Bringing System Modeling and Analysis Together at Enterprise Scale

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Problem Statement

A given flight project, whether CubeSat or flagship, must go through a huge number of trade studies, concept explorations, engineering change requests, what ifs, impact assessments … at the subsystem and system levels

At JPL, we are driving hard to connect systems architecture, requirements, design, and analysis via SysML-based tools

Problem Statement

Heavy bureaucracy to track and register every change in a document system

Try a "lightweight approach" that is quickly overcome by events

Inspiration

Open source communities have gathered large editor bases on large and distributed projects with surprising integrity:

- Wikipedia (30,000 English-language editors; 50,000 at peak)

- Git (20-80 edits per week, ~10 contributors)

- Alfresco (spikes of 100's of edits in a week, ~20 contributors)

Many Strategies and Observations

Strategies observed include:

- Do many small changes; fewer and simpler conflicts and edits than with many large ones

- Set regular regathering points and new baselines, which helps with above

- Employ a build / release manager for your technical design

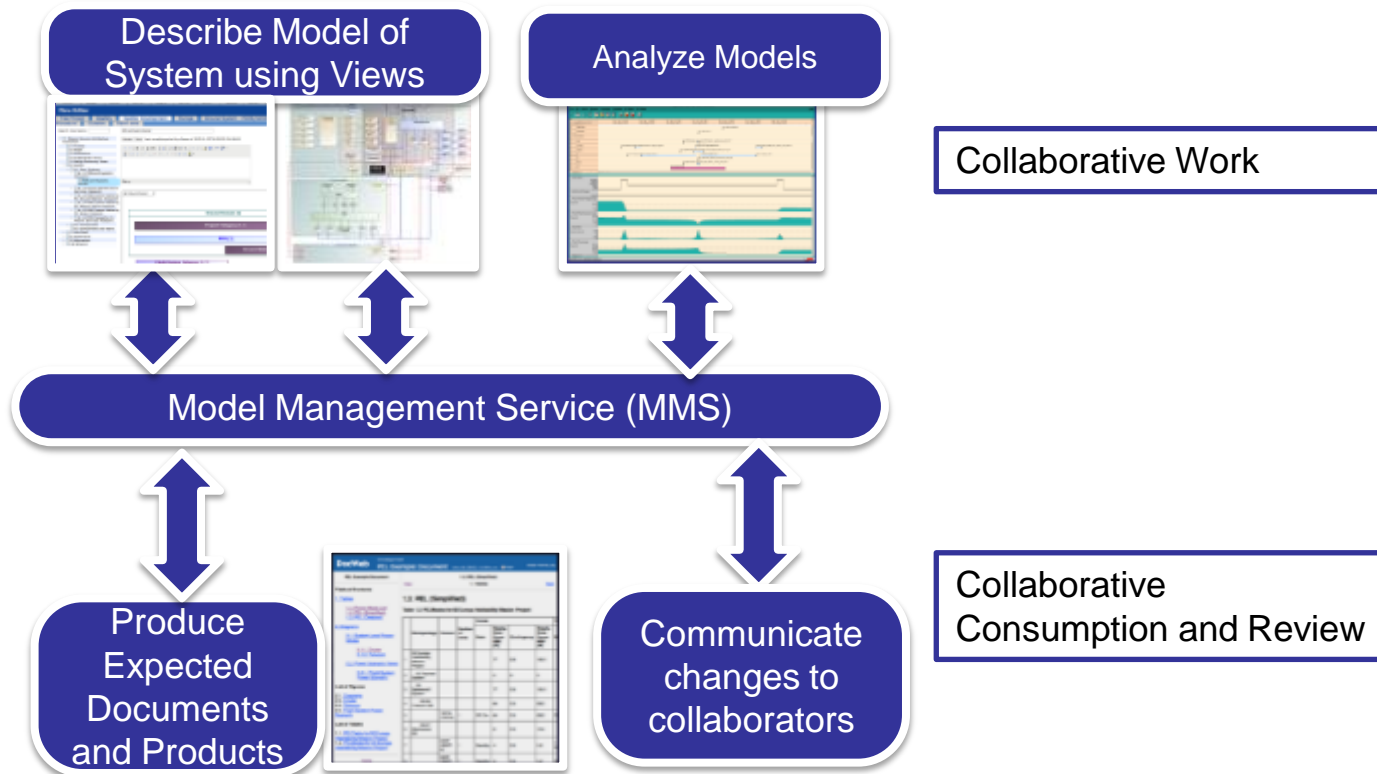- But before we get to that, let's talk about some software …
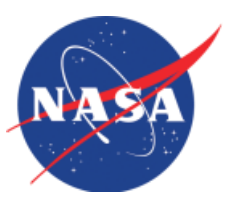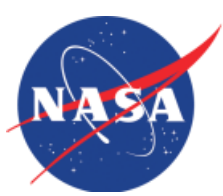
Open Model Based Engineering Environment (Open MBEE)

- An environment for describing, analyzing and communicating mutually correspondent engineering models.

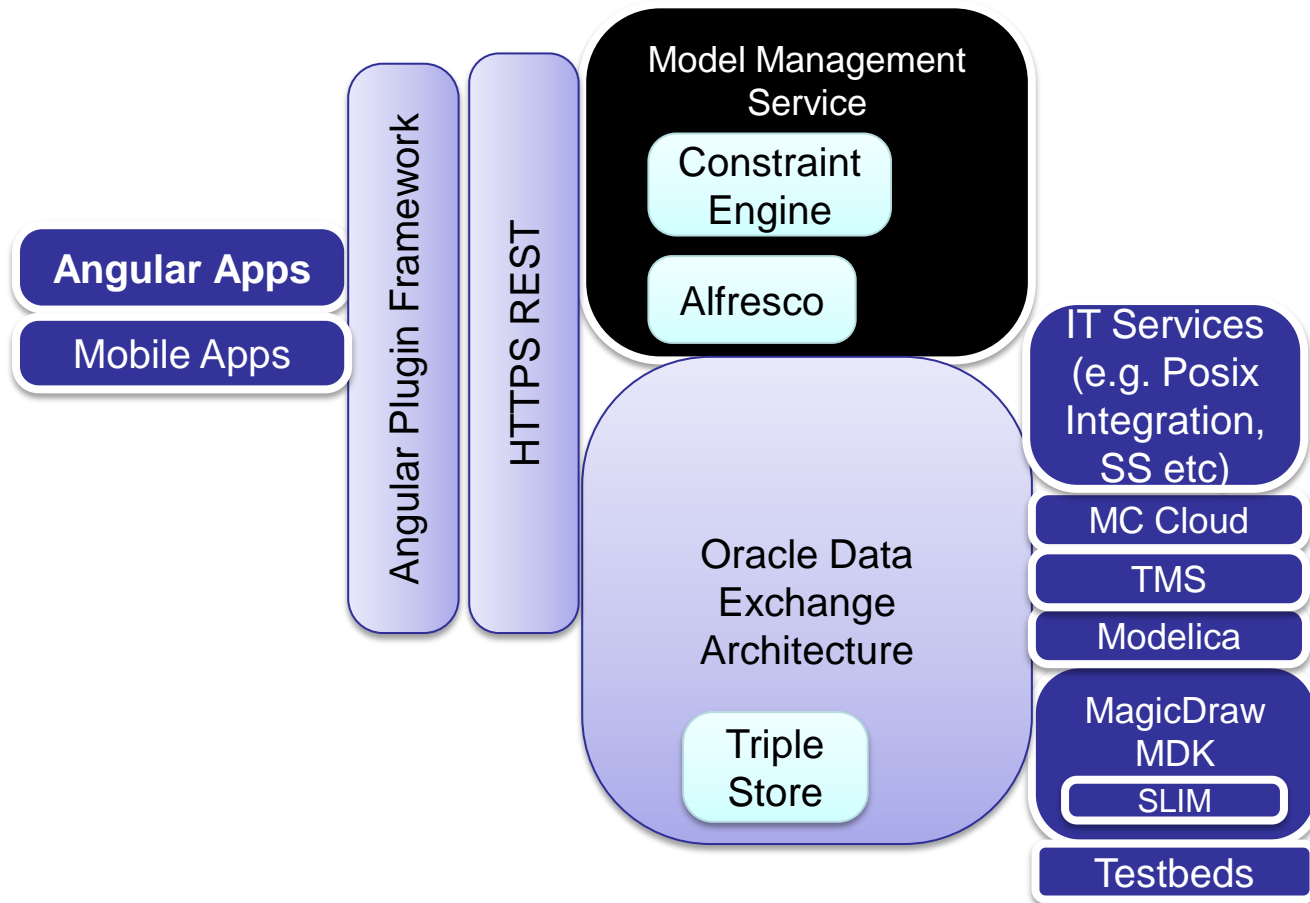- Supports modeling, reporting from the model, versioning, branching, and merging

Describe Analyze Communicate

MBEE System Realization

Angular Apps

Mobile Apps

Angular Plugin Framework

HTTPS REST

Model Management Service

Constraint Engine

Alfresco

Oracle Data Exchange Architecture

Triple Store

IT Services (e.g. Posix Integration, SS etc)

MC Cloud

TMS

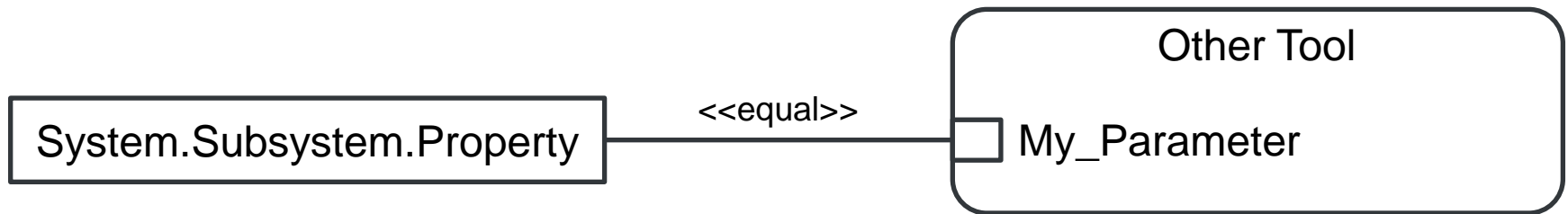Modelica

MagicDraw MDK

SLIM

Testbeds

Jumping Over to Analysis

Traditional Phoenix ModelCenter use case – build wrappers around analyses made by systems engineers and subsystem experts; mix of legacy and advanced tools

Hired builds for scriptwrapper capabilities for Wolfram Mathematica and Maplesoft symbolic engines (get Modelica tools for free!)
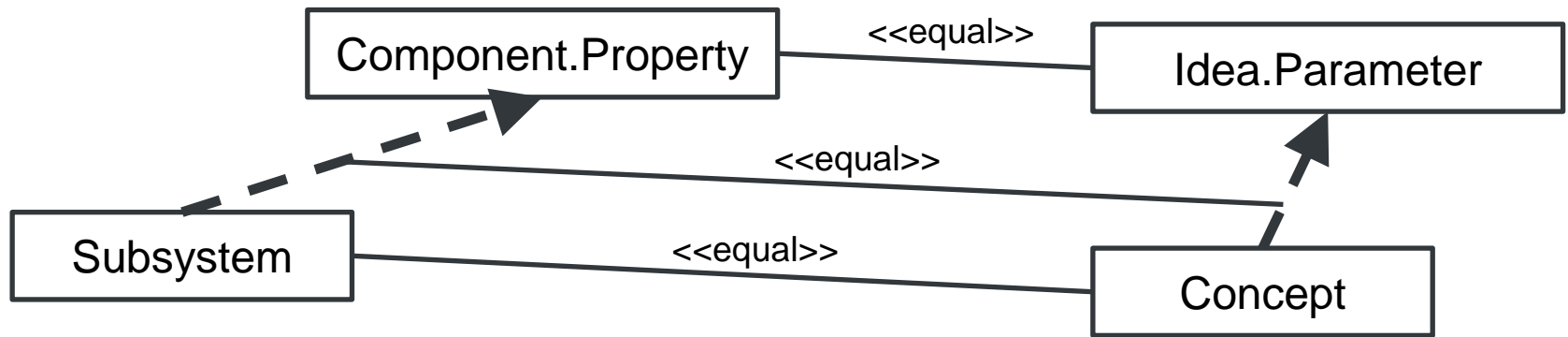
Generating partial input decks directly from the System model in multiple ways …
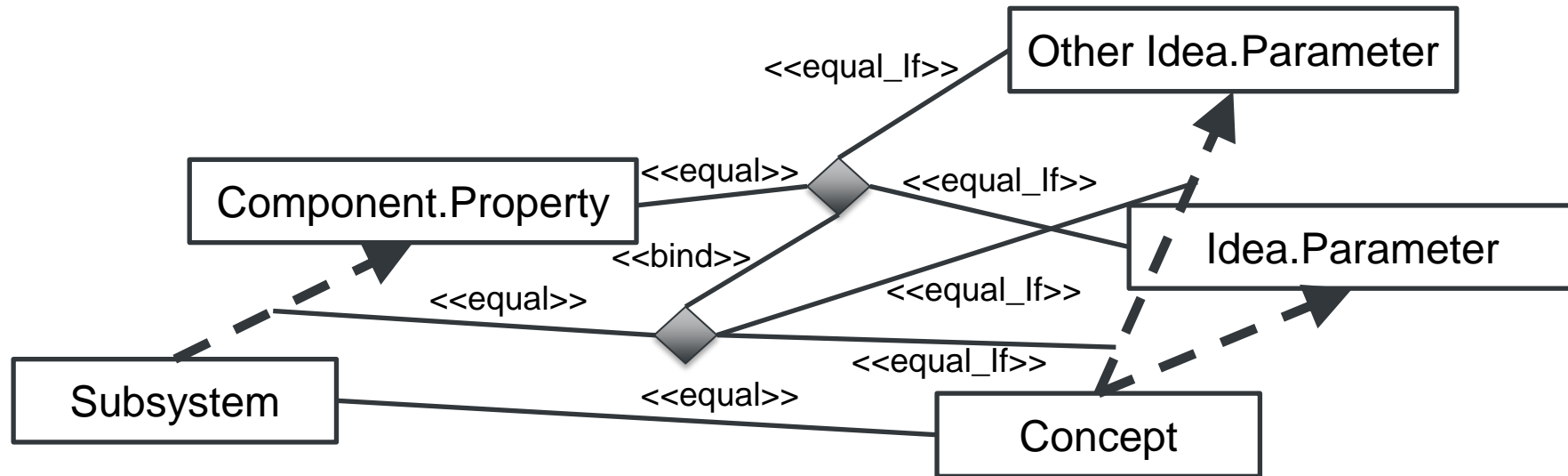
Transformation from the System Model

```
┌────────────────────────────────┐        ╭──────────────────────────────────╮
│                                │        │           Other Tool             │
│  System.Subsystem.Property     │─<<equal>>─□ My_Parameter                   │
│                                │        │                                  │
└────────────────────────────────┘        ╰──────────────────────────────────╯
```

Easy transformation – basic script wrapper and MBSE Pak
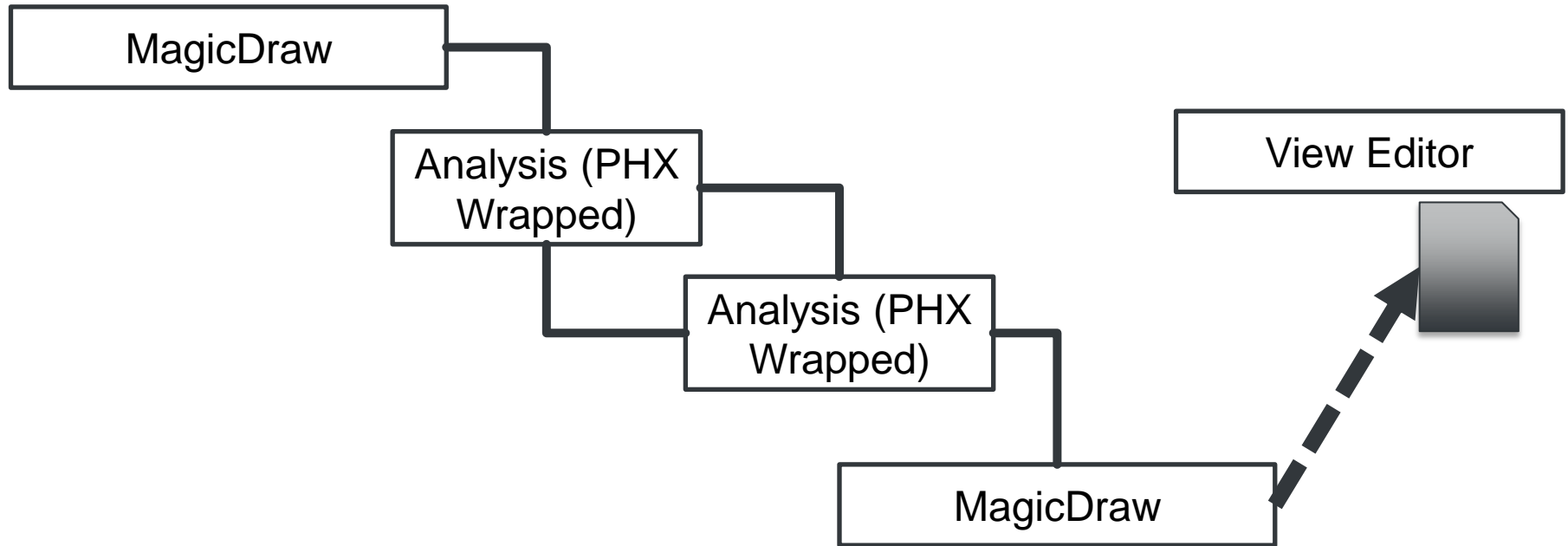
Transformation from the System Model

Relatively easy transformation; can also do in scripts fairly easily

Transformation from the System Model

Conditions, sub-ideas, and other non-unique mappings progressively make the problem harder but it can be done – know what you are getting into!
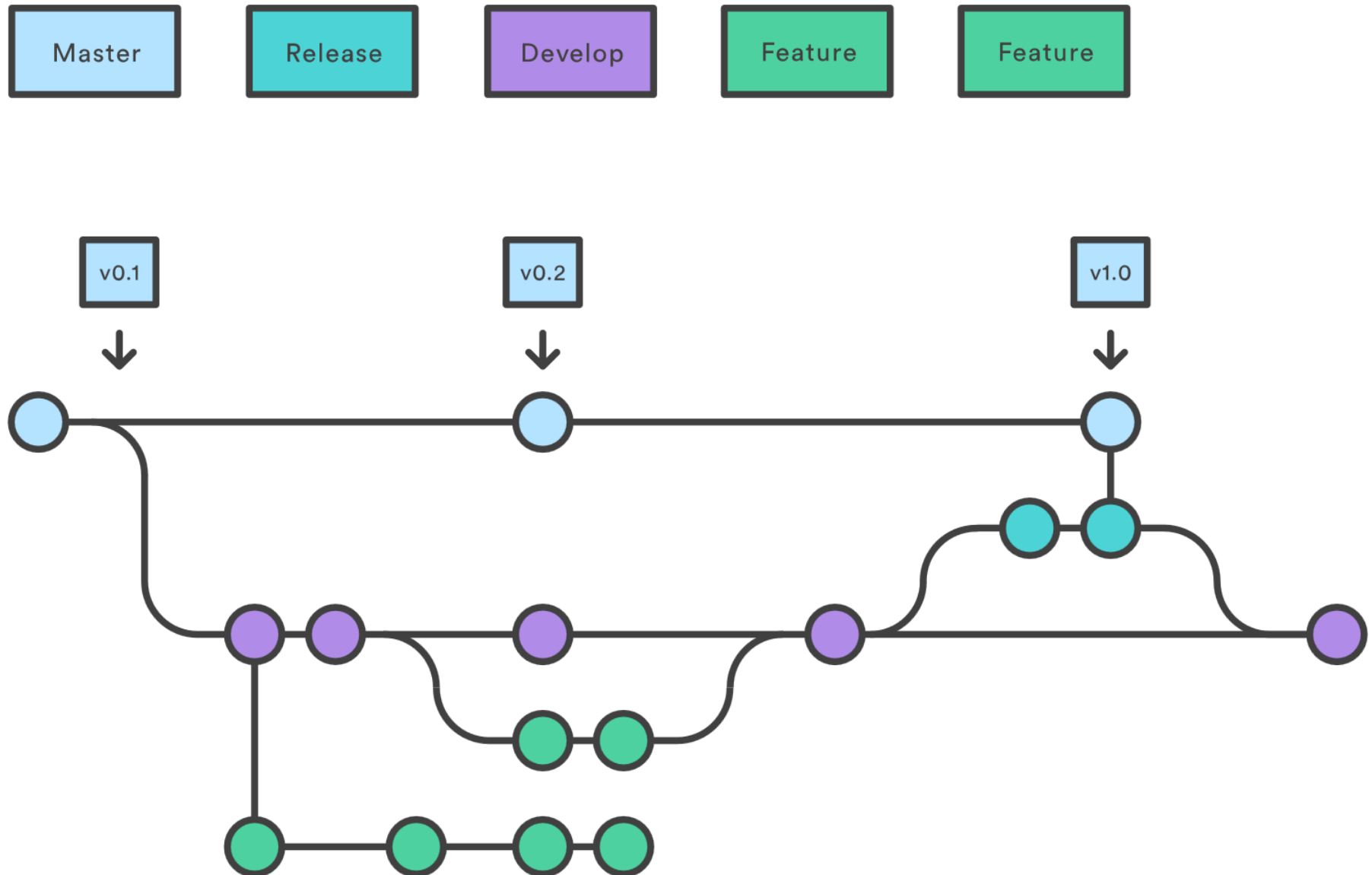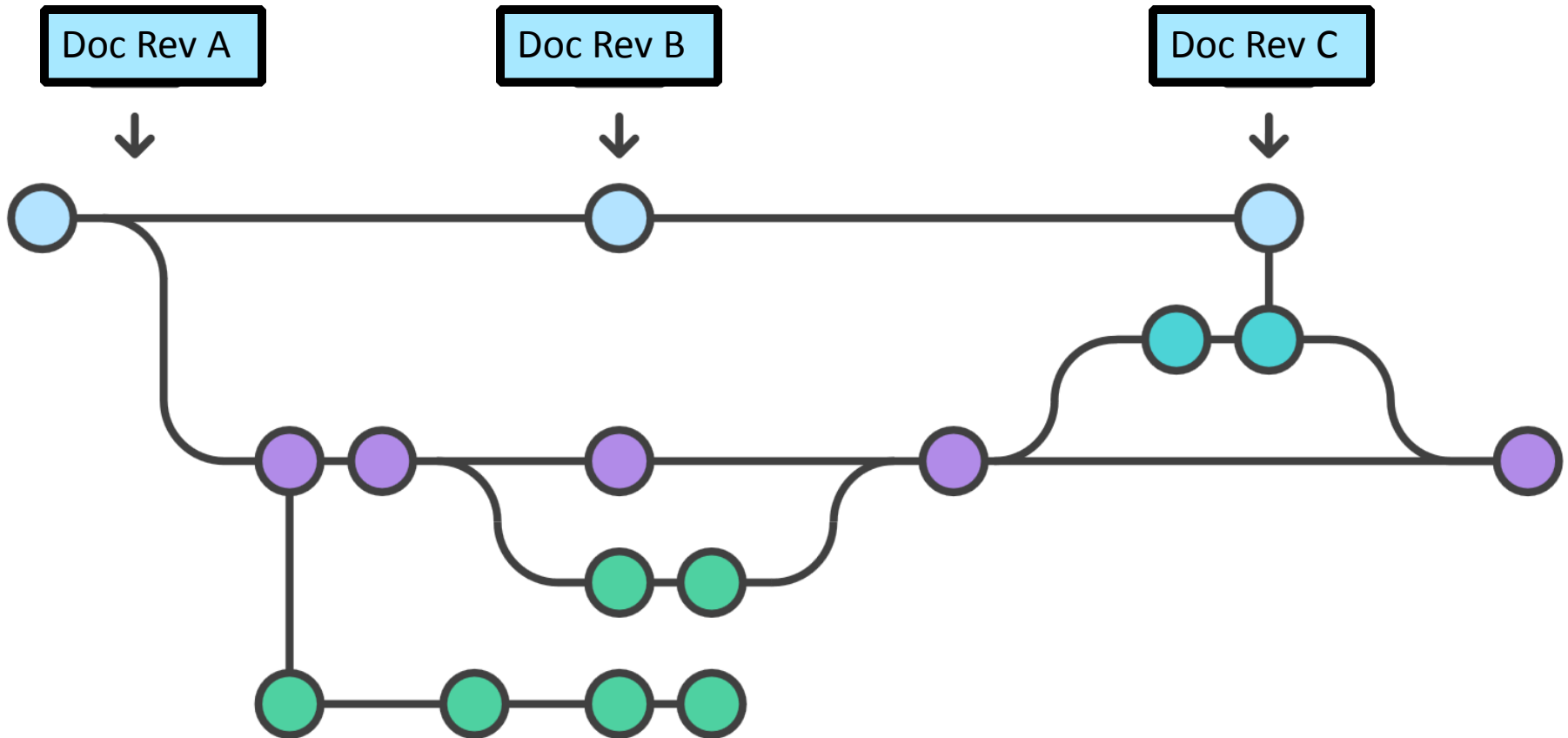
Overall Workflow

Sets up the analysis flow with the system model
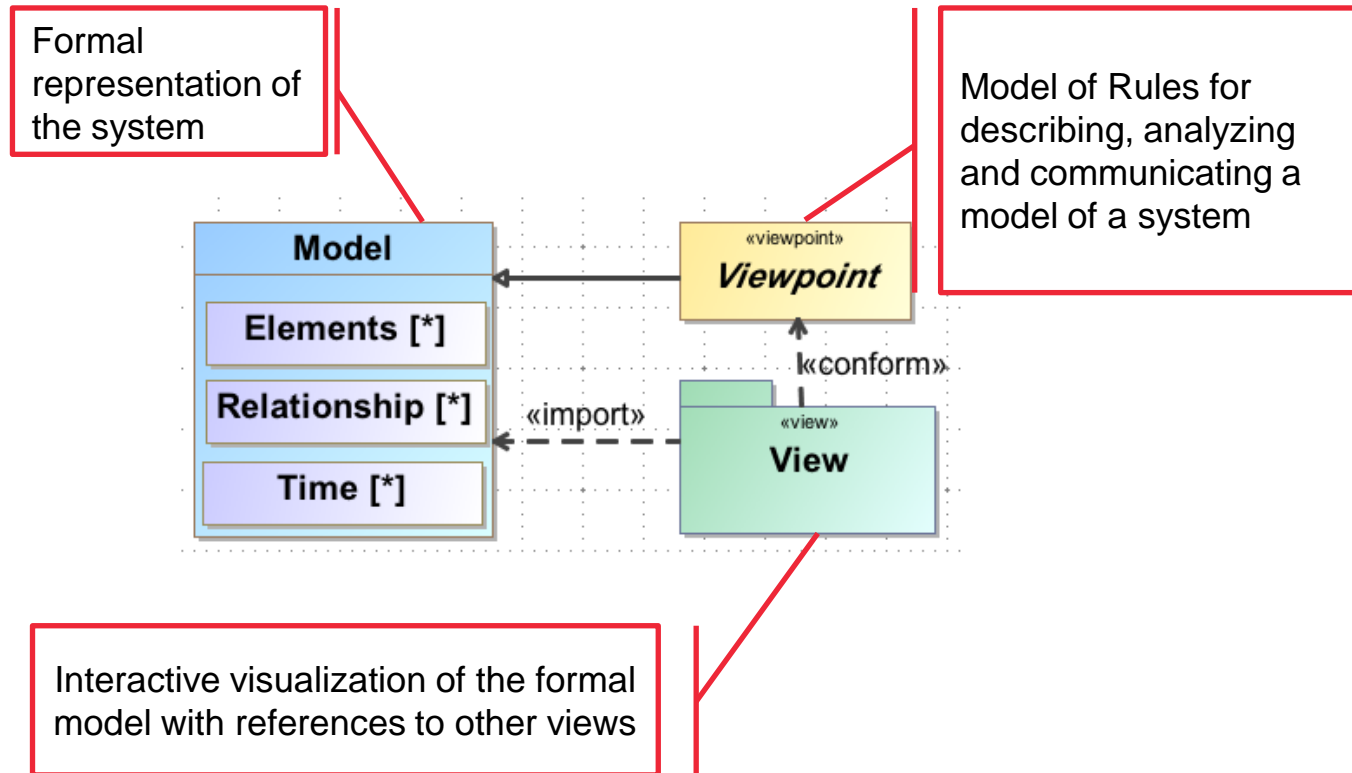Can mix MagicDraw and OpenMBEE above

Organization (h/t Atlassian)

Bringing System Modeling and Analysis Together at Enterprise Scale – Cole, Delp

Organization for Engineers

Baseline Release Develop Task Trade

Engineering Products

Doc Rev A

Doc Rev B

Doc Rev C

Viewpoint as a Foundational Concept

Formal representation of the system

Model of Rules for describing, analyzing and communicating a model of a system

Model
Elements [*]
Relationship [*]
Time [*]

«viewpoint»
Viewpoint

«conform»

«import»

«view»
View

Interactive visualization of the formal model with references to other views

Organization in the View Editor
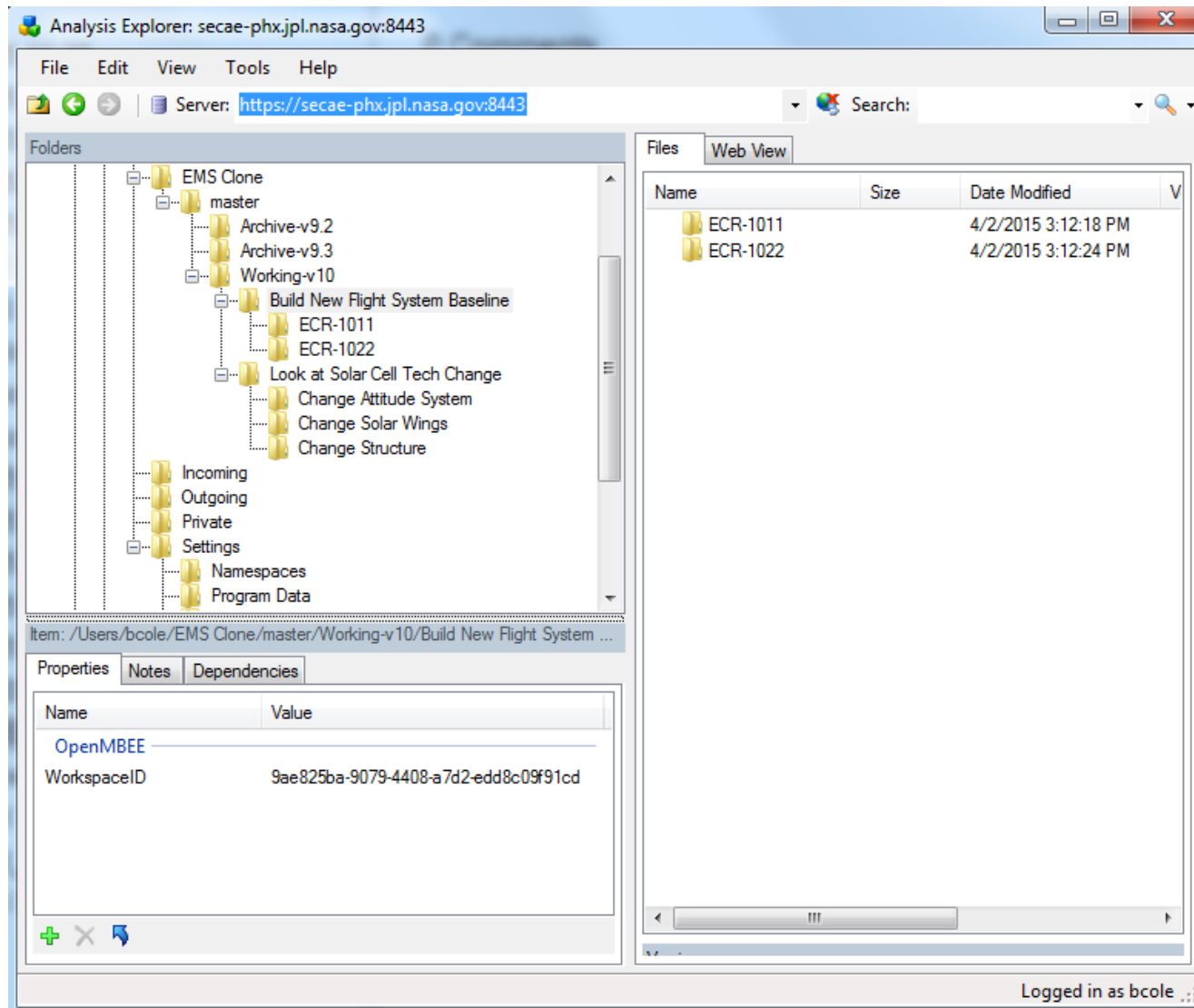
master »

Sites and Documents

0 Comments

▶ master

Working-v10

Look at Solar Cell Tech Change

Change Solar Wings

Change Attitude System

Change Structure

Build New Flight System Baseline
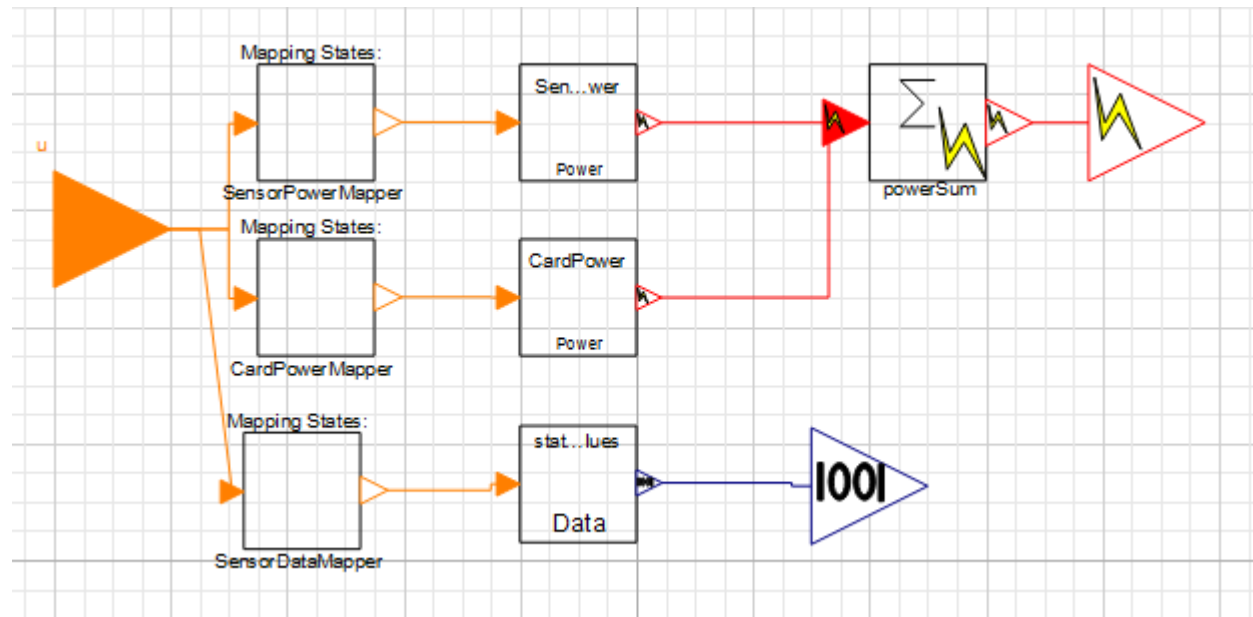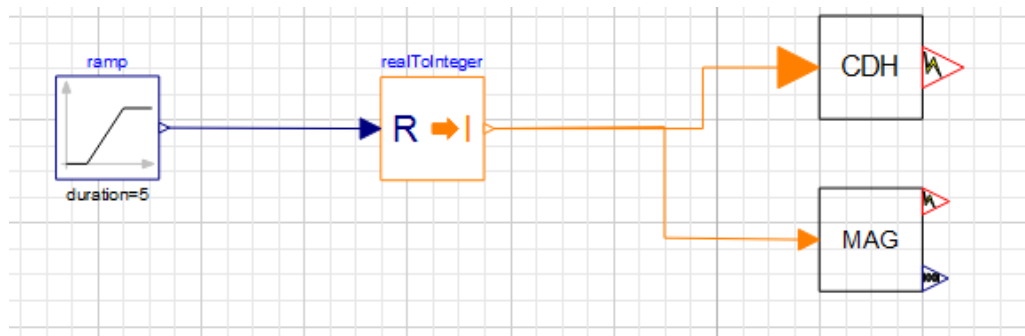
ECR-1011

ECR-1022

Archive-v9.3

Archive-v9.2

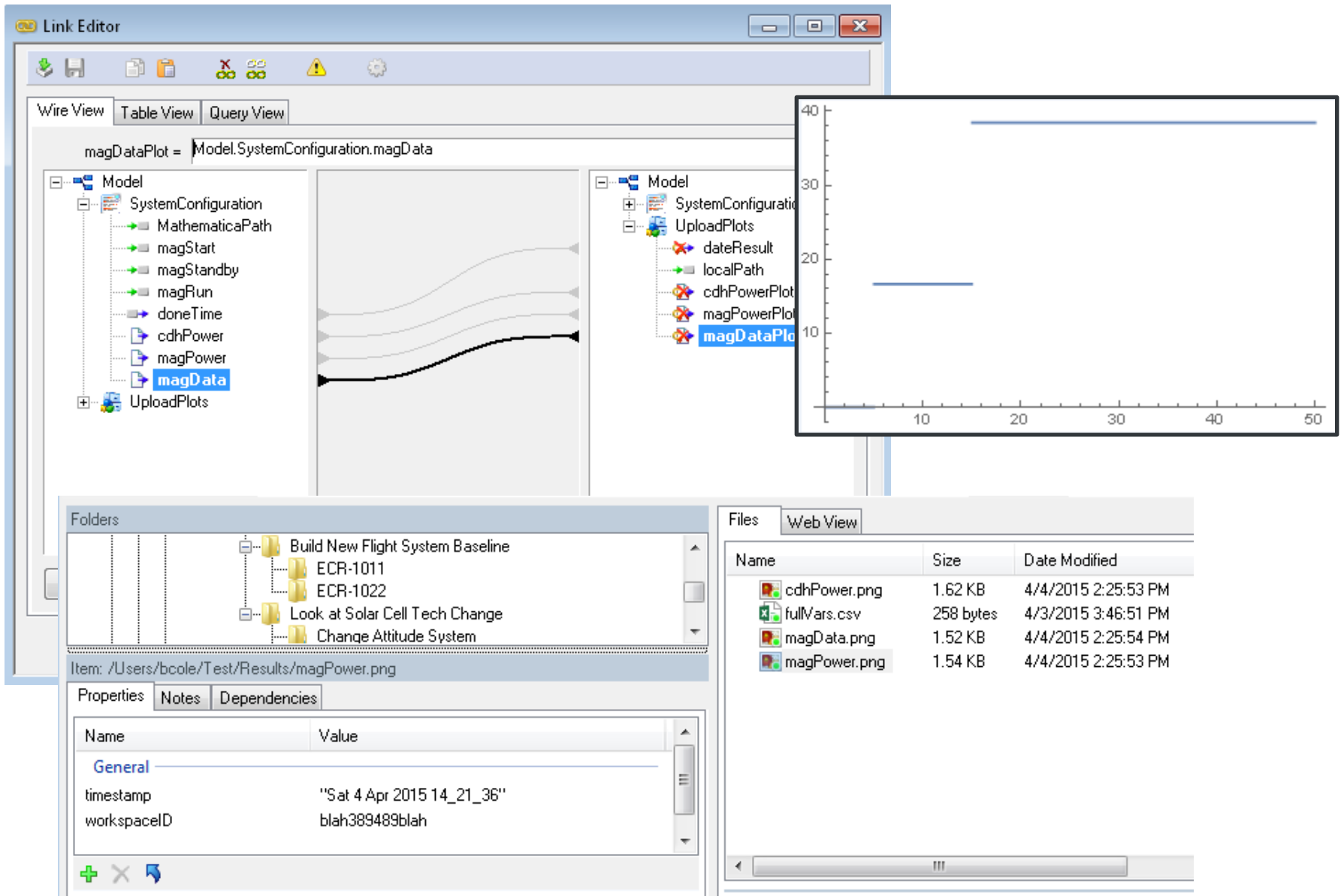Welcome to the Co

Incorporating MC Organize

Example: Configuration Driven by System Model

Example: Upload to MC Organize

Managing Results Data with MC Organize

Mirror package structure from OpenMBEE; can use the behavior of .analysisLibrary wrappers in ModelCenter to create folders as needed

Hired a custom "Plot Indexer" example to automatically tag up groups of executions for inclusion into the View Editor as they are made (or update existing plots)

Managing Analysis Versions with MC Organize

Can also mark up analyses with version information

New PacZ file format controls configuration and checks for needed tools and versions

Librarian interfaces in Analysis Server can work with controlled versions

Building Resultant Views

OpenMBEE has custom View Service for manipulating and updating view information including graphs

OpenMBEE has custom Element Service to allow for updating values that have been transcluded into a value as well as reporting revision history, including timestamp and branch

Summary

OpenMBEE and ModelCenter Cloud together represent a powerful capability for managing a wide variety of engineering analyses as needed for large organizations

System architecting, requirements development, and analysis are becoming progressively more seamless as our toolbase matures

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California Institute of Technology

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