



Innovation Connection Hub: *DE + MBSE at Goddard*

NASA Goddard Space Flight Center (GSFC)
Engineering and Technology Directorate (ETD)

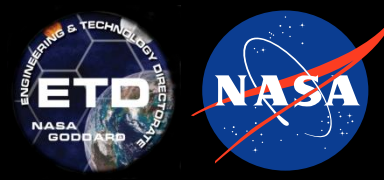
Presenters:

Aaron Comis, ETD/Chief Digital Engineer



Rob Morgenstern, ETD/MBSE Lead

September 12, 2023

What are we doing here?




- Systems are becoming increasingly complicated and interconnected
 - Includes missions across NASA
- Resources are decreasing
 - Funding, schedule, personnel, etc.
- Project complexity is increasing
 - Mission, partnership, competition, etc.
- Current practices are not sustainable
 - Goddard at increasing risk of falling behind



It is not necessary to change. Survival is not mandatory.

W. Edwards Deming
source: quotes.deming.org/10083



Systems Are Changing

From:	To:
<ul style="list-style-type: none">• Systems built to last• Heuristic-based decisions• Deeply integrated architectures• Hierarchical development organizations• Satisfying requirements• Automated systems• Static certification• Standalone systems	<ul style="list-style-type: none">• Systems built to evolve• Data-driven decisions• Layered, modular architectures• Ecosystems of partners, agile teams of teams• Constant experimentation and innovation• Learning systems• Dynamic, continuous certification• Composable sets of mission focused systems

Systems Engineering Needs to Change

Credit: Derived from David Long, Former INCOSE President

DAU Lunch n Learn May 2018, Page 6 DISTRIBUTION STATEMENT A: UNLIMITED DISTRIBUTION.

What is *Goddard's place* in a changing industry?

Digital Engineering Roadmap



- Definition of Digital Engineering (*per ETD*)

- *A cross-disciplinary field that leverages digital tools and processes for the design, development, and production of engineering products across the project lifecycle towards improved efficiency and accuracy of the engineering process, along with reduced project risk*

Align existing enabling capabilities towards a common vision

Stand up institutional ecosystem to enable cross-agency/model interconnection of information

Integrated system-level analysis and manufacturing modernization

Phase 0: Align and Advance Enabling Capabilities
Prove locally, interconnect globally

Phase 1: Implement Digital Thread
Foundational data-focused ecosystem linkage of technical information throughout the mission lifecycle

Phase 2: Assess Cross-Disciplinary Trades
Science-informed trade study analysis and optimization with manufacturing workflow modernization

Connect* cross-center/agency/partner organizational solutions to ecosystem

Phase 3: Interconnect Programmatic
Scalable coupling of technical information with cost, schedule, risk, safety, etc.

FY23

FY24

FY25

FY26

FY27

FY28

FY29+

Today

Intentional planning and **strategic use of pilots** will enable the smoothest transition (**technical** and **cultural**) from **'why'** to **'how'**

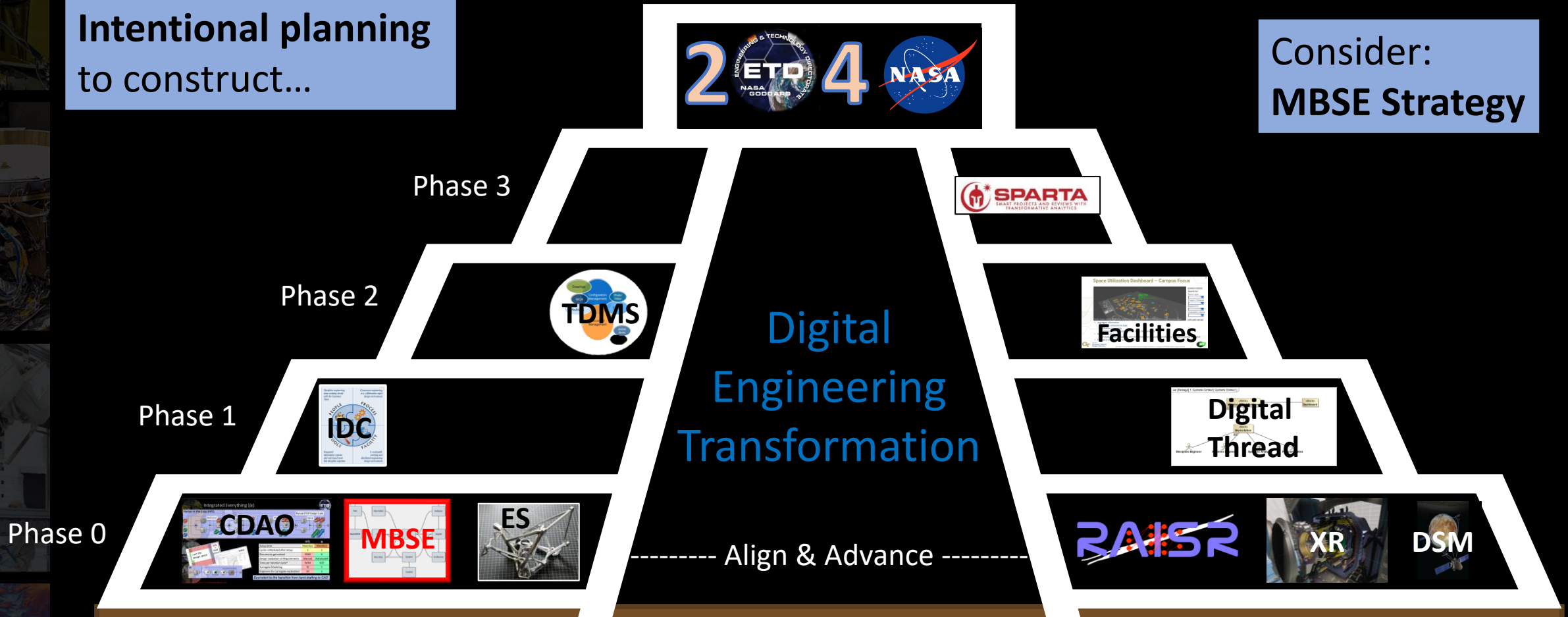
*Continuous coordination/piloting through all prior phases expected

Pyramid of Digital Success



Intentional planning to construct...

Consider: MBSE Strategy



Phase 0

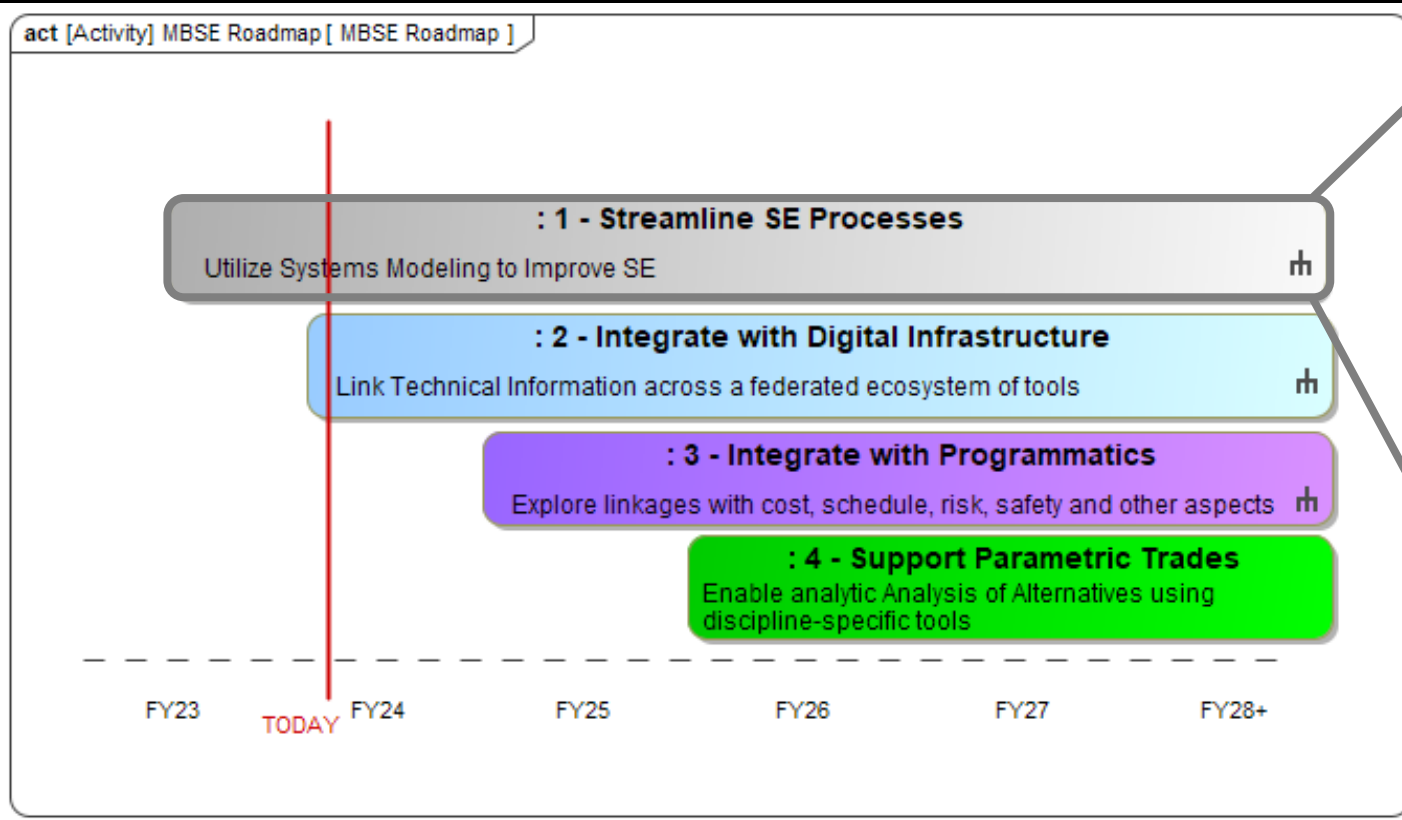
Phase 1

Phase 2

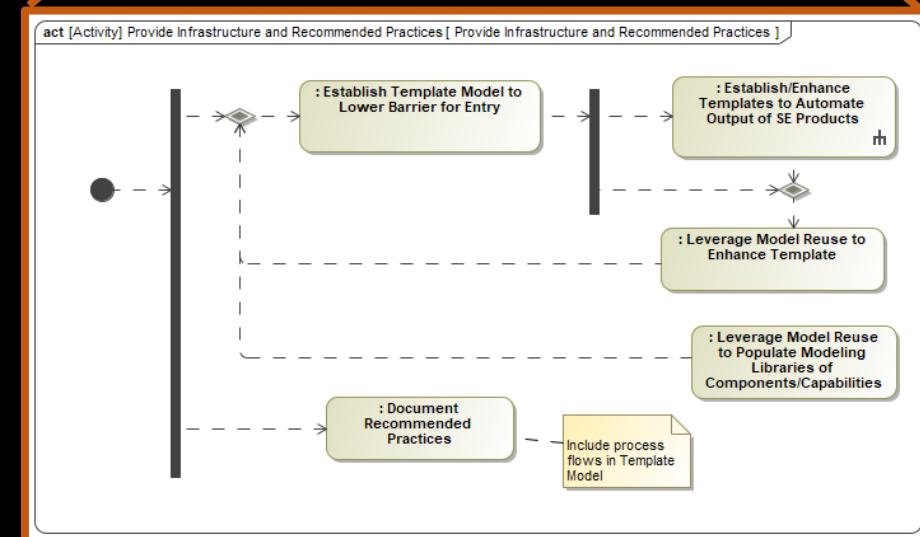
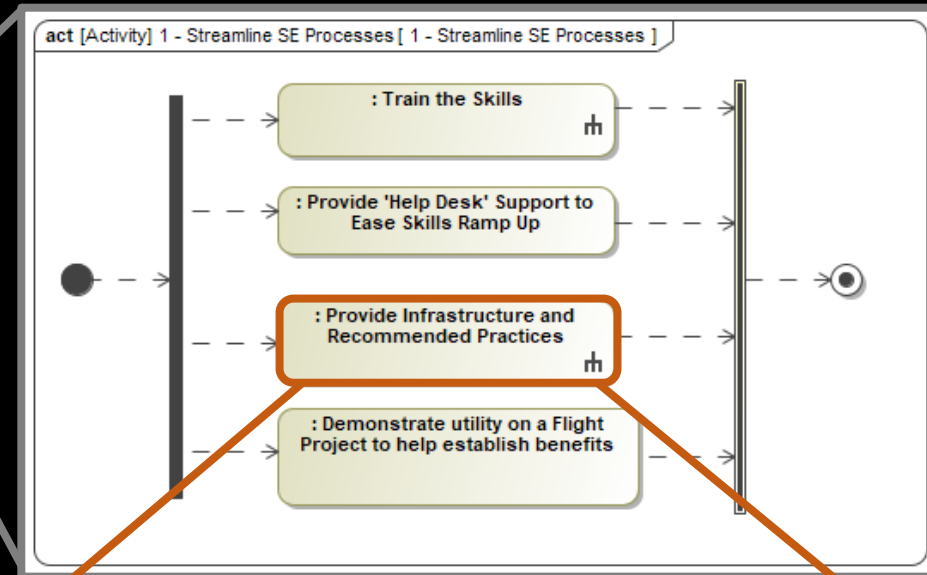
Phase 3

Planning & Learning

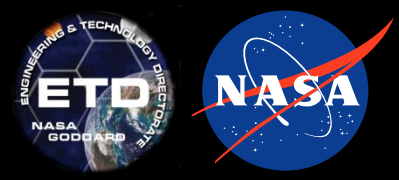
MBSE Roadmap



- Decomposition strategy repeated across all phases



MBSE Strategy Traceability to DE Roadmap



Phase 0: Align and Advance Enabling Capabilities

Prove locally, interconnect globally

MBSE-1: Streamline SE Processes

Phase 1: Implement Digital Thread

Foundational data-focused ecosystem linkage of technical information throughout the mission lifecycle

MBSE-2: Integrate with Digital Infrastructure

Phase 2: Assess Cross-Disciplinary Trades

Science-informed trade study analysis and optimization with manufacturing workflow modernization

MBSE-4: Support Parametric Trades

Phase 3: Interconnect Programmatics

Scalable coupling of technical information with cost, schedule, risk, safety, etc.

MBSE-3: Integrate with Programmatics

FY23

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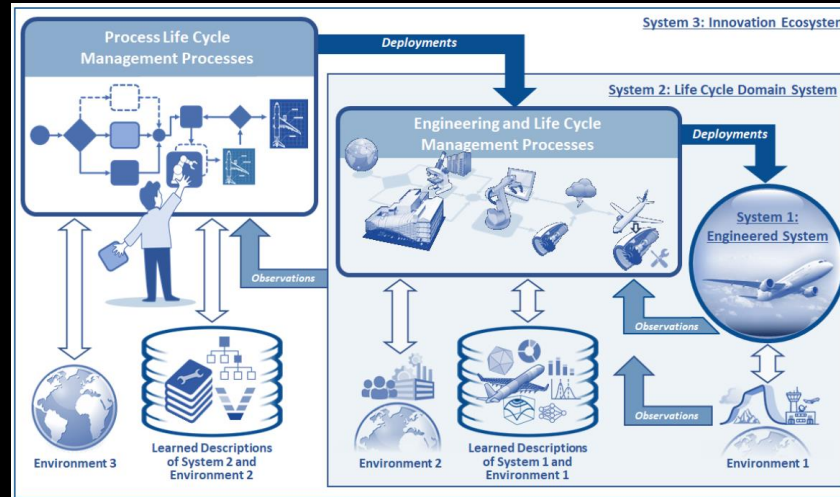
FY29+

Continuous learning and strategic alignment is critical for *successful Digital Engineering Transformation*

Industry Alignment



- Previous decade(s) show missions slowly shifting towards a partner-centric model

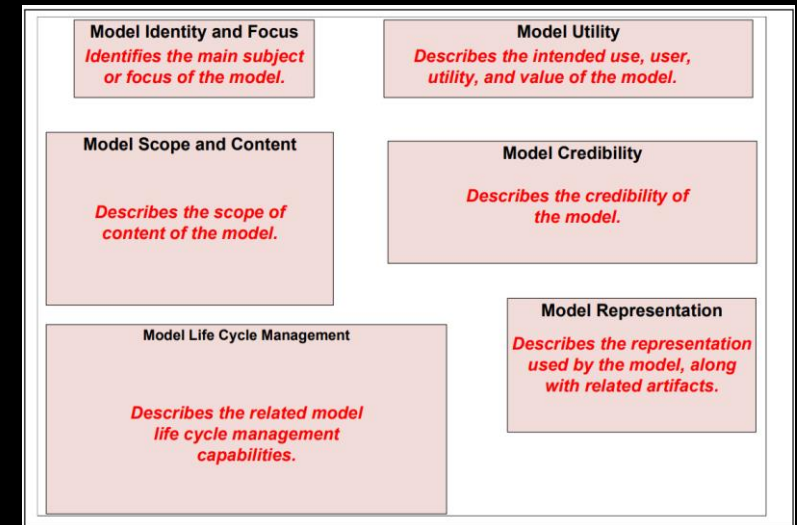


ASELCM Level 1

Intentional alignment with industry enables expanded future partnerships

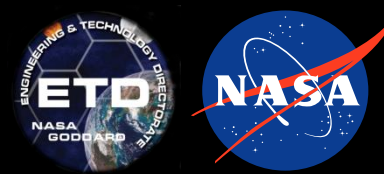
INCOSE ASELCM Pattern (left)
 Agile Systems Engineering
 Lifecycle Management
 Reference Pattern

OMG MCP (below)
 Model Characterization Pattern



OMG Wiki, "[The Model Characterization Pattern \(MCP\): A Universal Characterization & Labeling S*Pattern for All Computational Models](#)"
 W. Schindel, "[Realizing the Promise of Digital Engineering: Planning, Implementing, and Evolving the Ecosystem](#)"

Digital Engineering: Potential Gains & Pitfalls



- Ongoing market research of relevant, available case studies to constructively inform
 - Searching for good *and* bad

Digital Thread Activates \$700M+
in Productivity Gains for GE

About Digital Thread
Digital Thread is the connection of data throughout the value stream, leveraging assets as the key to drive automation, collective information, and insights. By continuing to connect the Digital Thread, we are able to improve on-time delivery, increase profitability, advance customer satisfaction, drive incremental productivity, and generate revenue. Digital Thread is representative of the full end-to-end business process linking data and information.

Digital Thread
~\$700M savings

**Cross-Disciplinary
Analysis & Optimization**
>50% labor reduction

SE Analysis and CM Effort

MBSE approach required 18%

**Model-Based
Systems Engineering**

~18% labor reduction
~18% error reduction

Database (e.g. DOORS) approach MBSE approach

MBSE approach provides significant, quantified savings

T-7A Delays Compound Pilot Shortage, Expose Digital Engineering Pitfalls

Boeing's T-7 Red Hawk delays aren't just a pilot production issue, they are also a reality check on 'transformational' digital engineering.

T-7A DE Pitfalls

Air Force Boss Gives Reality Check On "Over-Hyped" Digital Engineering Revolution

Air Force officials have trumpeted digital engineering as hugely transformative for years, but what it can and can't do is now setting in.

DE Over-Hype

Industry experience is mixed, but indicates potential for gains

Digital Twin

*TBD savings
(operations and sustainment)

*Not publicly quantified

Takeaway

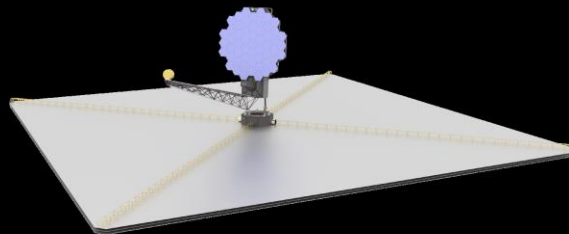


- Digital Engineering transformation of Goddard is a **HUGE** and **impactful** undertaking
- Focus is on understanding the '*why*' BEFORE shifting focus to the '*how*'
 - Market is saturated with cure-all solutions
...but what is the question being asked?



Ref. Deep Thought, Hitch Hikers Guide to the Galaxy

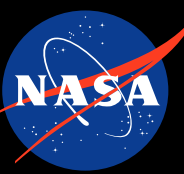
- Goddard is heavily involved in Agency efforts (DE and MBSE) and increasing involvement with professional societies



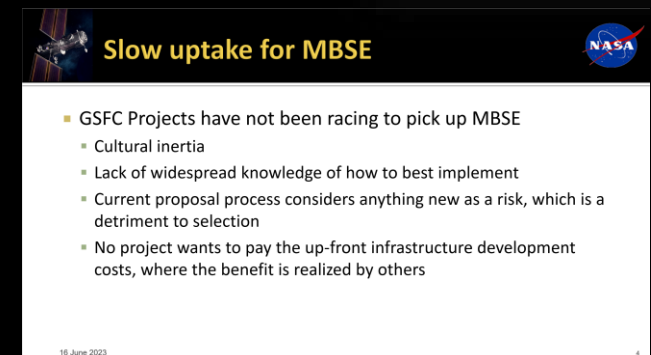
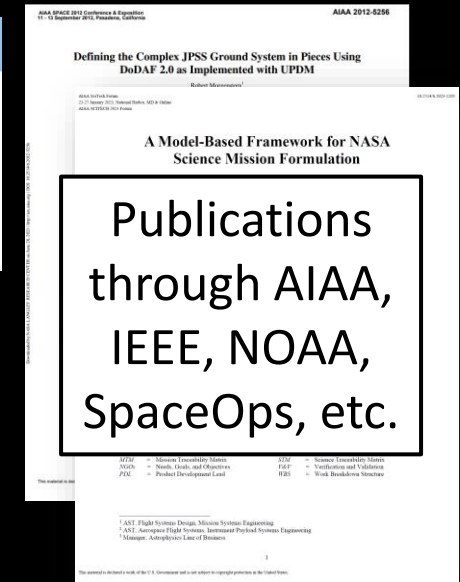
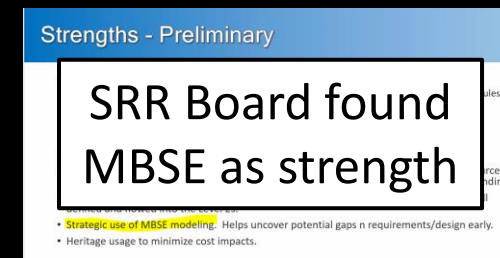
Digital Engineering will enable Goddard to achieve more *science per dollar*



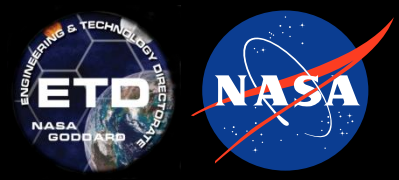
MBSE at Goddard (Greenbelt, Wallops, IV&V)



- Goddard involved with MBSE work for some time now
- Rob Morgenstern is leading Goddard MBSE strategy
- Accomplishments
 - Multitude of published papers with MBSE use-cases
 - Flight project usage with JPSS, DAVINCI, etc.
- Ongoing effort to reduce barrier to entry with starter models
 - Multiple complementary ongoing efforts focused on streamlining import and new project initiation with templates
 - POCs include GSFC/Rob Morgenstern, GSFC/Henock Legesse, WFF/Dave Kotsifakis
 - Growing list of capabilities (demonstrated and future) in backup
 - Model-Based Mission Assurance
 - IVV/Frank Huy and GSFC/Nancy Lindsey
- Supporting HQ DT NPR modeling effort



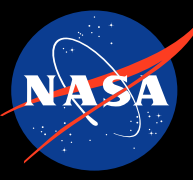
Train the Skills



- SATERN has APPEL courses for SysML training
- Can also leverage NoMagic and other commercial training
 - 590-sponsored class 8/14-18
- Practitioners Group has Beginners and Intermediate Guides on SPACES aimed at the NASA SE Handbook
 - NASA-HDBK-1009 MBSE Handbook released Dec 2022
 - Updates planned as MLT generates new guidance (leveraging Agency CoP)
 - Considering development of short video instructions on targeted tasks
- May need to define a class on more practical applications for GSFC missions
 - There are a number of GSFC classes in SATERN that are years old and need updating



Minimum Viable Starter Model



- Requirements Management
- Concept of Operations
- MEL/PEL/ThEL tracking
- Interface Tracking
- Test Planning
- Verification Closeout

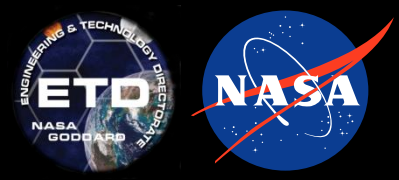
- Stretch capabilities:
 - Hazard Analysis/FTA/FMECA
 - JIRA integration (e.g., DR tracking, workflow tracking)

Interested parties can select
the level of MBSE
engagement desired

Prune out the
aspects not
needed



Consulting/Help Desk



- Have a paid-for group that system modelers can go to for advice
 - Use a Teams channel, so the contact point is stable, while the participants can expand/contract as needed
 - *Q: Have 1-3 Full-Time? / Assortment of Part-time / mix?*
 - Group can help expand the infrastructure when not otherwise engaged
 - Tiered service
 - Just answer questions
 - Help engage on the project for focused task (*more staffing would be needed*)
 - Might need to require project funding for this

