

NATIONAL RECONNAISSANCE OFFICE

Predictive Analytics: Schedule Execution Metrics

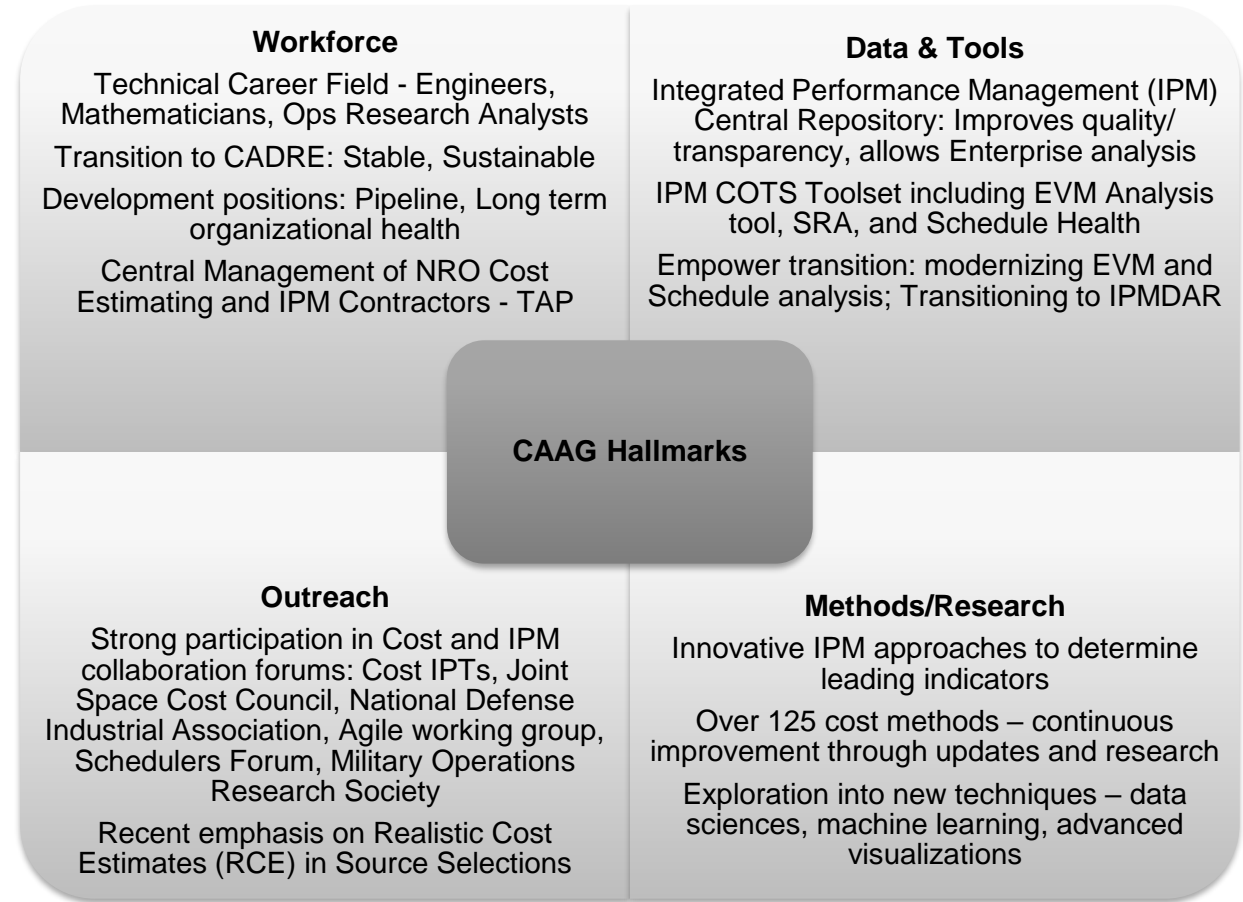
September 14, 2022



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National Reconnaissance Office (NRO) Cost and Acquisition Assessment Group (CAAG) Provides Data, Tools and Methods to Improve Acquisition Outcomes for Innovative Overhead Intelligence Systems





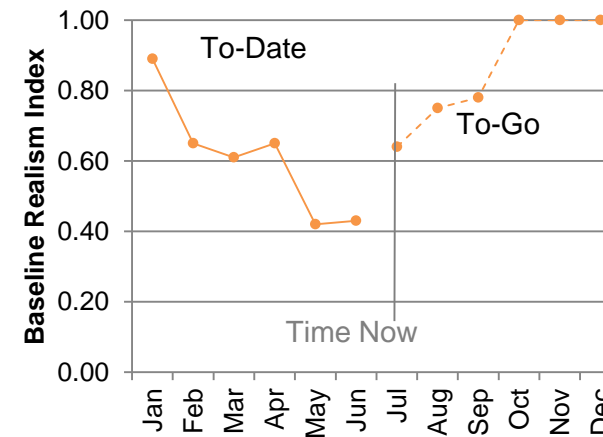
Context for the Development of Schedule Execution Metrics (SEM)

Situation: program was experiencing performance issues and senior leadership asked contractor and program office to present a one-slide performance summary to support management decision

Contractor assessment of performance:
Meeting schedule targets and performing better than cost targets, forecasting to complete without significant cost variance

Delivery	CUMSPI	CUMCPI	VAC
Total Program	0.99	1.12	
Element	0.96	1.18	
Element	0.98	1.04	
Element	0.99	1.16	

Program Office assessment of performance:
Steep downward trend in schedule execution and upward trend in forecasted finishes indicates a risk to the cost and schedule targets



Effective use of Baseline Realism Index for early detection of signs that the contractor was not achieving the baseline plan

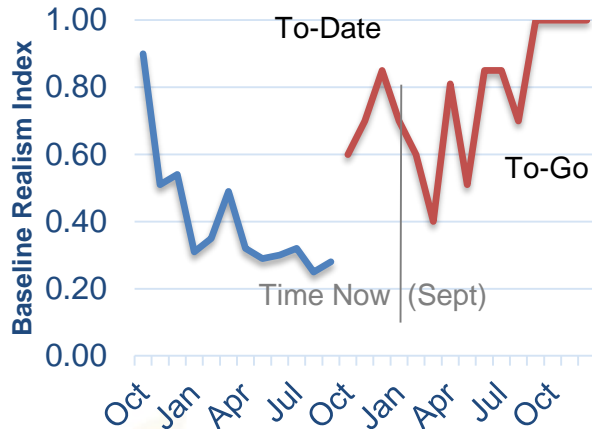


Context for the Development of SEM, Cont'd

Situation: An Over-Target Baseline and/or Over-Target Schedule scenario emerging.

Baseline Realism Index:

Early Warning of schedule problems in December



EVM Metrics:

Early Warning of cost performance in June
 Unfavorable indicators of cost performance in September
 No indication of schedule delay in the summarized metrics

	CUM SPI	CUM CPI	VAC
October	1	0.99	
November	0.99	0.98	
December	0.99	0.98	
January	0.99	0.99	
February	0.97	0.97	
March	0.98	0.98	
April	0.98	0.96	
May	0.98	0.95	
June	0.96	0.94	
July	0.97	0.93	
August	0.97	0.92	
September	0.97	0.87	

Time Now

Baseline Realism Index provides earlier warning of an emerging schedule delay than traditional "Gold Card" summary of metrics and analysis



Academic Year 2020-21, NRO Sponsored a Study at Naval Post-Graduate School

- To address an NRO senior leadership perception that IPM Analysis relied on anecdotal trends and professional judgement rather than data driven methods, we initiated a collaboration to explore data science methods and statistics for predictive analysis
- The Naval Post-Graduate School Capstone Project Study was supervised by Karen Mislick, sponsored by Ivan Bembers, NRO and Beth Corcoran, John Scaparro and Bruce Koontz, NAVAIR using NRO Methods with NAVAIR Unclassified dataset

Study Results: Final Briefing and Report

An Analysis of
Schedule Execution Metrics (SEMs)
Developed by the
National Reconnaissance Office (NRO)

NPS Capstone Project: Final Review

Team A-CATS
Lead: Candice Schultheis
Ryan Carey
Robert Dunn

Presented to:
CAPT Douglas Otte, USN (Ret.)

Presented on:
24 February 2021

NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

COST ESTIMATING AND ANALYSIS CAPSTONE PROJECT

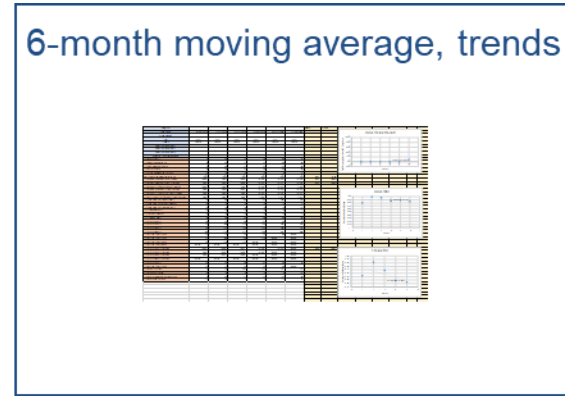
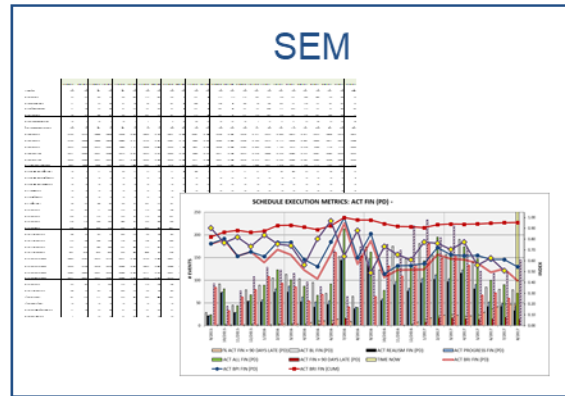
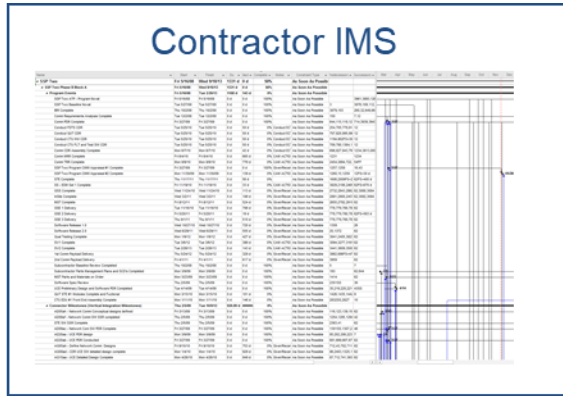
AN ANALYSIS OF SCHEDULE EXECUTION METRICS (SEMs) DEVELOPED BY THE NATIONAL RECONNAISSANCE OFFICE (NRO)
by
CANDICE SCHULTHEIS
RYAN CAREY
ROBERT DUNN

Advisor: Ivan Bembers, NRO & Beth Corcoran, NAVAIR
Professor: CAPT Douglas E. Otte USN (Ret.)

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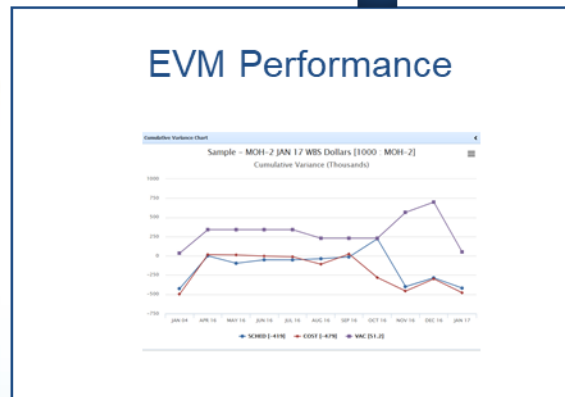
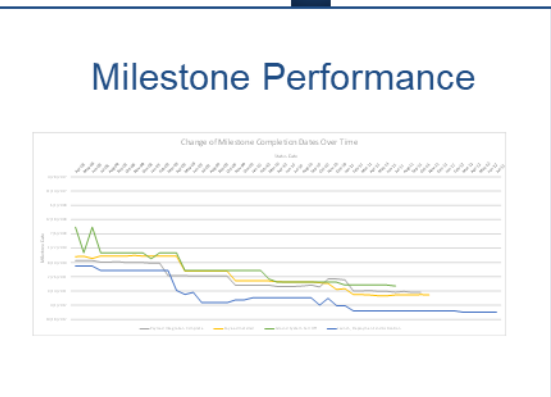
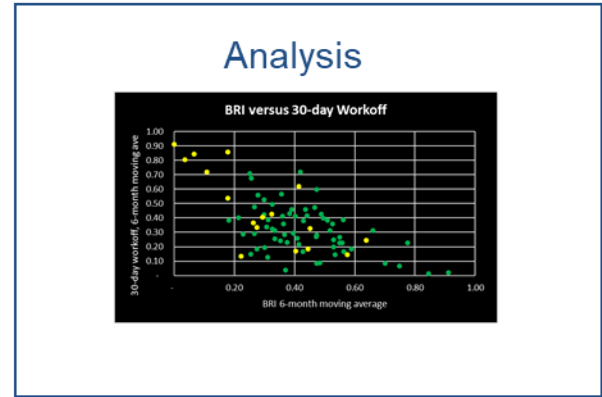
Continued Study Approach and Methods for Developing Data-Driven, Predictive Analytic Benchmarks



Connect schedule metrics and trends with milestone and EVM performance to develop thresholds that predict significant schedule growth

CALCULATE METRICS FROM INTEGRATED MASTER SCHEDULE

ANALYZE PERFORMANCE TO ASSESS 6-MONTH INCREMENTS



6-Month Increment Assessment

- Significant schedule growth
- Issue Emerging
- No Issue



Study Results and SEM Thresholds Card

Performance Indicator	Condition	Metric	Threshold	Indicator
●	On Plan	6-month moving average Baseline Realism Index (BRI) <u>AND</u> 6-month moving average 30-day workoff	≥ 0.65 <u>AND</u> < 0.32	Favorable
●	Smooth Sailing	6-month moving average Forecast Realism Index (FRI)	≥ 0.67	Favorable
●	Monitor Closely	6-month moving average BRI	≤ 0.65	Consuming cost and schedule margin
		6-month moving average BRI (little to no cost or schedule margin)	≤ 0.45	Unfavorable
		6-month moving average BRI (cost and schedule margin available)	≤ 0.20	Unfavorable
		To Complete Baseline Execution Index (TC-BEI)	> 1.10	Optimistic Forecast
●	Behind and trending worse	6-month BRI Trend <u>AND</u> 6-month moving average BRI	≤ -0.05 <u>AND</u> < 0.80	Unfavorable
●	Way off plan	6-month moving average BRI <u>OR</u> 6-month moving average Baseline Progress Index	≤ 0.20 <u>OR</u> ≤ 0.35	Unfavorable
●	Overwhelmed by late tasks	6-month moving average 30-day workoff	≥ 0.80	Unfavorable
●	Forecast does not reflect past performance	Delta (Baseline Execution Index (BEI) minus TC-BEI)	< -0.05	Unfavorable

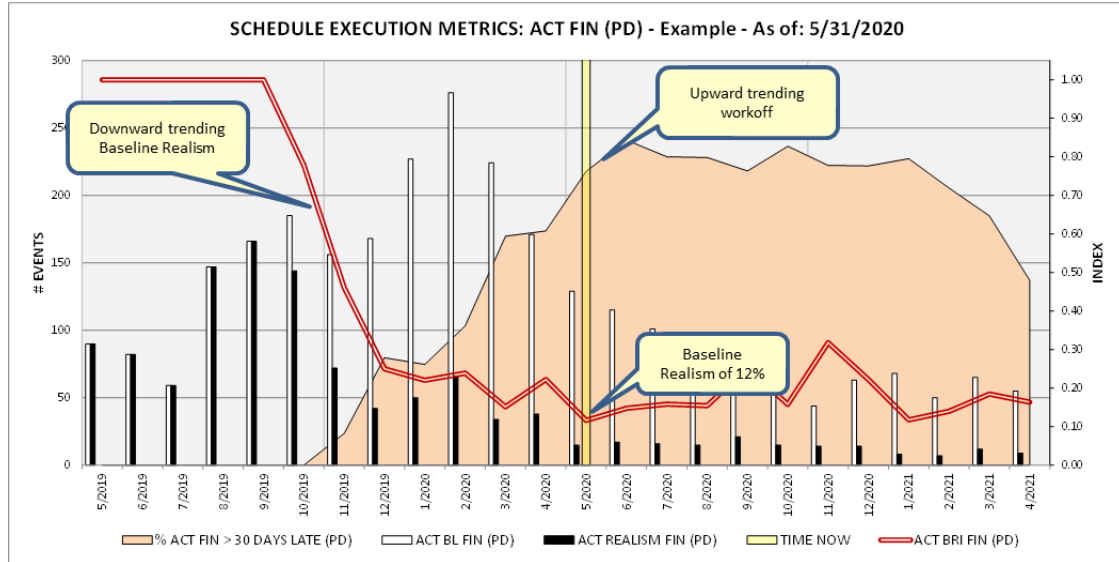
Metric: defined quantifiable performance measure used to track, monitor and assess schedule execution
Threshold: metric value cutoffs established to determine relative performance, used to understand the meaning of a metric
Indicator: interpretation of the metric based on performance against thresholds

● **Favorable:** not likely to experience major milestone delay or program restructure in next 6-12 months
 ● **Unfavorable:** likely to experience major milestone delay or program restructure in next 6-12 months



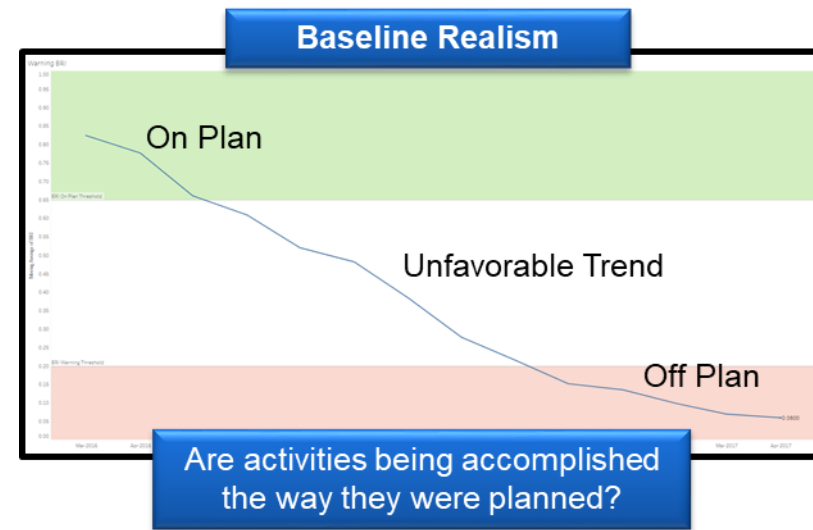
Applying “Decision-Ready” Visualizations

Before



*Power-user and Analyst view
(We still use this)*

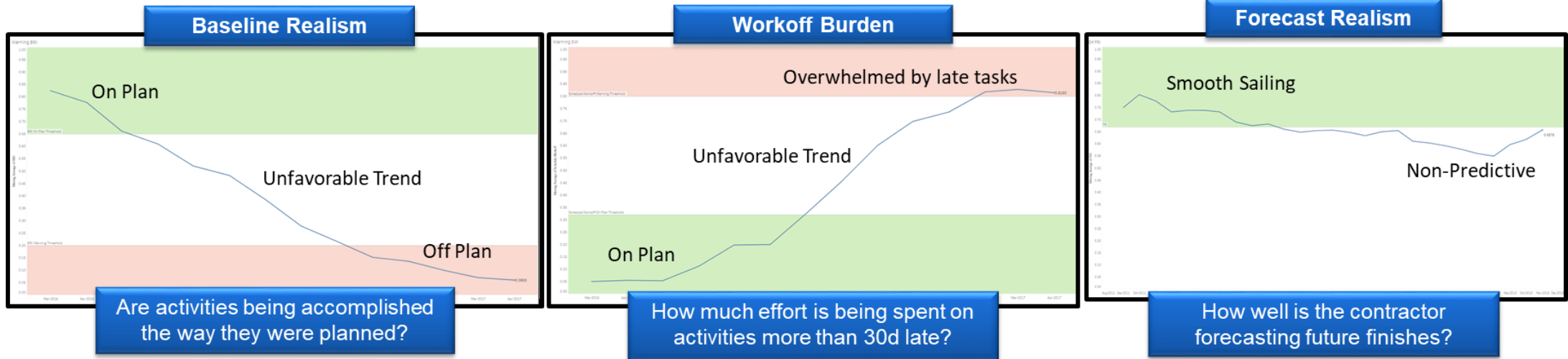
After



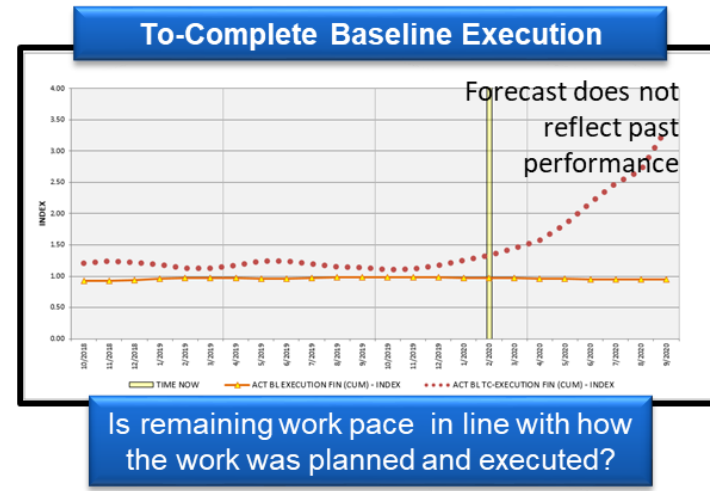
Decision-support visualization



Applying the Study Results, NRO Uses These Benchmarked Schedule Execution Metrics to Analyze Contract Schedule Performance



- Predictive analysis to identify when a schedule may be delayed, 6-12 months in advance of the schedule slip
- Early warning to allow time for recovery, trade-off, and acquisition decisions





Karen's Top Three References

- **Storytelling with Data** – a data visualization guide for business professionals
 - Cole, Nussbaumer, Knafflic
- **Storytelling with data – let's practice**
 - Cole, Nussbaumer, Knafflic
- **Visual Data Storytelling with Tableau**
 - Lindy Ryan



How Do We Apply this Going Forward?

- Shifting focus from *schedule data quality and compliance* to *schedule performance*
- Providing *objective* measures to program managers for schedule performance trends and realistic schedule forecasts
- Strengthens program office capabilities, independent schedule assessments and portfolio dashboards by providing data-driven benchmarks and thresholds for decision makers
- Early warning of schedule growth creates decision-window for timely course corrections
- Can be calculated on the entire IMS or a subset, e.g., payload, increment, or capability
- Answers the mail to senior leadership's request for data-driven, early warning of cost and schedule issues

Study results enables data-driven early warning of schedule performance problems to avoid late discovery and risk of program failure



Next Steps

- Our next steps:
 - Add more programs to the Study's data set and improve granularity of early warning
 - Apply machine learning models such as k-mean cluster, k-mean nearest neighbor modeling
 - Continue to engage with COTS tool vendors to make execution metrics widely available
- Steps industry can take:
 - Incorporate execution metrics into Corporate toolkit for program assessment reviews
 - Study your schedule data from past programs to establish thresholds that align with predictive program outcomes



Conclusion

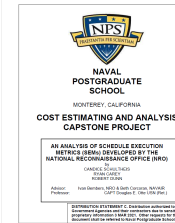
CAAG uses data science methods to advance schedule analysis

Accomplishments

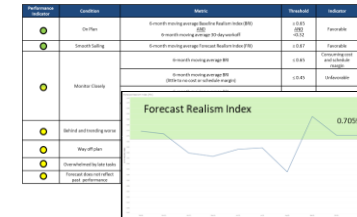
- Developed predictive schedule metrics and data-driven benchmarks using data science
- Proved predictive capability with completed programs
- Transitioned from GOTS to COTS to proliferate value to community
- Adding more programs to refine benchmarks & thresholds
- Applying machine learning models
- Collaborating with COTS tool vendors to increase adoption

Underway

Data Science Collaboration with Naval Post-Graduate School



Continued Data Science Study on NRO Data sets



Schedule Execution Metrics in COTS



A game changer for predictive analysis for early warning of schedule delay. Opportunity to expand into standard COTS analysis tools.

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Back-up



Metric Definitions (1 of 2)

Metric	Definition	Analytic Value	Range
Workoff 6-month moving average	Percentage of total completions in any period that are more than 30 calendar days late. This is an indicator of how much time is being spent each period getting caught up	How much of the work being done is “catch-up”?	Lower is better Theoretical Bounds: 0.00 to 1.00 Dataset: 0.00 to 0.94
Workoff Trend	Linear trend representing 6-month increment of Workoff	Is the program catching up or falling further behind?	Negative is better Dataset: -0.63 to 0.24
BRI 6-month moving average	Baseline Realism Index Percentage of planned events that actually finished in the planning period. This is an indicator of how well the contractor is following the plan in the period	Is the contractor executing the plan?	Higher is better Theoretical Bounds: 0.00 to 1.00 Dataset 0.00 to 1.00
BRI Trend	Linear trend representing 6-month increment of BRI	Is performance falling off of the plan, or getting back on plan?	Positive is better Dataset: -0.24 to 0.42
BRI cum	Cumulative Baseline Realism Index Percentage of planned events that actually finished since the beginning of the program. This is an indicator of how well the contractor is following the plan.	Cumulatively, is the program on plan?	Higher is better Dataset: 0.34 to 1.00
BPI 6-month moving average	Baseline Progress Index Percentage of planned events that actually finished in or before the planning period. This is an indicator of how many of the planned events in the period have actually be accomplished	Is the contractor keeping up with planned work?	Higher is better Theoretical Bounds: 0.00 to 1.00 Dataset: 0.00 – 1.00
BPI Trend	Linear trend representing 6-month increment of BPI	Is the program falling behind or catching up?	Positive is better Dataset: -0.20 to 0.47



Metric Definitions (2 of 2)

Metric	Definition	Analytic Value	Range
FRI 6-month moving average	Forecast Realism Index Percentage of forecasted events that actually finished in the forecast period. This is an indicator of how well the contractor is accomplishing the forecast for the period.	Can the contractor achieve last month's forecasted finishes?	Higher is better Theoretical Bounds: 0.00 to 1.00 Dataset: 0.21 to 0.96
FRI Trend	Linear trend representing 6-month increment	Is forecast execution getting better or worse?	Positive is better Dataset: -0.18 to 0.20
BEI cum	Cumulative Baseline Execution Index Percentage of total events that actually finished in the planning period. This is an indicator of the contractor's pace of work	Pace of work to date	Higher is better <1.0 indicates falling behind =1.0 indicates on plan >1.0 indicates catch-up Dataset: 0.66 to 46.41
TC-BEI	To-Complete Baseline Execution Index Number of all Remaining finishes divided by number of remaining baseline finishes	Provides insight into how many more activities are left versus what was planned Can identify compression of significant activity in the remaining time	Above 1.00 indicates potential performance risk <1.0 indicates fewer than planned =1.0 indicates on plan >1.0 indicates more than planned Dataset: 0.00 to 2.02
Delta (BEI vs TC-BEI)	Change in efficiency needed to achieve the forecast	Assess whether the forecast is realistic based on pace of work to date	> 0.00 indicates potential performance risk > 0 indicates more efficiency in future than in past (potentially unachievable forecast) Dataset: -1.35 to 46.25