



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

MBX/Digital Ecosystems Challenge Team

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Update for INCOSE MBSE Initiative

Sat Jan 30, 2021

https://www.omgwiki.org/MBSE/doku.php?id=mbse:incose_mbse_iw_2021

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>



MBSE Wiki



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*We help organizations better define & manage their **digital ecosystems** ...*

mbse:ecosystems

Digital Ecosystems Challenge Team -- DECO

Purpose

The INCOSE Digital Ecosystems Challenge Team collaborates on pre-competitive capabilities that help organizations better define and manage their digital ecosystems using model-based technology. Originally we were called the "MBX Ecosystems" Challenge Team since MBX ecosystems are an important subclass of digital ecosystems.

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

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

To date digital ecosystems are typically implicit systems that are documented and managed (if at all) using various ad-hoc, disconnected, and silo'ed techniques. Our challenge team targets to improve the situation by helping model-based approaches become standard practice for digital ecosystems.

If these digital ecosystem topics are of interest to you, come and join us to help move things forward!

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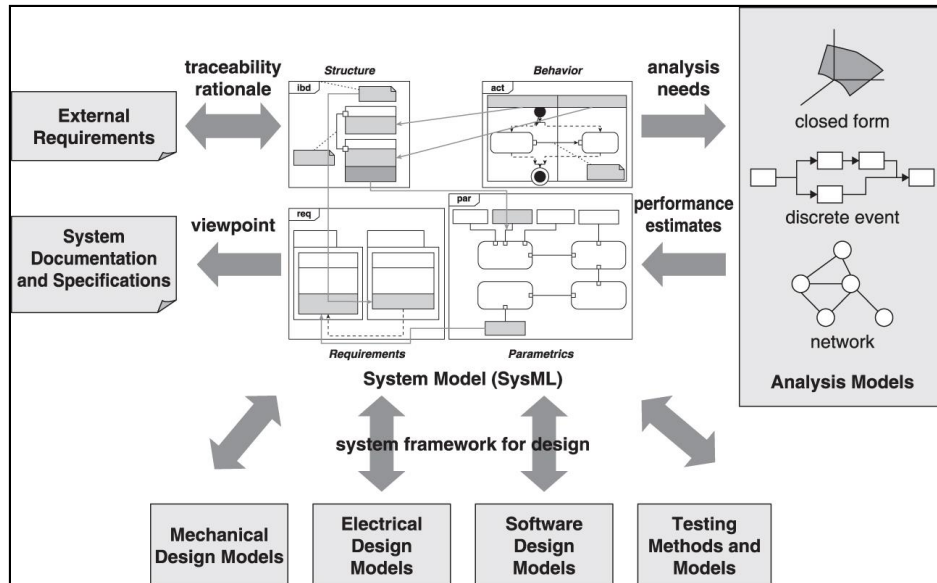
- ♦ [Digital Ecosystems Challenge Team -- DECO](#)
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Context: What is a “Digital Ecosystem”?

SysML-based Ecosystems: Example Early Work

Generic Model Architecture in a SysML-based Ecosystem

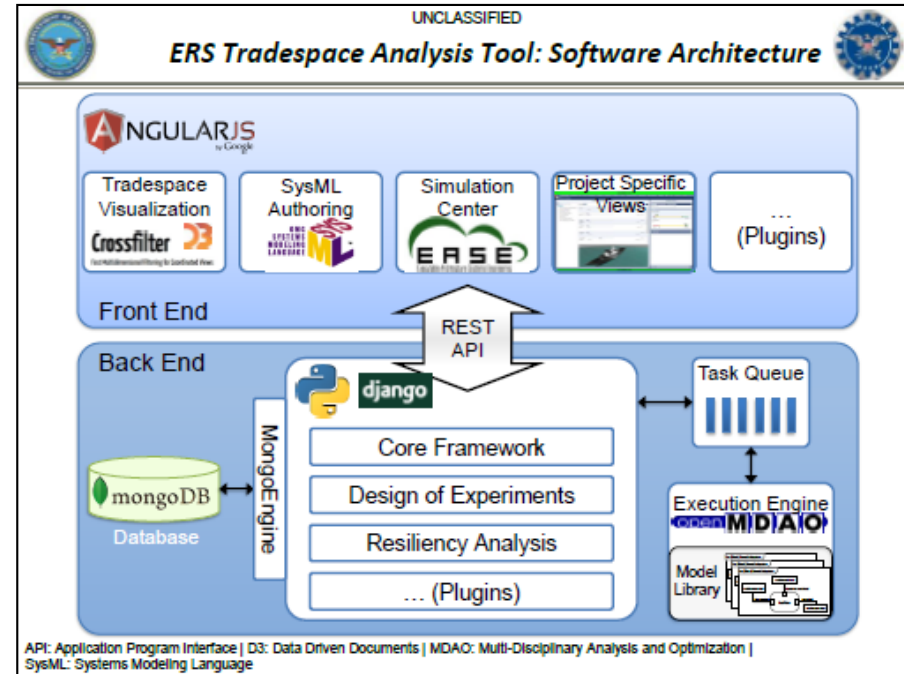
View: Framework for Models, Design/Analysis, and Traceability



Source: [Friedenthal et al. 2012]

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

View: Software Implementation Architecture



API: Application Program Interface | D3: Data Driven Documents | MDAO: Multi-Disciplinary Analysis and Optimization | SysML: Systems Modeling Language

Source: [Ender et al. 2014]

Context: What is a “Digital Ecosystem”?

Early Example in INCOSE MBSE Initiative

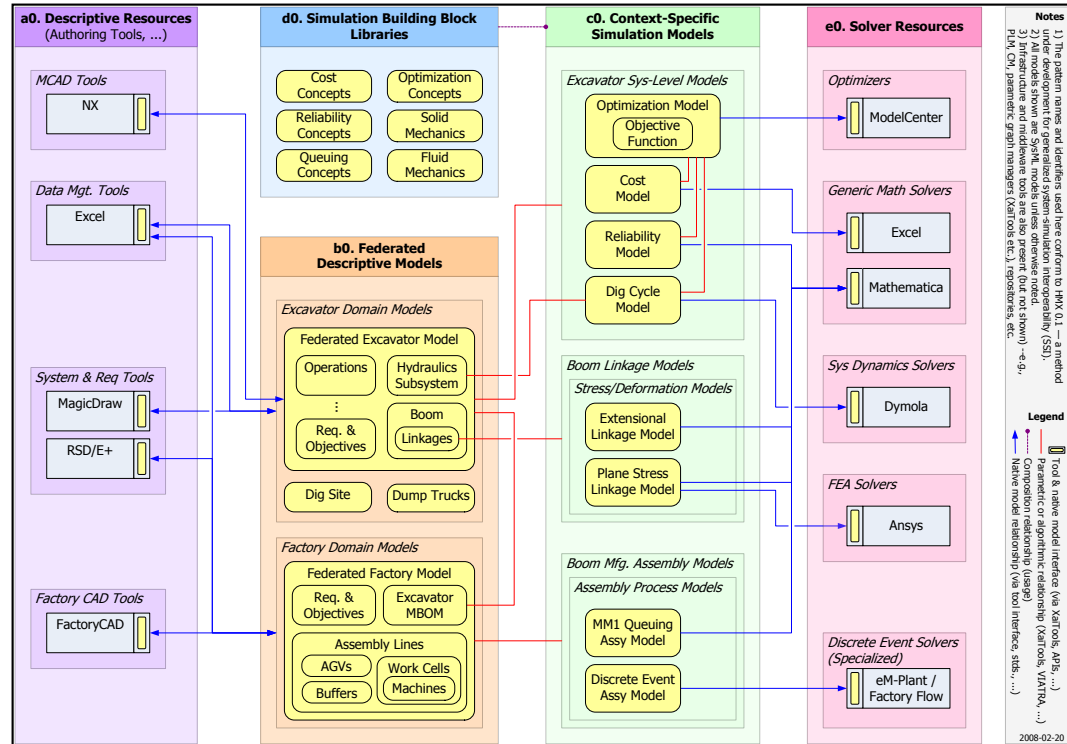
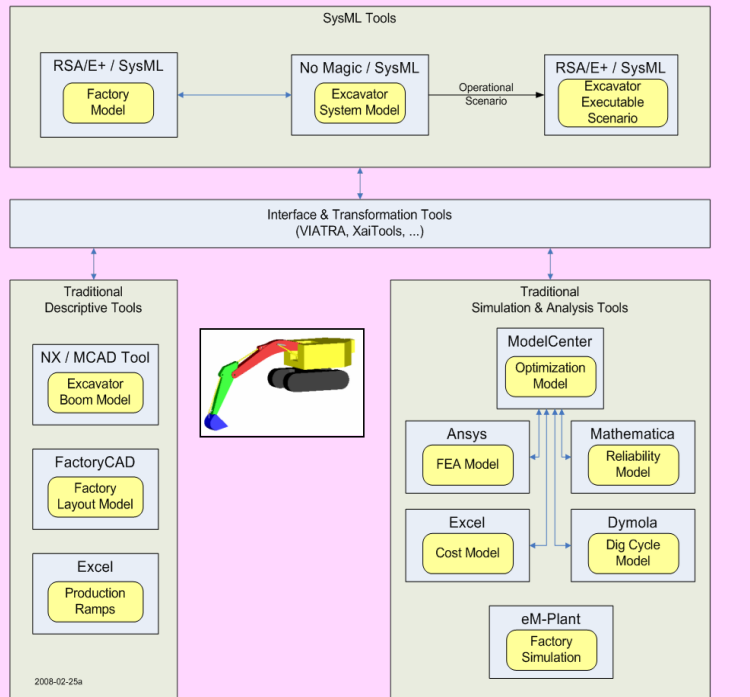
Prototype SysML-based MBX/Digital Ecosystem for Excavator Systems

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

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

View1: Tool Categories (with coarse-grain connections)

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



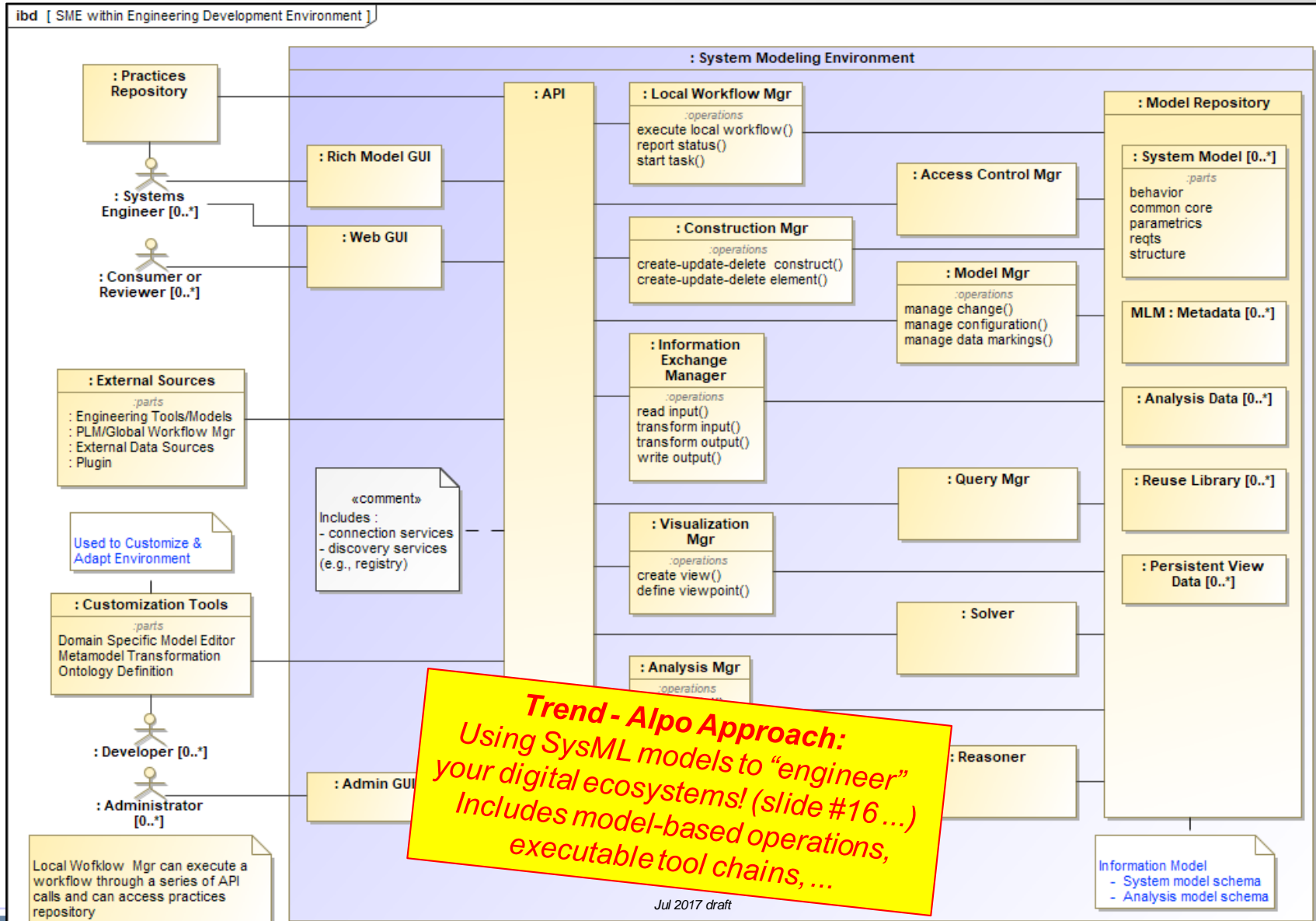
Notes
 1) The pattern names and interfaces used here conform to IECX 0.1 - a method under development for operational system simulation interoperability (OSI).
 2) All models shown are SysML models unless otherwise noted.
 3) Architecture and middleware tools are also present (but not shown) - e.g., PEX, C#, parametric graph managers (all tools etc.), repositories, etc.

Legend
 [Icon] Tool & native model interface (via XAI tools, APIs, ...)
 [Icon] Federated or aggregate relationship (via tools: VIATRA, ...)
 [Icon] Native model relationship (via tool interface, etc., ...)

2008-02-20

Context: What is a “Digital Ecosystem”?

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



Context: What is a “Digital/MBX Ecosystem”? (cont.)

Context & Terminology (Informal) *Digital/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, ...

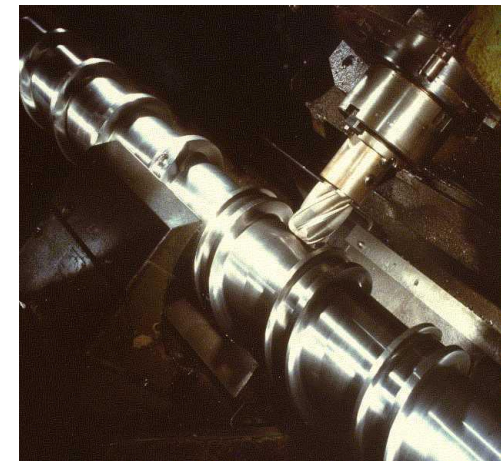
Context: What is a “Digital/MBX Ecosystem”? (cont.)

Digital / MBX Ecosystem Metrics & Objectives

Benefits of SysML-based MBE/MBSE Approach

Primary Impacts <i>enterprise MOEs</i> <i>(measures of effectiveness)</i>						
<i>ecosystem MOPs</i> <i>(measures of performance)</i>	Reduced Time	Reduced Cost	Reduced Risk	Increased Understanding	Increased Corporate Memory	Increased Artifact Performance
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*



INCOSE DECO Challenge Team Collaboration with OpenMBEE/NumFOCUS and OMG

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

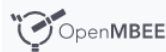
INCOSE DECO Challenge Team Webcons

We currently do not hold a separate webcon specific to our INCOSE DECO Challenge Team. Instead, we join other in-person meetings and webcons highlighted in the next subsection below. We hold INCOSE DECO Challenge Team-specific discussions during those meetings/webcons on an as-needed basis.

Other Meetings, Webcons, and Collaborations

We collaborate closely with the following groups and periodically hold joint meetings at their in-person events:

- **OpenMBEE community** – a NumFOCUS-based group (www.openmbee.org)
 - Includes biweekly general group webcons and biweekly leadership team webcons
- **OMG model-based engineering environment (MBEE) interest group** (omg.org)
 - Includes quarterly technical meetings (usually in-person)



Home About ▾ Contribute Participate Projects ▾ Community ▾ Events ▾

Connected engineering information for a connected world

OpenMBEE (Open Model Based Engineering Environment) is an open source collaborative engineering system. It enables engineers to work in the language of their choice and easily share and document their work across other tools.



Edit once, use everywhere

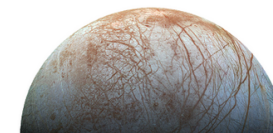
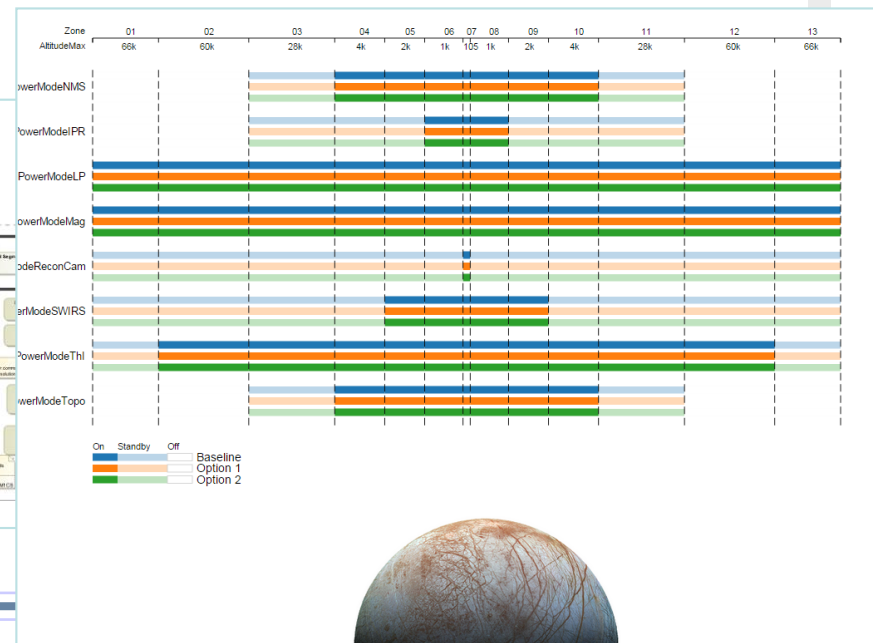
OpenMBEE: An Open Framework for Digital Ecosystems

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

The screenshot shows the OpenMBEE project interface. On the left is a navigation tree for 'Project TMT-test' with sections like 'TMT-APS DDD', 'System Concept', 'Key and Driving Requirements', 'Operations Concept', 'Responsibilities', 'Use Cases', 'High Level Activities', 'Lower Level Activities', 'Opto-Mechanical Design', and 'APS Bench Overview'. The main area displays a SysML model with various components and relationships. Below the model is a 3D rendering of the telescope assembly, labeled with 'NFIRAOS', 'IRMS', 'APS', 'WFO5', and 'Broad Band Phasing'.



Ecosystems/OpenMBEE Community Info

www.openmbee.org

- ~420 participants in email list / google group (Jan 2021)
- ~35 participants in biweekly webcons (started ~Feb 2017)
- ~45 participants in biweekly developer webcons
- INCOSE ecosystem topic formalized as a Challenge Team within the INCOSE MBSE Initiative (Jan 2019)
- Semi-public OpenMBEE instance:
 - <https://mms.openmbee.org>
 - <https://twc.openmbee.org:8443/webapp>
 - Used for collaboration on work by OMG / INCOSE / etc. (pre-competitive topics & resources)
 - *Thanks to No Magic / Dassault for hosting & support!*

OpenMBEE Users: Deployments as of Jan 2021

(as updated *live* w/ participants in OpenMBEE webcon Jan 19, 2021) p1/4

Organization	Projects Using OpenMBEE	OpenMBEE Deployment Status
Boeing	Various programs (<i>it is their enterprise model-based solution; ~40+ programs; ~100-1000+ concurrent users</i>)	Production Usage
Lockheed	Various programs (~10+ concurrent users of ~200 total users, ~50 projects)	Production Usage (unclassified & classified)
NASA JPL	~15 main flight projects: Europa Clipper, Mars 2020, Mars Sample Return, ... (~800+ TWC/Jupyter/Syndeia users; ~190 TWC/Jupyter/Syndeia projects)	Production Usage (unclassified & classified)
OMG ^[1]	SysML 1.x spec; SysML v2 SST proposed specs (initial submission Sept 2020); TIWG; spec style sheet; <i>Coming: CSRM(?), UML 2.6 spec, ...</i>	Production Usage
www.tmt.org ^[1]	Thirty Meter Telescope (TMT) project (~5 users)	Production Usage
Thales/Obeo	(tbd)	(status tbd)

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

OpenMBEE Users: Deployments as of Jan 2021

(as updated *live* w/ participants in OpenMBEE webcon Jan 19, 2021) p2/4

Organization	Projects Using OpenMBEE	OpenMBEE Deployment Status
Georgia Tech (GT/ASDL)	~5 research projects/demos	<i>Semi-Production Usage</i> <i>Pilots/Demos/Research</i>
Stevens/SERC	Several research projects/demos: Surrogate Pilot with NAVAIR (supply chain); ARDEC project; class projects; WRT-1006 DE Competency Framework	<i>Semi-Production Usage</i> <i>Pilots/Demos/Research</i>
Ford	Various pilots (~4 projects, ~10 users)	<i>Pilots</i>
GTRI	Various projects (after setup is ready) (intent: ~6 projects, ~20 users)	<i>Prototyping</i>
JAXA	For ~2 projects; ~10 users	<i>Pilots/Demos</i>
NSWC Crane	Intent for production projects – timeline TBD	<i>TBD</i>
Naval IME	Investigating (status = tbd)	<i>TBD</i>
Raytheon	Piloting setup underway (Jan 2021)	<i>TBD</i>
Rick Steiner [1]	Educational examples in openmbee.org (WW1 rifle, etc.)	<i>Online</i>
DoD/Army	Joint Multi-Role Technology Demonstrator (JMRTD) Army Huntsville (Adventium contractor)	<i>TBD</i>

Others Interested to Tryout/Use OpenMBEE ...

(as updated *live* w/ participants in OpenMBEE webcon Jan 19, 2021) p3/4

- **Gov/Industry Organizations**
 - Aerospace Corp, BAE Systems, Cox, Draper, ...
 - ESA, Harris, Integrity Applications Inc, ...
 - Nova Systems (Australia), SAIC, Sandia, ...
 - AIAA (?)
- **INCOSE Groups**
 - Smart Cities; Telecom WG (Guy Meador)
 - Digital Engineering Information Exchange (DEIX) WG
 - Natural Systems WG
 - ...

Organizations Providing Commercial Support for OpenMBEE

*(as updated **live** w/ participants in OpenMBEE webcon Jan 19, 2021) p4/4*

NOTE: This slide is provided as-is and does not constitute endorsements for the below organizations by INCOSE or by any of the MBX Ecosystem Challenge Team members.

Setup/Support

(willing to do installation, etc. for-hire for your organization)

- Tietronix (Houston TX - USA)
- Tucson Embedded Systems (Tucson AZ - USA)

Development/Integrations

(willing to do customizations for-hire for your organization)

- IncQuery Labs (Budapest, Hungary)
- InterCAX (Atlanta GA - USA)
- LieberLieber (Vienna, Austria)
- Phoenix Integration (Blacksburg VA - USA)
- Tietronix (Houston TX - USA)
- Tucson Embedded Systems (Tucson AZ - USA)

Recent SysML Applications in Industry/Gov

Example published stats/usage in production programs

★ = Using OpenMBEE

- ◆ Lockheed - Navy SWFTS submarine SysML model:
More than 400k model elements
- ◆ Thirty Meter Telescope (TMT) Alignment & Phasing System (APS): ★
More than 250k^[1] elements; open source SysML model; executable stm/act/par
- ◆ ESO APE/Extremely Large Telescope (ELT) SysML model:
Generated production code containing 432 states & 1260 transitions
- ◆ NASA SMAP satellite SysML model:
Executable state machines with ~2000 states and ~3000 transitions
- ◆ SysML model size for key NASA missions^[2]:
 - Asteroid Redirect Robotic Mission (ARRM): 1M+ elements ★
 - Mars 2020 Rover: 1M+ elements ★
 - Europa Clipper: 2M+ elements (17M+ including branches) ★
- ◆ Boeing 787 SysML model: 44M+ elements^[3]
- ◆ How will SysML v2 affect these #s?
- ◆ Contact Russell Peak if you can provide similar sanitized #s for your projects.

[1] As of ~6/2017

[2] As of ~5/2016

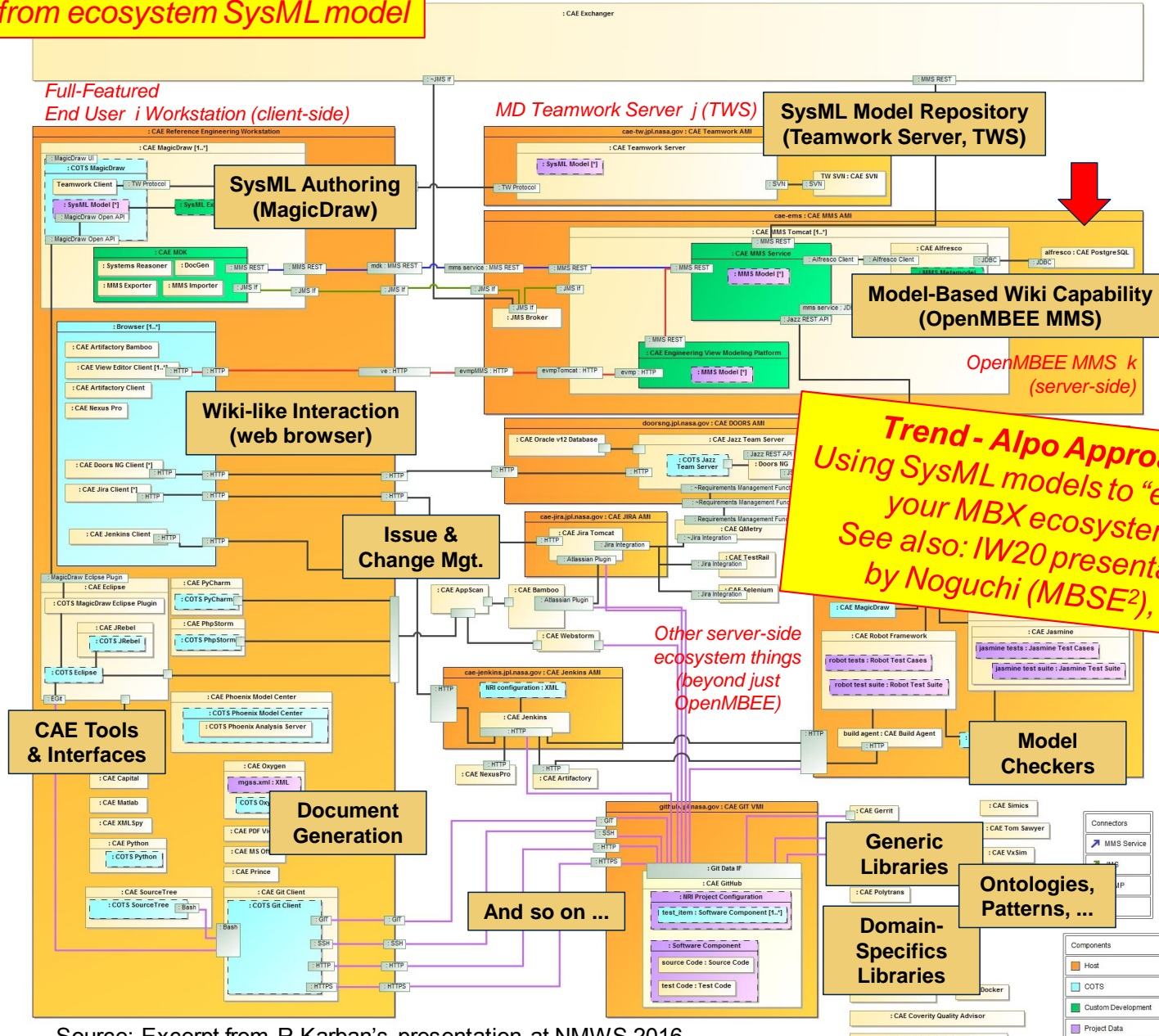
[3] As of ~1/2020

Source: SysML 101 short course [www.pslm.gatech.edu/courses]

Context: What is a “Digital 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 IW21!

Mon Feb 1, 2020

- See Challenge Team wiki for agenda specifics
 - <https://www.omgwiki.org/MBSE/doku.php?id=mbse:ecosystems:iw2021>
 - <https://www.openmbee.org/incose2021.html>
 - Our current & past IW sessions include overviews of production ecosystems:
 - Boeing, Ford (pilot), JPL, Lockheed
 - Plus research/edu usage by Georgia Tech, Stevens/SERC, etc.
 - Plus OpenMBEE architecture roadmap, OpenMBEE-SysML2 outlook, ...