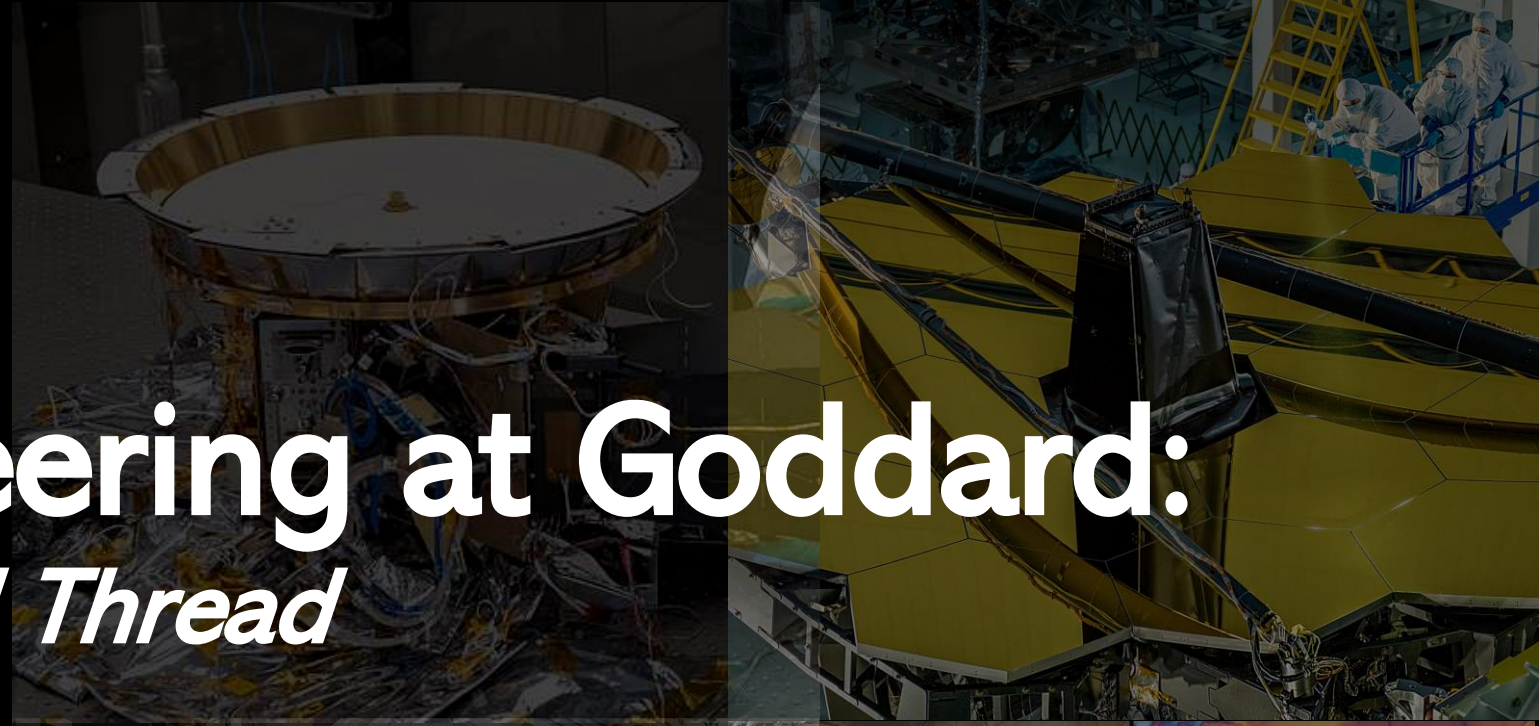
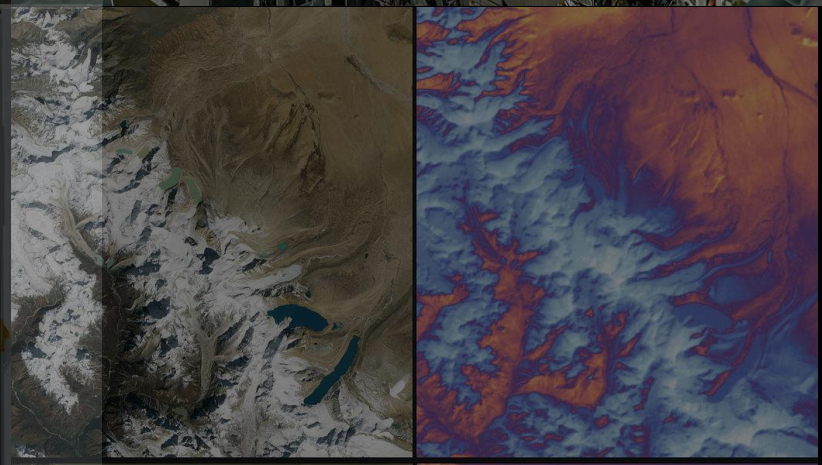
Digital Engineering at Goddard:
Exploring the Digital Thread





NASA Goddard Space Flight Center (GSFC)

Engineering and Technology Directorate (ETD)

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September 8, 2023

Concept of a *Thread (1/2)*

- Scenario: Professor assigns homework
  - Professor: Discusses assignment, uploads file to course website
  - Student: Reviews file, completes assignment, and uploads completed file to course website
  - Professor: Grades assignment, provides feedback

- Characteristics
  - **Two** actors (professor + students)
  - **One** input (assignment)
  - **One** output (completed assignment)
  - **One** format (MS Word)

	Inputs	
Outputs	P	S
P		X
S	X	

- **Two** communication paths to manage
  - $P = (actors)(inputs)(outputs)(formats)$
  - $P_{HW} = (2)(1)(1)(1) = 2$

Concept of a *Thread (2/2)*

- Scenario: Professor assigns group project
  - Professor: Discusses assignment, identifies teams (of three), uploads file(s) to course website
  - Students: Self-organize, review file(s), collaborate on assignment, upload completed file to course website
  - Professor grades assignment, provides feedback

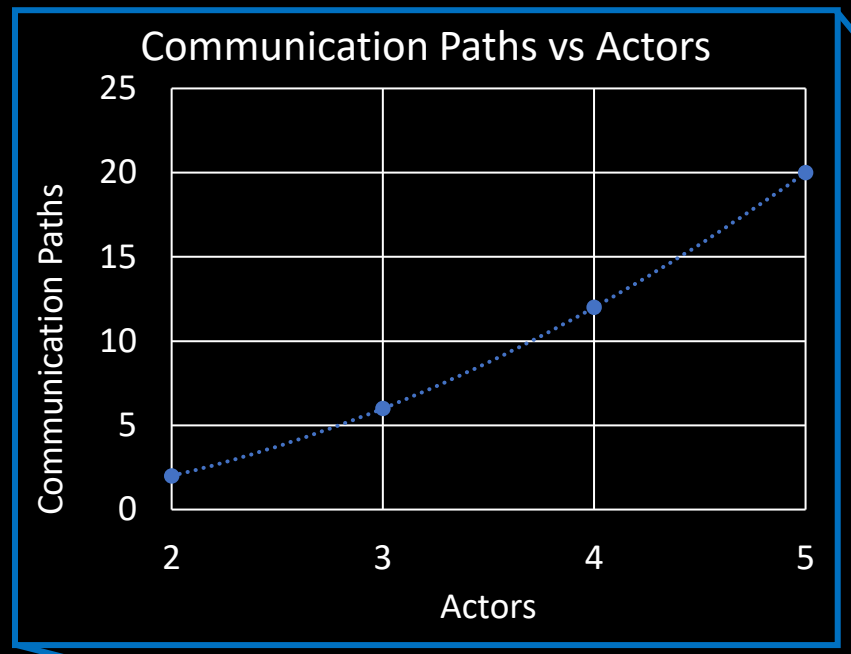
- Characteristics
  - ~~2~~ **4** actors (professor + 3 student)
  - **1** input (assignment)
  - **1** output (completed assignment)
  - **1** format (MS Word)

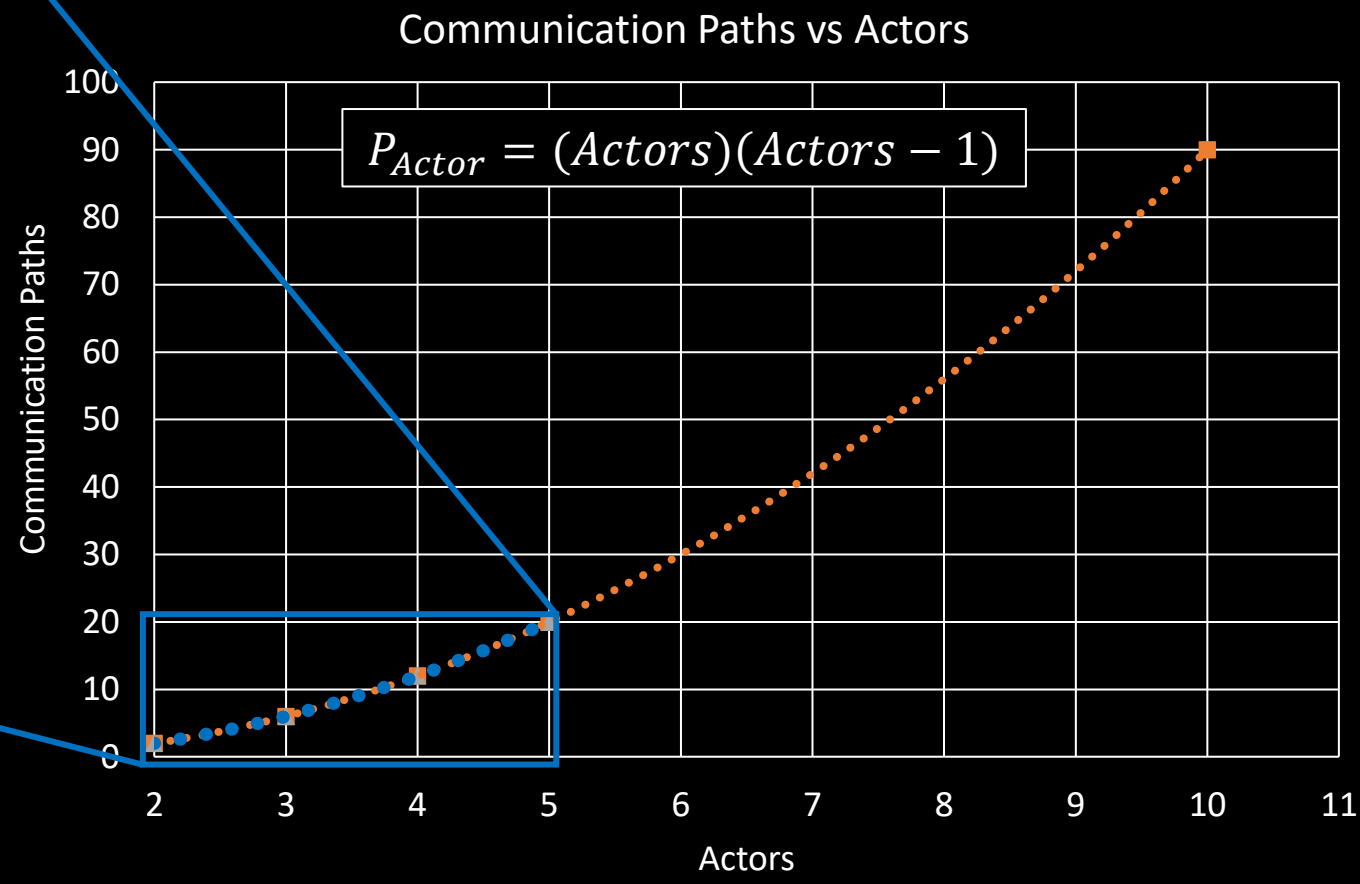
		Inputs			
		P	S.1	S.2	S.3
Outputs	P		X	X	X
	S.1	X		X	X
	S.2	X	X		X
	S.3	X	X	X	

- ~~Two~~ **Twelve** communication paths to manage
  - $P = (actors)(inputs)(outputs)(formats)$
  - $P_{HW} = (4)(1)(1)(1) \neq 12$

Quantifying Thread Connections

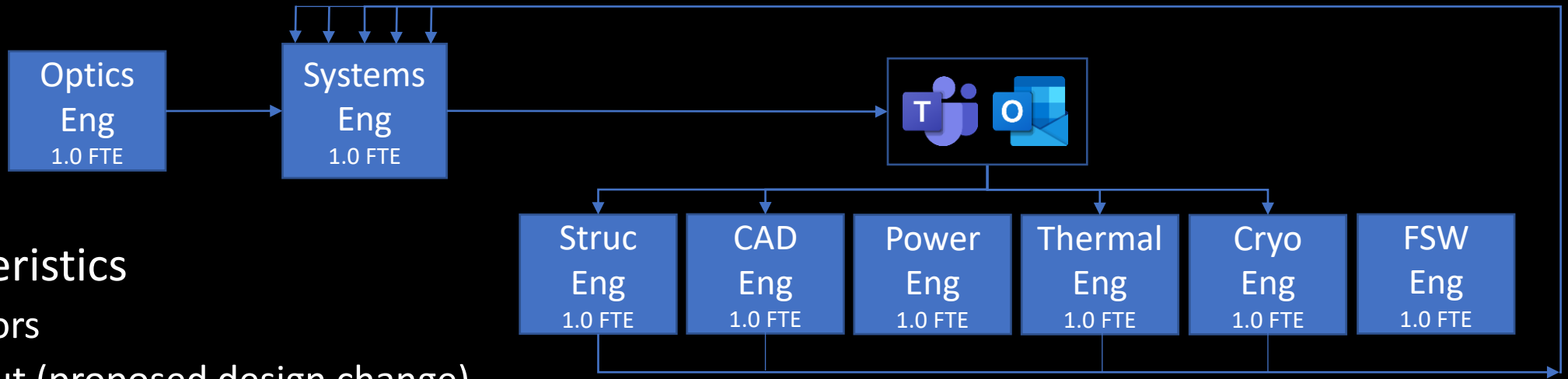
- Team communication is non-linear
  - 2x increase in actors results in 6x increase





Thread Concept Application to Design Cycle

- Scenario: Optical engineer needs to increase the diameter of a mirror within a cryogenic instrument to achieve required performance

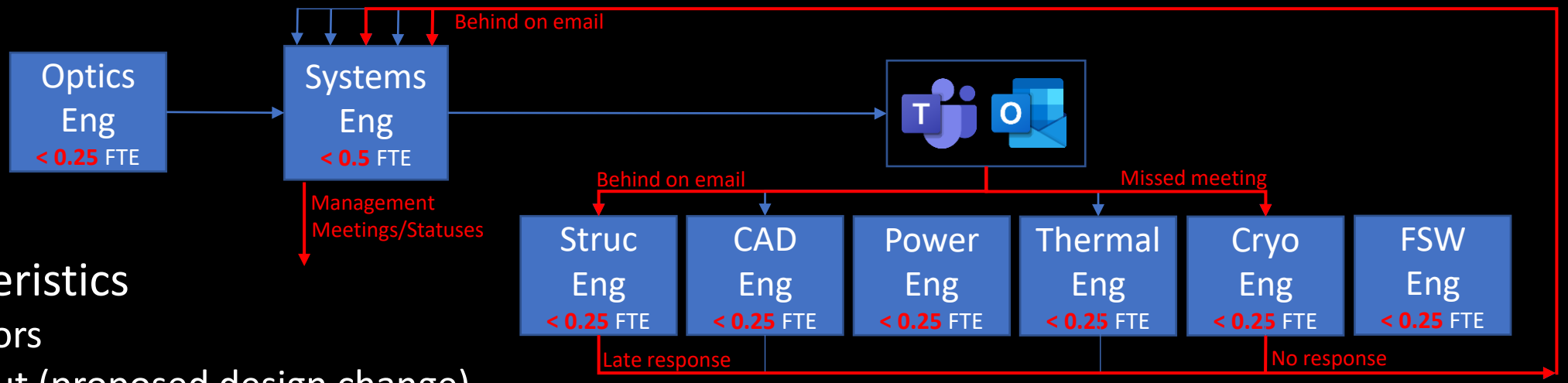


- Characteristics
  - **8** actors
  - **1** input (proposed design change)
  - **7** outputs (design change impacts)
  - **8+** format (discipline specific tools, excel, email, TEAMS, etc.)

- **Thousands** of communication paths to manage
  - $P = (P_{actors})(inputs)(outputs)(formats)$
  - $P_{HW} = [8(8-1)](1)(7)(8+) = 3136+$

Thread Concept Application to Design Cycle

- Scenario: Optical engineer needs to increase the diameter of a mirror within a cryogenic instrument to achieve required performance



- Characteristics
  - **8** actors
  - **1** input (proposed design change)
  - **7** outputs (design change impacts)
  - **8+** format (discipline specific tools, excel, email, TEAMS, etc.)
  - *Missed communication

- **Thousands** of communication paths to manage
  - $P = (P_{actors})(inputs)(outputs)(formats)(missed\ communications)$
  - $P_{HW} = [8(8-1)](1)(7)(8+)(x) = 3136x +$

What is a Digital Thread (DTh)?

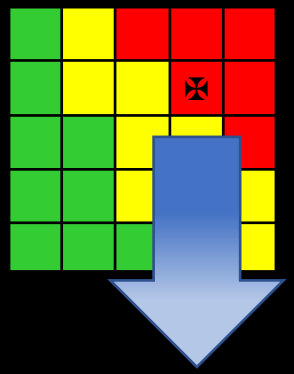
- Disconnects within technical teams are standard due to communication overhead, but what if these *disconnects* could be *dramatically reduced*?

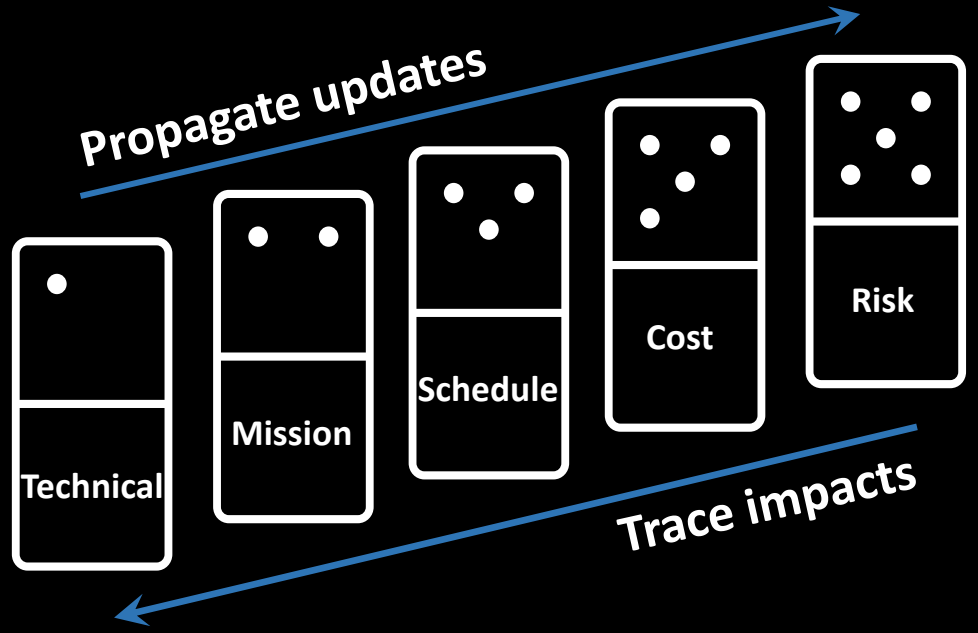
- Digital Thread is "*a linked set of digital artifacts whose consistency is actively managed over the lifecycle of a product, process, or system*"

- Key attributes of Digital Thread
  - Digital artifacts (i.e., model-based documents)
  - Federation
  - Consistency Management (~~Configuration Management~~)

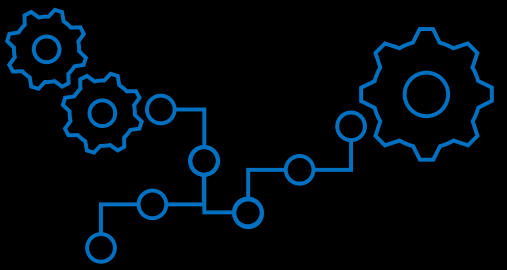
Digital Thread is Foundational to Collaboration

Reduce Mission Risk

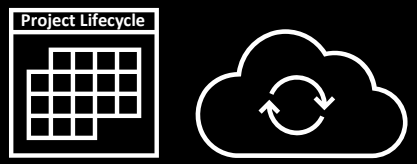




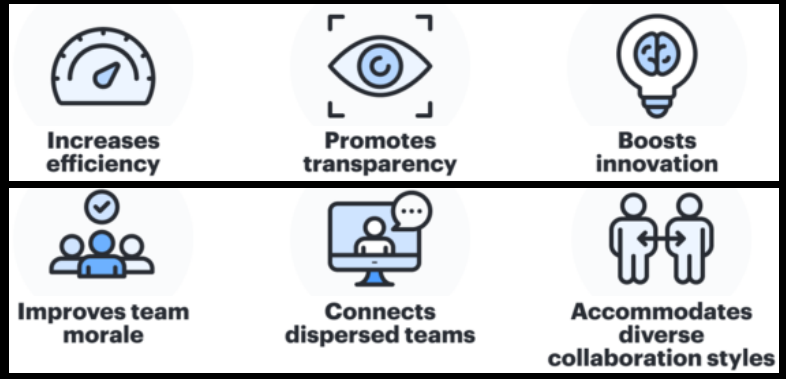
Connect Existing Tools



Built For Scalability



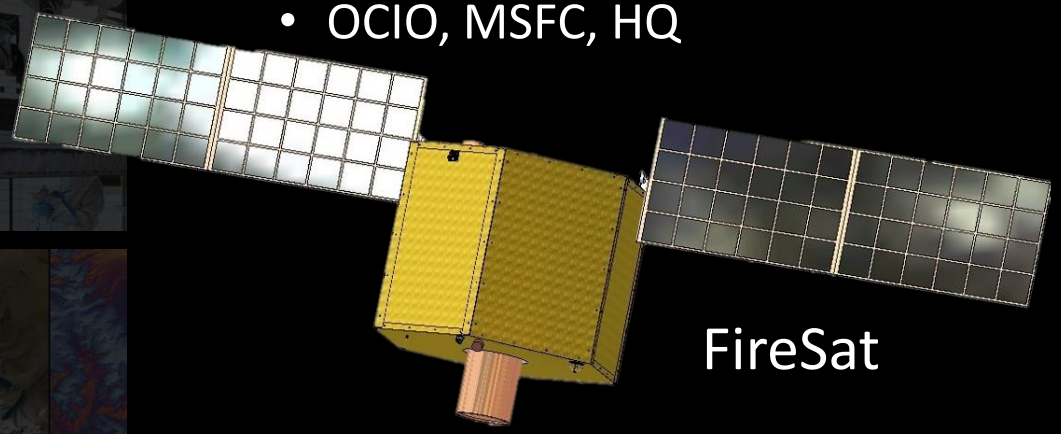
Enable Asynchronous Collaboration



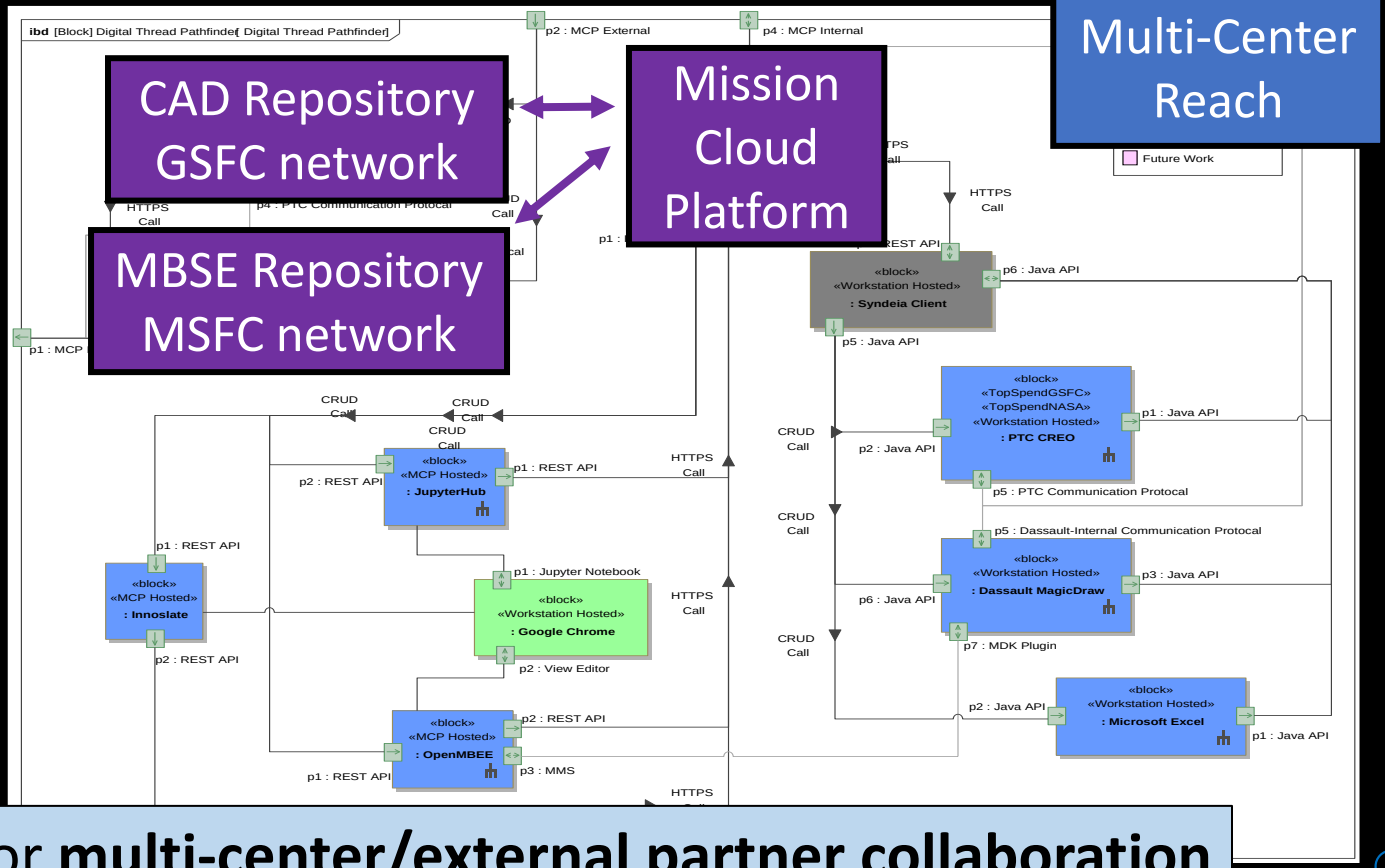
Ref. Lucid.co, Asynchronous Collaboration Guide

Multi-Center Digital Thread Pathfinder

- Digital Thread will be the foundation for improved project coordination, asynchronous matrixed collaboration, and consistency management.
- Multi-sourced funding from Goddard investment and HQ proposal award
  - Goddard investment: FY23+
  - HQ PoP: July – September 2023
- Cross-agency collaboration
  - Aaron Comis (GSFC Engineering)
  - Matt Dosberg (GSFC OCIO)
  - OCIO, MSFC, HQ



FireSat



Pathfinder MVP paves the way for **multi-center/external partner collaboration**

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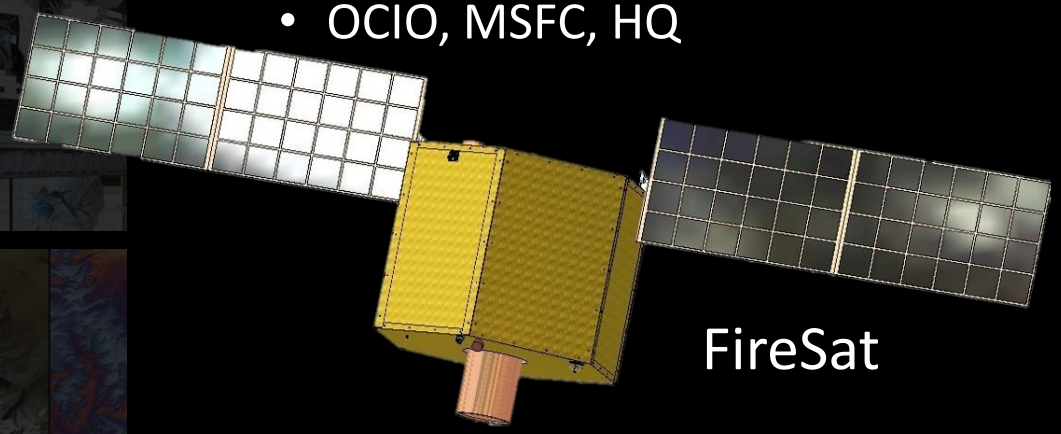

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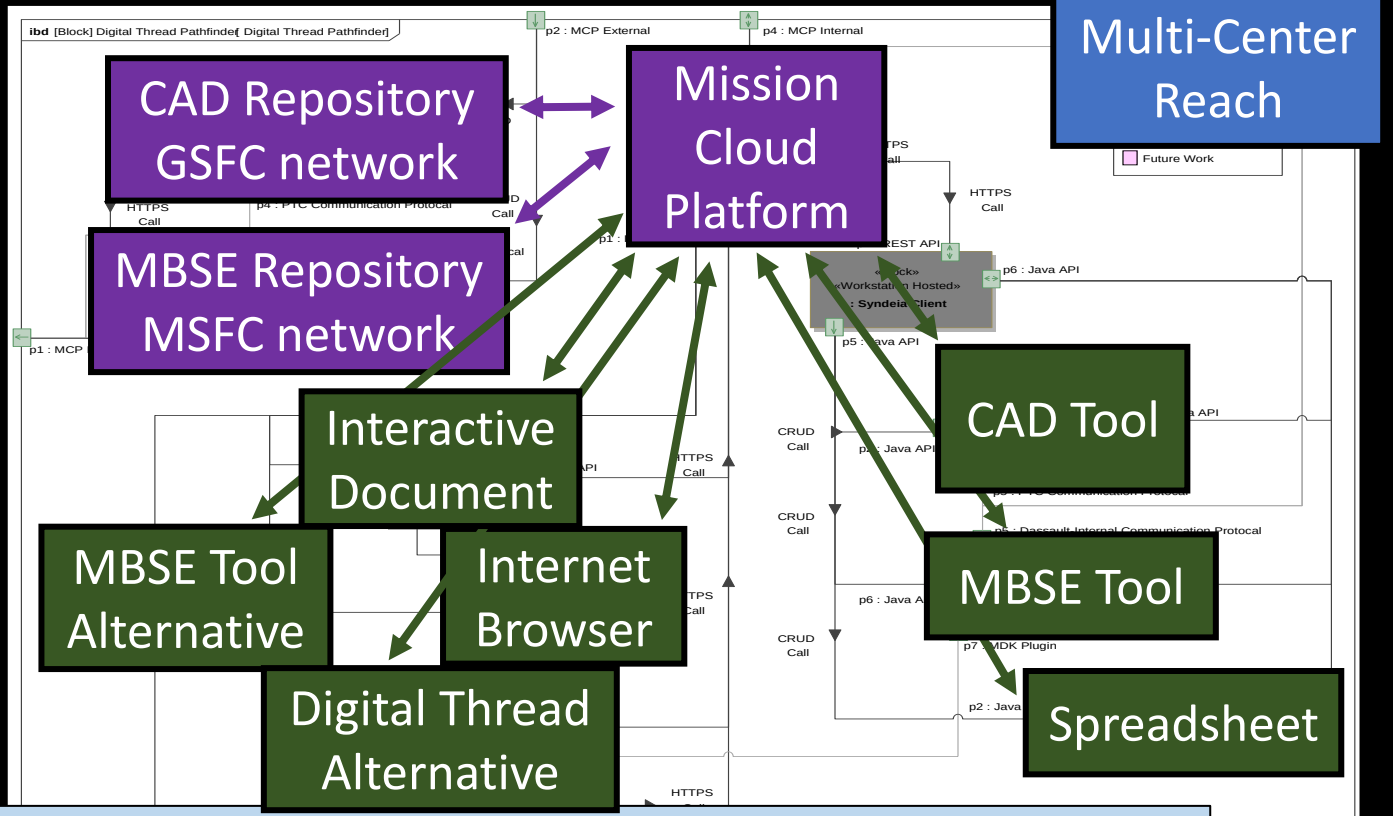
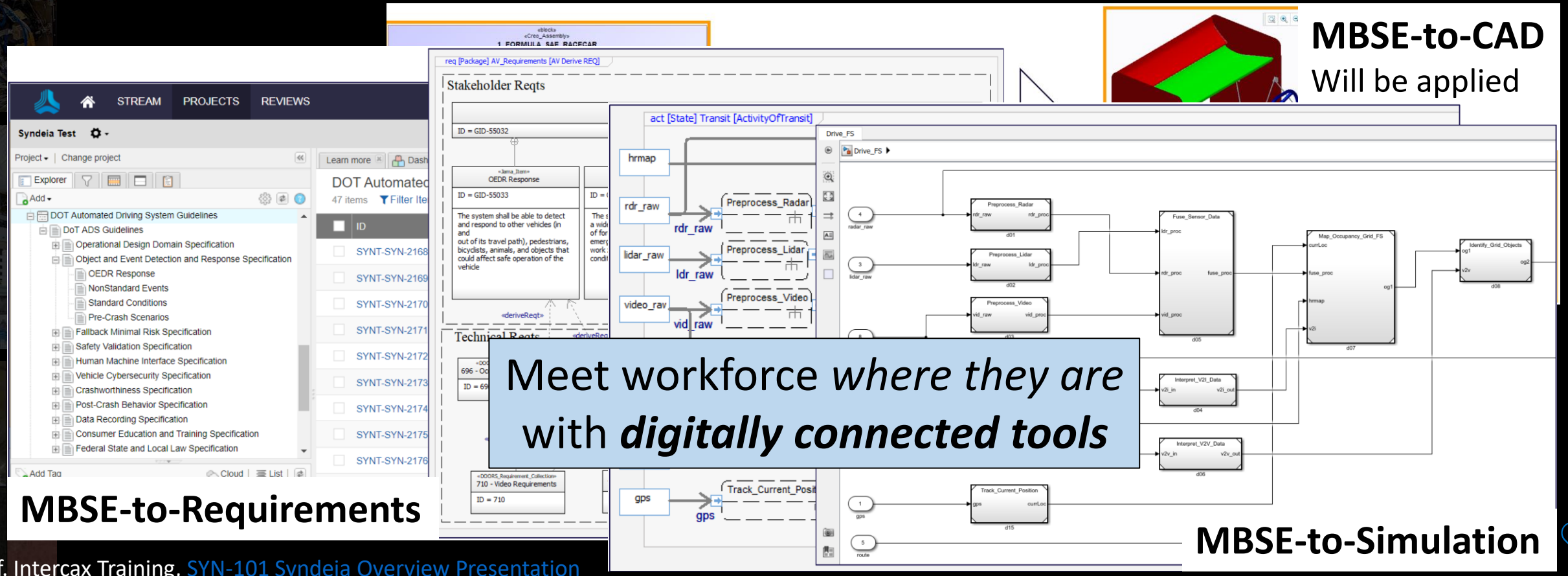


Pathfinder extension paves the way for connectivity of **additional disciplines**

FireSat graphic from TSTI/Jerry Sellers

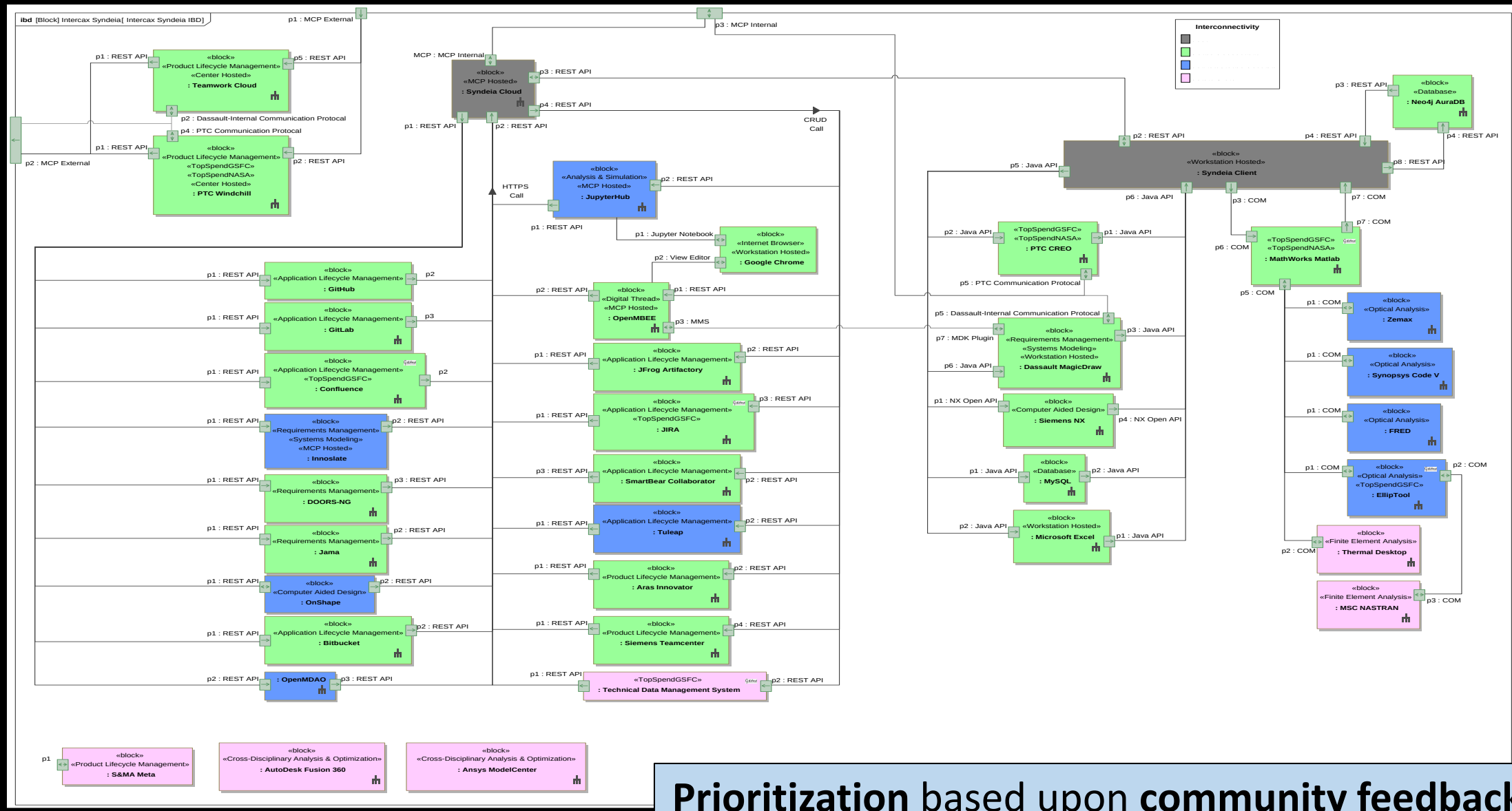
Digital Engineering enabled by Digital Thread

- Reference Connection
  - Connects anything-to-anything
- Model Transform Connection
  - Takes elements in one tool and creates new elements in another tool (bi-directional)



Ref. Intercax Training, SYN-101 Syndeia Overview Presentation

Future Digital Thread Architecture (In-Work)



Prioritization based upon **community feedback**

Exploring Digital Thread Metrics, per Intercax (1/2)

- Intercax released a 9-part blog describing Critical Metrics for Digital Thread
  - Excellent starting point for consideration
- How does the Digital Thread satisfy the Digital Engineering need statement?

«businessRequirement»
«Need»
Need

Id = "N"

Text = "Inform timely data-driven decision making across the lifecycle with increasingly complex missions and decreasing resources and timeframes to achieve GSFC 2040 vision"

Real-time development status

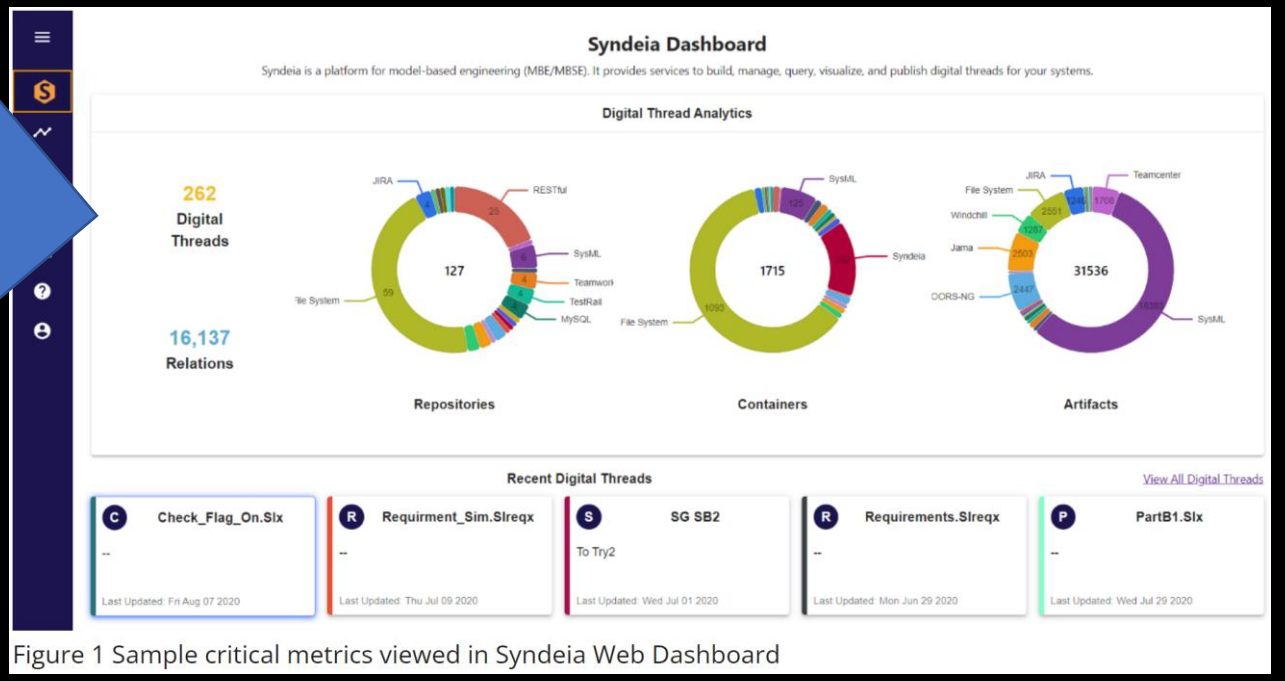


Figure 1 Sample critical metrics viewed in Syndeia Web Dashboard

How do repositories, containers, and artifacts inform project cost, schedule, and risk?

Ref. Intercax
Critical Metrics for Digital Threads, Part 1 | Intercax

Exploring Digital Thread Metrics, per Intercax (2/2)

- What are some characteristics of a good metric?
  - Actionable: User should have clear steps to complete an activity
  - Timely: User should be able to act while information is valid
  - Universal: Applicable across all projects to enable portfolio management
  - Secure: Information is only exposed to authorized users

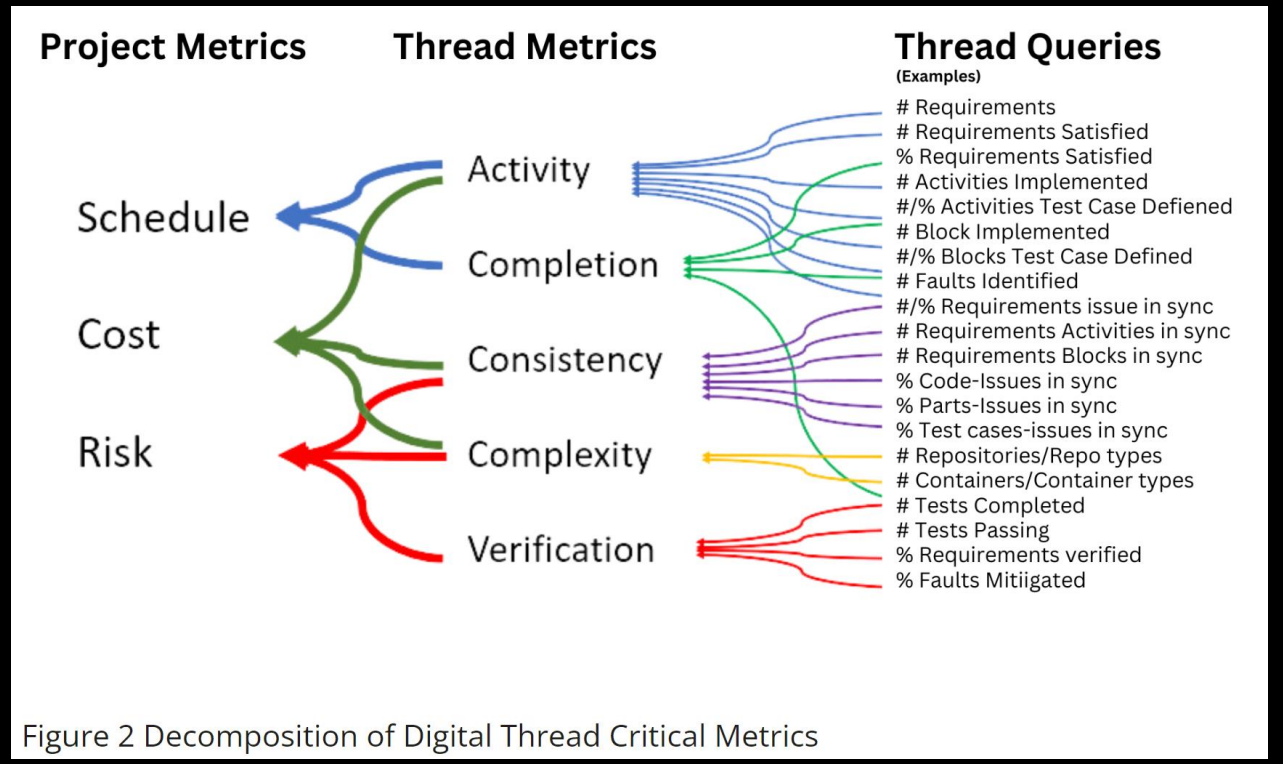


Figure 2 Decomposition of Digital Thread Critical Metrics

Ref. Intercax
[Critical Metrics for Digital Threads, Part 1 | Intercax]

Digital Thread at Goddard

- Expand Digital Thread pilot
- Explore Digital Thread metrics
  - Focus on traceability to existing NASA Standards
- Collaborate with projects on Digital Thread infusion opportunities
  - Identify value-added metrics for engineering/project teams
- Expand *coalition of the willing* to help develop future engineering tools and processes at Goddard