



A Prime Contractor's View Using JCL

Tools and Techniques

Agenda for JCL

- **Lockheed Martin's History of Integrating cost and schedule to assist Programs**
 - **Business Development**
 - **Assist Management to Manage Programs**
- **LM's approach to Joint Confidence Level analysis**
 - **Approach/ Process**
 - **Tools & Techniques**
 - **Examples of JCL analysis**
 - **Funding Constraints**
- **How JCL analysis is used to influence decision makers**



LM History of Using Integrating Cost and Schedule Models

Historical Perspective of Integrating Cost and Schedule Models

- Business Development utilizes Integrated Cost and Schedule (ICS) models during the capture and design phases enabling programs to meet cost, schedule, and performance objectives
 - Minimize cost to manufacture, operate, and sustain
 - Minimize schedule duration and variability
 - Optimize system reliability, maintainability, availability
 - Easily and quickly assess engineering change impacts
- Lockheed Martin has developed and utilized ICS models for analysis of manufacturing and processing operations for more than 10 years

ICS models link Program Schedules and Program Cost data through common data fields (WBS, IPT, IMP/IMS, CLIN, etc)



ICS Model Usage at Lockheed Martin

- ICS models use a Monte-Carlo analysis method that is ideal for these types of analyses due to the complexities, dynamics (time evolution), uncertainties, and variability associated with these operations
- ICS models need to be able to interface with engineering databases
- ICS models provide capability to analyze program variables
 - Supply chain and logistics schedules and delays (probabilities and durations)
 - Production schedules and processes (including variability and learning)
 - Resource quantities available (personnel, equipment, facilities)
 - Work shift schedules (hours/shift, shifts/day, and days/week for resources and processes)
 - Work selection/prioritization rules for resource allocation
 - Planned maintenance (interval and duration) and unplanned maintenance (based on MTBF/MTTR) for facilities, equipment, and delivered hardware

ICS Model Outputs and Assessments

ICS models evaluate key program metrics

- Cost
 - Schedule
 - Production rates
 - Availability
 - Resource quantities and utilizations
 - Affordability
- Diagnostics**



Predictive Modeling

ICS models provide systems engineering support functions

- Trade study support
- Requirements compliance
- Sensitivity and optimization analyses
- Identification of process, cost, and schedule improvement opportunities

Example of Programs Using ICS models

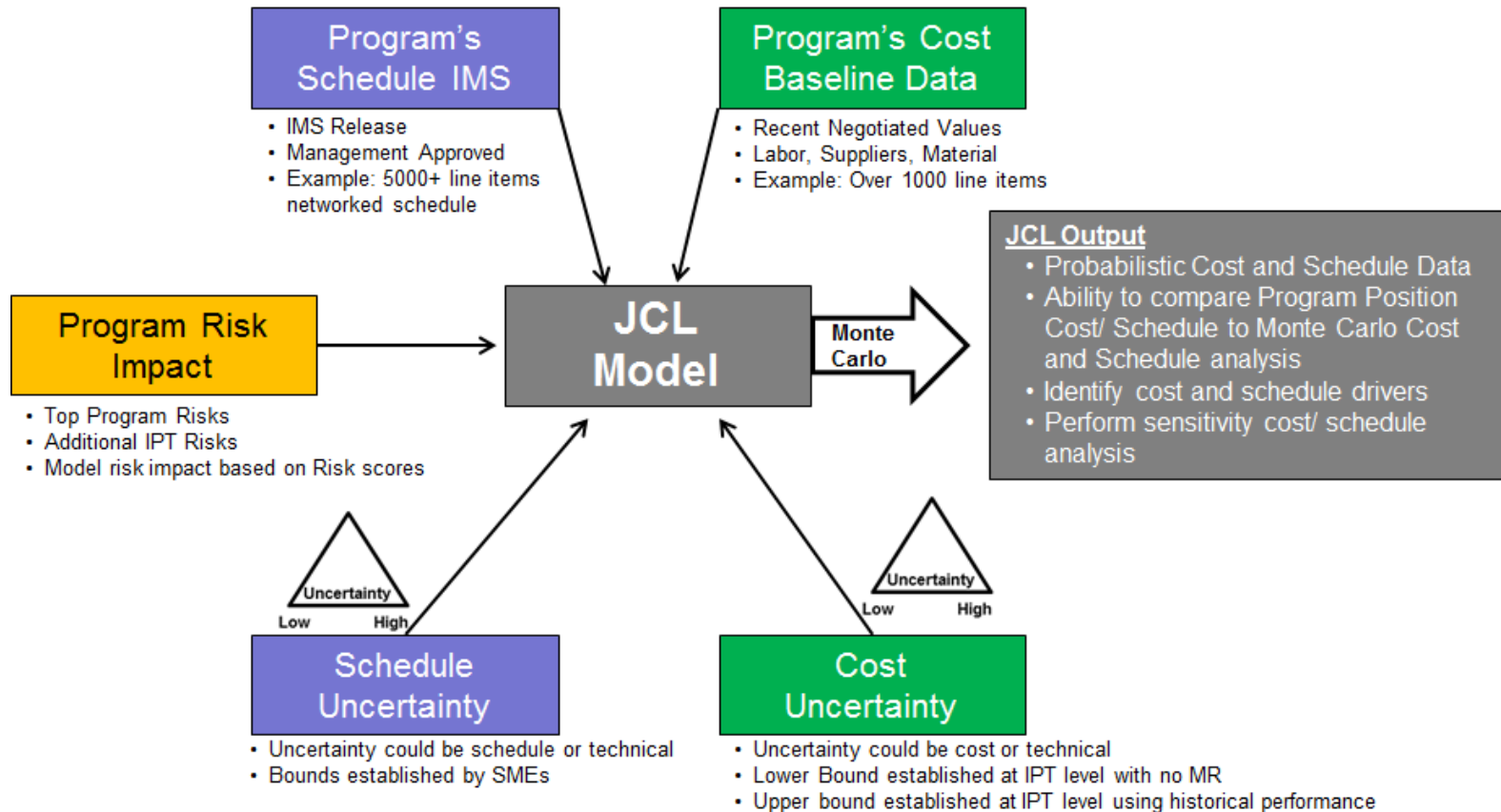
- 2GRLV
- Orion
- CEV
- New Launch Vehicles

LM Joint Confidence Level Approach

JCL Tools & Advantages

- **We leverage standard COTS tools**
 - MS Project
 - MS Excel
 - MS Access
 - Tableau Software
- **Data Integration**
 - Schedule information from MS Project is exported and “wired” in Excel
 - Program Cost data from the Cost Accounting system is synced with the schedule
 - This is accomplished by mapping common data fields (WBS, CLIN, IPT, CA, WP, etc)
 - Relationship between LOE and schedule durations are created such that schedule growth directly translates into cost growth
 - Cost & Schedule uncertainty are modeled using Tri-Gen Distributions based on uncertainty assessment provided by Subject Matter Experts (SMEs)
 - Program Risk data is synced with Cost & Schedule data
 - The specific program cost & schedule Consequence associated with each Risk Item is modeled as a unique element in the JCL model
 - The Likelihood of the risk item occurring is modeled probabilistically – with the impacts mentioned above “switching” on or off based on the likelihood of the risk manifesting
- **Probabilistic Simulations**
 - Oracle’s Crystal Ball software is used to perform Monte Carlo simulations against the JCL Model
 - Cost, Schedule & Program Risk uncertainties and risks are simultaneously manipulated during the Monte Carlo simulation to generate JCL results

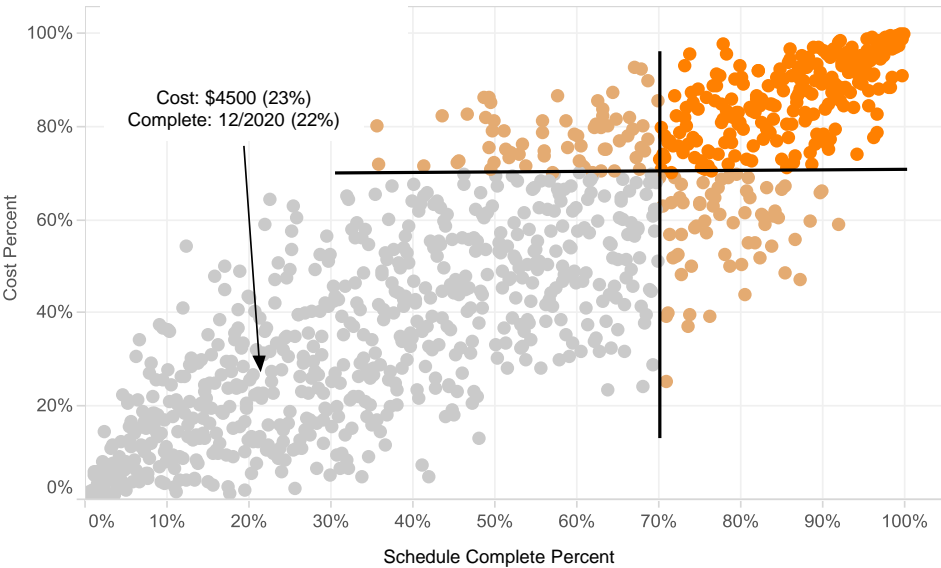
Overview of LM JCL Process



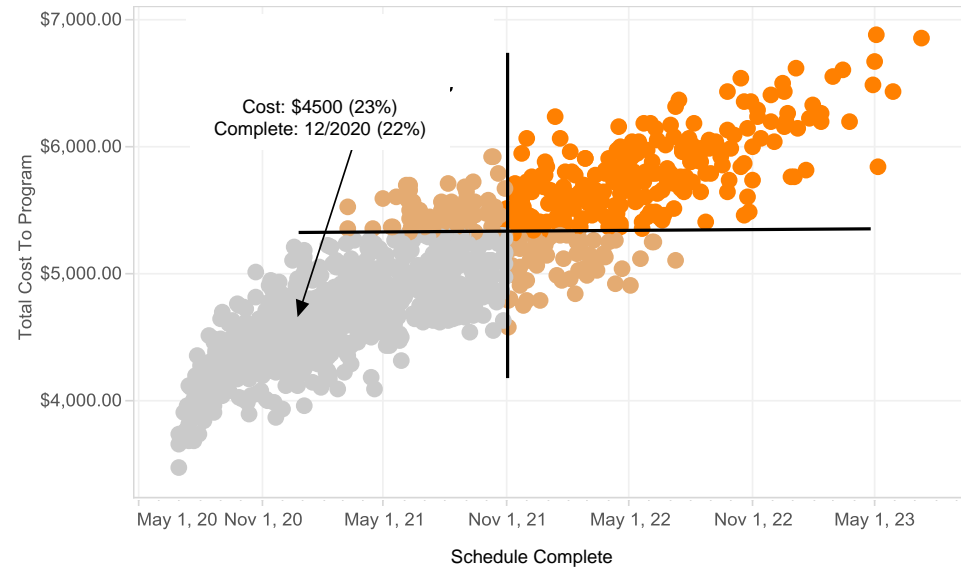
Proven Lockheed Martin JCL Process

JCL Model Results

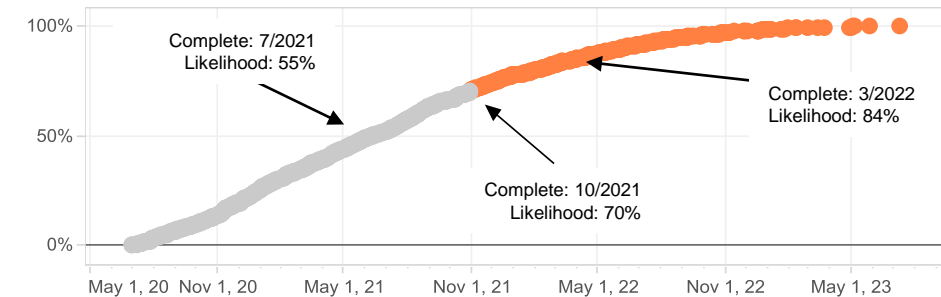
JCL Scatter Plot - Percents



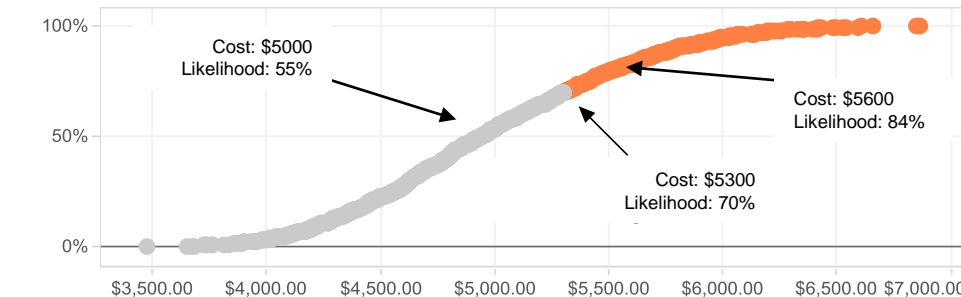
JCL Scatter Plot - Discrete Values



Schedule S-Curve



Cost S-Curve

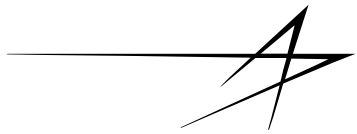


- JCL results provide program decision makers with a quantifiable measure of the combined likelihood of completing the project by a specified date and within a specified budget
- By understanding their position within this continuum of results, decision makers can quantify the additional funding that must be secured and the required schedule margin needed to assure success

How LM Accounts for Funding Constraints in Analysis

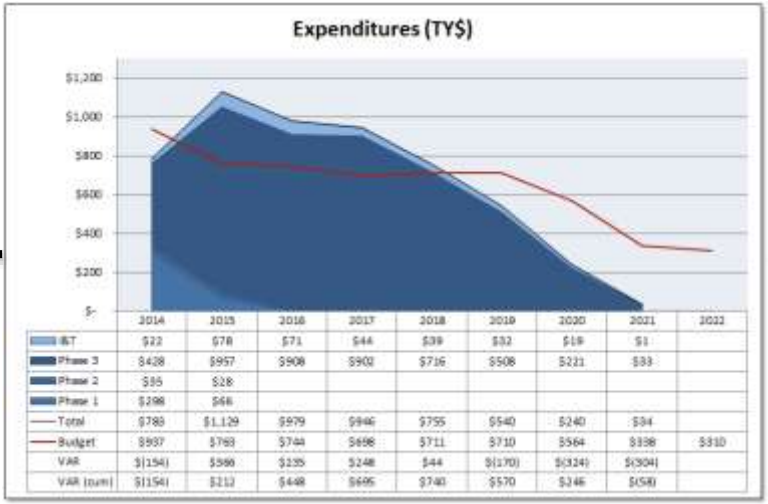
- ICS models provide a discrete link between a program's Cost & Schedule elements
 - Moving a program schedule element dynamically moves its cost
 - The effect of moving content ripples through the program and updates the program's overall fiscal year funding requirement
 - This modeled relationship can be leveraged to automate the process of rapidly exploring hundreds, thousands of alternatives in minutes – making it possible to find “optimized” program planning solutions for any number of funding constraints
- ICS models allow for numerous funding analyses to be performed, each solving for the program's funding constraints
- Key sensitivities regarding the relationship between major program milestones and funding compliance can be identified and leveraged to achieve budget compliance with minimal program impact
- Use of Monte Carlo simulation and optimization tools allow for the rapid exploration of alternatives and the identification of different solutions that optimize on the basis of cost, schedule or risk
- This analysis feeds the establishment of Funding Constraint Risk Items
 - By comparing alternate program solutions with the program's nominal state the specific cost and schedule impacts of achieving budget compliance can be quantified and documented
 - Through the Funding Analysis a Risk can now be documented and characterize in such a way as to feed the JCL analysis

Funding Analysis with an ICS Model



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Multiple iterations are performed to “dial-in” a program plan that satisfies a funding constraint while mitigating schedule impacts – the entire process can be performed manually, or automated



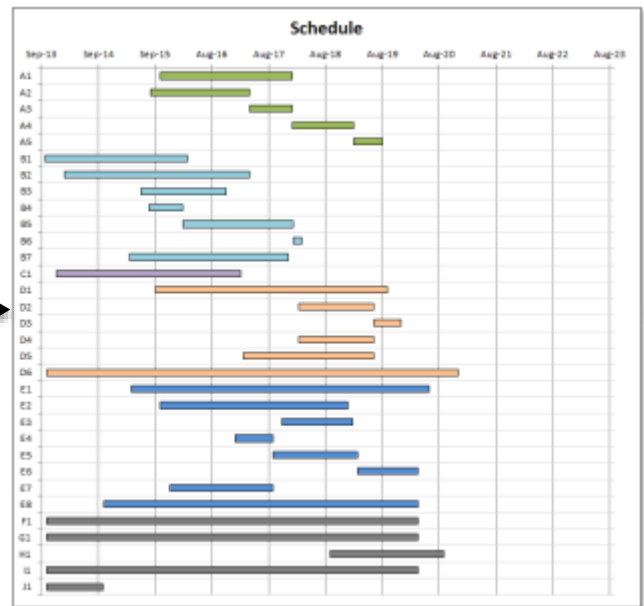
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As the program schedule is modified, the associated program expenditures are updated in real-time to reflect the new funding need

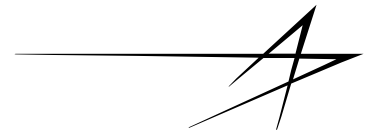
CAT	Start	Finish	Fin Delta	Finish Date	Elasticity
PHASE 3.1	1/24/2014	12/31/2018	0.0	< >	< >
PHASE 3.2	10/8/2014	12/31/2020	0.0	< >	< >
PHASE 3.3	9/4/2016	12/31/2019	0.0	< >	< >
PHASE 3.4	10/1/2013	4/18/2020	0.0		
LOE	10/1/2013	4/18/2020	0.0		
SITE	10/1/2013	4/18/2020	0.0		
NRE	9/25/2013	12/31/2020	0.0		
TEST	8/1/2015	9/1/2019	0.0		
PROP	10/1/2013	9/30/2014	0.0		
SPT	12/4/2013	3/2/2017			

1

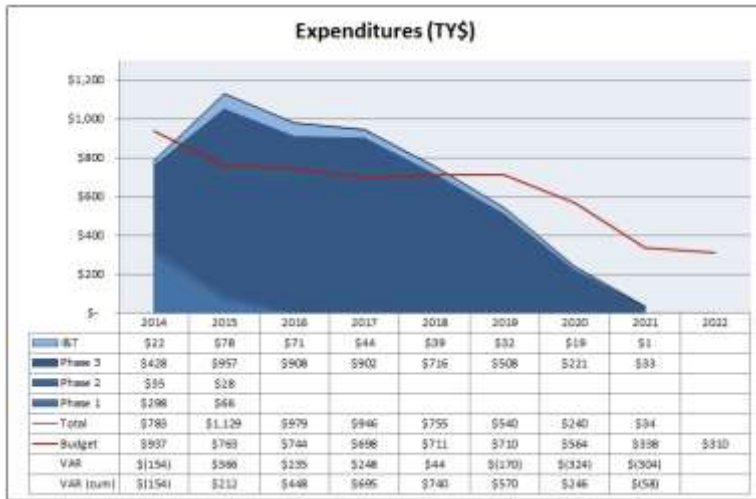
Simple variable controls allow a user, or computer, to adjust the program schedule (dates & durations)



Funding Analysis with an ICS Model

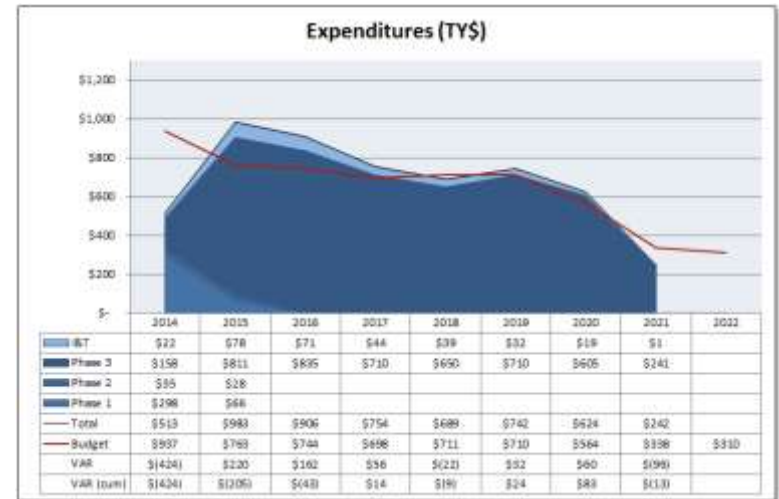


WAS



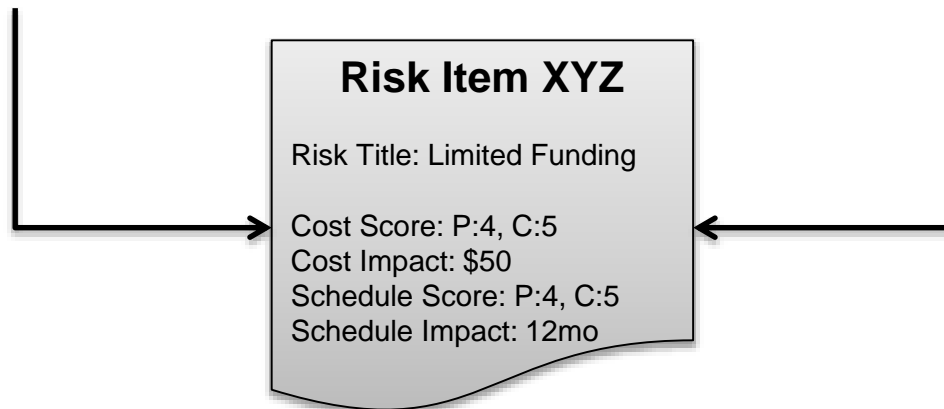
Total Cost: \$5400
Schedule Complete: 12/2020

NOW



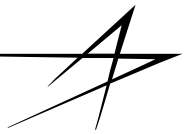
Total Cost: \$5450
Schedule Complete: 12/2021

ICS Models allow programs to discretely quantify, document & track Risk Items related to budgetary constraints

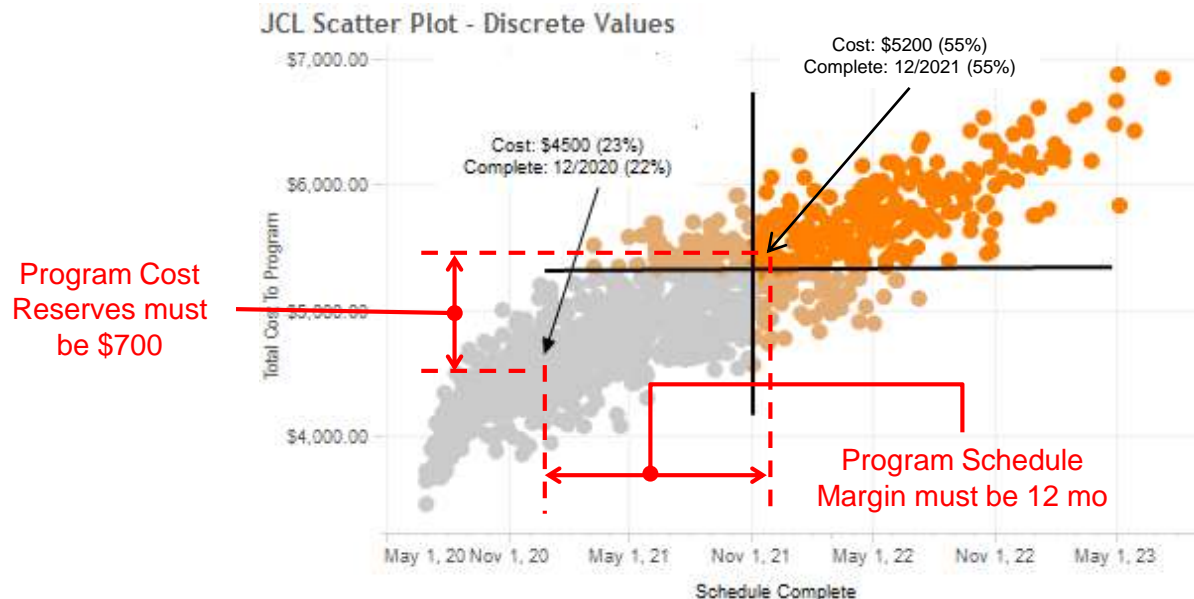


How JCL Analysis is Used to Influence Decision Makers

How JCL Analysis is Used to Influence Decision Makers



- JCL analysis provides a quantitative means of evaluating the relative cost, schedule and risk impacts of program alternatives
- The JCL process forces program personnel and decision makers to consider the integrated nature of cost and schedule and to evaluate the risks involved in various decisions
- Allows contractors to take a pro-active role in the forward budgeting and planning of large aerospace and defense acquisition programs
- JCL analysis guides program decision makers in the establishment of Cost & Schedule margins needed to successfully manage the program to a successful completion



Questions