



**2019**  
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international workshop  
Torrance, CA, USA  
January 26 - 29, 2019

*INCOSE MBSE Initiative - Challenge Team Wiki*  
<https://www.omgwiki.org/MBSE/doku.php?id=mbse:ecosystems>

# *MBX Ecosystems Challenge Team*

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Chris Delp (NASA/JPL), Brittany Friedland (Boeing)

## *Overview for INCOSE MBSE Initiative*

Sun Jan 27, 2019

[https://www.omgwiki.org/MBSE/doku.php?id=mbse:incose\\_mbse\\_iw\\_2019](https://www.omgwiki.org/MBSE/doku.php?id=mbse:incose_mbse_iw_2019)

MBX = model-based X, where X includes engineering (MBE), systems engineering (MBSE), manufacturing (MBM), test (MBT), operations (MBO), ..., enterprise (MBE), sales/application engineering (MBSAE), ..., living (MBL), ...

# Challenge Team Wiki @ INCOSE/OMG Site

<https://www.omgwiki.org/MBSE/doku.php?id=mbse:ecosystems>



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mbse:ecosystems

## MBX Ecosystems Challenge Team

### Purpose

This challenge team collaborates on pre-competitive capabilities that help organizations better define and manage their MBX ecosystems. We officially kicked off at IW19 (Jan 2019) based on prior workshops at IW15, IW17, and IW18 organized by the INCOSE MBSE [Modeling & Simulation Interoperability \(MSI\) Challenge Team](#).

In simple terms, your MBX ecosystems consist of the models, tools, processes, and people/roles that come together to develop the systems/products that your organization cares about.

But an ecosystem can be broader than that, depending on the scope you are concerned about. For example some organizations utilize their ecosystems to also support the operation of their systems/products. And some organizations include cross-project libraries and methods in their ecosystems, as well as interconnections with their supply chain ecosystems.

If these type of ecosystems are of interest to you, come and join us to help move things forward!

MBX = model-based X, where X includes engineering (MBE), systems engineering (MBSE), manufacturing (MBM), test (MBT), operations (MBO), ..., enterprise (MBE), sales/application engineering (MBSAE), ..., living (MBL), and so on.

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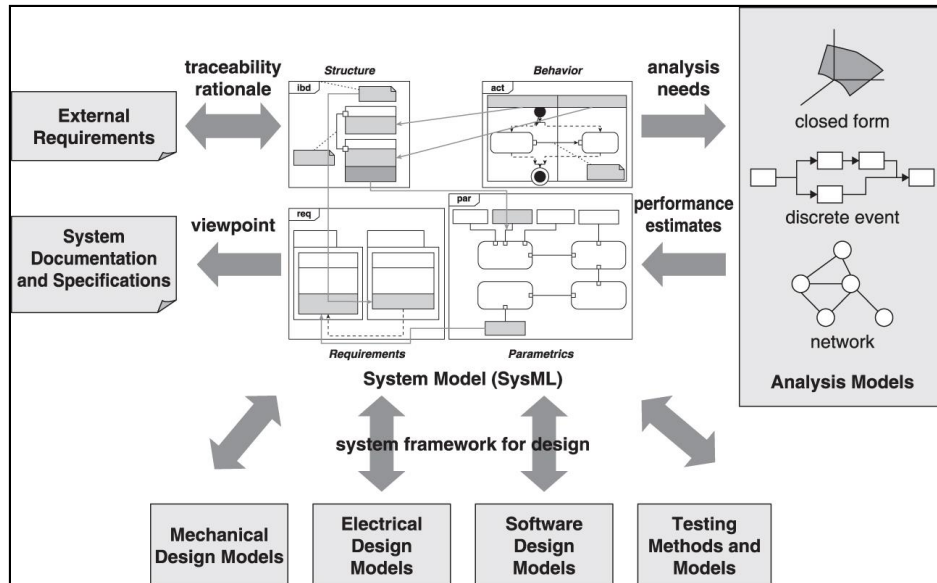
- ◆ [MBX Ecosystems Challenge Team](#)
- ◆ [Purpose](#)
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# Context: What is an “MBX Ecosystem”?

## SysML-based Ecosystems: Example Early Work

### Generic Model Architecture in a SysML-based Ecosystem

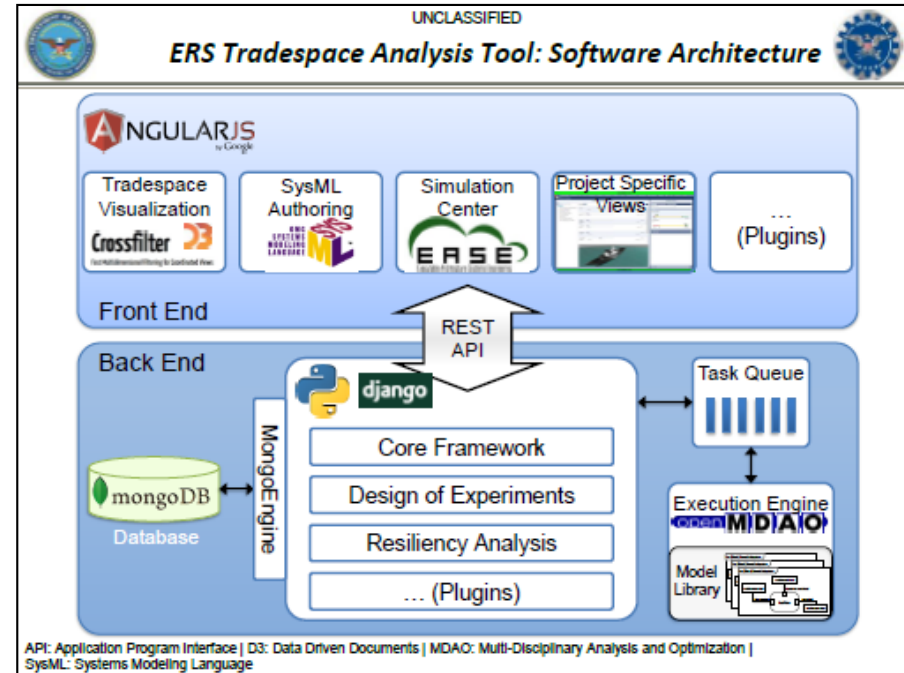
View: Framework for Models, Design/Analysis, and Traceability



Source: [Friedenthal et al. 2012]

### FACT/ERS Environment (example MBX ecosystem for trade studies)

View: Software Implementation Architecture



Source: [Ender et al. 2014]

# Context: What is an “MBX Ecosystem”?

## Early Example in INCOSE MBSE Initiative

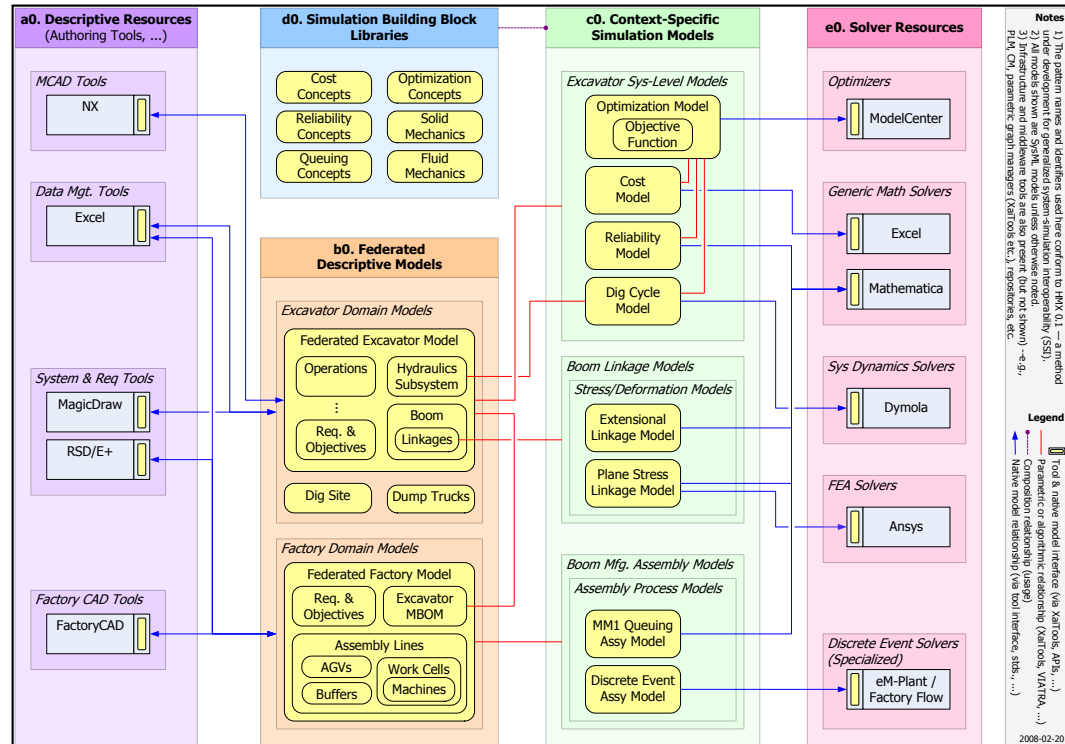
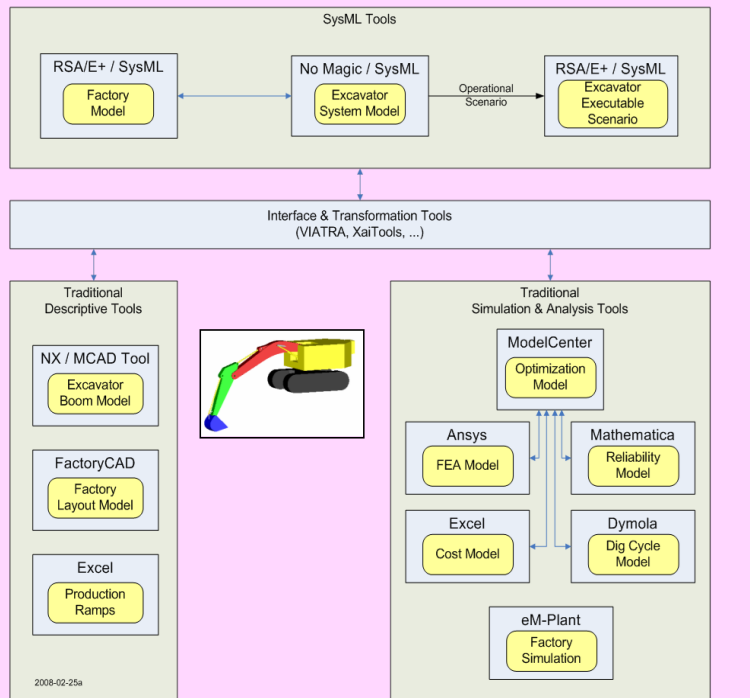
### Prototype SysML-based MBX Ecosystem for Excavator Systems

Case study c.2008-2010 in Georgia Tech project sponsored by Deere and Lockheed Martin

<http://www.pslm.gatech.edu/projects/incose-mbse-msi/> including presentations at IW09 and IW10

View1: Tool Categories (with coarse-grain connections)

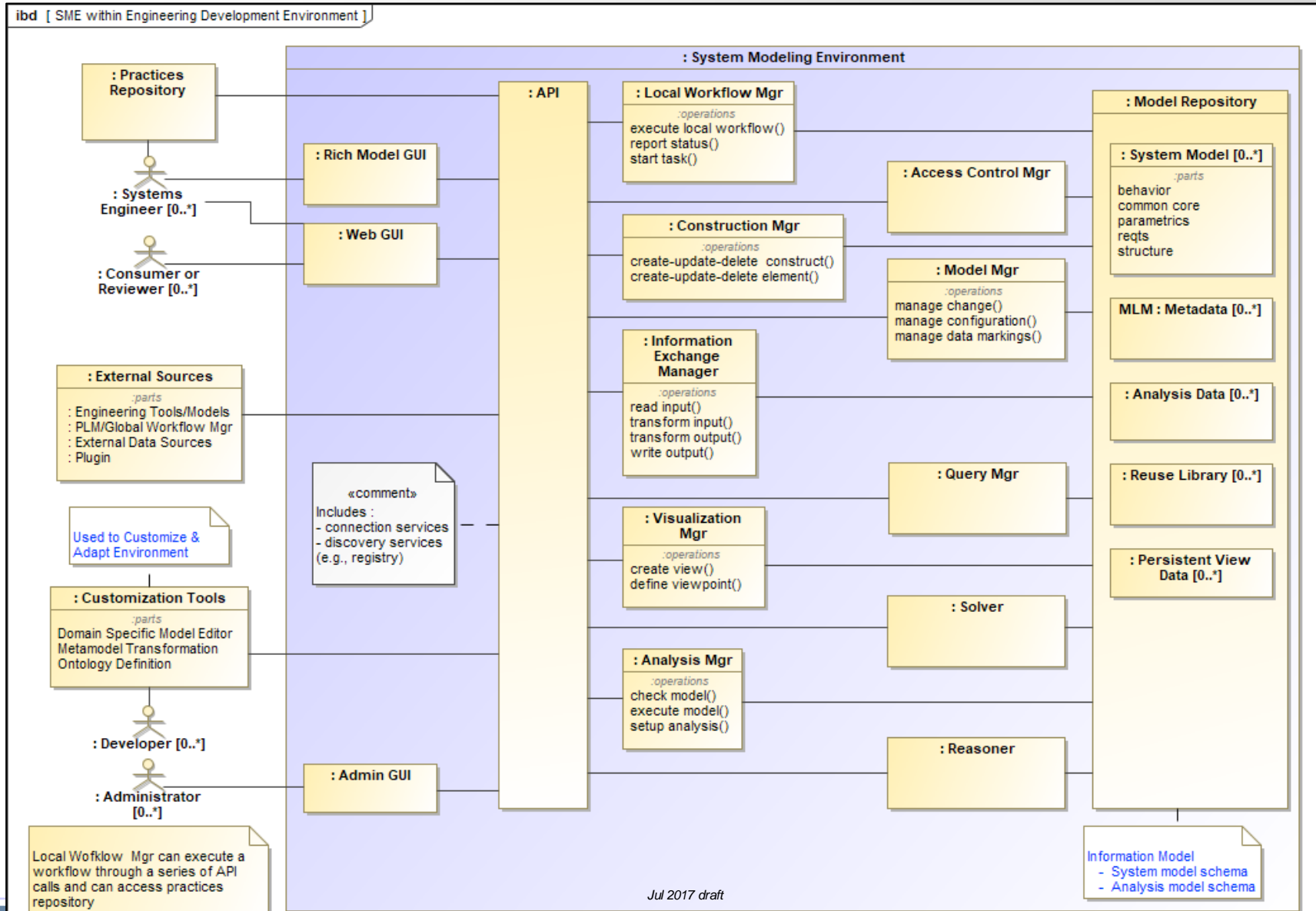
View2: Model Architecture - Patterns & Tools (with medium-grain connections)



Notes  
 1) The pattern names and interfaces used here conform to RMX 0.1 - a method under development for generalized system simulation interoperability (SSII).  
 2) All models shown are SysML models unless otherwise noted.  
 3) Architecture and middleware tools are also present (but not shown) - e.g., PEX, C#, parametric graph managers (all tools), repositories, etc.  
 Legend  
 - Tool & native model interface (via xmi tools, APIs, ...)  
 - Federated or aggregate relationships (via tools, VIATRA, ...)  
 - Native model relationships (via tool interface, stubs, ...)  
 2008-02-20

# Context: What is an “MBX Ecosystem”?

## Generic Example - OMG SysML v2 RFP (SysML model excerpt)



# Context: What is an “MBX Ecosystem”? (cont.)

## Context & Terminology (Informal)

### *MBX Ecosystem Management*

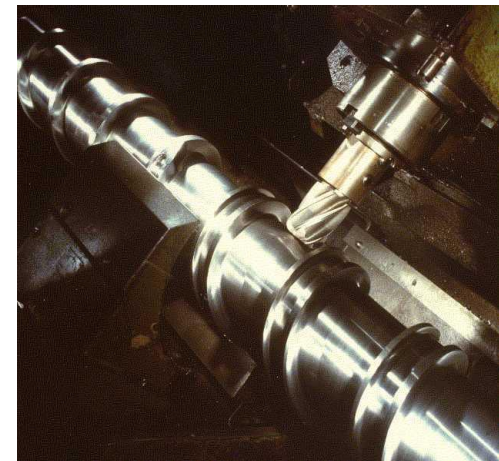
- ◆ **MBX**, where X = MBE, MBSE, MBM, ...
- ◆ **Ecosystem** = combined system of tools, models, products, repositories, interconnections, people, processes, workflows, ... [a “system of systems” - largely computer-based]
  - Level 1 – Overall ecosystem for organization X
  - Level 2 – Division sub-ecosystems
  - Level 0 – Level 1 in a global ecosystem with interfaces to ecosystems of customers, suppliers, regulators, ...
- ◆ **Management** = handling all ecosystem lifecycle phases
  - Vision/concepts, prototype, preliminary design, detailed design, deployment, maintenance, updates, migration, decommissioning
- ◆ Therefore, treat your MBX ecosystem as a system!
  - Apply systems engineering principles (“Alpo” approach) w/ ecosystem know-how
- ◆ Similar terms: system development environment, decision support system, modeling & simulation framework, ...

# Context: What is an “MBX Ecosystem”? *(cont.)*

## MBX Ecosystem Metrics & Objectives *Benefits of SysML-based MBE/MBSE Approach*

Primary Impacts <i>enterprise MOEs (measures of effectiveness)</i>	Reduced Time	Reduced Cost	Reduced Risk	Increased Understanding	Increased Corporate Memory	Increased Artifact Performance
<i>ecosystem MOPs (measures of performance)</i>						
Enabling Capabilities						
Increased Knowledge Capture & Completeness			■	■	■	■
Increased Modularity & Reusability	■	■	■	■	■	
Increased Traceability			■	■	■	
Reduced Manual Re-Creation	■	■	■			
Increased Automation	■	■	■			
Reduced Modeling Effort	■	■				
Increased Analysis Intensity			■			■

*Precision Knowledge  
for the  
Model-Based Enterprise*





# OpenMBEE: An Open Framework for MBX Ecosystems

[www.openmbee.org](http://www.openmbee.org)

## Simplified View:

- A practical combination of commercial tools and open-source tools within an extensible framework
- Includes “model-based wiki”-like capabilities
  - Exposes rich underlying SysML models as web pages
  - Engages project members who do not know SysML

Project TMT-test - TMT-APS-SE - TMT-APS DDD - TMT-APS DDD Branch: m

Type here to filter items in the tree

- ▼ TMT-APS DDD
  - ▶ 1 Introduction
  - ▼ 2 System Concept
    - ▶ 2.1 Background
    - ▶ 2.2 System Overview
  - ▶ 3 Key and Driving Requirements
  - ▼ 4 Operations Concept
    - ▶ 4.1 Responsibilities
      - ▶ 4.1.1 APS Development Te
      - ▶ 4.1.2 TMT Observatory Sta
    - ▶ 4.2 Facilities
    - ▶ 4.3 Use Cases
    - ▶ 4.4 High Level Activities
      - ▶ 4.4.1 Acquisition & Guiding
      - ▶ 4.4.2 Coarse Tilt Alignment
      - ▶ 4.4.3 Rigid Body and Segm
      - ▶ 4.4.4 Broad Band Phasing
      - ▶ 4.4.5 Narrow Band Phasing
      - ▶ 4.4.6 Measure Warping Har
      - ▶ 4.4.7 Self Test
    - ▶ 4.5 Lower Level Activities
  - ▼ 5 Opto-Mechanical Design
    - ▶ 5.1 APS Bench Overview
    - ▶ 5.2 Fore-Optics Assembly
    - ▶ 5.3 Acquisition Pointing and Tr
    - ▶ 5.4 Collimator Assembly
    - ▶ 5.5 Shack-Hartmann Assembl
    - ▶ 5.6 Pupil Image and Tracking
    - ▶ 5.7 Optical Enclosure
  - ▼ 6 ICS Software Architecture
    - ▶ 6.1 ICS Overview
    - ▶ 6.2 PEAS and APS Top Layer
    - ▶ 6.3 Assembly Layer
    - ▶ 6.4 Adherence to TMT Commc

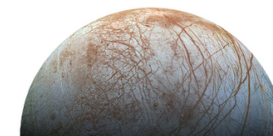
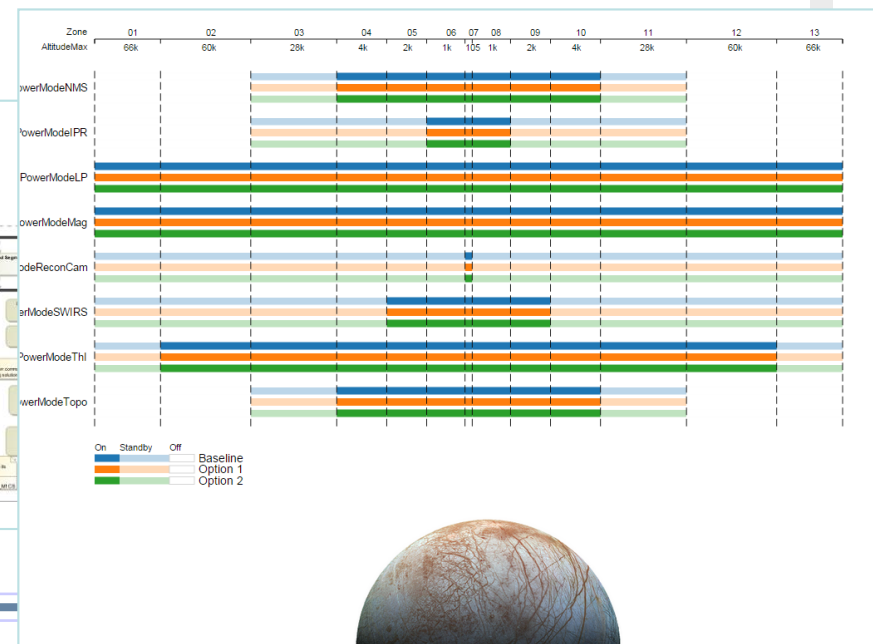
APS will use starlight to measure the wavefront errors and then will determine the appropriate commands to send to align the optics. Once the optics are aligned, the various control systems will record the set points for later use. In particular APS will align TMT by adjusting the following parameters as required.

- M1 segments in piston, tip, and tilt
- M1 segment surface figure
- M2 piston and tip/tilt (or x/y-decenter)
- M3 tip and rotation

APS will align the telescope at various elevation angles and then from lookup tables will be generated to correct for gravity-induced deformat various temperatures over time, and lookup tables will be built as a fun necessary data, but the lookup tables will be generated by the TMT of Approximately every two weeks six segments will be exchanged in TM installed segments in piston, tip, and tilt, and to correct the segment fig secondary rigid body motions. The APS measurements and associate hours of observation time. In general our experience at Keck is that AF are no segment exchanges to ensure that the telescope remains prop minutes of observation time. Initial APS operations will be conducted with the APS on the elevation However, after early operations the APS might be moved to a position

Broad Band Phasing

NFIRAOS IRMS APS WFOS





# Ecosystems/OpenMBEE Community Info

[www.openmbee.org](http://www.openmbee.org)

- ~200 participants in email list / google group
- ~35 participants in biweekly webcons (started ~Feb 2017)
- ~45 participants in biweekly developer webcons
- Formalized as a Challenge Team in the INCOSE MBSE Initiative (Jan 2019)
- Semi-public OpenMBEE instance (*thanks to No Magic, Inc*)
  - Used for collaboration on work by OMG / INCOSE / etc. (pre-competitive topics & resources)

# OpenMBEE Users: Deployments as of Jan 2018

(per responses from participants in IW18 workshop - Jan 23, 2018)

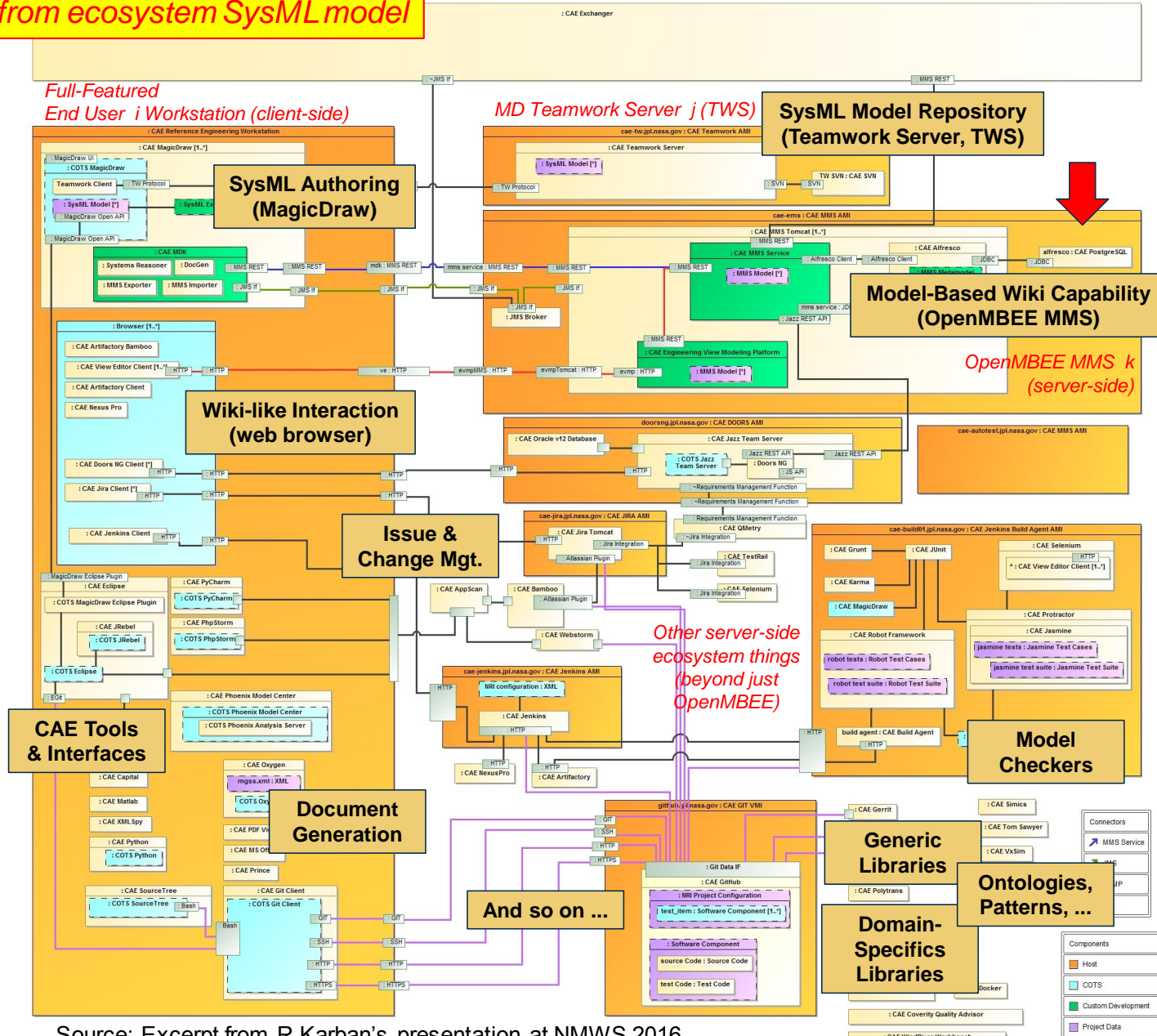
Organization	Projects Using OpenMBEE	OpenMBEE Deployment Status
Boeing	Various programs ( <i>it is their enterprise model-based solution</i> )	Production
Ford	Various pilots	<i>Pilot</i>
GT/ASDL	~5 research projects/demos	<i>Pilot/Demo</i>
GTRI	Various projects ( <i>after setup is ready</i> )	<i>WIP</i>
Lockheed	Various programs	Production
NASA JPL	~8 main flight projects (Europa Clipper, Mars 2020, Mars Sample Return, ...)	Production
OMG <sup>[1]</sup>	SysML 1.x spec; SysML v2 SST proposal	Production
Stevens/SERC	Several research projects/demos	<i>Pilot/Demo</i>
www.tmt.org <sup>[1]</sup>	Thirty Meter Telescope (TMT)	Production

[1] = Using openmbee.org semi-public instance

# Context: What is an “MBX Ecosystem”?

Example Production Ecosystem @ JPL Using OpenMBEE

Excerpt from ecosystem SysML model



Source: Excerpt from R Karban's presentation at NMWS 2016

# Join us at IW19!

Mon-Tue Jan 28-29, 2019

- See Challenge Team wiki for agenda specifics
  - <https://www.omgwiki.org/MBSE/doku.php?id=mbse:ecosystems:iw2019>
  - Includes overviews of production ecosystems at Boeing, ESA, JPL, Lockheed, ...

Day/Time	Group	Location
Mon 8:00-17:30	<a href="#">MBX Ecosystems &amp; OpenMBEE</a>	Salon E
Tue 8:00-16:30	<a href="#">MBX Ecosystems &amp; OpenMBEE</a>	Salon F/G