Open Model-Based Engineering Environments

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Outline

• Introduction
• Model-Based Engineering Environments (MBEE)
• JPL Model-Based Engineering Environment
• Open MBEE Community and Software
• Engineering Models as Commodity Information
• Engineers as Humans
• Welcome to the World of Tomorrow
Introduction
Presenter: Christopher Delp

Background
- Systems Engineering
- Software Development
- Safety Critical Software
- Model-Based Systems Engineering

JPL
- Deep Space Network
- Curiosity
- Europa Clipper
JPL is part of NASA and Caltech

- Federally-funded (NASA-owned) Research and Development Center (FFRDC)
- University Operated (Caltech)
- $2.7B Business Base
- 6,000 Employees

- 167 Acres (includes 12 acres leased for parking)
- 139 Buildings; 36 Trailers
- 673,000 Net Square Feet of Office Space
- 906,000 Net Square Feet of Non-Office Space (e.g., Labs)
Some Notable Firsts

Surveyor 1, First soft landing on the moon

Viking, first landing on another planet

Voyager 1, First interstellar traveler

Continuous presence on Mars since 1997
21 Spacecraft and 8 instruments across the Solar System and Beyond...

**Earth Science**
- MISR (1999)
- AIRS (2002)
- MLS (2004)
- ASTER (2009)
- OPALS (2014)
- ECOSTRESS (2018)
- CAL (2018)

**Planetary**
- MARSIS (2003)
JPL Vision – Dare Mighty Things

- Pursue long-term scientific Quests with a diverse and bold portfolio of missions
- Push the limits of space exploration technology by developing and fielding ever more capable autonomous robotic systems
- Strengthen our core expertise while developing and maintaining strategic partnerships with other NASA centers, U.S. national laboratories, academia, industry, and our international partners
- Build a robust Laboratory of the future that fosters a culture of innovation, openness, and inclusiveness
- Transform our systems to promote easier collaboration and information sharing
- Strengthen our end-to-end mission capabilities and accelerate the infusion of new technologies and capabilities into our future missions
- Inspire the world through our stories and our journey into space
- Support American leadership in space and as we Dare Ever Mightier Things
JPL Vision – Seven Quests

• Understand how Earth works as a system and how it is changing
• Help pave the way for human exploration of space
• Understand how our Solar System formed and how it is evolving
• Understand how life emerged on Earth and possibly elsewhere in our Solar System
• Understand the diversity of planetary systems in our Galaxy
• Understand how the Universe began and how it is evolving
• Use our unique expertise to benefit the nation and planet Earth
Model-Based Engineering Environments (MBEE)
Precise Engineering Information and Products
Correspondent Engineering Information and Products
Seat at the Table for Domains and Apps

Web Services

- Timelines
- Maps
- Artifacts
- Analyses
- Search
- Code/Models

Process Orchestration

Multi-Machine Analysis

Engineering Tools
Engineering Code and Models
DIY Web App
Pipelines

Engineering Pipelines

- Process (traceable, auditable, repeatable)
  - Capture
  - Requirements/Design
  - Analysis
  - Publication

Software Pipelines

- Process (traceable, auditable, repeatable)
  - Design
  - Development
  - Testing
  - Operation
Process (traceable, auditable, repeatable)

Capture
- Mapping
- Deconfliction
- Discovery

Requirements/Design
- Requirements Management
- Design Modeling
- Specifications
- Configurations

Analysis
- Simulation Analysis
- Model Checking
- Visualizations

Publication
- Products
- Documents

Issue management
- Continuous Integration
- Process orchestration

Model Pipeline
Safety Critical Software Pipeline
JPL Model-Based Engineering Environment
JPL Seat at the Table for Domains and Apps

Web Services

NX/EPDM
JIRA
DOORS NG

MPS
Timelines
Syndeia Cloud
Maps
Artifactory
Artifacts

ModelCenter Cloud
Analyses
MMS
Search
Teamwork Cloud
Models

Helix
Python
View Editor

Systems Tool Kit
Analysis Orchestrator

Multi-Machine Analysis

Maple
Tom Sawyer
DIY Web App

MagicDraw + MDK

MAP
Cloud Analyses
MPS
Timelines
Multi-Machine Analysis

Mathematica
MATLAB
XL Release
Phoenix ModelCenter
MapleMBSE
Syndeia
Safety-Critical Software Environment
Process (traceable, auditable, repeatable)

Capture ➞ Requirements/Design ➞ Analysis ➞ Publication

Systems Environment Pipeline
Modeling Languages

Graphical

Hybrid Graphical/Text

Code/Text

Information
Software Languages
Software Languages
Evolving Cloud Compute Services

- 14 Server Set-ups - over 200 servers
- Full Test String - Test, Integration, User Acceptance, Production
- Managed Services
- Software as a Service
Open MBEE Community and Software
Open Model-Based Engineering Environment

- OpenMBEE is a community for open source modeling software and models
  - Number of open source software activities
  - Number of open source models
- JPL is a participant and adopter of OpenMBEE software and models
- Along with Boeing, Lockheed Martin, OMG, NavAir, Ford, Stevens, Georgia Tech, ESO
- Vendor participants
- ~300 members
Open MBEE Models and Software

• Models and Model Libraries
• Software
Linked Data Documents with Open MBEE
OpenMBEE Pipeline
Engineering Models as Commodity Information
The Significance of Engineering Models

- Unique
- Valuable
- Durable
Commoditization Unlocks the Value

- Open - Innersource
- Discoverable
- Searchable
- Learnable
Engineers as Humans
Human Challenges

- Cultural Resistance
- Systemic Process Impact
- No Users - The Risk of Failure
Incorporating the Engineers

- Empathy
- Human Centered Design
- Incremental Improvement
Welcome to the World of Tomorrow
Path to Success
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