National Aeronautics and Space Administration

An Exploration of Lessons Learned from NASA's MBSE Infusion and Modernization Initiative (MIAMI)

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NASA Systems Engineering
MODEL BASED SYSTEMS ENGINEERING

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MBSE

Agenda

- NASA MBSE Timeline – What is MIAMI?
- Top Lessons Learned from MIAMI
  - Models Should Have a Purpose
  - “Slow and Steady Wins the Race”
  - New Technology Aligns with New Ways of Thinking
  - Training is Continually Needed
  - Honorable Mentions
- MIAMI Next Steps

NASA MBSE Timeline

Legend
- Loose Partnering
- Tight Partnership
- Mainline Work

Key Activities

- **MBSE Pathfinder** — Strategy and Use Cases Defined
- **NIMA** — 4 Yr Effort, Whitepaper, Benchmarks
- **Request to EDs** — "Volunteers"
- **OCE Cloud** — Enterprise MD Licensing
- **MBSE Pathfinder Kickoff** — 30 Participants, 9 Centers + DoD, 4 Use Cases, Training via GT
- **MBSE Pathfinder Review** — Six Months Later, W/F Adoption, Use Case Value
- **NASA MBSE CoP Start**
- **Pathfinder 2 Kickoff** — 50 Participants, 10 Centers + DoD, 5 Use Cases, Training via GT
- **UMD** — Dsn. Thinking Trng.
- **Pathfinder 2 Midterm Review** — Technical Advisory Board formed
- **Pathfinder 2 Final Review** — ROI 80%, SoS Integration, Discipline Integration
- **APPEL** — training offered
- **MIAMI Kickoff** — 50 Participants, 9 Centers, 11 P/p Applications, CoP Integrated
- **MIAMI Midterm** — Peer Review, Design Thinking
- **Strategy Group** — Kick Off
- **Strategy Delivered** — 20 year vision
- **Engineering Management**
- **Agency Program Management**
- **Imp Plans** — MBSE and MBx
- **MIAMI Knowledge Capture Meeting** — Gaps & Lesson Learned
- **Targeted Deployment** — Testing current resources with ExMC

Can We? **Why?** **Infusion** **Direction**

~200 MIAMI participants over 5 years
- Evaluated Lessons Learned
- Performed Gap Analysis

2016 2017 2018 2019 2020

Partnerships

- NASA Office of the Chief Engineer
- Department of Defense
- Georgia Institute of Technology
- NASA Safety and Mission Assurance
- Japanese Aerospace Exploration Agency
- Academy of Program, Project and Engineering Leadership
- University of Maryland
- NASA OCIO
- NASA Space Technology Missions
- The University of Alabama in Huntsville
- Stevens Institute of Technology
- Boeing
- USMC Strategic Command
- USAF Space & Missile Command
- NIST
- NASA Tournament Lab

Programs and Projects

- Joint Polar Satellite System
- NASA Engineering and Safety Center
- Asteroid Retrieval Mission
- Europa
- SLS
- Commercial Crew Program
- Resource Prospector
- Space Comm and Nav
- X-Ray Imaging and Spectroscopy Mission
- Exploration Medical Capability
- Gateway Lvl1
- Mars Ascent Vehicle
- Urban Air Mobility

Chart content is not standalone, complements paper and verbal presentation.

Lesson: Models Should Have a Purpose

Background:

- Modelers initially created models with as much information as they could fit into the model because the tools provide that capability
- The MIAMI Advisory Board recommended that models should exist to answer an engineering question in order to keep MBSE from adding additional unnecessary work

What it means:

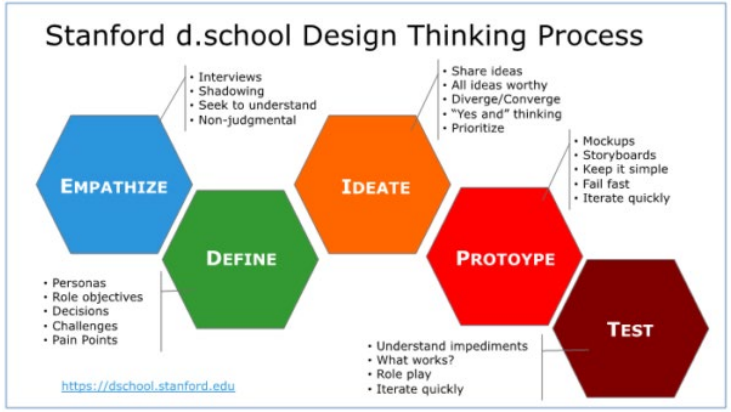
- **Models should be created to answer an engineering question**
  - Models should be tailored to that question
  - Models can expand to answer additional questions
- Models can help with maintaining and evaluating:
  - The technical baseline
  - Technical “priorities” across the system life-cycle
  - Risks and opportunities (technical, cost, and schedule)
  - Efficient engagement of the engineering team

MBSE does not and will not replace the engineer; the **systems engineer still needs** to perform the engineering function and have **effective practices**.

Lesson: “Slow and Steady Wins the Race”

Background:

- MIAMI teams took an agile approach to model creation
  - Build a little, test a little, evaluate, repeat
- MIAMI started as the MBSE Pathfinder and then expanded to include a Community of Practice, Active Project Partnerships, a Strategy Group, and an Advisory Board



What it means:

- Do not try to take huge leaps immediately
  - “Slow and steady” does NOT mean to waste time or to wait until more information is available
- **Incremental iteration with small experiments** yields better adoption since it allows for
  - Easy course correction as more stakeholder feedback is available
  - A shorter learning curve
  - More immediate value added to stakeholders
- Understand the end goal, but focus on one step at a time
- Do not try to immediately implement the full scope of MBSE on one large program or projects
  - Grow from small projects and small portions of projects

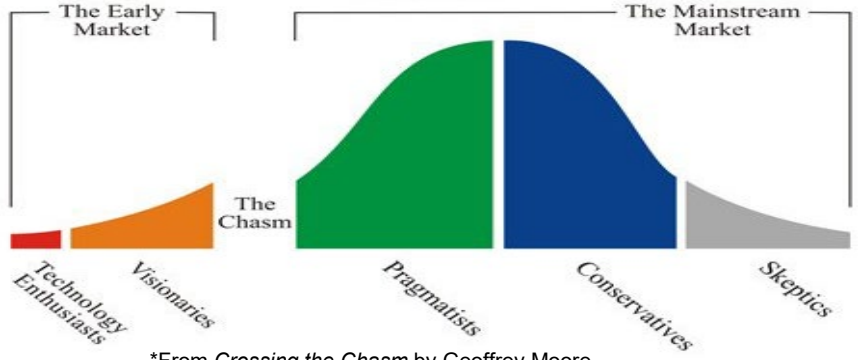
Lesson: New Technology Aligns with New Ways of Thinking

Background:

- MIAMI leads sought information from diverse areas beyond engineering to augment historic document based systems engineering
- MIAMI leads led or participated in multiple design thinking, lean startup, high tech marketing, and strategic thinking training sessions

What it means:

- Combination of methodologies and tools lead to solutions that allowed the modelers to **apply their limited resources** to areas most likely to drive MBSE adoption and success
  - Focus on the user experience
  - Use models, prototypes and testing
  - High failure tolerance
  - Experimentation over elaborate planning
  - Customer feedback over intuition
  - Iterative design over traditional 'big design up front' development
  - Select who you want to target and determine what is their compelling reason to buy



*From *Crossing the Chasm* by Geoffrey Moore

Lesson: Training is Continually Needed

Background:

- MIAMI participants find value in turning to the NASA agency level CoP for questions and for best practices
- NASA MBSE CoP is a small, resource limited team that serves all of NASA

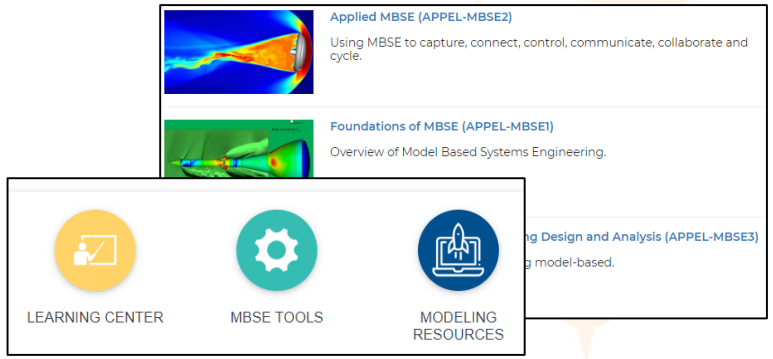
What it means:

Make

- Need to make MBSE theory and practice training available to meet workforce and project demand
- Communities of Practice (CoPs)
  - Federated approach where organizational CoPs focus on their specific use cases while the enterprise CoP looks at common needs
  - Capture and consolidate best practices (for example: architecture frameworks, configuration and data mgt.

Buy – ***Advice, On the Job Training, and direct modeling support have driven MBSE success***

- Need bench depth of people (especially highly skilled ones) to build models
  - Provides surge capability
  - Provides on the job training learning opportunities for in-house workforce
- Desired Attributes
  - Early career and later career members
  - Modeling and scripting skills



Summary

Top Lessons:

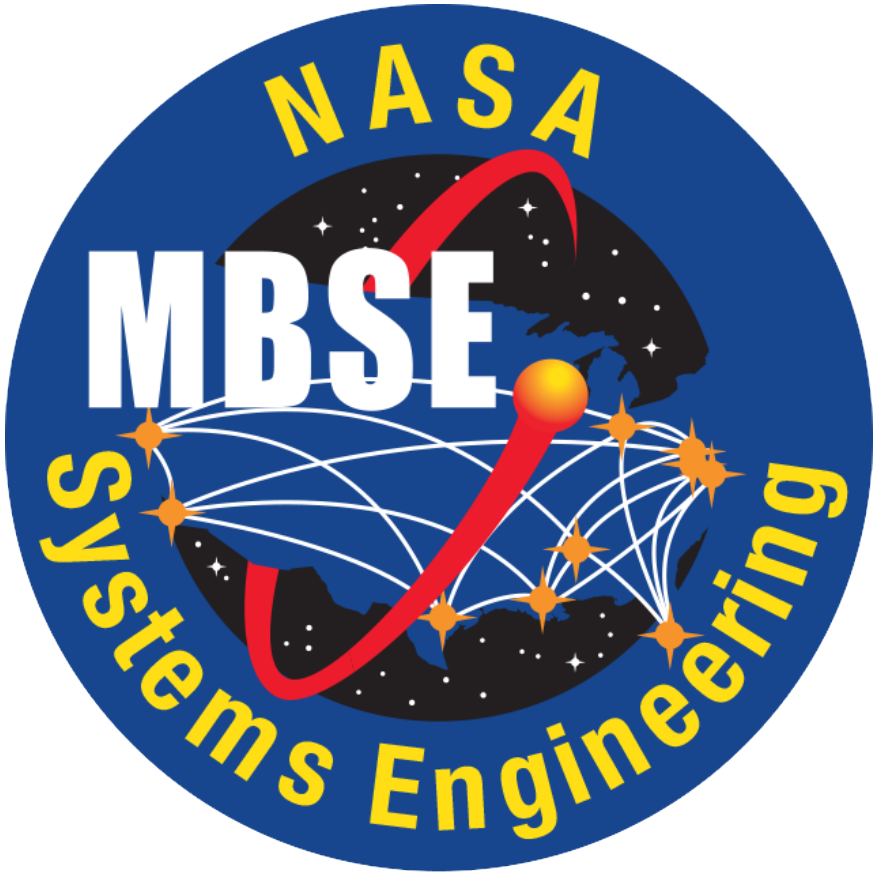
- Models should have a purpose.
- “Slow and steady wins the race.”
- New technology aligns with new ways of thinking.
- Training is continually needed.

Honorable Mentions:

- Modelers and innovators benefit from continual stakeholder engagement and re-engagement.
- Don’t reinvent the wheel. Use and re-use existing modeling infrastructure.
- Streamline license access and infrastructure for modeling.
- Amount of resources (time, money, and people) for MBSE innovation and implementation are still difficult to estimate.
- Configuration Management (CM) and Data Management (DM) are obstacles for using MBSE for a larger or more dispersed group. A model management plan can help.

MIAMI Next Steps

- MIAMI will now focus on **targeting a larger, more pragmatic, group** for implementing MBSE on active NASA programs and projects:
  - **Incrementally infuse** MBSE onto NASA programs and projects
  - Provide resources to a targeted deployment project in exchange for feedback and positive communication to engineering peers
  - Move systems engineering towards **alignment of technology and people with our future missions**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