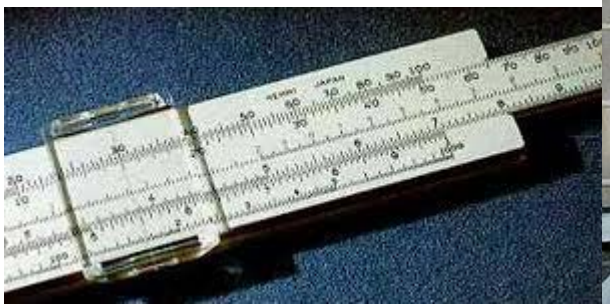
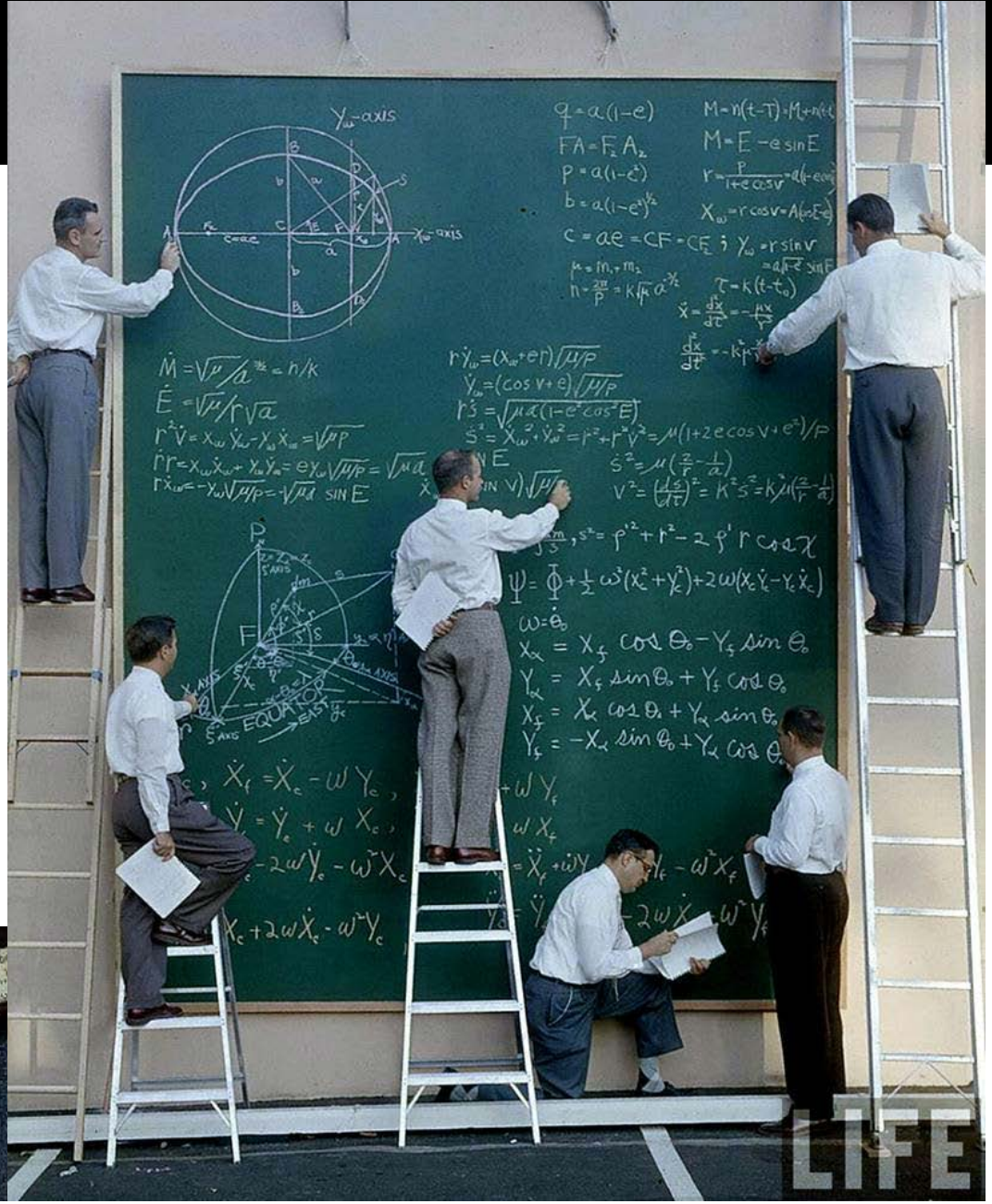
The Value of Successful MBSE Adoption

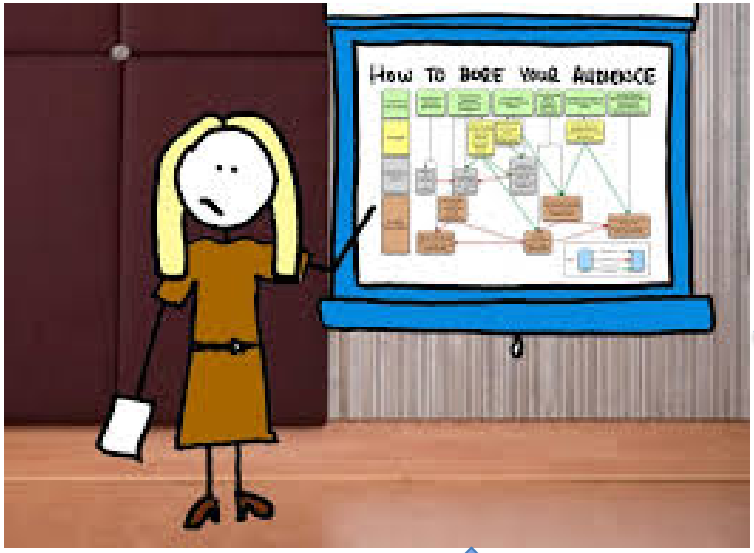
Edith Parrott
NASA Glenn Research Center





NASA Before PowerPoint

The physics are the same, how we can communicate has changed.



NASA with PowerPoint

The physics are the same, how we can communicate has changed.

GRC Training and MBSE Concept Timeline

2007
- Concept brought to GRC

2010
- GRC Working Group (WG) kick-off*
- SysML Introductory Training

2011
- DoDAF Training
- GRC WG perform MSBE Tool Trade*

2012
- SysML Introductory Training
- GRC Practitioner's Forum kick-off

2013
- Internal MBSE Overview Training
- GRC WG developed MBSE Roadmap*

2014
- Internal Hands-On Training

2015
- Internal MBSE 1-day Hands-on Training
- SysML Introductory and Advanced Training

2016 *
- GRC developed MBSE Kickstarter document
- GRC created ID Digit Widget plug-in

Key elements are * and are explained in subsequent charts.

MBSE Working Group Purpose

- Improve practice of systems engineering at GRC by:
  - Increasing Center's understanding and utilization of MBSE
  - Improving MBSE capabilities within Systems Engineering Division
  - Maintaining awareness of MBSE's application across the center and agency

MBSE Practitioner's Forum Purpose

- Collaborative setting for Modelers to:
  - Exchange ideas
  - Discuss challenges
  - Keep skills fresh with training sessions

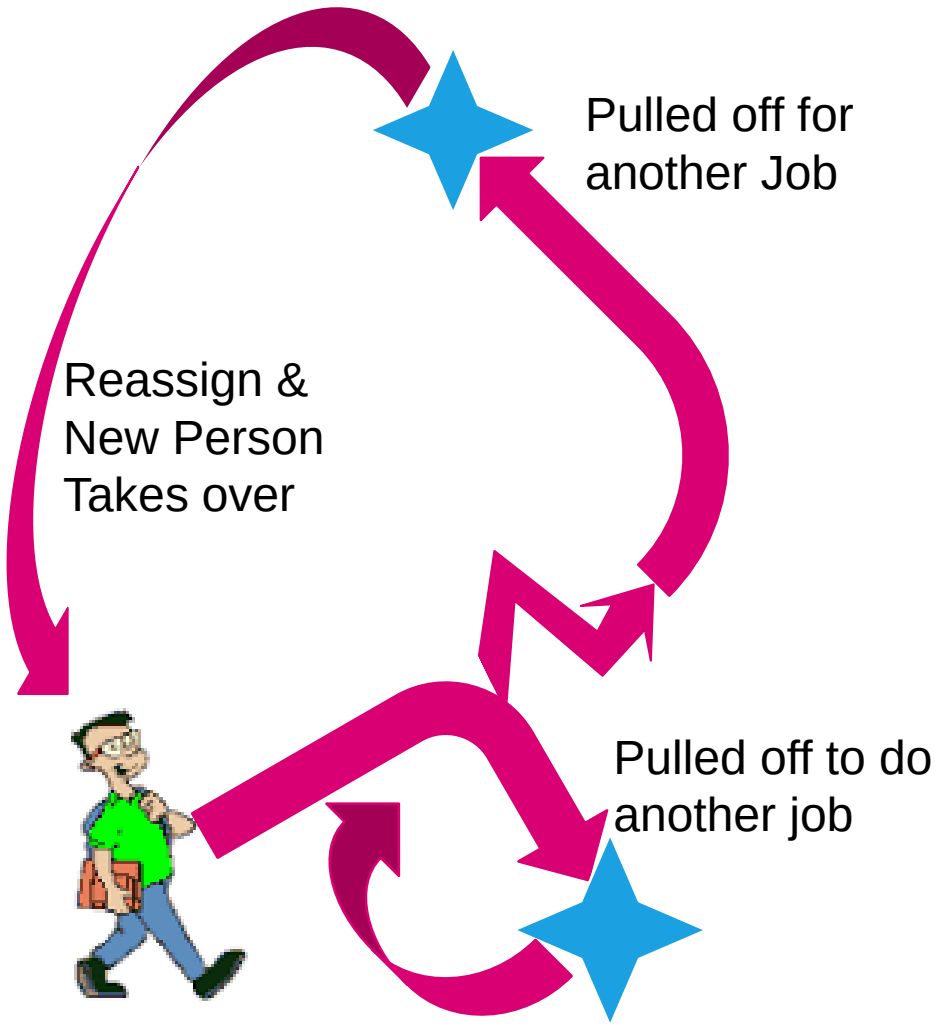
Key MBSE Tool Trade

- **GRC performed a Tool Trade in 2011**
  - 6 tool Vendors were reviewed in-depth
  - The MBSE WG created a set of requirements that were used to aid in the evaluation process
    - The set of criteria were formulated by the WG to specifically reflect items that are important for an MBSE tool to be used at GRC

- **Recommendation**
  - The MBSE WG recommended that the selected tool be used and supported as the standard MBSE tool at GRC
  - The MBSE WG also recommends that a re-evaluation of MBSE tools be made in approximately 3-5 years after gaining more experience with the MBSE process.

How Most Adoption Efforts Begin

MBSE Adoption

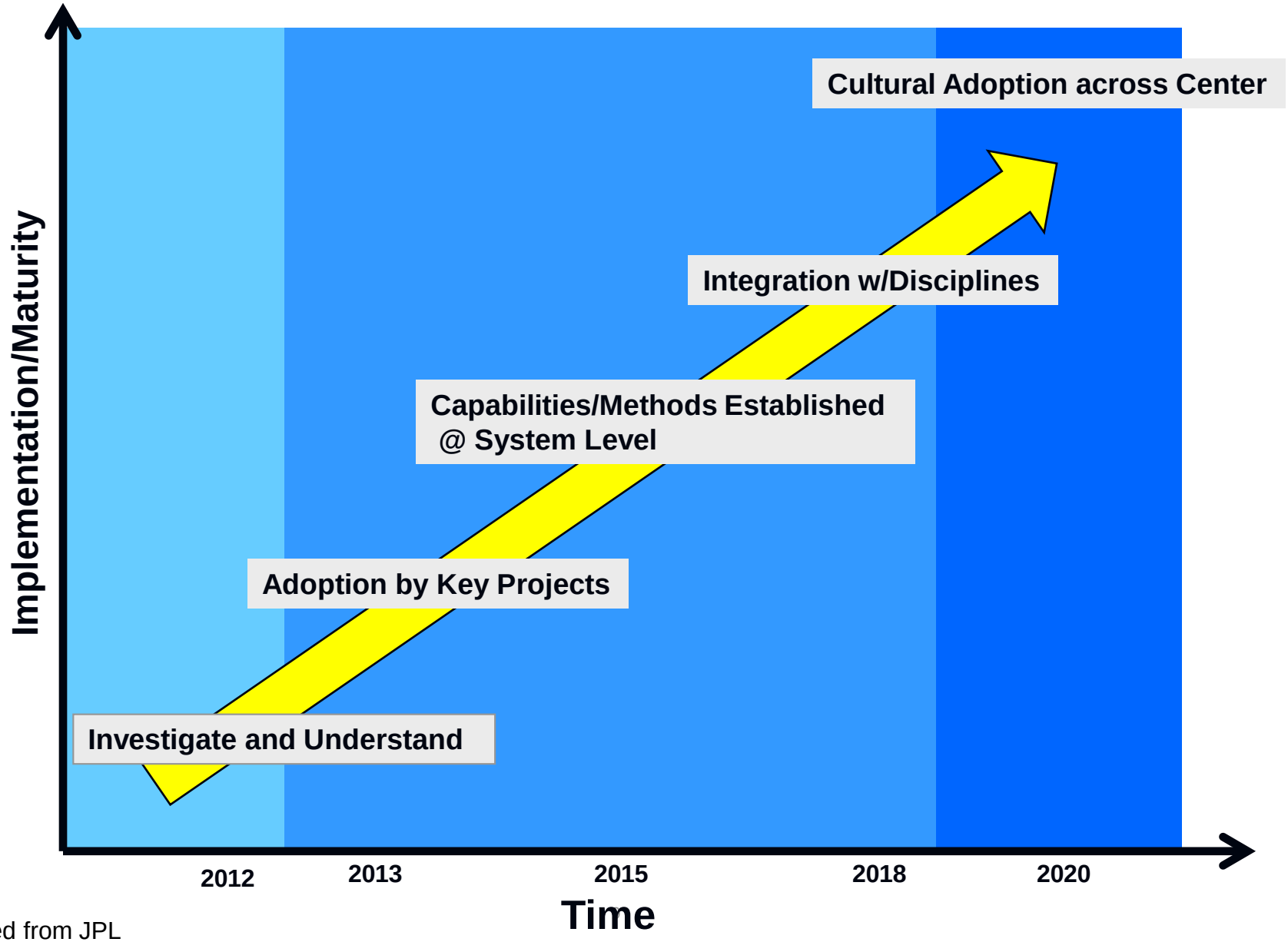


Implementation of a Roadmap

- Benefits for having a roadmap
  - Aligns the Strategic Plan
  - Gives the WG and Forum a way to judge and manage the work
  - Informs Management on status of the MBSE initiative

- MBSE Roadmap helps assess and plan GRC MBSE future by answering
  - Knowing where the center is, in relation to MBSE
  - What activities need to be accomplished for GRC to continue to grow the MBSE effort

Roadmap



*Adapted from JPL

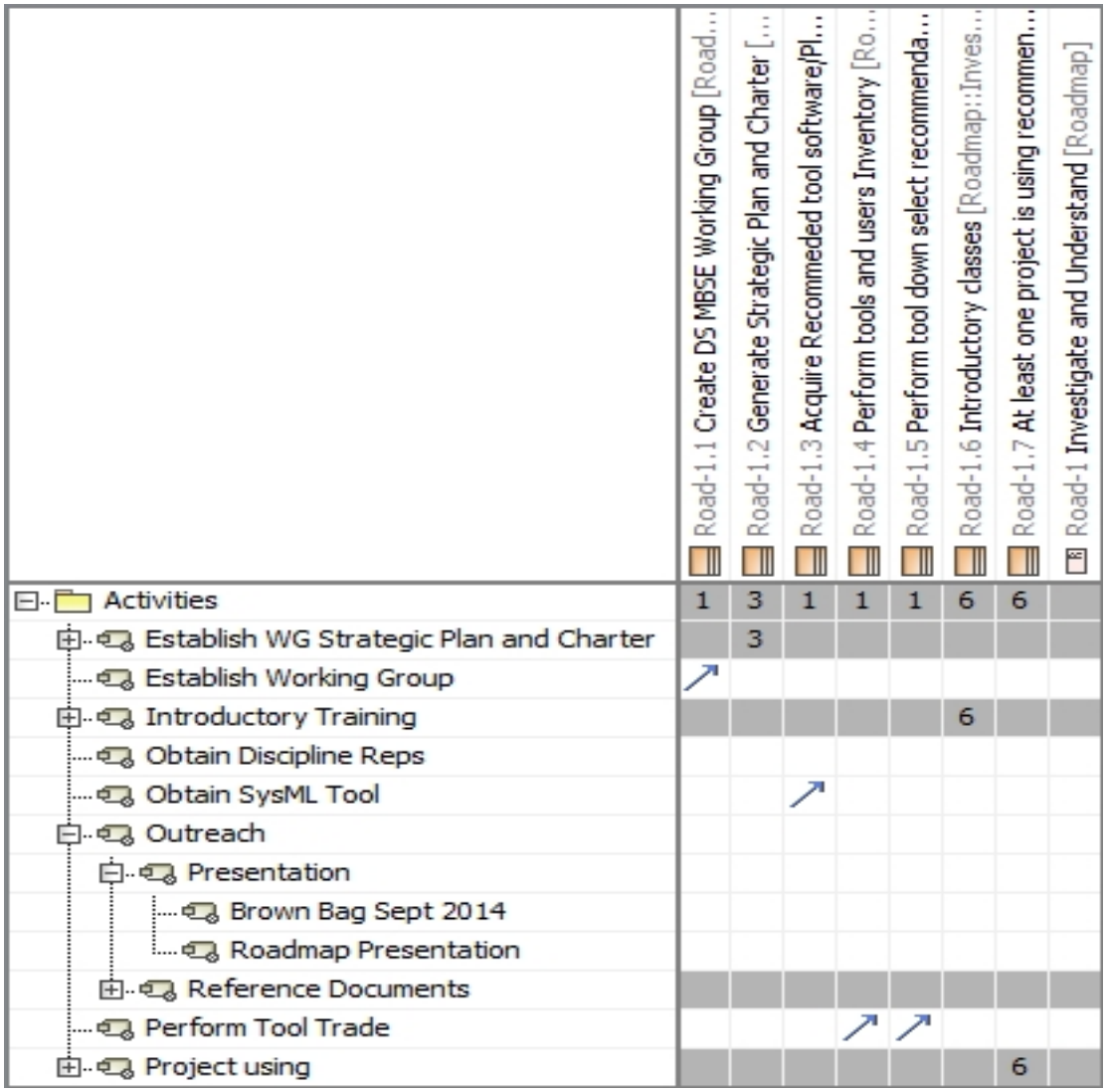
Roadmap Definitions

- **Investigate and Understand Phase**
  - Included efforts to create the GRC MBSE Working Group and bring initial MBSE tool capability to the center.
- **Adoption by Key Projects Phase**
  - Includes increased efforts to encourage the use of MBSE on projects through a variety of learning opportunities and “ready-to-use” tools.
- **Capabilities and Methods Established Phase**
  - Emphasizes the growing availability of shared, reusable resources across GRC.
- **Integration with Disciplines Phase**
  - Expand the application of MBSE to other engineering disciplines through greater process and tool integration.
- **Cultural Adoption across Center Phase**
  - Seeks to standardize the tools, methodologies, and processes developed and deployed in previous phases.

Investigate and Understand (sample)

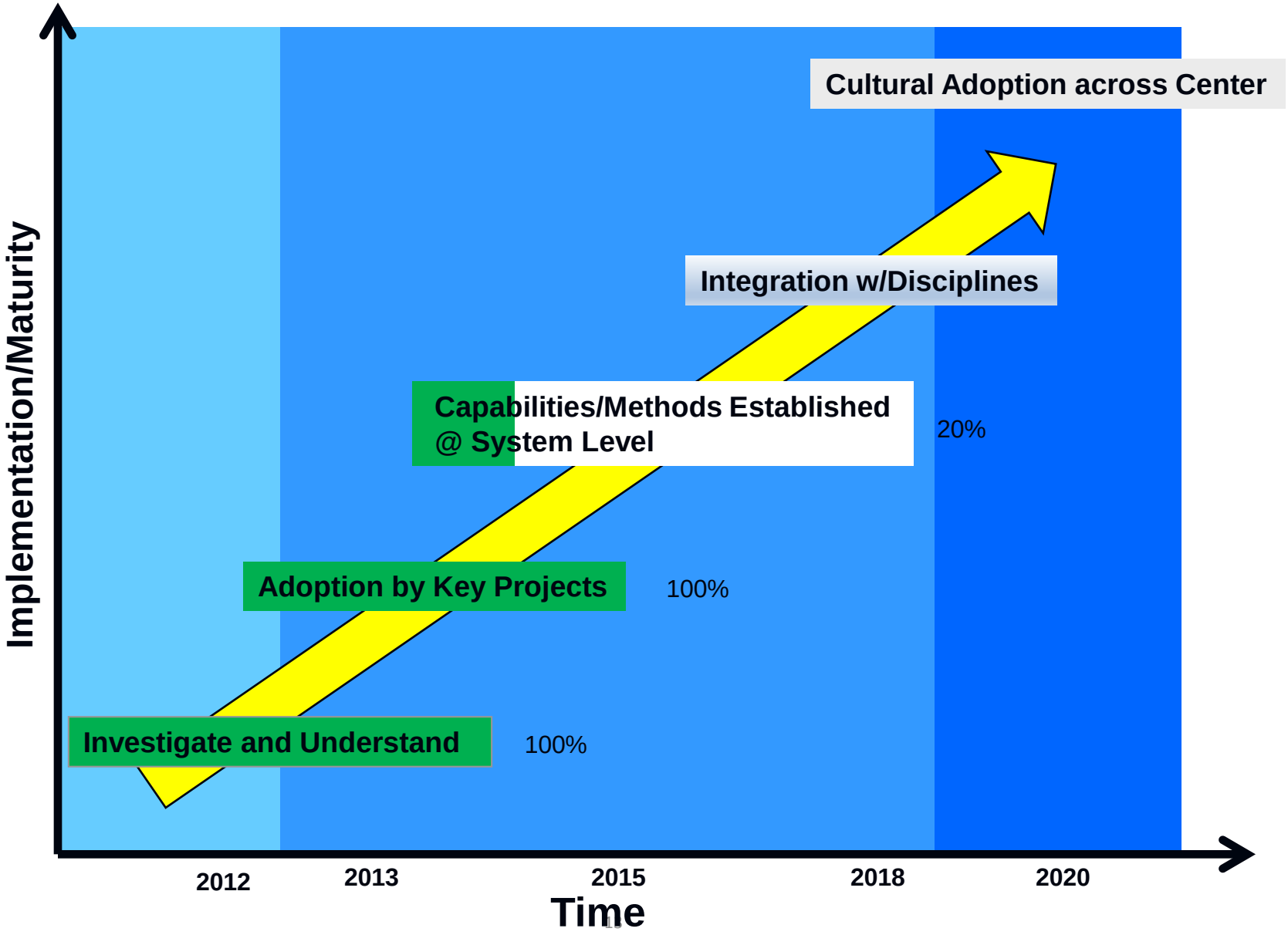
	Goals	Status
Process, Practice & Procedures	• Establish and maintain LS MBSE WG • Generate Strategic Plan and Charter	• LS MBSE WG established in 2011; • WG Charter bi-annually updated
Architecture & Infrastructure Development	• Determine recommended MBSE modeling language • Acquire recommended tool software/plugins/licenses	• WG recommended SysML in 2011; • WG acquired recommended software tool in 2011
Tools & Technology Enhancements	• Perform tools and users Inventory • Perform tool down select recommendation	• WG surveyed MBSE users in 2014; • WG surveyed MBSE tools and recommended a software tool in 2011
Outreach & Education	• Introductory MBSE classes • Code L reps outreach	• MBSE courses by external vendors held in 2011, 2012, 2015; MBSE course produced by WG held in 2013, 2015 • WG Membership extended to Code L Divisions in 2011
Pilots & Infusion	• At least one project is using recommended tool	• WG survey of users in 2015 revealed 6 projects using MBSE

Roadmap Captured in MBSE



	Road-1.1 Create DS MBSE Working Group [Road...	Road-1.2 Generate Strategic Plan and Charter [...	Road-1.3 Acquire Recommeded tool software/Pl...	Road-1.4 Perform tools and users Inventory [Ro...	Road-1.5 Perform tool down select recommenda...	Road-1.6 Introductory classes [Roadmap::Inves...	Road-1.7 At least one project is using recommen...	Road-1 Investigate and Understand [Roadmap]
Activities	1	3	1	1	1	6	6	
Establish WG Strategic Plan and Charter		3						
Establish Working Group	↗							
Introductory Training						6		
Obtain Discipline Reps								
Obtain SysML Tool			↗					
Outreach								
Presentation								
Brown Bag Sept 2014								
Roadmap Presentation								
Reference Documents								
Perform Tool Trade				↗	↗			
Project using							6	

Roadmap with Status



Challenges in Adopting MBSE

- **Significant investment required to become effective a MBSE practitioner**
  - Project budgets are tight and are unable to devote money (in development time or resources) for SE to learn
  - Learning how to read and present effectively using SysML
  - Jumping from basic tool knowledge to modeling to satisfy SE deliverables
  - Applying best practices often requires failing a few times, first
- **Collaboration in a multi-center modeling effort**
  - Model storage so all SE team members can access efficiently
  - Model access so all domain team members can access effectively
- **Resources**
  - More experienced modelers often do not have availability to mentor less experienced modelers or to capture lessons learned
  - Contracted modeling support can be expensive
- **Aging Workforce**
  - SE that are nearing retirement don’t want to change how they do system engineering

Key Documents

- **Kickstarter Document**
  - Informs new modelers on how to:
    - Obtain a MD license and access to the teamwork server.
    - Where to start
    - Best Practices

- **Cross-reference Table**
  - Help modelers know what type of diagrams are useful when satisfying review criteria or standard practices.

- **Modeling Plan**
  - Capture the tools used, formulate project modeling philosophy, model organization, how the model will be reviewed and maintained, what the model will capture and show, and any analysis/ simulations that will be performed.

Key Modeling Implementation Takeaways

- Don’t need an elaborate MBSE environment to start seeing value
  - Corollary – don’t need a lot of MBSE training
- Focus on simple products with obvious near term value that the SEs would have to create anyway
- Grow capabilities slowly (through a roadmap) to more advanced capabilities

NASA Agency MBSE Initiatives Timeline

2009
- NASA SEWG Started MBSE Study

2011
- NASA Integrated Model-Centric Architecture (NIMA) Team Started
- LaRC Started Mapping NASA SE Process into MBSE

2012
- NASA held their first MBSE Workshop/symposium

2012-3
- SEWG completed the NASA SE Process Mapping

2014
- NIMA added content to NASA SE Process Model to show versatility

2016
- Agency started the Pathfinder Activity

NASA Pathfinder Overview

- Established by the NASA Systems Engineering Technical Discipline Team to advance the Agency's application of model-based systems engineering (MBSE)
  - More effectively utilize 21st Century technology, tools and methods across its diverse portfolio of programs, projects, and technological innovations
- Goals and Objectives:
  - Multi-center collaboration that applies MBSE to real NASA issues
  - Develop aligned capability and user and practitioner community across the Centers
  - Develop expert capability that can assist in developing a systems engineering vision
  - Capture issues and opportunities for evaluating next steps
- Four Technical Areas
  1. Architectures and Mission Campaigns
  2. Additive Manufacturing and Re-Tooling Engineering
  3. Hardware/Design Commonality
  4. Mission Flow Shadowing

?? QUESTIONS ??

Abstract

The value of successful adoption of Model Based System Engineering (MBSE) practices is hard to quantify. Most engineers and project managers look at the success in terms of cost. But there are other ways to quantify the value of MBSE and the steps necessary to achieve adoption. The Glenn Research Center (GRC) has been doing Model-Based Engineering (design, structural, etc.) for years, but the system engineering side has not. Since 2010, GRC has been moving from documents centric to MBSE/SysML. Project adoption of MBSE has been slow, but is steadily increasing in both MBSE usage and complexity of generated products. Sharing of knowledge of lessons learned in the implementation of MBSE/SysML is key for others who want to be successful. Along with GRC's implementation, NASA is working hard to increase the successful implementation of MBSE across all the other centers by developing guidelines, templates and libraries for projects to utilize. This presentation will provide insight into recent GRC and NASA adoption efforts, lessons learned and best practices.