health***
  - Before and After
- ***Tasks required to create an Analysis Schedule***
  - Obtain IMS and other documentation to get familiar with program and dependencies
  - Use IMS as database to query, group and filter tasks and durations
  - List all major milestones, tests and key programmatic events and identify critical path for each
  - Review and add key tasks/deliveries
  - Maintain traceability to original IMS using UIDs
- ***Create the Analysis Schedule***
  - Add duration and logic
    - Easy example
    - Complex example
  - Add hammock tasks
    - PM and SE
- ***Validate Analysis Schedule***
  - It must accurately model behavior of parent IMS
- ***Add Duration Uncertainty***
- ***Map Costs and Uncertainty***
- ***Integrate Risks***

Assess Schedule Health

- ***Not every IMS is created equal***
  - Each IMS varies by source, purposes, and quality
  - Calculate DCMA/GAO metrics to get a feel for the schedule strengths and weaknesses
- ***Assessed Schedule had "deficiencies"***
  - Incomplete logic (no predecessor or successor)
  - Hard date constraints on major milestones
  - Nested IMS (Total of 13 MS Project Server Files)
  - IMS occupied default columns assigned by tool
- ***Analysis Schedule Impacts***
  - Added missing logic in Analysis Schedule
  - Removed fixed dates and replaced them with "softer" constraints
    - Given manually scheduled date of 12/05/2018
    - Replaced fixed date with Auto Scheduled "Start No Earlier Than" 12/05/2018 constraint
  - Tool and structure prohibited the "nested" IMS from being used as the Analysis Schedule "as is"

DCMA 14 Point Assessment

Description	Count		Percentage	Comments
Metric #1: Logic	197		16%	CALCULATION: (# of Tasks missing Logic) / (# of Incomplete Tasks) TRIPWIRES: Less than 3% = GREEN, between 3% and 5% YELLOW, greater than 5% = RED
Metric #2: Leads	1		0%	CALCULATION: (# of tasks with a relationship with negative lag) / (# of Incomplete Tasks) TRIPWIRES: Goal for the metric in "0". Any leads found in the schedule will warrant RED rating.
Metric #3: Lags	9		1%	CALCULATION: (# of tasks with relationship with positive lag) / (# of Incomplete Tasks) TRIPWIRES: Less than 3% = GREEN, between 3% and 5% YELLOW, greater than 5% = RED
Metric #4: Relationship Types	SS,SF,FF 9	FS Only 1124	91%	CALCULATION: The number of tasks with a Start-to-Start (SS), Finish-to-Finish (FF), and Start-to-Finish (SF) relationship type versus the number of tasks with only of Finish-to-Start (FS) relationships. TRIPWIRES: The goal for this metric should be 90% FS. Greater than 95% = GREEN, between 90% and 95% YELLOW, Less than 90% = RED
Metric #5: Hard Constraints	0		0%	CALCULATION: (# of Tasks w/ MFO, MSO, FNET, FNLT) / (# of Incomplete Tasks) TRIPWIRES: Less than 3% = GREEN, between 3% and 5% YELLOW, greater than 5% = RED
Metric #6: High Float	315		25%	CALCULATION: (# of Tasks with total slack > 44 working days) / (# of Incomplete Tasks) TRIPWIRES: Less than 3% = GREEN, between 3% and 5% YELLOW, greater than 5% = RED
Metric #7: Negative Float	292		24%	CALCULATION: (# of Tasks with negative total slack) / (# of Incomplete Tasks) TRIPWIRES: Goal for the metric in "0". Any negative float in the schedule will warrant RED rating.
Metric #8: High Duration	0		0%	CALCULATION: (# of Tasks with duration > 44 working days) / (# of Incomplete Tasks) TRIPWIRES: Less than 3% = GREEN, between 3% and 5% YELLOW, greater than 5% = RED
Metric #9: Invalid Dates	0		0%	CALCULATION: (# of Tasks with Actual Start or Finish Dates in the Future) / (# of Total Tasks) TRIPWIRES: Goal for the metric in "0". Any invalid date issues in the IMS will warrant RED rating.
Metric #10: Resources	500		40%	CALCULATION: (# of Tasks without resources / (# of Incomplete Tasks) TRIPWIRES: Goal for the metric is that all discrete tasks have resources. Any resource issues in the IMS will warrant RED rating.
Metric #11: Missed Tasks	0		0%	CALCULATION: (# of Missed Tasks) / (Baseline Count) TRIPWIRES: Less than 3% = GREEN, between 3% and 5% YELLOW, greater than 5% = RED
Metric #12: Critical Path Test	No Float		FALSE	CALCULATION: Add one day to the duration of the earliest critical task and check the number of days for the total duration slips by one day. TRIPWIRES: Goal for the metric is that a one day slip is reported on total duration. If the IMS fails to show a one-for-one slip, then the IMS will warrant RED rating.
Metric #13: Critical Path Length Index (CPLI)	Critical Path Length 1293	Total Float 0	1.00	CALCULATION: (Critical Path Length + Total Project Float) / (Critical Path Length) The goal for this metric should be 1.00 or more, less than 1.00 is unfavorable. Greater than 1.00 = GREEN, between .95 and 1.00 YELLOW, Less than .95 = RED
Metric #14: Baseline Execution Index (BEI)			0.31	CALCULATION: (# of Completed Tasks) / (Baseline Count) TRIPWIRE: The goal for this metric should be 1.00 or more, less than 1.00 is unfavorable. At least 1.00 = GREEN, between .95 and 1.00 YELLOW, Less than .95 = RED

Metrics	Initial IMS
Lines	2,426
Start Date	3/4/2013
End Date	5/30/2018
#1 Logic	78
#5 Hard Constraints	1,030
#12 Float	Float on Critical Path
Tool overlap	178

Create Analysis Schedule (1 of 2)

- ***Analysis schedules are simpler versions of the IMS used for analysis***
  - It does not recreate the IMS but should faithfully mimic its behavior
- ***Developing a condensed list of tasks***
  - Start with the IMS and other documentation to get familiar with program and dependencies
  - List all major milestones, tests, events
  - Add key GFCP/GFE/GFI deliveries
  - Identify the critical path for each
  - Review and add key items back in, consolidate, refine, etc.
  - **Important:** Tasks must map to Cost Work Breakdown Structure (CWBS)

Analysis Schedule Milestones Examples

Milestones	Major Events	Dependencies
SRR	Contract Award	Third Party Software Delivery
PDR	Software Build Complete	Test Site Equipment Delivery
CDR	Major Test Event	Simulation Development
TRR	Demonstration	GFE Hardware Delivery
MS A, B, or C		

Use IMS as a database of tasks and durations

Create Analysis Schedule (2 of 2)

- ***Create the Analysis Schedule***
  - Approximate related task durations and linkages
    - Use IMS as database
      - See example to right
  - Kept traceability to original IMS using UIDs
    - Good documentation allows for easier Analysis Schedule updates
- ***Add hammock tasks***
  - PM and SE

Parent IMS

Name	Start	Finish	UID
Create Initial System Test Cases	11/22/2013	12/28/2013	83886464
…10 related tasks…	…	…	…
Perform Requirements Testability Analysis on Domain Level Requirements through PDR	3/31/2014	10/3/2014	83886505

Analysis Schedule

Name	Start	Finish	Notes
Create preliminary test plans, analysis, scenarios, and test cases	11/20/2013	9/30/2014	83886464 start 83886505 end

Hammock Example

Name	Start	Finish	Predecessors
PM	**Mon 3/4/13**	**Wed 5/30/18**	
PM to SRR	**Mon 3/4/13**	**Wed 11/20/13**	
PM to SRR Start	Mon 3/4/13	Mon 3/4/13	2
PM to SRR End	Wed 11/20/13	Wed 11/20/13	3
PM to SFR	**Wed 11/20/13**	**Sun 3/9/14**	
PM to SFR Start	Wed 11/20/13	Wed 11/20/13	3
PM to SFR End	Sun 3/9/14	Sun 3/9/14	4
PM to PDR	**Sun 3/9/14**	**Tue 12/16/14**	
PM to PDR Start	Sun 3/9/14	Sun 3/9/14	4
PM to PDR End	Tue 12/16/14	Tue 12/16/14	5

SRR

SFR

Validate Analysis Schedule

- ***Analysis Schedule should mimic parent IMS***
  - Validate by shocking the Analysis Schedule and the parent IMS and capturing the results
  - We shocked the IMS by adding large durations to specific tasks and comparing impacts on specific key milestone dates
  - The table below on the left captures the results of that test
  - The table to the right captures some key information of the adjusted IMS and the Analysis Schedule

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End Dates	Initial IMS	Analysis Schedule
6 month slip PDR	1.5 month	2 month
6 month slip Testing Begins	4 month	5 month
6 month slip Certification	6 month	6 month

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Start Date	3/4/2013	3/4/2013
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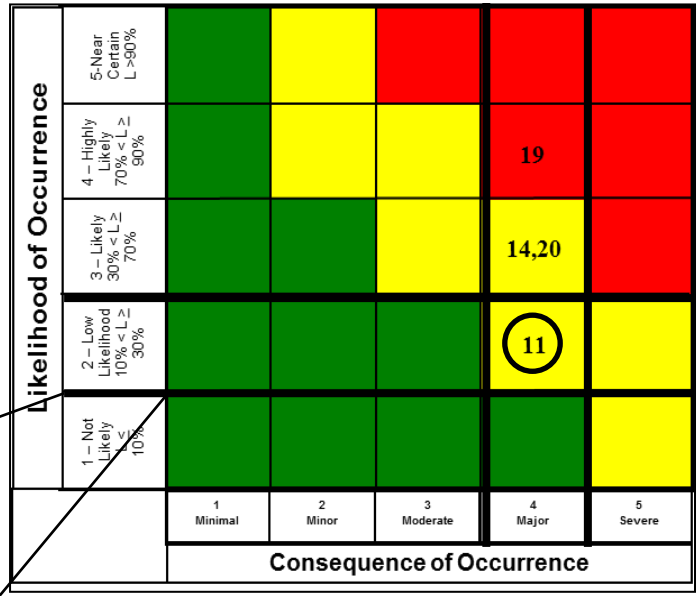
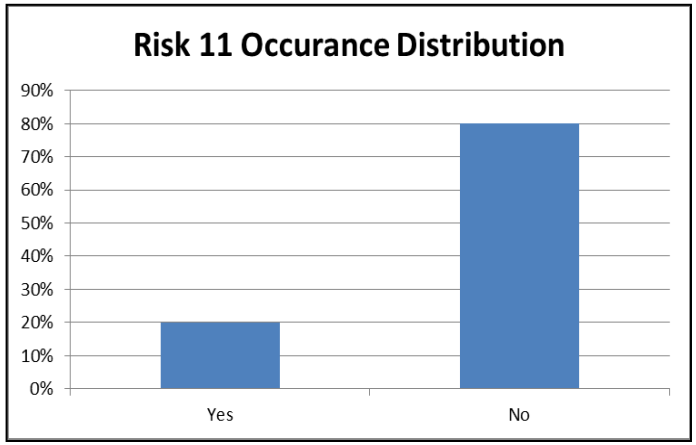
#5 Hard Constraints	1,030	0
#12 Float	Float on Critical Path	Float on Critical Path

Map Risks and Add Uncertainty

- ***Risk Events***
  - Defined by risk register information
  - Risk cube defines likelihood and duration impact
- ***Risks were added in separate section in Analysis Schedule***
  - Keep risks together
  - Best practice for organization
  - Each risk is individually threaded through schedule
    - *Assess impacted tasks*
    - *Assess impacted logic*
- ***Add uncertainty***
  - Likelihood of occurrence given by risk cube location
    - *Sets when risk event is triggered*
    - *Binary distribution (on or off)*
  - Consequences of occurrence also from risk cube
    - *Typically in terms of Cost or Schedule impact*
    - *Details of particular risk determine which one impacted; Cost and/or Schedule*



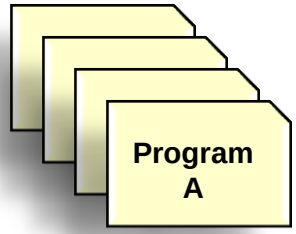
2-Low Likelihood 10%<L<30%

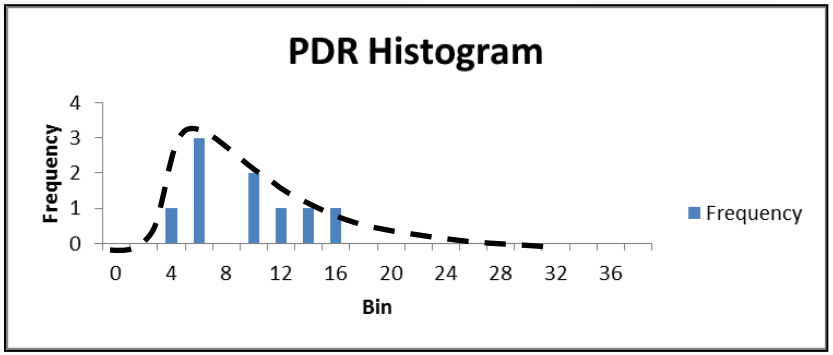


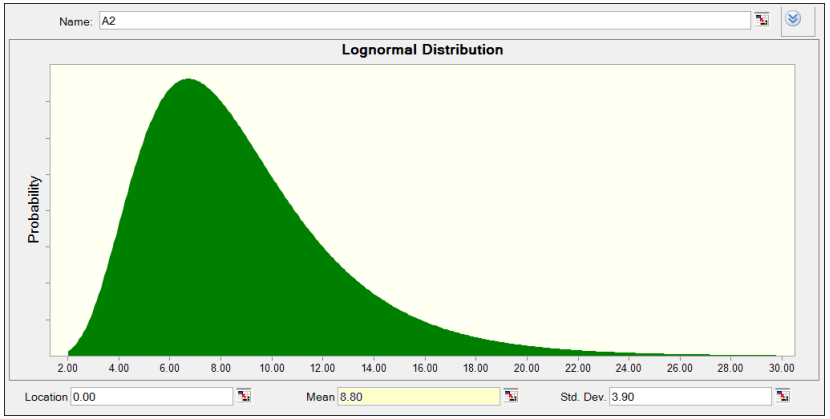
Duration Uncertainty

- ***Duration uncertainty distributions were developed using historical schedules and durations***
  - For example: SDR to PDR has a mean duration of 8.8 months, 3.9 month standard deviation, and roughly lognormal histogram shape
- ***Duration distributions applied to each CWBS using most applicable milestone***
  - For example software development most closely aligns to the period between PDR and System Test
- ***Alternative method***
  - Collect baseline, current and actual for several IMSs
  - Bin task by task type
  - Measure variance between baseline and final
  - Apply to each task type in Analysis Schedule
  - Lack of data prohibited application in timeframe of study

Historical Milestone Schedules Collected and Assessed







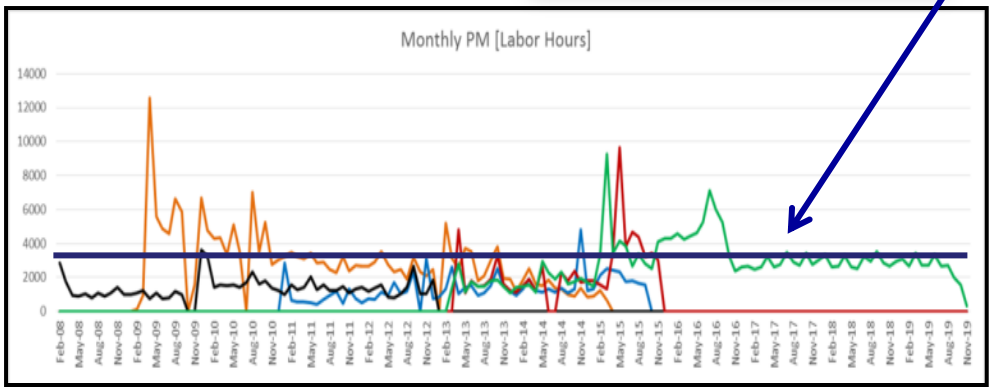
Map Costs and Cost Uncertainty

- ***Mapping of Cost to Schedule***
  - Analysis Schedule summary sections defined by design of CWBS
  - Summary level costs allocated using historical costs of CWBS
  - Lower level costs were allocated using engineering judgment
- ***Costs divided***
  - Time Independent (TI) and
  - Time Dependent (TD)
  - Used $/month plots and engineering judgment
- ***Cost Uncertainty***
  - Selected program has existing cost estimate already developed
  - For areas without existing cost uncertainty, historical data was used to developed higher level distributions and allocated to lower levels
  - Cost uncertainty added to all cost items

Summary Sections Map One to One

Analysis Schedule Summary Sections	Cost WBS Summary Sections
Milestones	N/A
Program Management	Program Management
Systems Engineering	Systems Engineering
Etc.	Etc.

Steady state hours suggests Time Dependency of PM

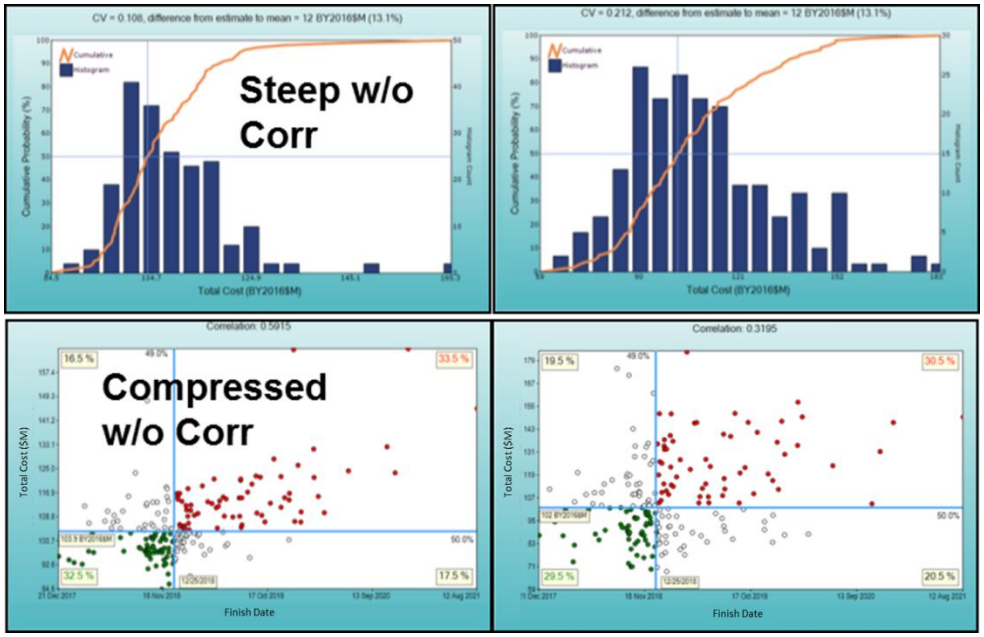


Analysis of Results

Using ACEIT Joint Analysis of Cost & Schedule (JACS) Tool

Analyze FICSM Results:

- ***Standardize risk run assumptions***
  - Capture JACS cost result, JACS Cost CV, JACS duration result, and JACS finish date
  - Document annual cost and CDF Chart: Scatter plots for mean, median and 80%
- ***Test and compare with and without correlation***
- ***Test and compare with and without Risk Events***
- ***Use the FICSM model for 12 common acquisition questions***
  - FICSM model provides quantitative data to answer common Cost, Schedule and Risk acquisition questions



Name	JACS Cost Result (50%)	JACS Duration Result (50%)	JACS Finish Result (50%)
Program Total	$101.98	1517 days	Tue 12/25/18
Analysis Schedule Milestones	$0.00	1517 days	Tue 12/25/18
PM	$25.32	1468 days	Thu 10/18/18
SE	$16.56	1468 days	Thu 10/18/18
System Test and Evaluation	$12.59	1281 days	Thu 10/18/18
ILS	$1.19	1467 days	Wed 10/17/18
Computer Program Development	$45.71	927 days	Tue 9/12/17
Event Risks	$0.00	135 days	Mon 3/21/16

Common Acquisition Questions

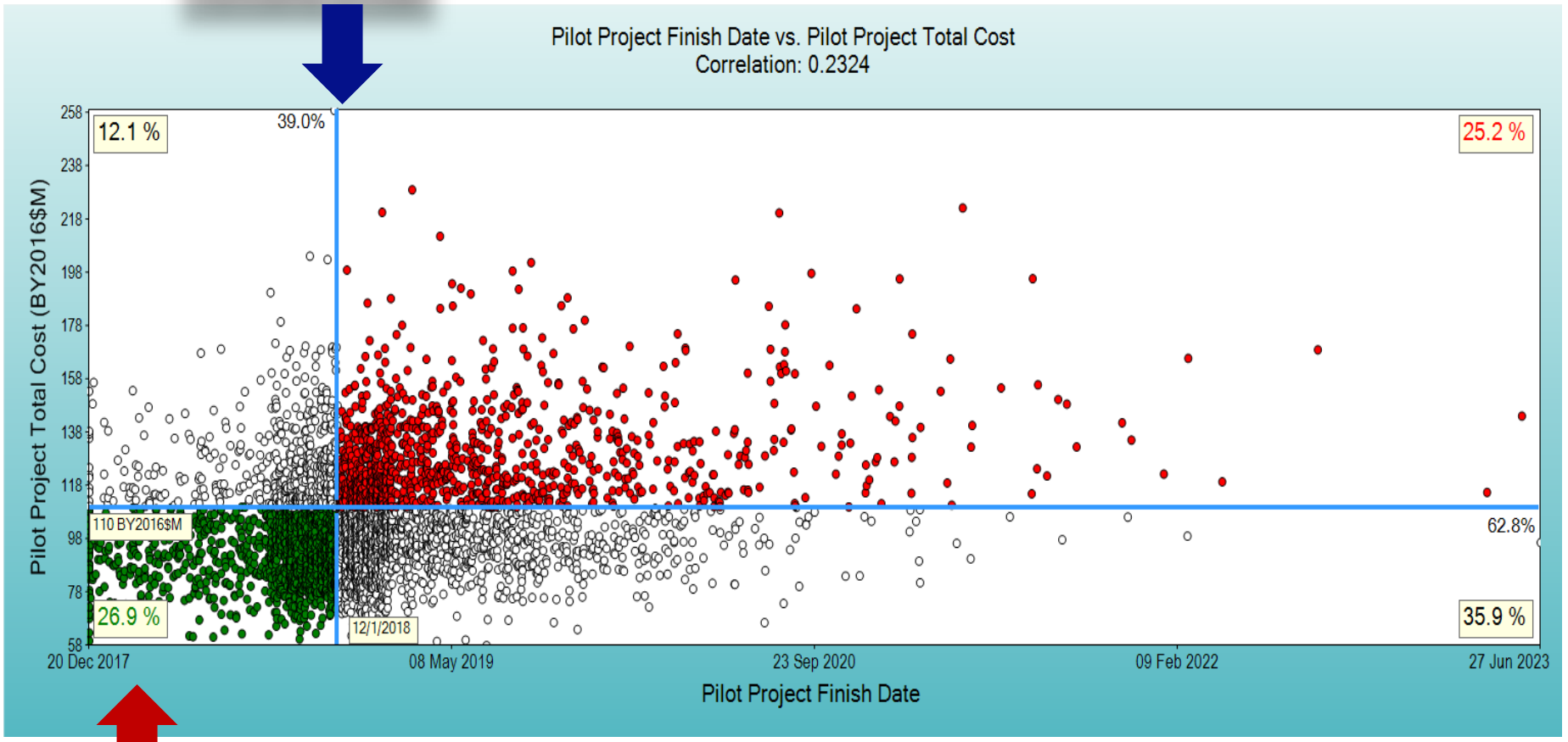
Examples:

- ***What is the likelihood that we can meet schedule and budget?***
  - FICSM is the only way to estimate the probability of achieving both Cost and Schedule targets: the Joint Confidence Level (JCL) (JA CSRUH)

- ***What tasks or risk events are on or near the critical path?***
  - FICSM results can be sorted by the likelihood a task or event lands on the critical path
  - Predictive indicator of problems before they happen; enabling decision makers to focus resources where they will have the most impact

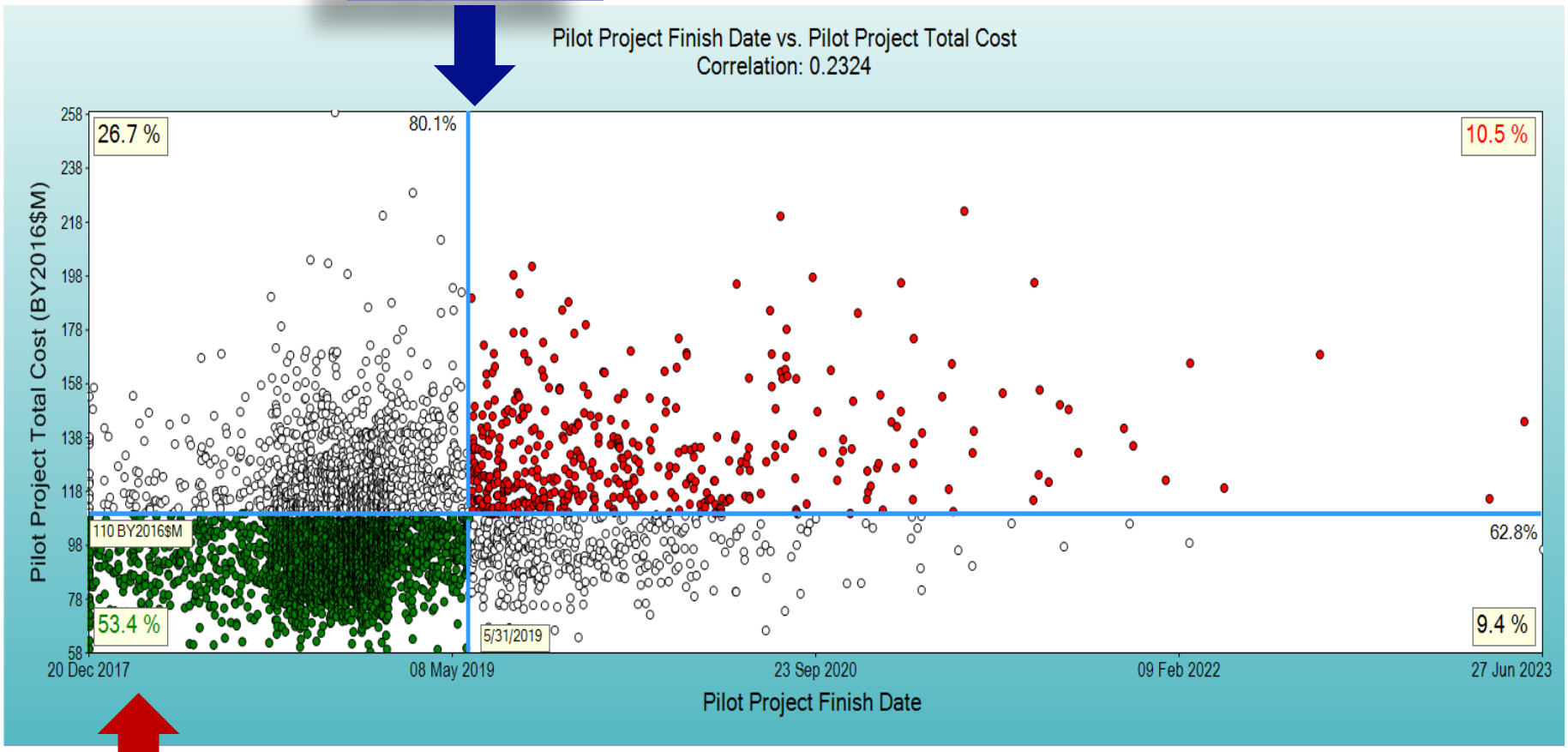
Planned Completion

12/1/2018, $110M

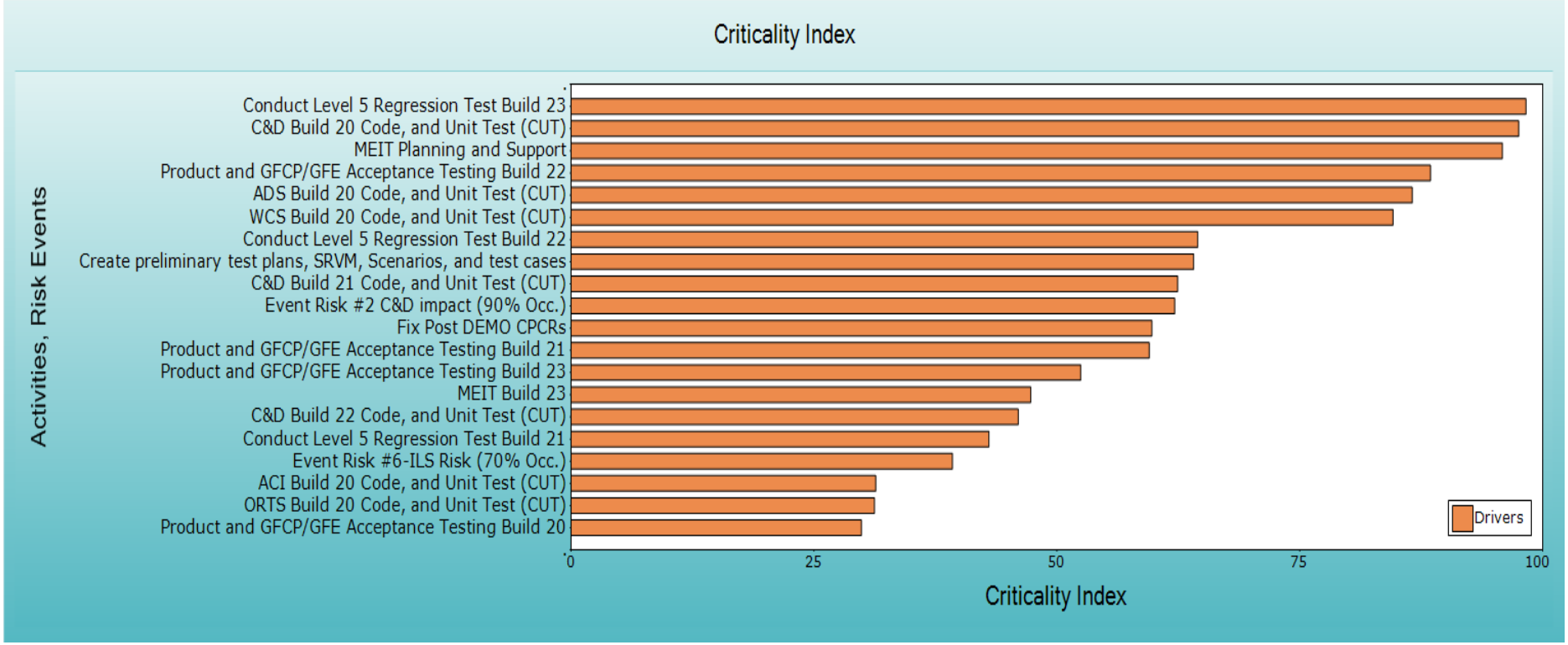


6 Month Slip Impact

5/31/2019, $110M



Criticality Index



Criticality Index: Probability that a specific task lies on the schedule's critical path.

NISE Study Summary

- ***Created a fully working, integrated, FICSM model based on a large, relevant host program***
- ***FICSM process was completed and tested on existing program data***
  - Additional data is required for the development of detailed duration uncertainties
- ***Analysis of the results suggests the FICSM model provides***
  - Additional program insight for better informed decisions
  - Quantitative answers to common acquisition questions
  - Consistent framework and processes that can quickly adapt to program changes
- ***Identified tools that have imbedded validation metrics***
  - Measurable GAO and DCMA Schedule metrics quantify IMS confidence
  - Defendable decision support requires traceability through the Analysis Schedule to the detailed IMS where work is defined

Conclusion

Questions, Answers and Discussion

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