

## Fully Integrated Cost/Schedule Method Model Team

The Whole is Greater Than the Sum of its Parts

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**“Time is Money”**  
-Ben Franklin (1748)



So why do we largely ignore it in our estimates?

## CISM and FICSM

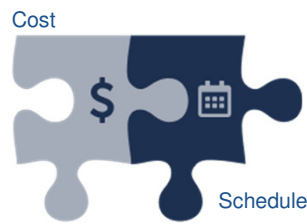
- There are two predominant methods for assembling cost models

### Cost Informed by Schedule Method



Many cost models developed in industry follow the CISM paradigm but ignore the "IS" portion of CISM

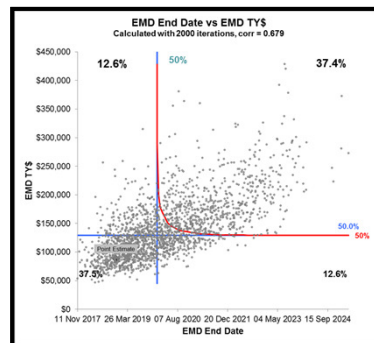
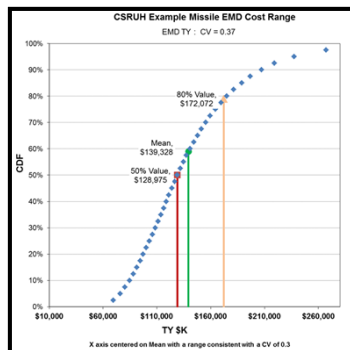
### Fully Integrated Cost/Schedule Method



Identifying and establishing the appropriate team members and points of contact is instrumental for success

## Cost Is Not Enough

- Now** we report the statistics of our cost uncertainty estimates
- Future** will be more emphasis on integrated cost and schedule analysis
- Deliver the probability of achieving a cost target
- Deliver the joint probability of achieving BOTH cost and schedule targets



# The Case for FICSM

- Traditionally cost estimates focus on one dimension of a system...the cost
- Schedule and Risk Events can be significant contributors to a system's total costs -> **Enter CISM and FICSM**
- The U.S. General Accounting Office (now Government Accountability Office) first assessed cost and schedule performance at NASA in 1975<sup>2</sup>

**GAO FOUND THAT:**

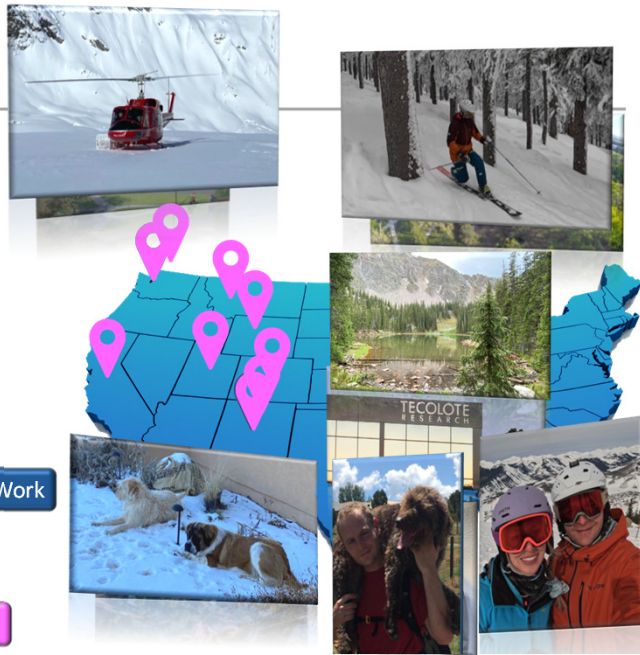
NASA's cost and schedule estimates have frequently been optimistic. Specifically, on certain major unmanned satellite projects

--costs increased 89 and 13 percent respectively over the planning and development estimates (see p. 5) and

--schedule delays ranged from no delay to 29 and 13 months respectively over the planning and development estimates. (See p. 6.)

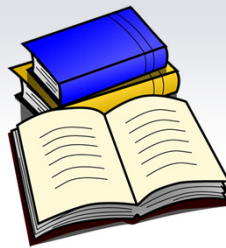
**If this is not new, then why do we still only build cost estimates?  
...because it's hard to build integrated estimates.**

## But Who Am I?



# The Context

## CISM and FICSM In Theory

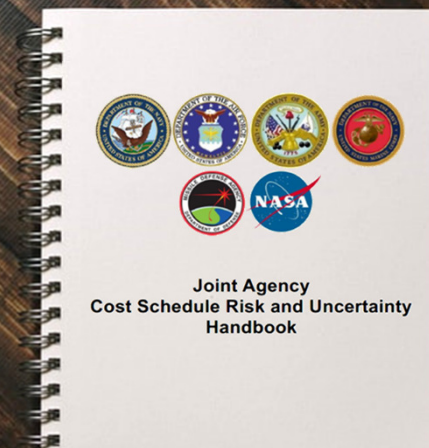


# Joint Agency Cost Schedule Risk and Uncertainty Handbook

The Driving Guidance

JA CSRUH:  
The **Authoritative Document** of  
Cost Schedule Risk and Uncertainty  
for the US DoD and NASA

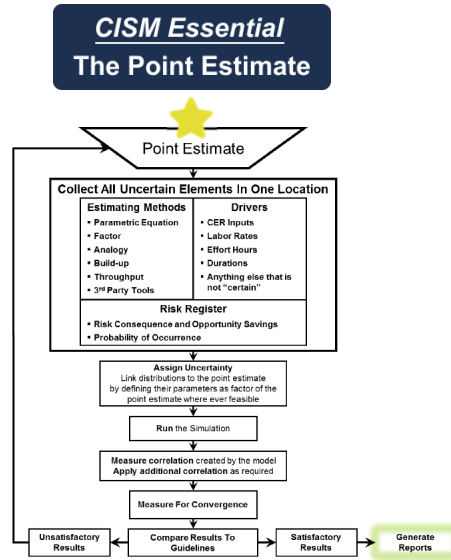
**Goal:** Define and clearly present  
simple, well-defined cost risk and  
uncertainty analysis processes that  
are repeatable, defensible, and  
easily understood



**Defines Uncertainty Best Practice for the Cost Community**

## What is the CISM?

- The CISM is a cost uncertainty model that has *some* level of duration uncertainty built into it such that the duration uncertainty influences the cost of simulation results
- The CISM follows a very standard method for development
- CISM Models are generally assembled in a cost estimating software tool (ACEIT, Crystal Ball, @RISK, etc)

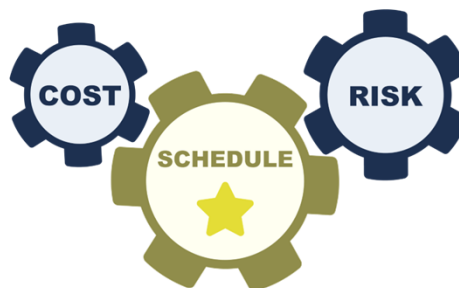


## What is the FICSM?

- The FICSM is typically a cost loaded schedule model with cost/schedule risks and uncertainty addressed
- Three distinct disciplines are married to create a holistic look at project execution

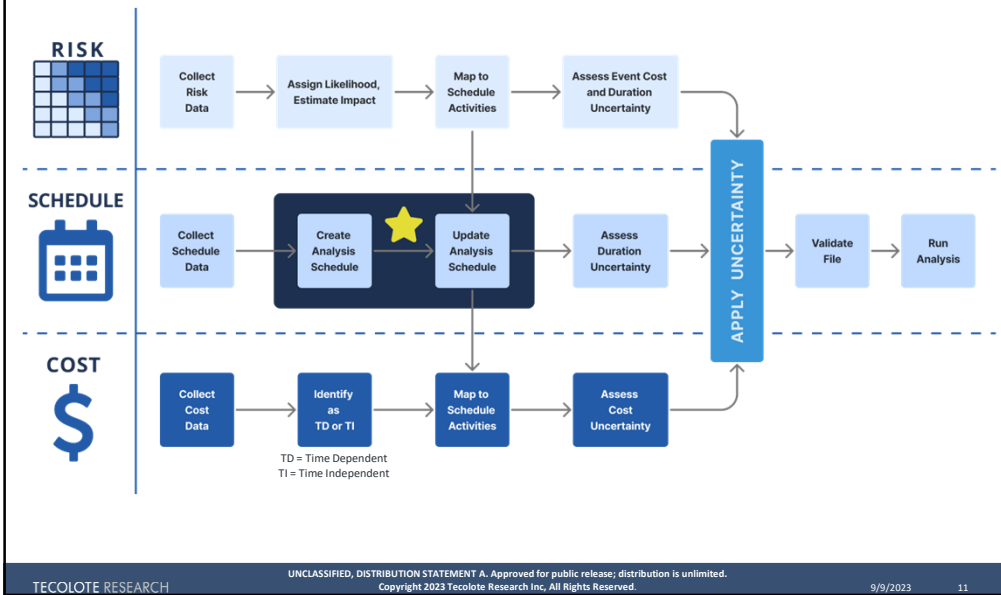
**FICSM Essential**  
**The Schedule**

All subsequent analyses are based on the simulations/excursions of the schedule model



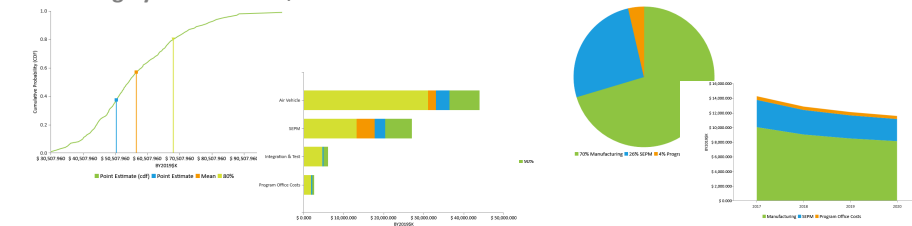
FICSM Models are assembled via add-ins to a scheduling tool (JACS, Primavera Risk Analysis, @Risk for Project, Risky Project, Acumen Fuse, Polaris, Safran Risk, etc)

# FICSM Progression – Schedule is Key

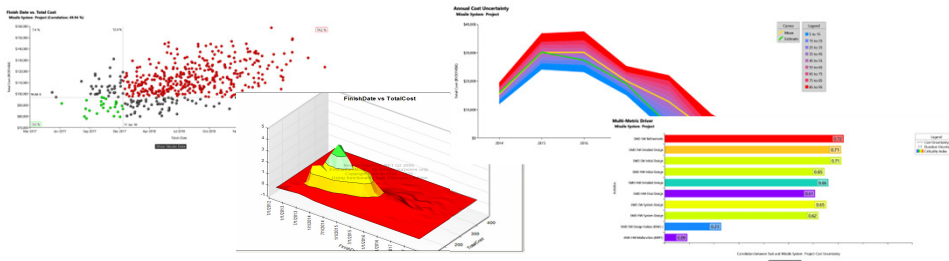


# CISM vs FICSM Outputs

## CISM – Largely described in \$ in Cost dimension



## FICSM – Described in \$ and Time in Cost & Schedule Dimensions



## NASA Mandates Joint Confidence Level (JCL)

...and so should others



### Prior to 2002

- NASA utilized similar approach to US DoD
- Found no approaches connect cost, schedule risk in coherent **actionable** analysis



### 2002 - 2004

- GAO Reports cited major causes of cost growth included incomplete cost-risk assessment and flawed initial program planning
- Schedule impacts to cost lacking



### 2004 - 2009

- FICSM modeling and JCL approaches developed and refined
- Concurrently, first iteration of JA CSRUH released 2004
- Multiple companies developing FICSM modeling tools



### 2009 and Beyond

- NASA directs JCL through NPD 7120.5E
- "Mission Directorates shall plan and budget...projects with an estimated life-cycle cost >\$250M based on a 70% **joint cost and schedule** confidence level..."

## FICSM Modeling and JCL

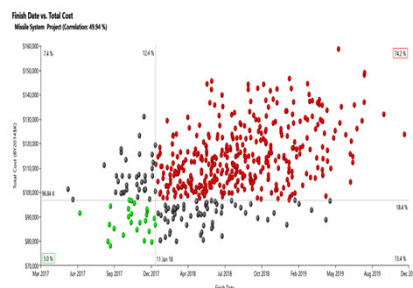
JCL = Probability that a project or program's cost will be equal or less than the targeted cost **and** the schedule date will occur on or before the targeted schedule date

### More than a Scatter Plot

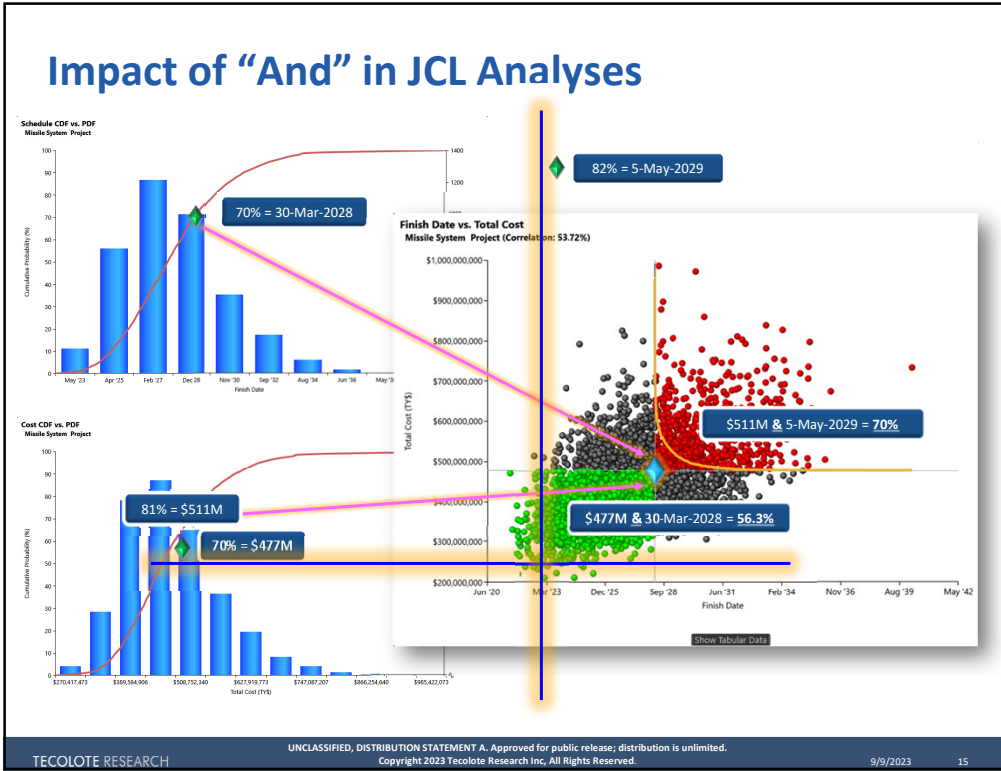
- Integrates cost, schedule, risk
- Provides transparency on probabilities of meeting expectations
- Cohesive and holistic view of achieving cost/schedule goals to help determine reserve/margin amounts

### Key decision support information

- Does project have sufficient funding?
- Can we meet schedule?
- Can we invest more to gain schedule?
- How much might it cost to accelerate schedule?
- Which risk areas should we/can we focus on?
- How do risks impact costs/schedules?







## Standard Process for Assembling JCL

### The Four Key JCL Inputs

**Schedule**  
The network schedule of activities is the foundation of the JCL analysis.

**Cost**  
Project cost data by element is linked to the schedule and mapped to activities.

**Risk**  
An itemized list of risks with likelihood and impact is included in the JCL.

**Uncertainty**  
Uncertainty in the cost and duration can capture additional unknown risk.

1. Build a JCL schedule/logic network
  - Logic network
  - Minimize use of constraints
  - Link to major milestones
  - Schedule health check for viability for analysis
2. Cost load the schedule
  - Map cost to schedule
  - Load as resources if using schedule system
  - Determine phased fixed/variable costs and assign to schedule/logic network
3. Implement risk list
  - Quantify likelihood and cost/schedule impacts
  - Link to schedule/network activities
  - Load risks
4. Conduct uncertainty analysis
  - Schedule uncertainty
  - Cost uncertainty
  - Discrete Risk uncertainty
5. View results & plot
6. Analyze results and refine (steps 1-5)

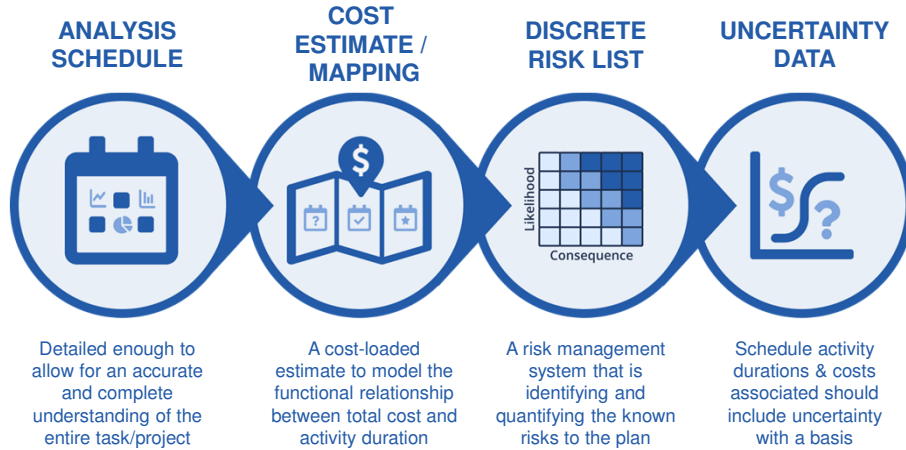
**Step Zero: Identify goals for JCL**  
 What questions to answer?  
**Who to use?**  
 What insight to gather?

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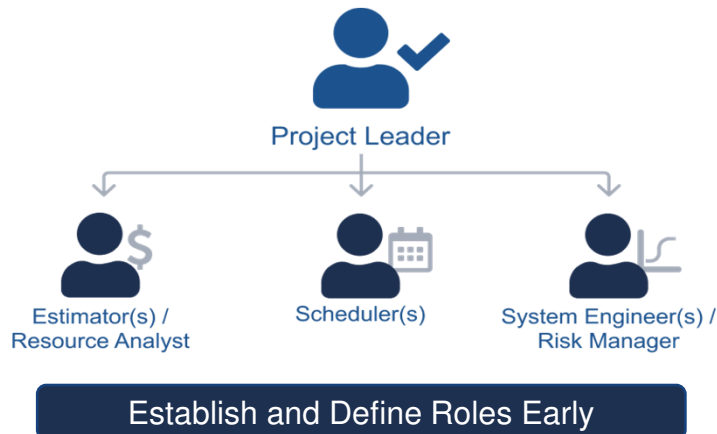


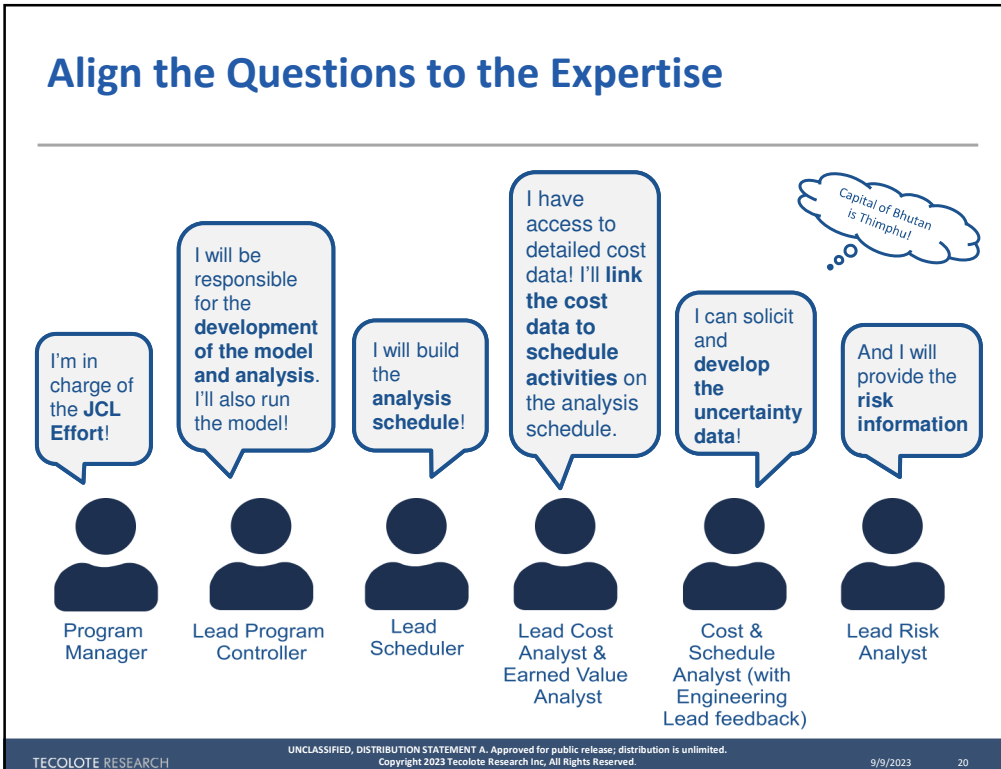
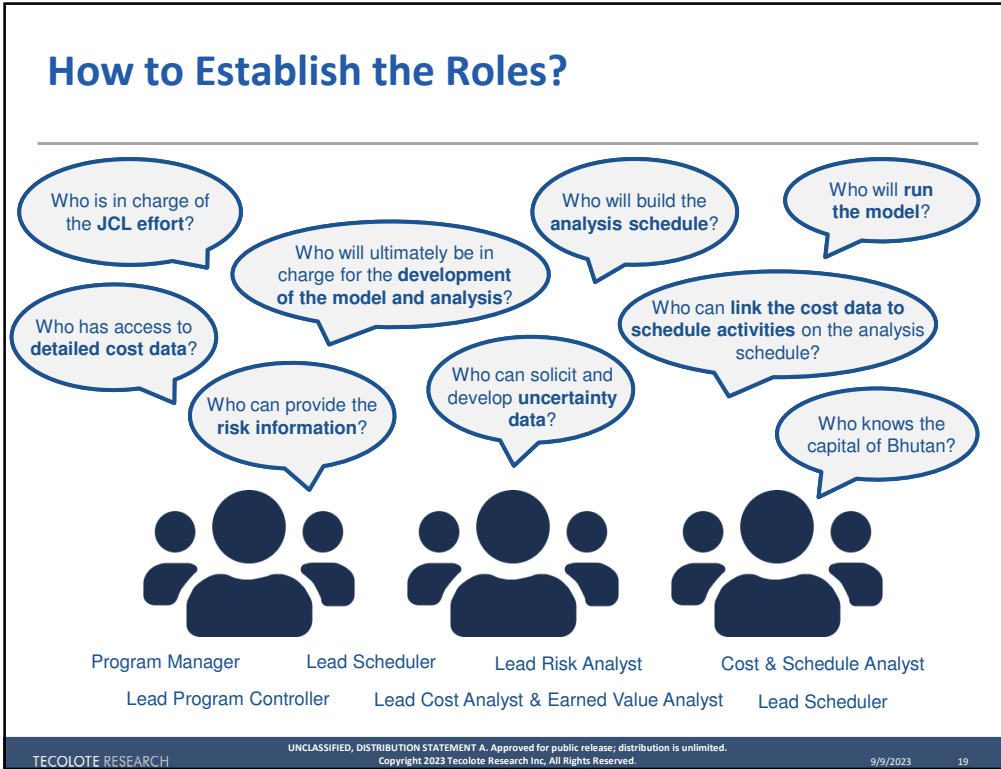
## What is needed for FICSM Model?



## Who is needed for a FICSM Model?

- FICSM models are completed with an integrated project team rather than traditional estimates built by cost analysts



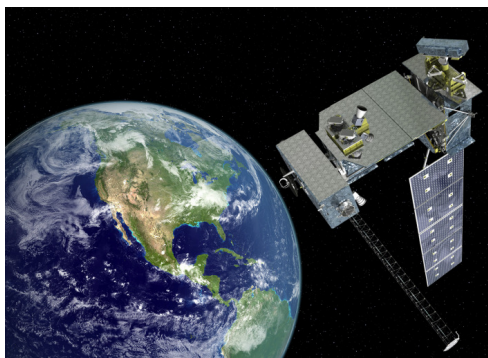


## Now In Action

FICSM Development for Experimental Satellite



## Satellite Project Overview



### Mission Description

- Launch Mass: >1500 kg
- Mission Life: >5-Year Requirement (>8-Year Goal)
- Orbit: GEO
- Payloads: >5
- Multi U.S. Gov Agency effort

### Mission Goal

- Advance capabilities across Communications, Space Weather, Situational Awareness and other mission areas

## Program Office Desire for JCL

## SCENARIO

Program Office Leadership under focused scrutiny from four primary stakeholders for mission execution



Barely underway and already concerned...

Cost team participated in proposal evaluation and highlighted multiple cost risk areas before hardware contractor even started. Hardware contractor did not submit detailed IMS with proposal, leading to concern with viability of advertised delivery dates

Requested our team to develop comprehensive assessment of cost/schedule/risk exposure to project completion

Program Office Response

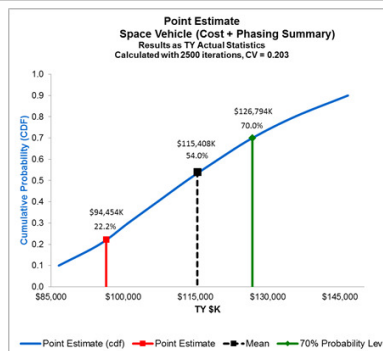


FISCM model required to complete assessment



## CISM Estimate

- Cost team had developed CISM-based estimate prior to contract award
  - Schedule was a Ground Rule to CISM model and not considered in uncertainty analysis
- Immediately after contract award, the launch date was moved from Apr 2019 to Oct 2019



Task Name	2015				2016				2017				2018				2019			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
Space Vehicle (SV)																				
SV Development									12/12											
Payload Assembly, Integration, and Test													4/4							
SV Integration													7/25							
SV Performance Testing																	10/17			
Initial Launch Capability (ILC)																		2/13		
																		4/24		

## Need for FICSM Model

Program Office needed to answer questions from internal and external stakeholders... *but couldn't with their current CISM model.*

### Program Office



- What is the confidence in the new launch date? (Oct-2019)
- What is the confidence in the contractor proposed costs against the new launch date? (~\$93M – Cost Reimbursable Contract)
- How might significant risks impact the new launch date and cost of mission? (19 tracked risks at the time)
- Which External Agencies might be responsible for funding cost overruns?

These questions could only be answered through development and assessment of a FICSM model.

## Convince Mission Team to Perform FICSM

- Program Office couldn't quantifiably answer basic questions... *and neither could the Mission Team*
- Various team members had different answers and viewpoints to the same questions:

### WHAT IF THERE IS A FIRE RISK TO SPACECRAFT BUS STRUCTURE DESIGN?

Lead	Who would pay for that issue? One of my customers or does it come from my own budget?
Schedule	We don't see any connections in the IMS where a delay in structure design would impact any other subsystems
Cost	If there is a schedule impact, the standing army costs are likely to expand
Risk	Likelihood of risk was x% with potential cost and schedule impacts directly related to risk
Engineer	If structure design is not settled, that precludes the completion of payload module design, harness design, solar and battery design, etc

The best they could do was project, but not quantifiably assess, the outcomes.

The team quickly agreed to the FICSM approach!

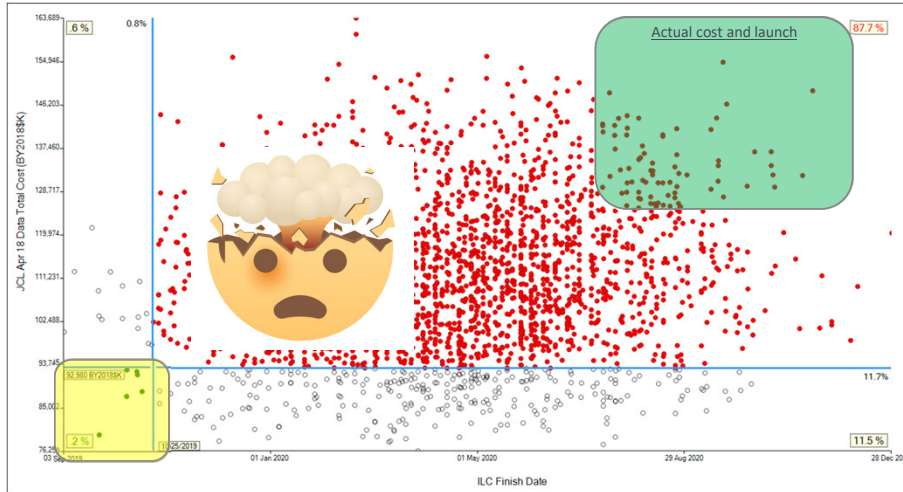
## Who Did we Assemble?



## FISCMS Model Development

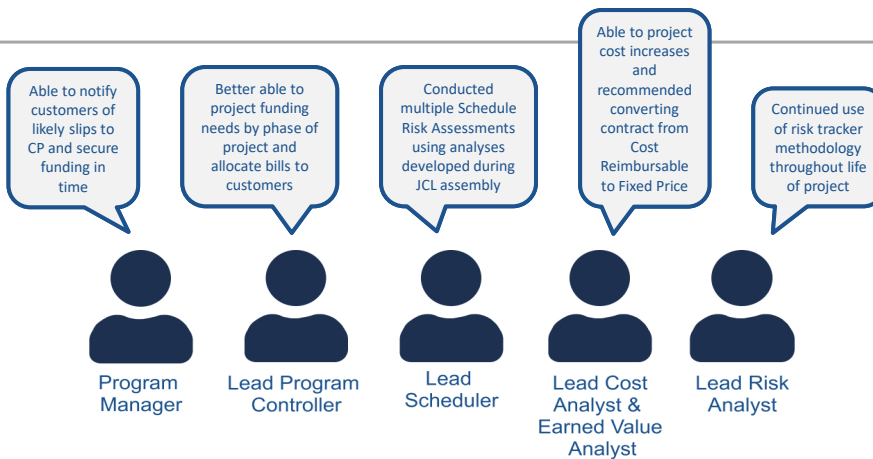
MONTHS:	0-2	3	4 (milestone)	4-5
<b>Schedule</b>	Developed analysis schedule.	Located risks with Risk Team. Assembled Schedule Uncertainty.	Finalized model. Briefed Project Lead. Incorporated Feedback.	Briefed Leadership & Customers. Completed model updates.
<b>Cost</b>	Collected Cost Reports. Coordinated Cost Structure with Schedule Team.	Allocated TI/TD Costs. Generated Cost Uncertainty. Mapped to Schedule with Schedule Team.		
<b>Risk</b>	Conducted risk workshops with Engineering, Cost, & Schedule Teams.	Located risks with Schedule Team. Continued Risk Workshops.		
<b>Engineer</b>	Informed Risk Posture. Mapped task logic with Schedule Team.	Continued support to Risk and Schedule Teams.		

## FICSM/JCL Results



Chance of meeting Oct 2019 Launch with \$93.0M (+ Fixed Fee) = 0.2%

## Lasting Benefits



### Overall Team

Project ultimately was late and overran, but team remained tightly coupled and were able to view integrated impacts of issues arising during project execution from inception through launch

**Most Importantly:** Team was not surprised by any issue that arose during project execution



## Thank You

“

It is easy enough to start a project  
if you have no clue about  
**The Cost And Schedule**

- Anonymous US Air Force Colonel

”

## References

1. Joint Agency Cost Schedule Risk Uncertainty Handbook (2014)  
[https://www.ncca.navy.mil/tools/csruh/JA\\_CSRUH\\_16Sep2014.pdf](https://www.ncca.navy.mil/tools/csruh/JA_CSRUH_16Sep2014.pdf)
2. Government Accounting Office. (2013). Need for Improved Reporting and Cost Estimating on Major Unmanned Satellite Projects. (GAO Publication PSAD-75-90). Washington, D.C.: U.S. Government Printing Office  
<https://www.gao.gov/assets/psad-75-90.pdf>