National Institutes of Standards and Technology - Model Based Enterprise Summit 2019

Open Model-Based Engineering Environments

Christopher Delp April 2, 2019

Jet Propulsion Laboratory
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Comments do not imply any endorsement of any software vendor or company.

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)

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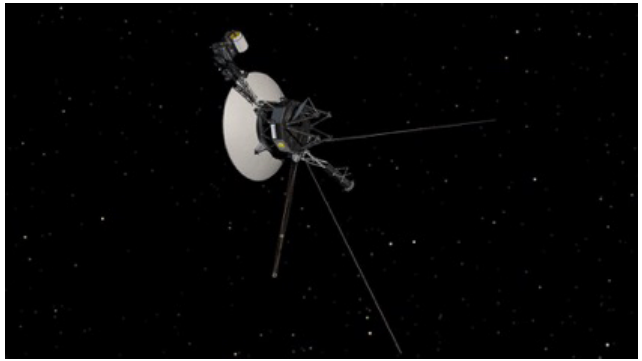
Some Notable Firsts

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

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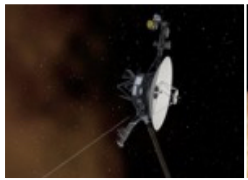
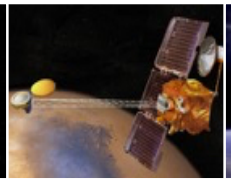
21 Spacecraft and 8 instruments across the Solar System and Beyond…

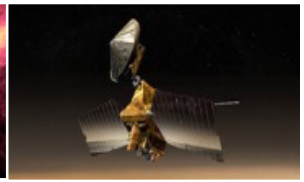

Two Voyagers (1977)


Mars Odyssey (2001)


Jason-2 (2008)


Opportunity (2003)

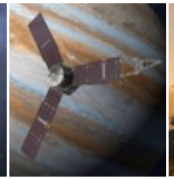

Spitzer (2003)


Mars Reconnaissance Orbiter (2005)

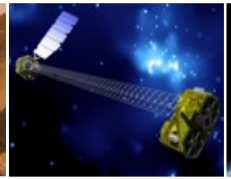

CloudSat (2006)


Dawn (2007)

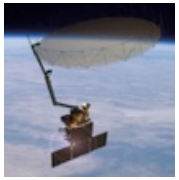

NEOWISE (2009)

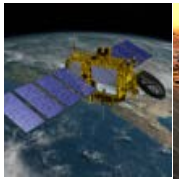

Juno (2011)


Curiosity (2011)

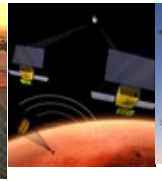

NuSTAR (2012)

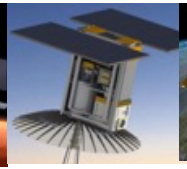

OCO-2 (2014)

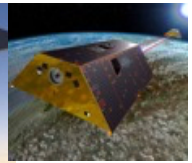

SMAP (2015)


Jason-3 (2016)


InSight (2018)


MarCO (2018)


RainCube (2018)


Grace Follow-On (2018)

Instruments

Earth Science

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

Planetary

- MARSIS (2003)

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JPL Vision – Dare Mighty Things

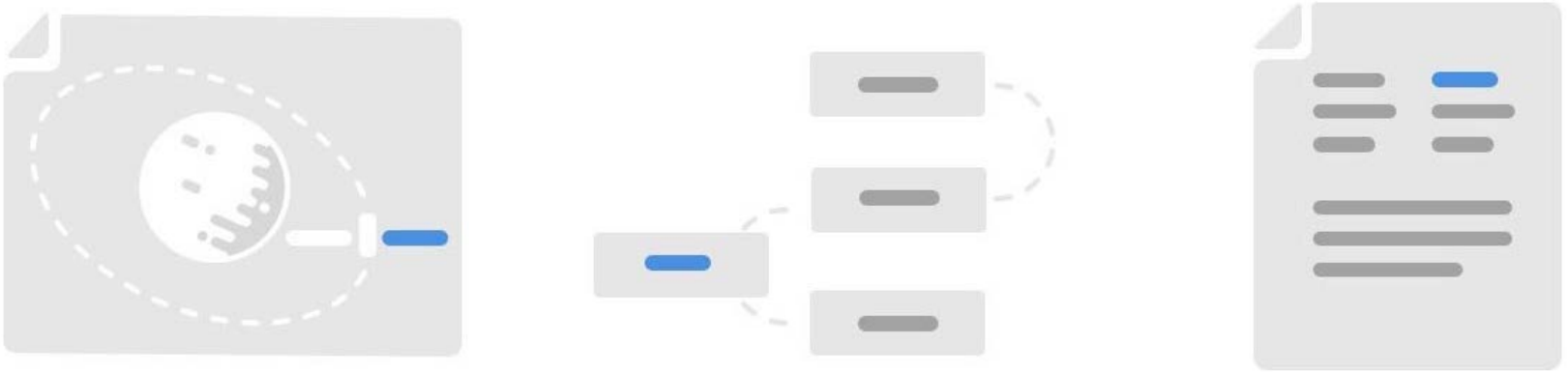
- Pursue long-term scientific Quests with a diverse and bold portfolio of missions
- Push the limits of space exploration technology by developing and fielding ever more capable autonomous robotic systems
- Strengthen our core expertise while developing and maintaining strategic partnerships with other 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

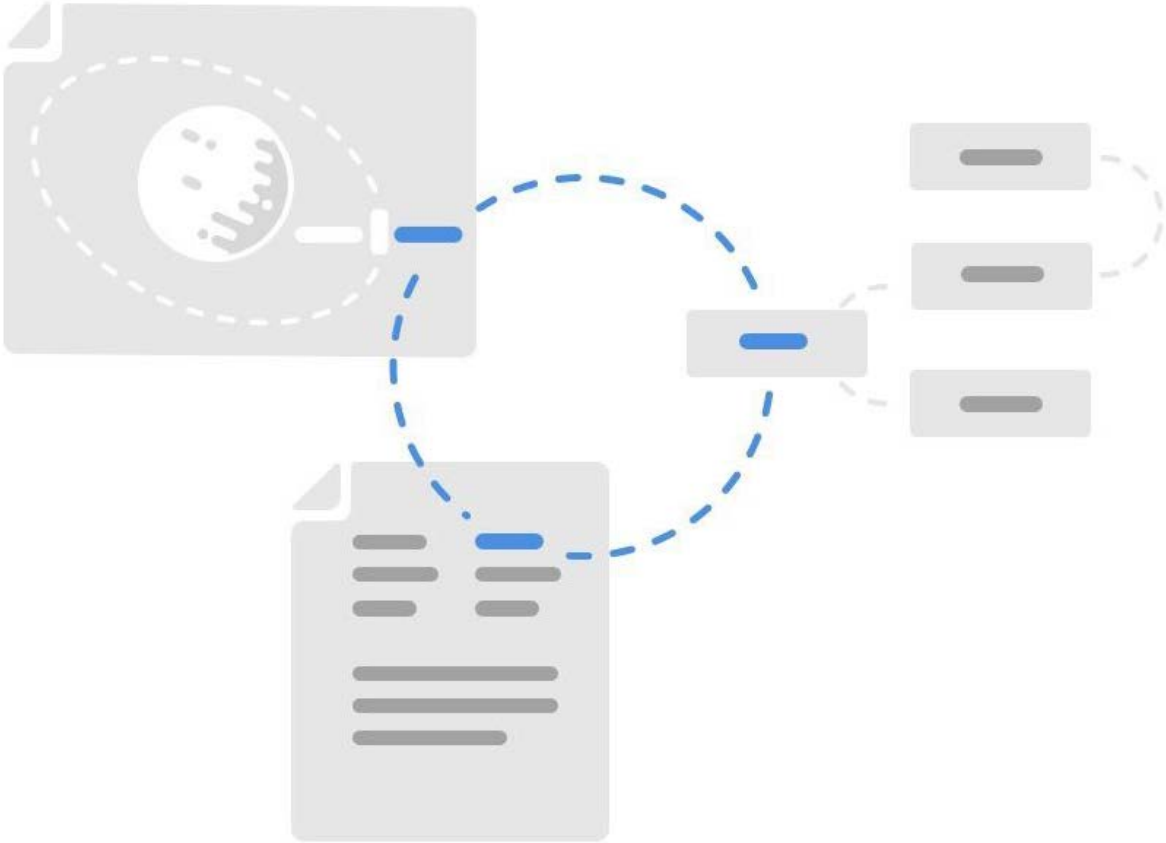
- Understand how Earth works as a system and how it is changing
- Help pave the way for human exploration of space
- Understand how our Solar System formed and how it is evolving
- Understand how life emerged on Earth and possibly elsewhere in our Solar System
- Understand the diversity of planetary 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)

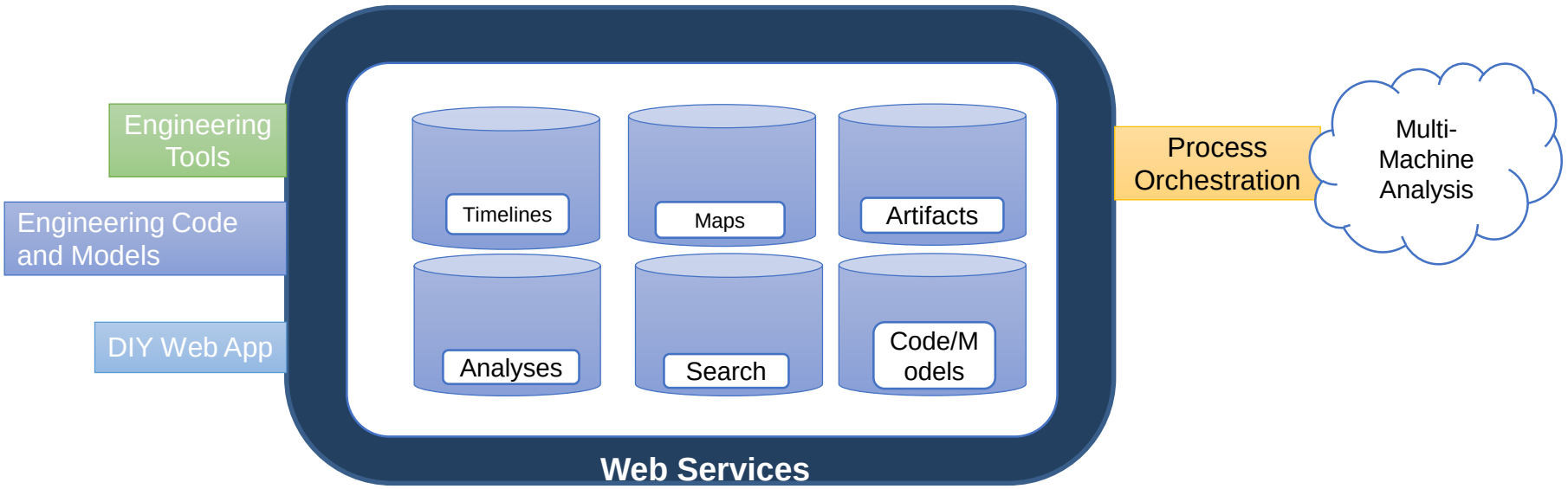
Precise Engineering Information and Products



Correspondent Engineering Information and Products

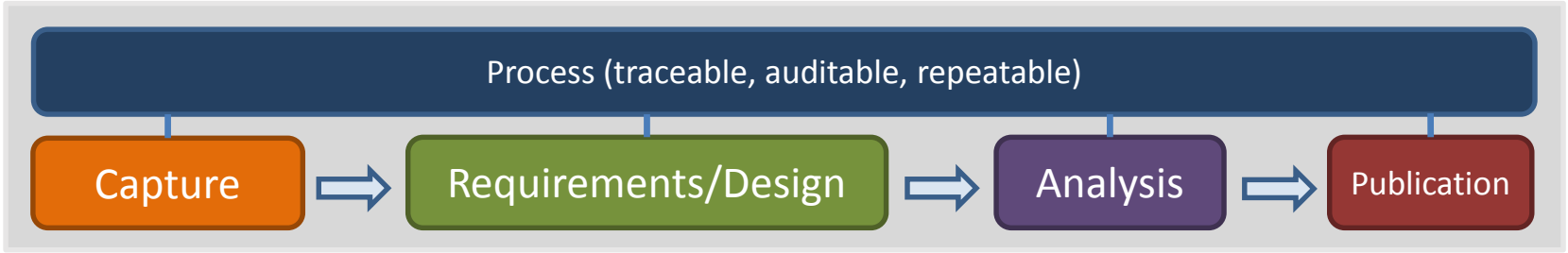


Seat at the Table for Domains and Apps

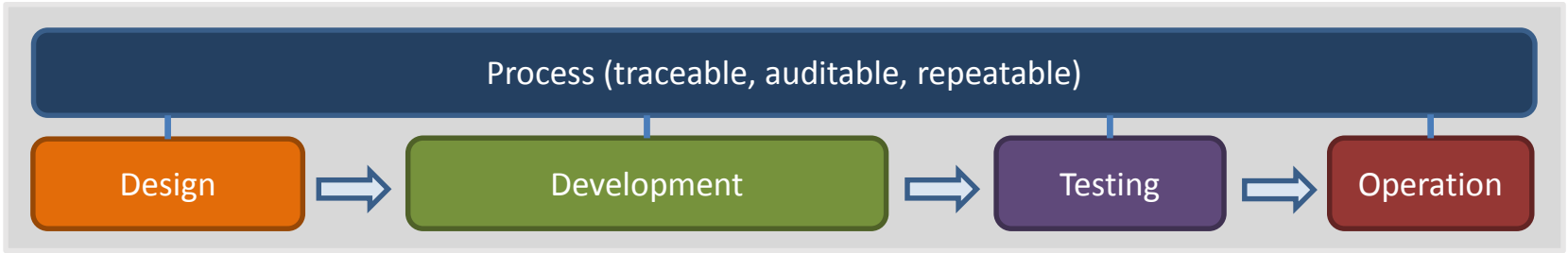


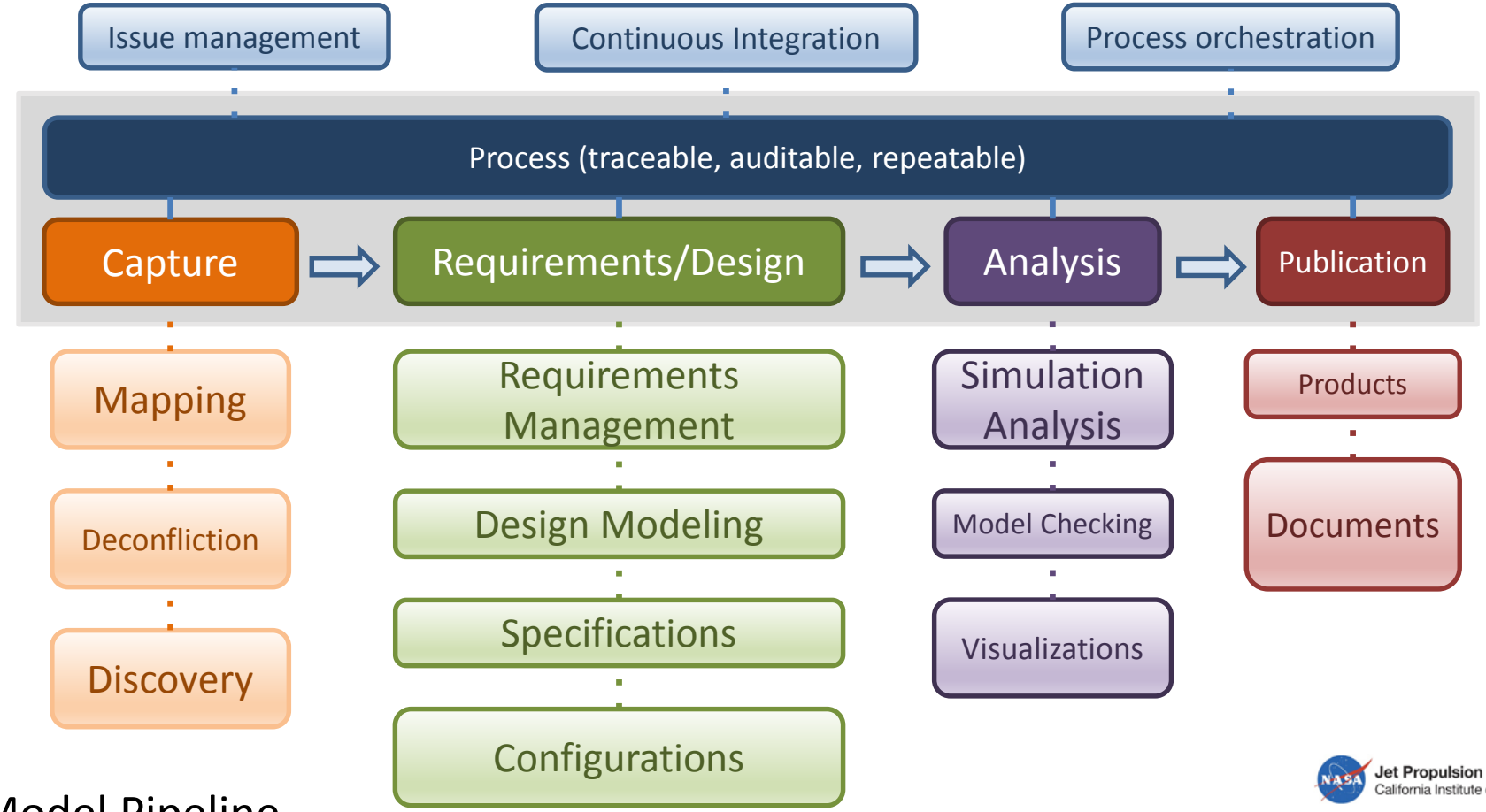
Pipelines

Engineering Pipelines

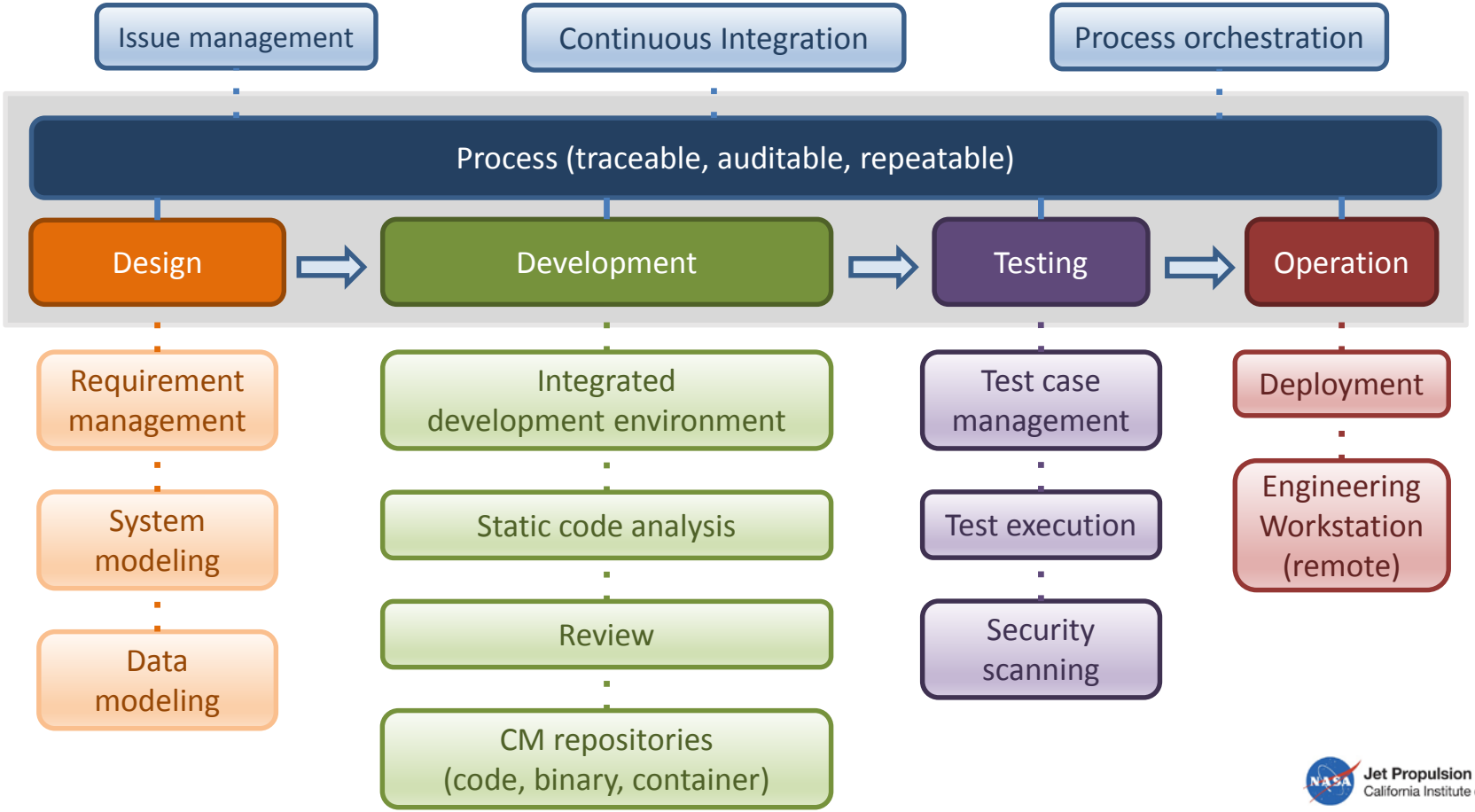


Software Pipelines





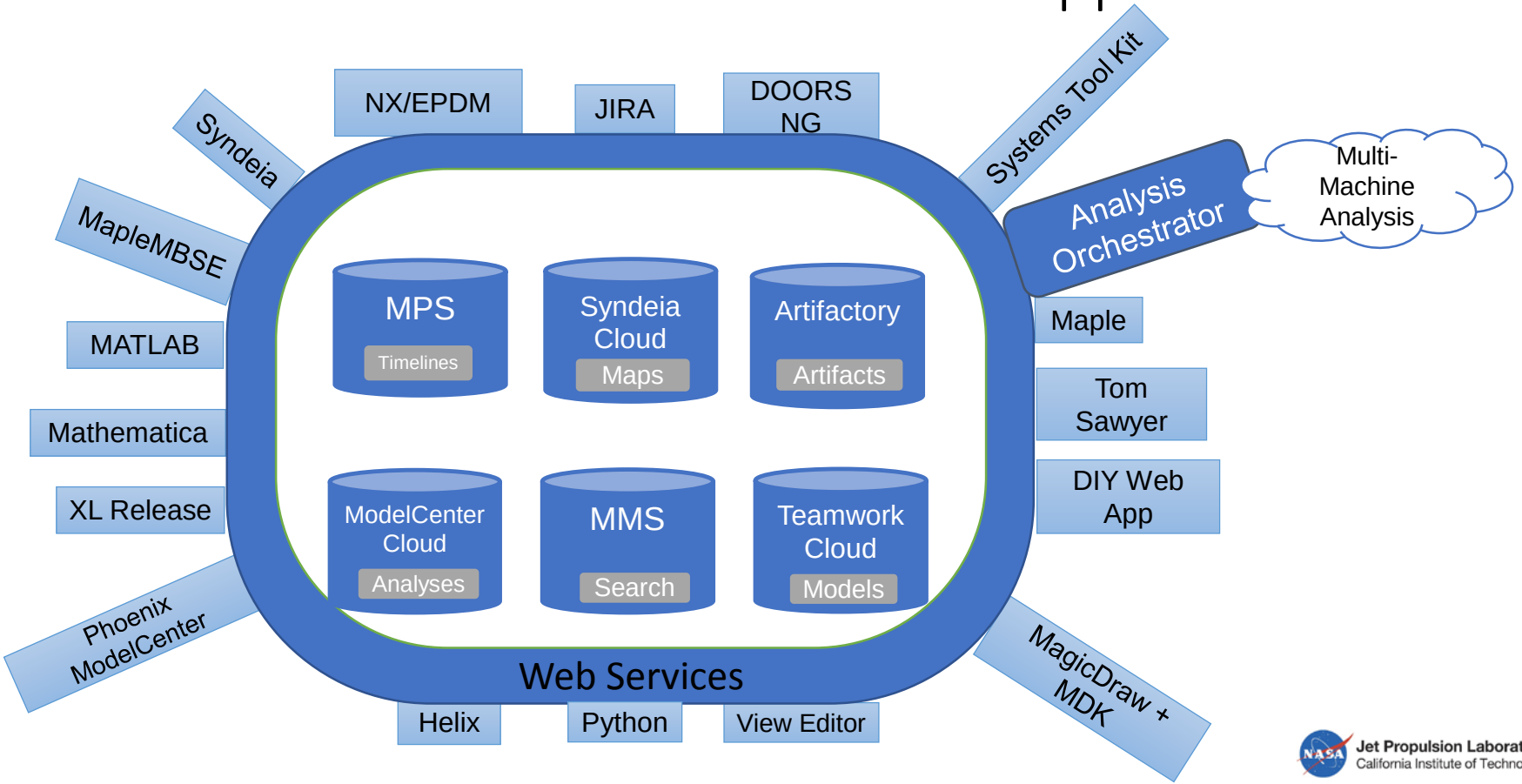
Model Pipeline



Safety Critical Software Pipeline

JPL Model-Based Engineering Environment

JPL Seat at the Table for Domains and Apps



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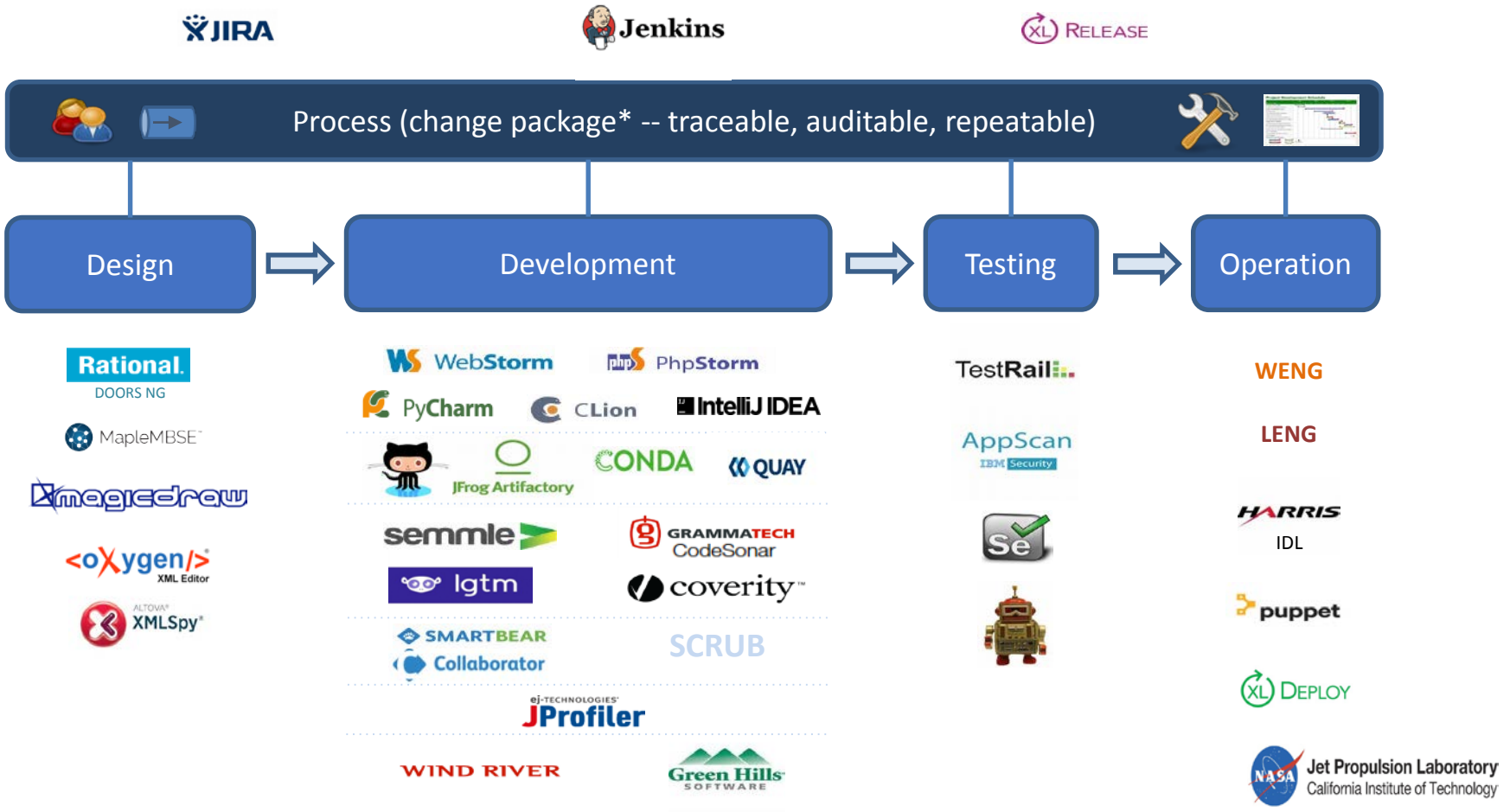
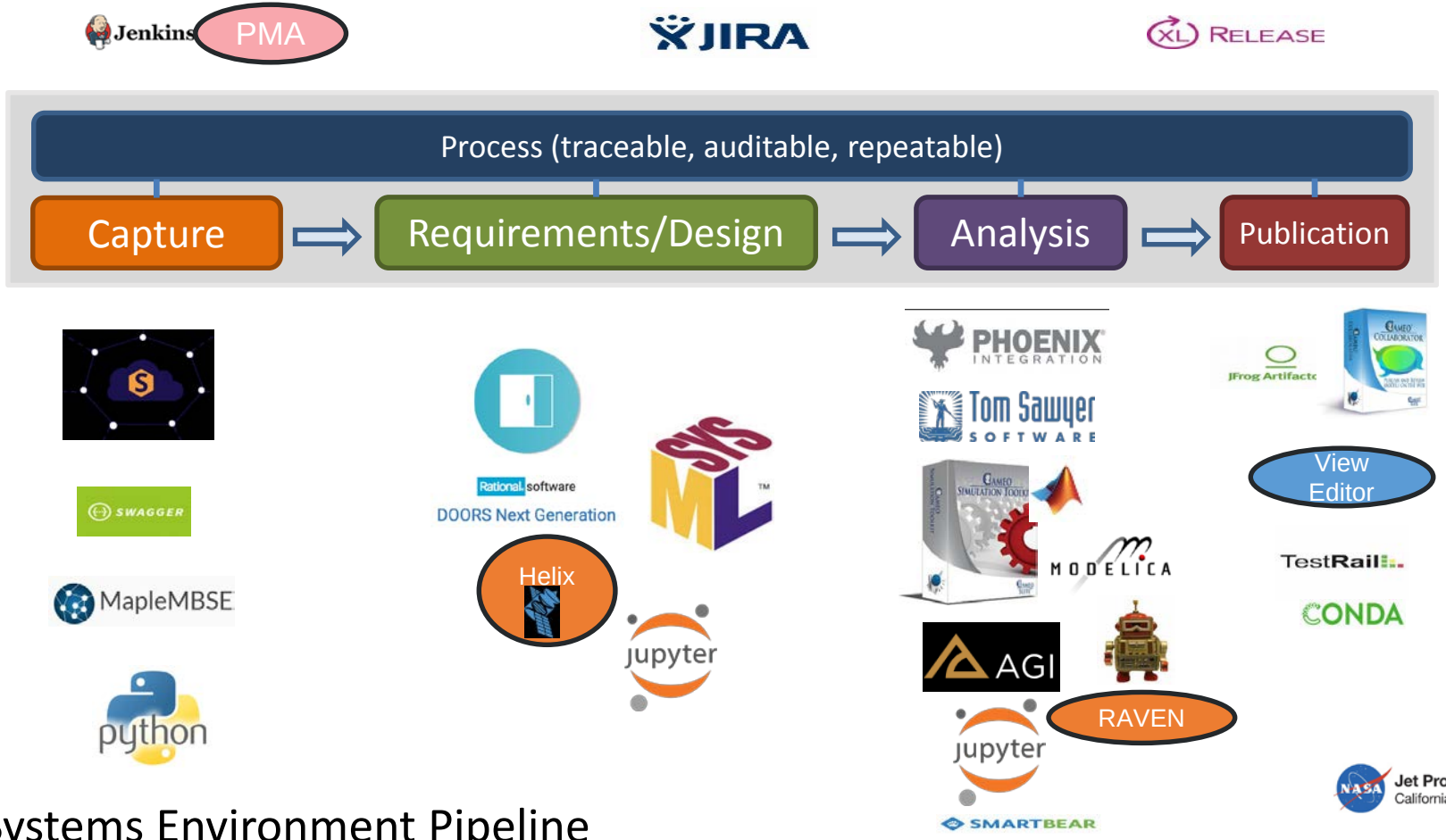


Safety-Critical Software Environment



Systems Environment Pipeline

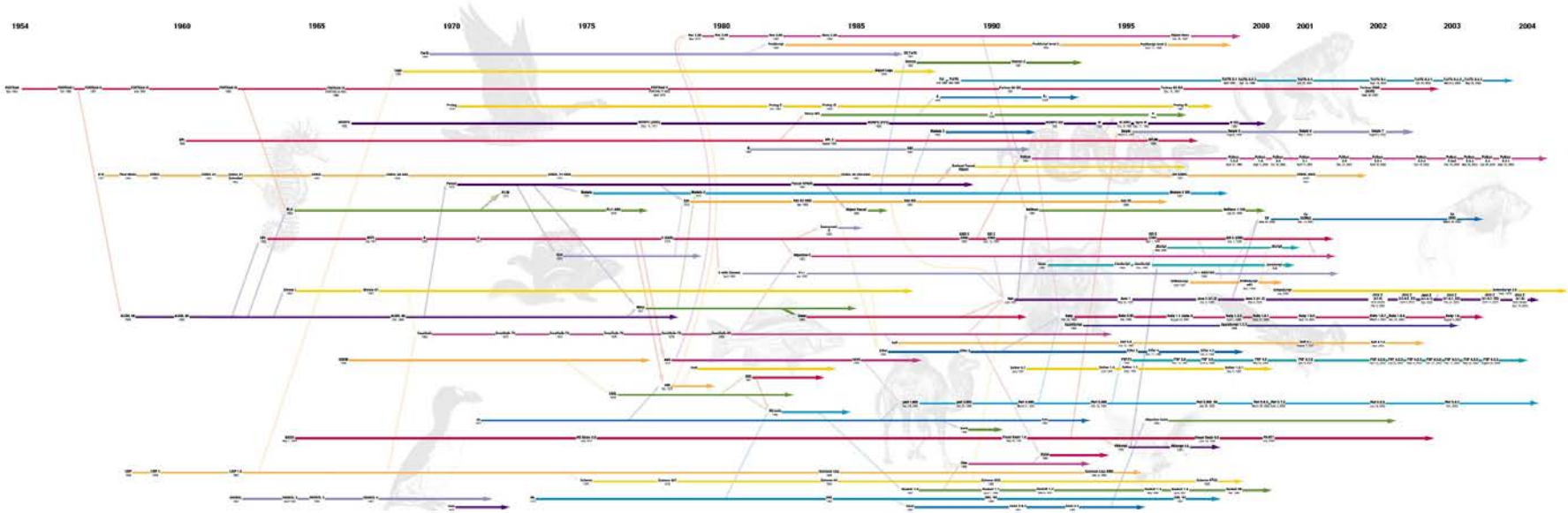
Modeling Languages

Graphical

Hybrid Graphical/Text

Code/Text

Information



Software Languages

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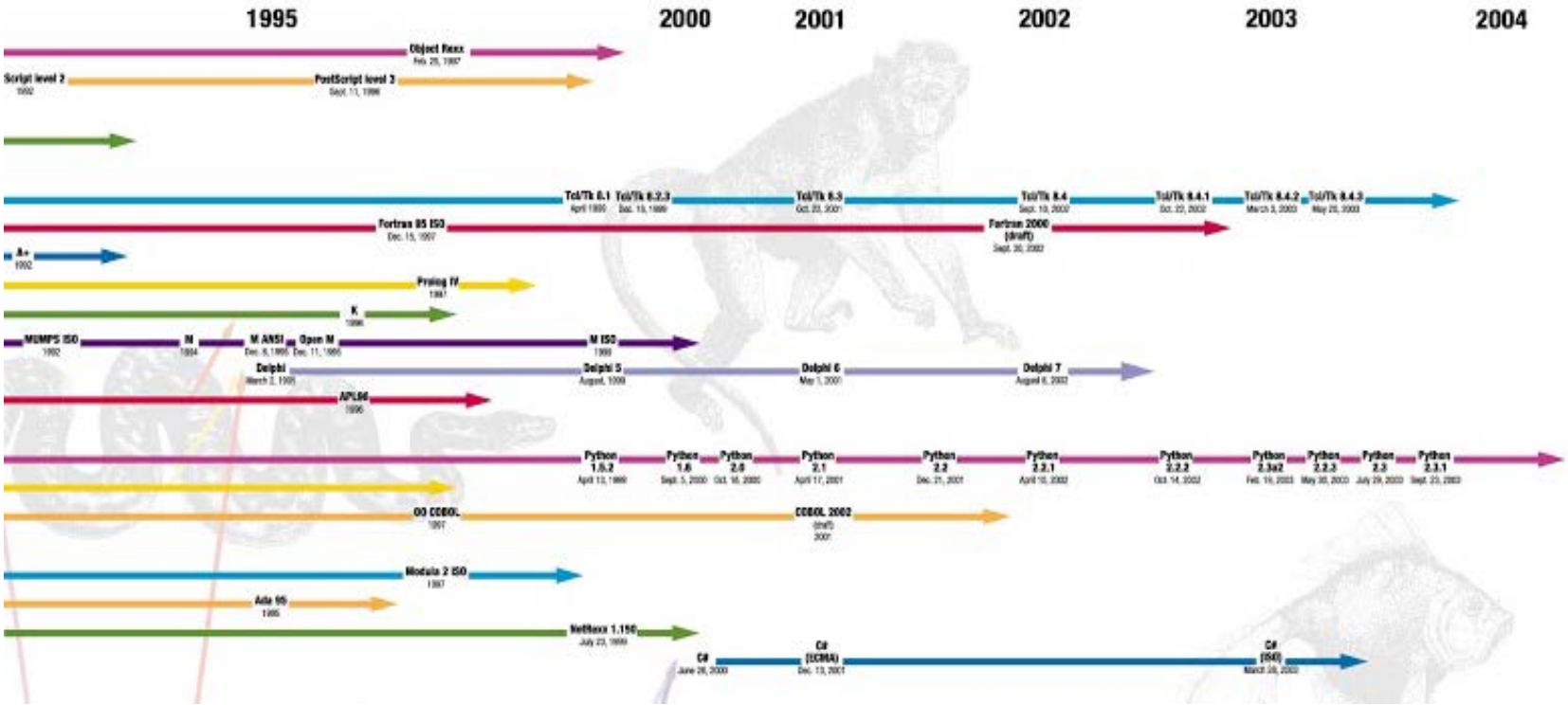


Software Languages

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

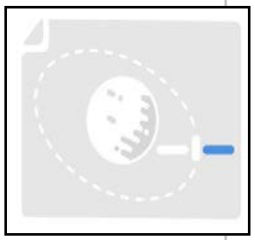
openmbee.org

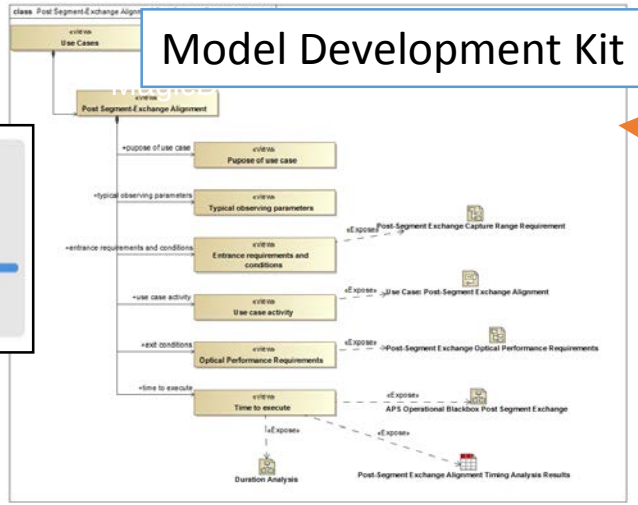
Open Model-Based Engineering Environment

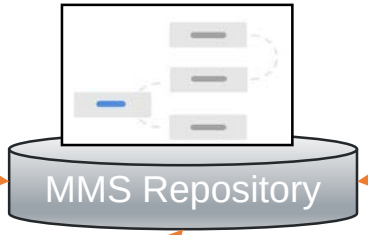
- OpenMBEE is a community for open source modeling software and models
  - Number of open source software activities
  - Number of open source models

- 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

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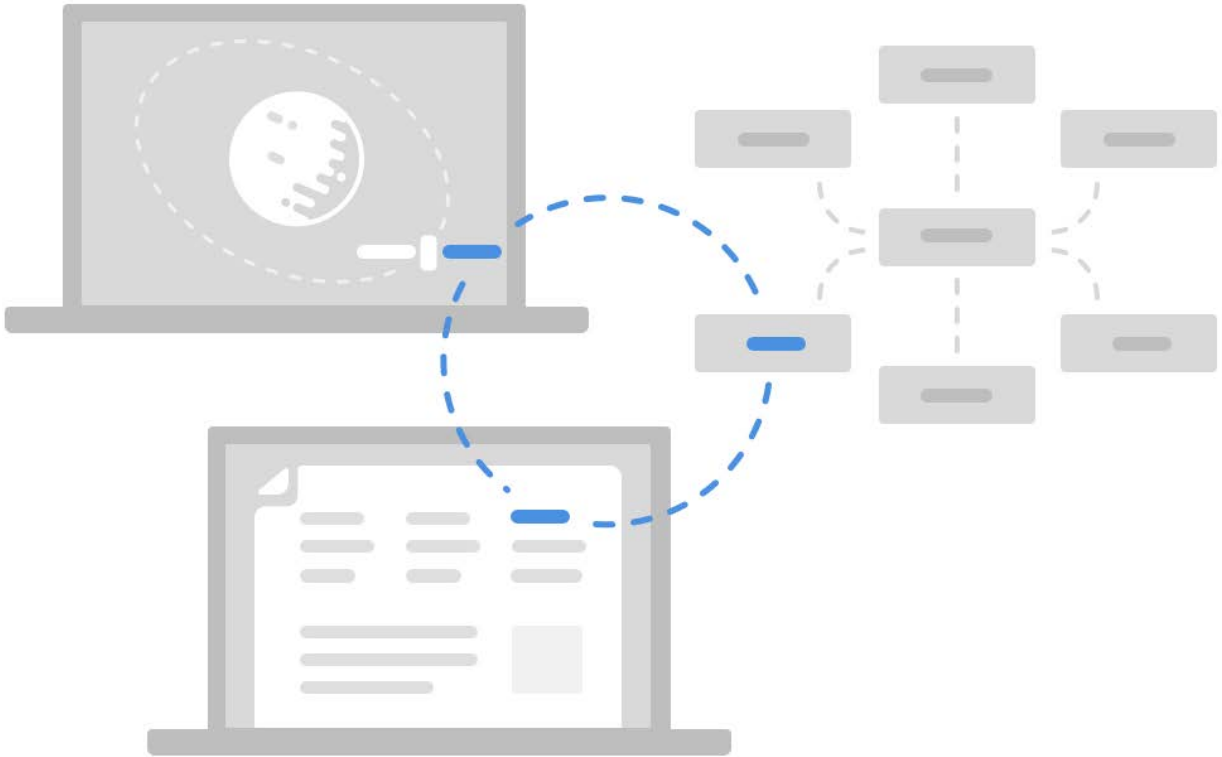
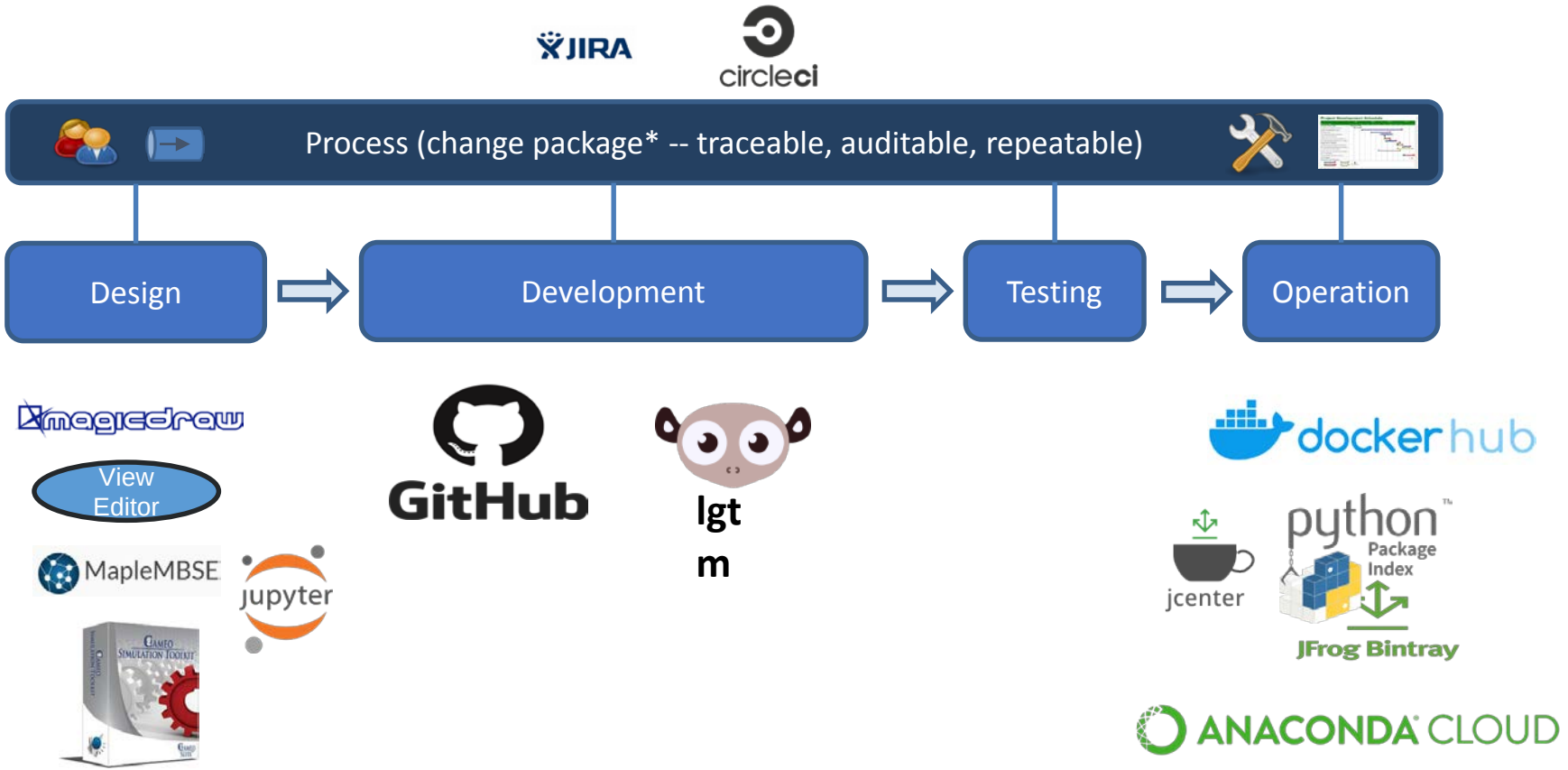
Linked Data Documents with Open MBEE





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

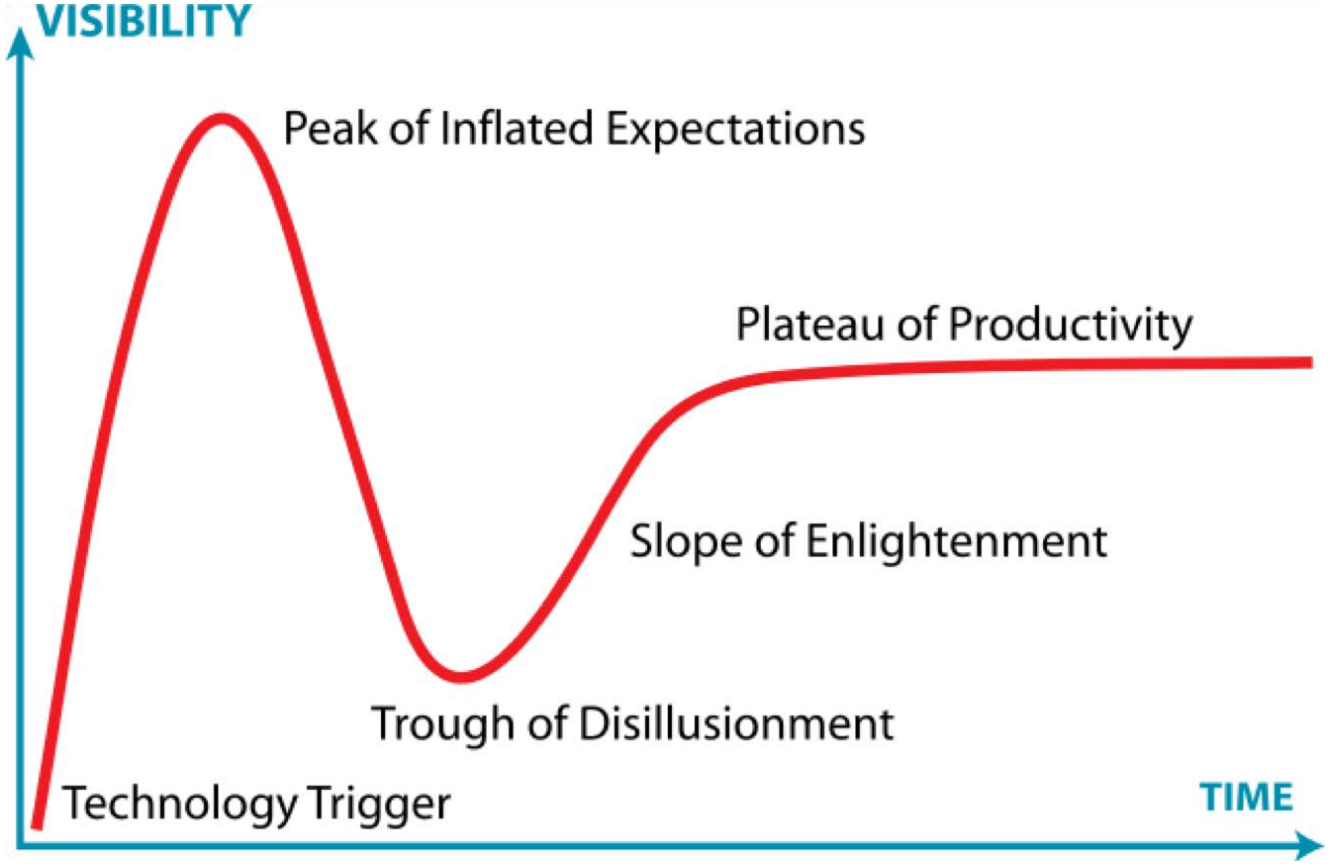
Human Challenges

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

Incorporating the Engineers

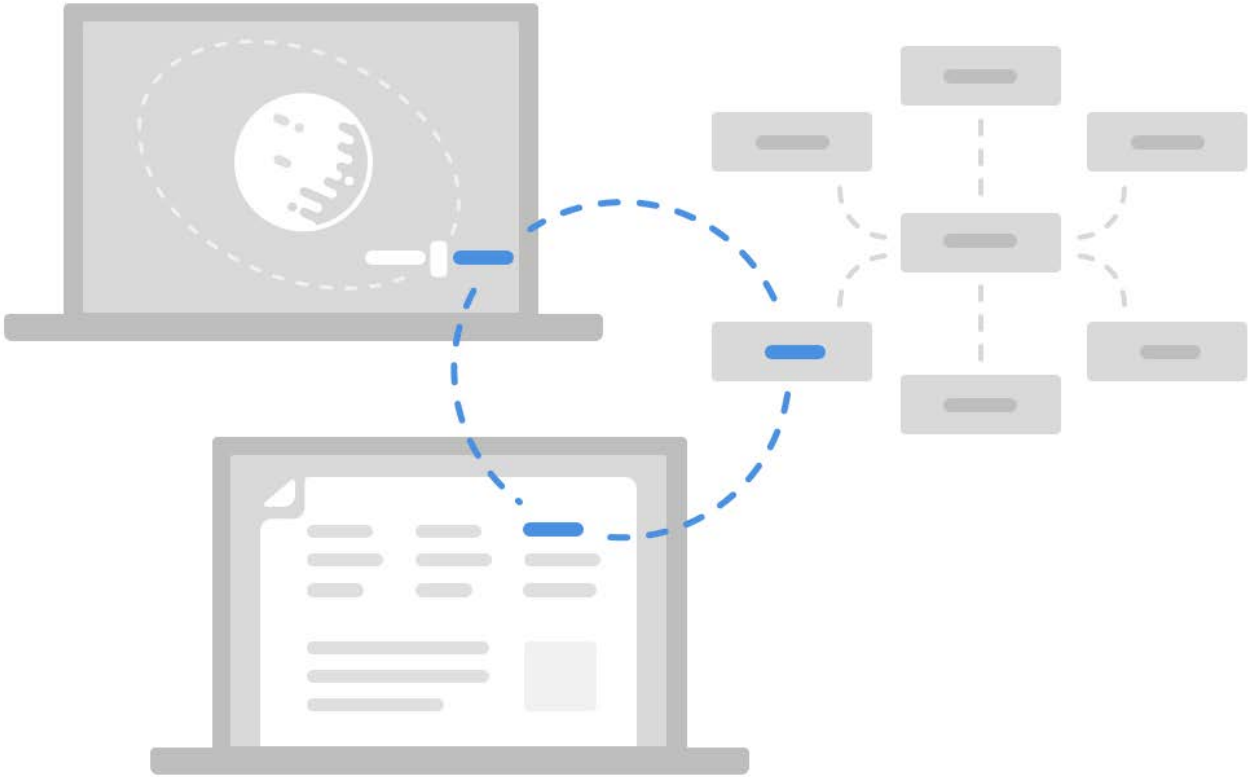
- Empathy
- Human Centered Design
- Incremental Improvement

Welcome to the World of Tomorrow



Path to Success

Unlocking the Power of Commodity Information



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- Abstractions for Executable and Checkable Fault Management Models, Corrina Gibson, RobertKarban, Luigi Andolfato, John Day, 2014 Conference on Systems Engineering Research
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- Open Source Engineering Environment: openmbee.org
- A Practical Guide to SysML, 3rd Edition, Chapter 17 by Friedenthal, Moore, and Steiner
- https://www.jpl.nasa.gov/spaceimages/
- Satellite by Made by Made from the Noun Project