Using AP239 for a Publish-Subscribe Architecture

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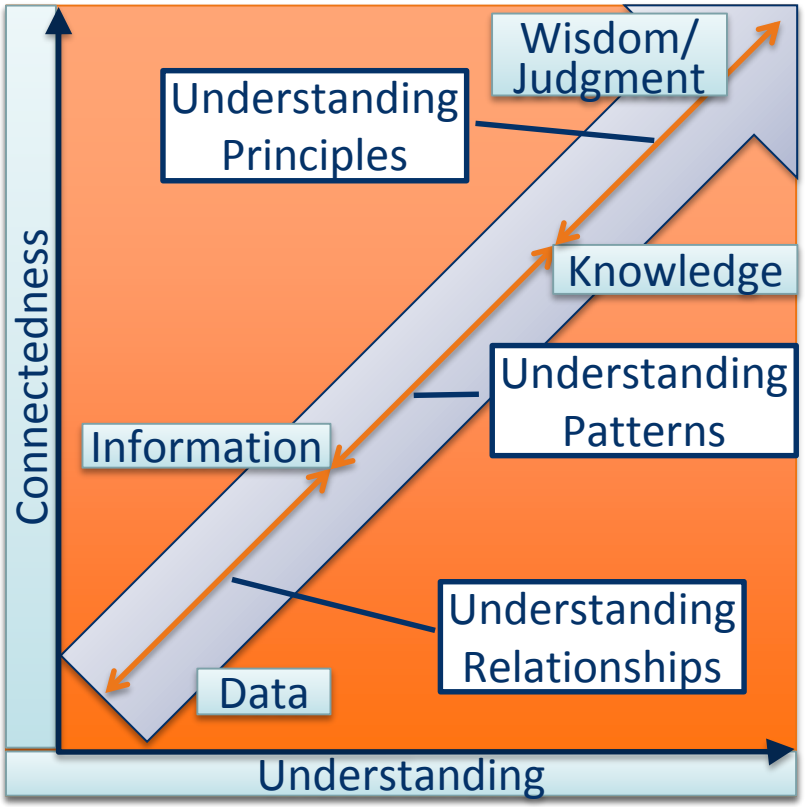
What Are Your MBSE Data Interoperability Use Cases?

- **Audience Input**

Why STEP 233/239?

- 80% of product development success relates back to the development activities in the early phases.
- Virtual Product development helps the organization cope with
  - large product scope;
  - product & process complexity;
  - diverse management & maintenance.
- Virtual product development is a collaborative activity of diverse contributors to translate market/customer needs to system(s) functions.

MBE: Complex Systems Judgment



Adapted From: http://www.systems-thinking.org/dikw/dikw.htm

Early Phase Flourishing—*Delivered Business Success*

- **Early Phases are characterized by:**
  - Dynamic – Aligning Product Features to Changing Conditions
  - Evolutionary – Gradually Emerging Patterns
  - Vague – Loose and Fuzzy Product Requirements
  - Incomplete & Sometimes Conflicting Specifications
  - Imprecise Product Defining Data Managed on Heterogeneous

Trust & Belief

Note:

✓ "*knowledge*" is the content of a thought in the individual's mind, which is characterized by the individual's justifiable belief that it is true;

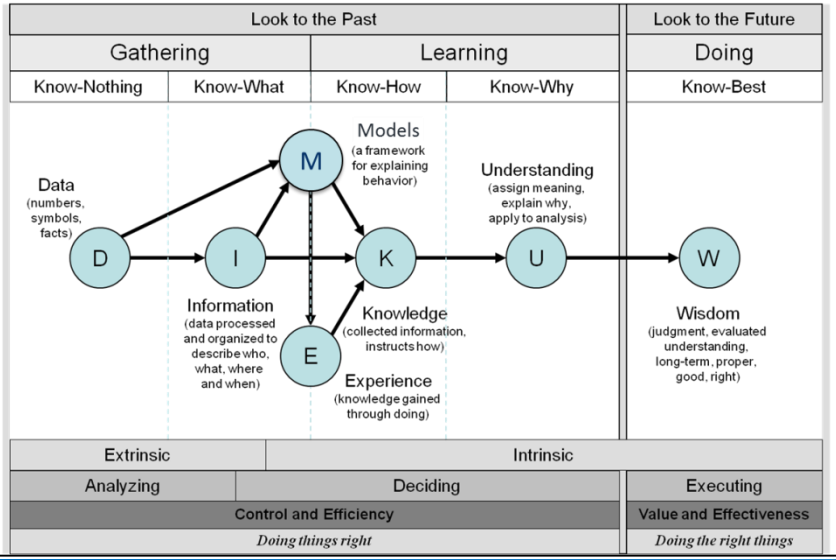
✓ while *"knowing"* is a state of mind which is characterized by the three conditions:

(1) the individual believe that it is true,

(2) S/he can justify it, and

(3) It is true, or it is appear to be true.

Data Ascending to Future Implications



Adapted from: Systemswiki.org 2012 (Public Domain)

Example MBSE Data Interoperability Use Cases

- **Requirements exchange**
- **Inter-organization model management**
- **Multi-domain inter-model analysis**
- **Publish-Subscribe Architecture**

Publish-Subscribe Architecture

- **Publish-Subscribe model**
  - **“Producers” and ”Consumers”**
  - **Power**
  - **Information**
  - **Fluids**
  - **Signals**
  - **Information**
- **Linked models**
  - **MCAD (Mechanical Computer Aided Design)**
  - **Wiring harness**
  - **Hydraulics**
  - **ECAD (Electrical Computer Aided Design)**
  - **Behavior**

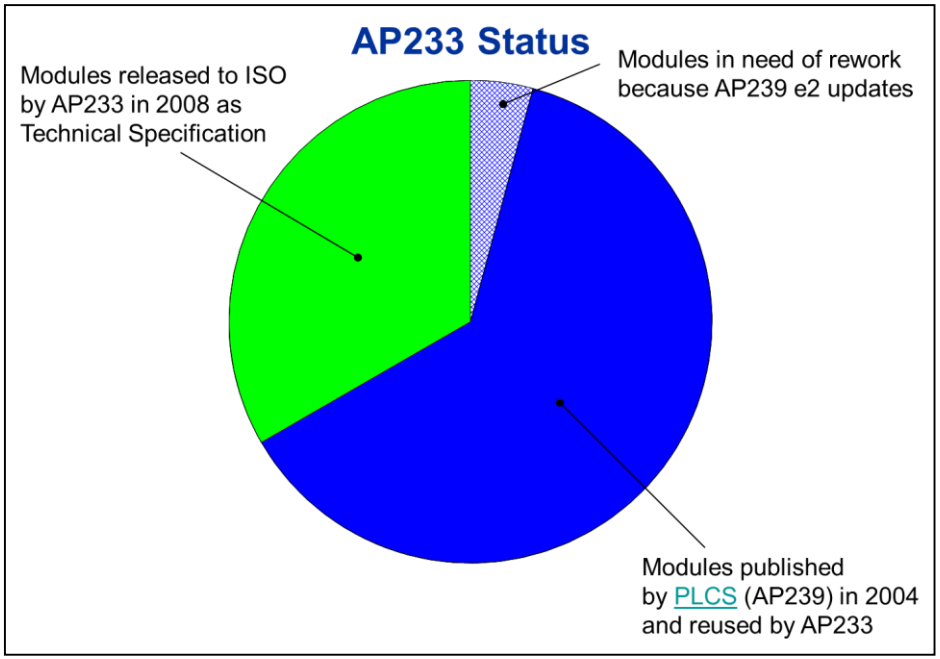
What is AP239?

- **Audience Input**

AP239 and Reuse in AP233

- ISO 10303-239 (PLCS) is an international standard that specifies an information model that defines what information can be exchanged and represented to support a product through life.

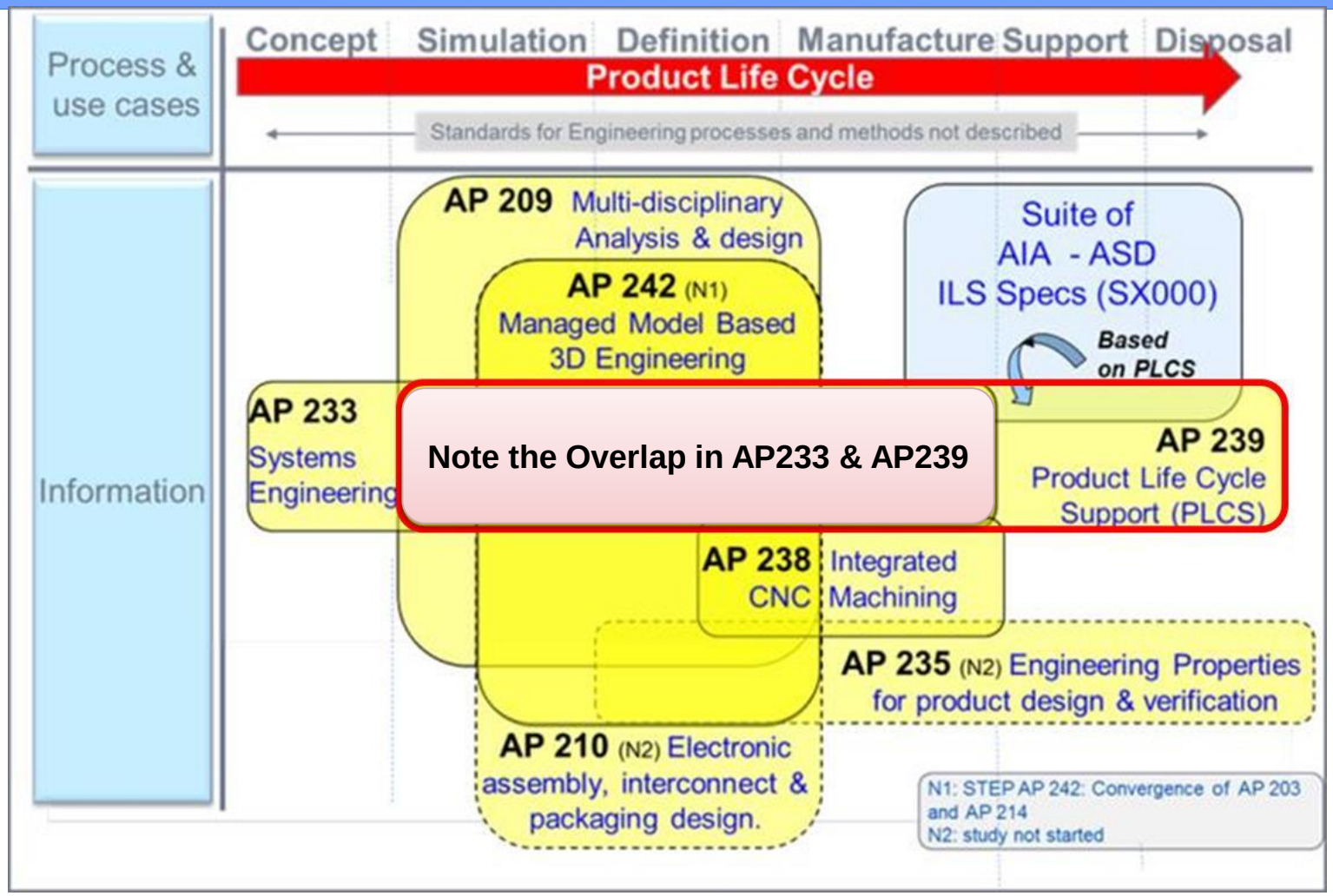
- ISO 10303 AP 239 (PLCS) seeks to provide a mechanism to maintain the information needed to support complex products and systems such as ships, aircraft, engines, or oil platforms, in line with the changing product over its complete life cycle from **concept through design and manufacture to operation and disposal**.



Contact: Yves Baudier, Airbus Group, Rick Zuray, Boeing, to join this project

Georg Siebes, 11th NASA/ESA Workshop on Product Data Exchange, Copyright 2009 California Institute of Technology Government Sponsorship Acknowledged

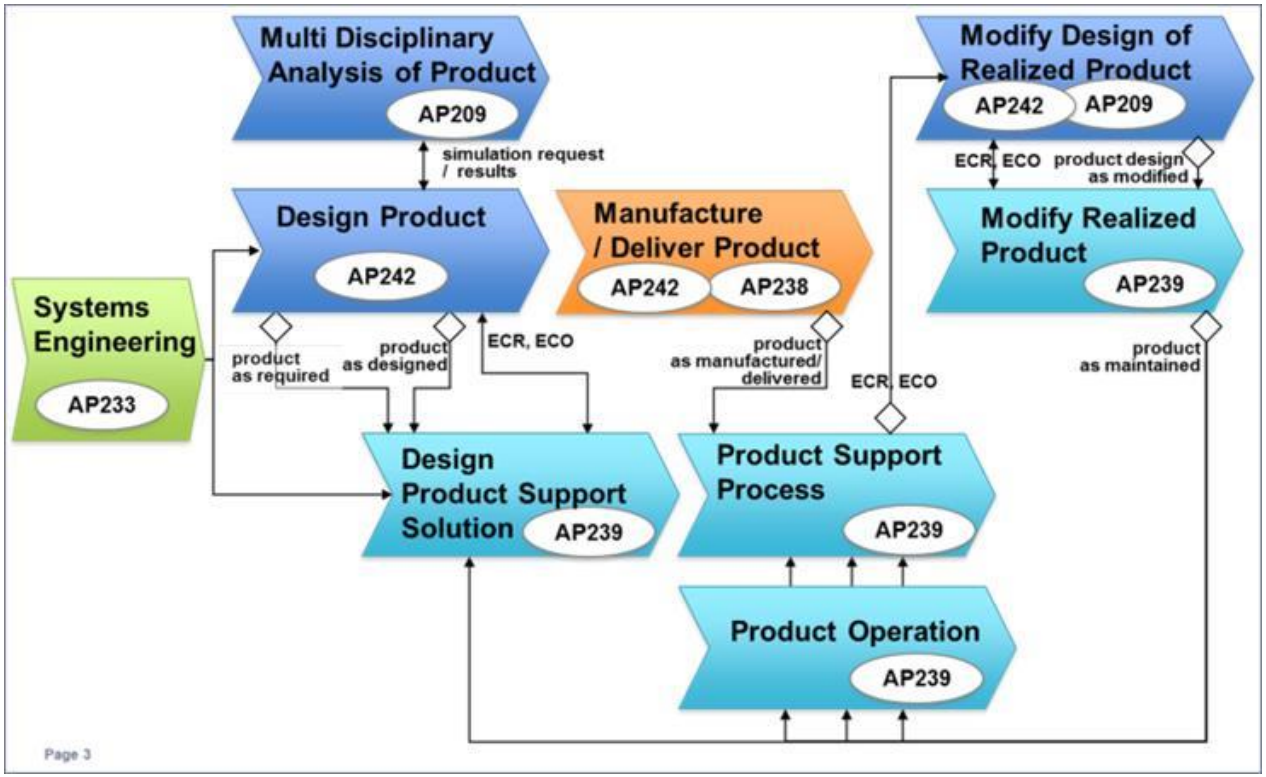
ISO 10303 STEP Modular Application Protocols



http://www.asd-ssg.org/step-ap239-ed3;jsessionid=76ea46ac41acb45512eb775eaf21

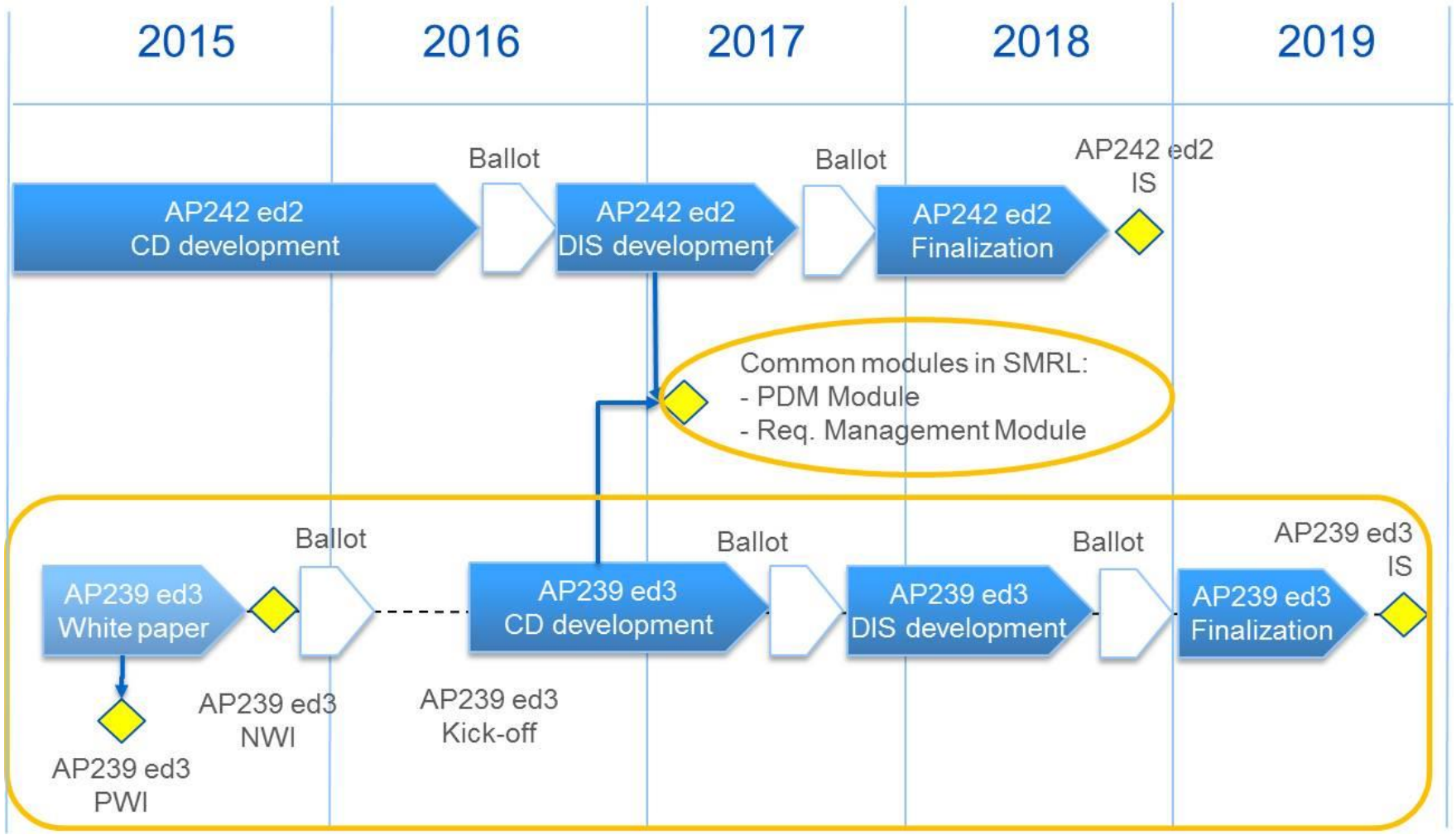
Relationship Between STEP Modular Application Protocols

Together these STEP Application Protocols will be the foundation for ILS (Integrated Logistics Support) specifications, for developing the support solution based on product design data and support requirements, to maintaining the product and providing feedback to Aerospace and Defense industries. This should extend the use of STEP by the main manufacturing industries and the support by PLM software suppliers and integrators.



http://www.asd-ssg.org/step-ap239-ed3;jsessionid=76ea46ac41acb45512eb775eaf21

STEP AP239 Maturity



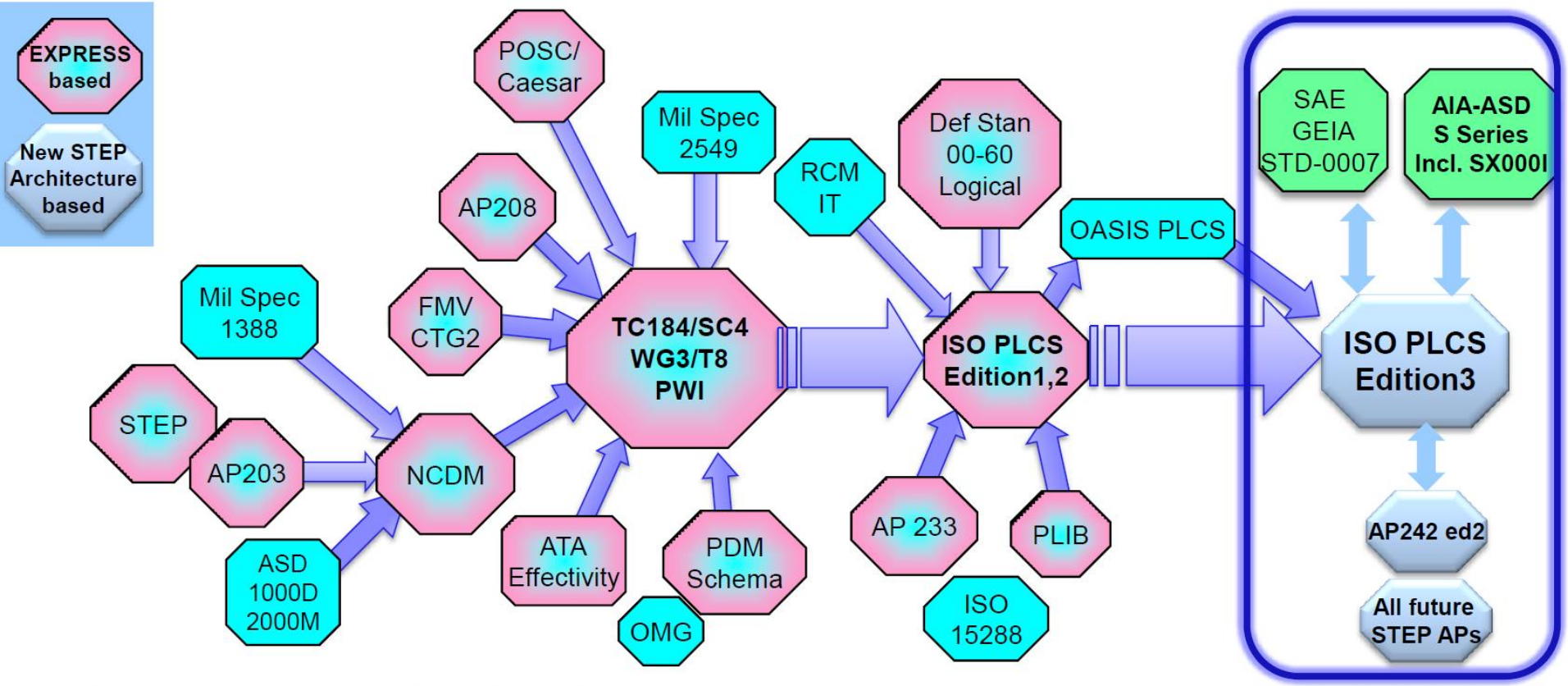
http://www.asd-ssg.org/step-ap239-ed3;jsessionid=76ea46ac41acb45512eb775eaf21

Merging Standards

ASD
E-Business SSG

History

Towards a consistent set of standards



What Can AP239 Do for a Publish-Subscribe Model?

- **The following SAVI (Systems Architecture Virtual Integration) example shows some possibilities**
- **SAVI approach:**

Models – increasing number and complexity

↓

Find and fix errors before build

↓

Inter-model consistency checking, simulation, analysis

SAVI Example

- **SAVI**
  - **Start simple, then expand complexity**
    - **ECAD-MCAD integration**
    - **“Publish-Subscribe” system interconnect table**
- **Model Repository and Data Extraction Layer**
  - **AP239-based data model**

SAVI Project

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Rockwell Collins

NASA

SIKORSKY
A LOCKHEED MARTIN COMPANY

Honeywell

Software Engineering Institute

GE

SAVI
System Architecture Virtual Integration

AIRBUS

FEDERAL AVIATION ADMINISTRATION

BOEING

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

EMBRAER

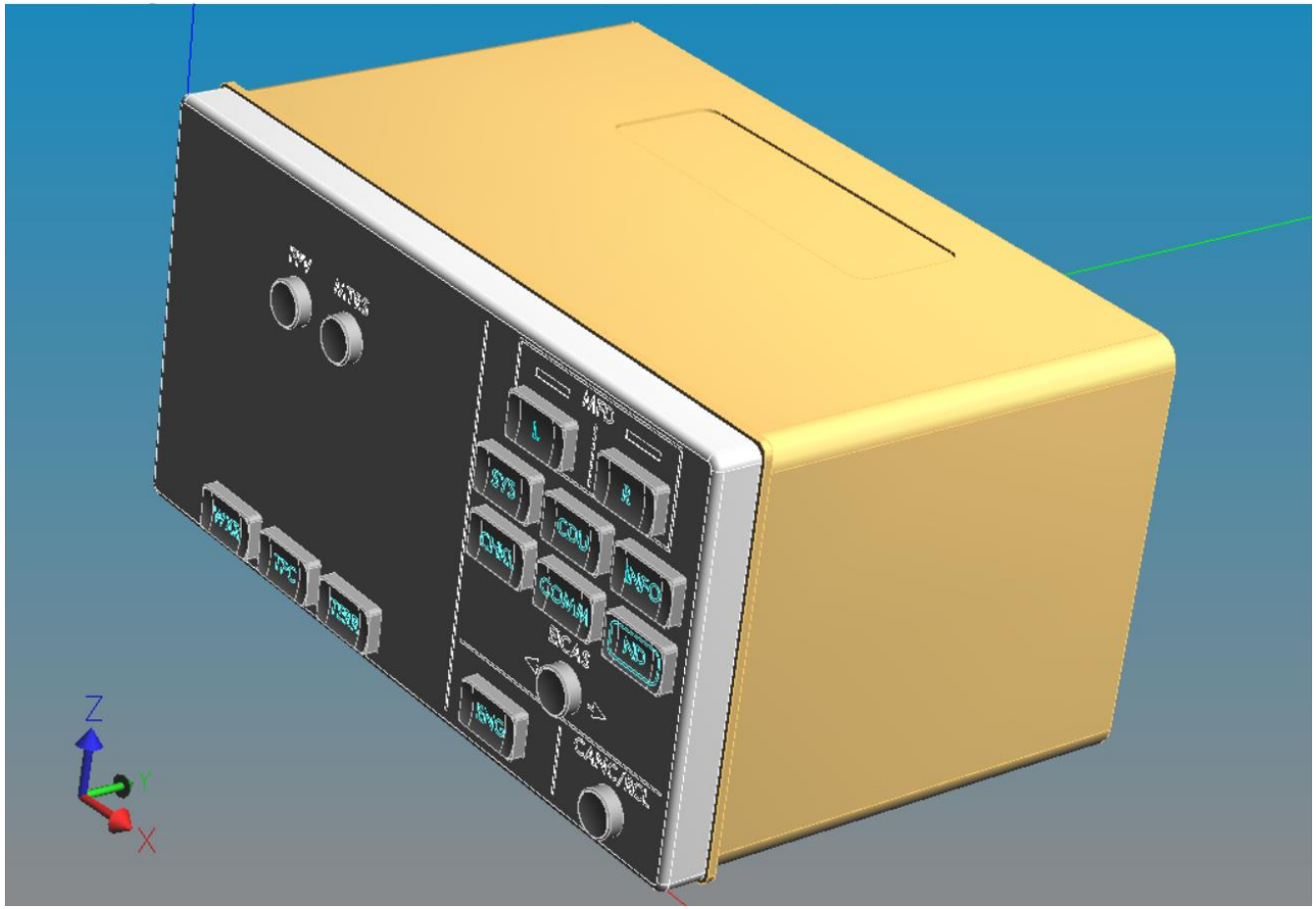
Adventium LABS

ANSYS

eurostep

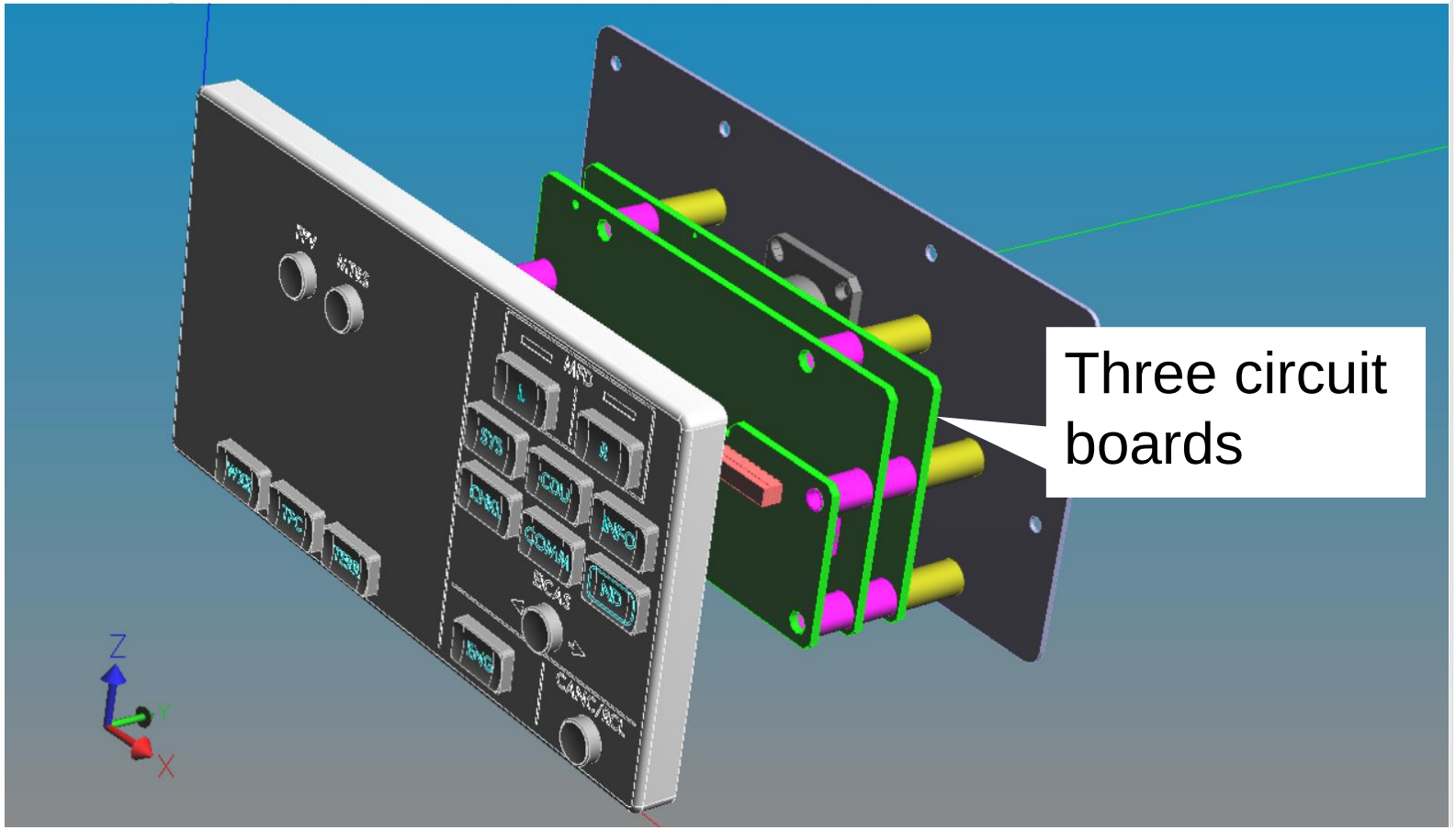
A SAVI Use Case for Consistency Checking

Start with the mechanical view

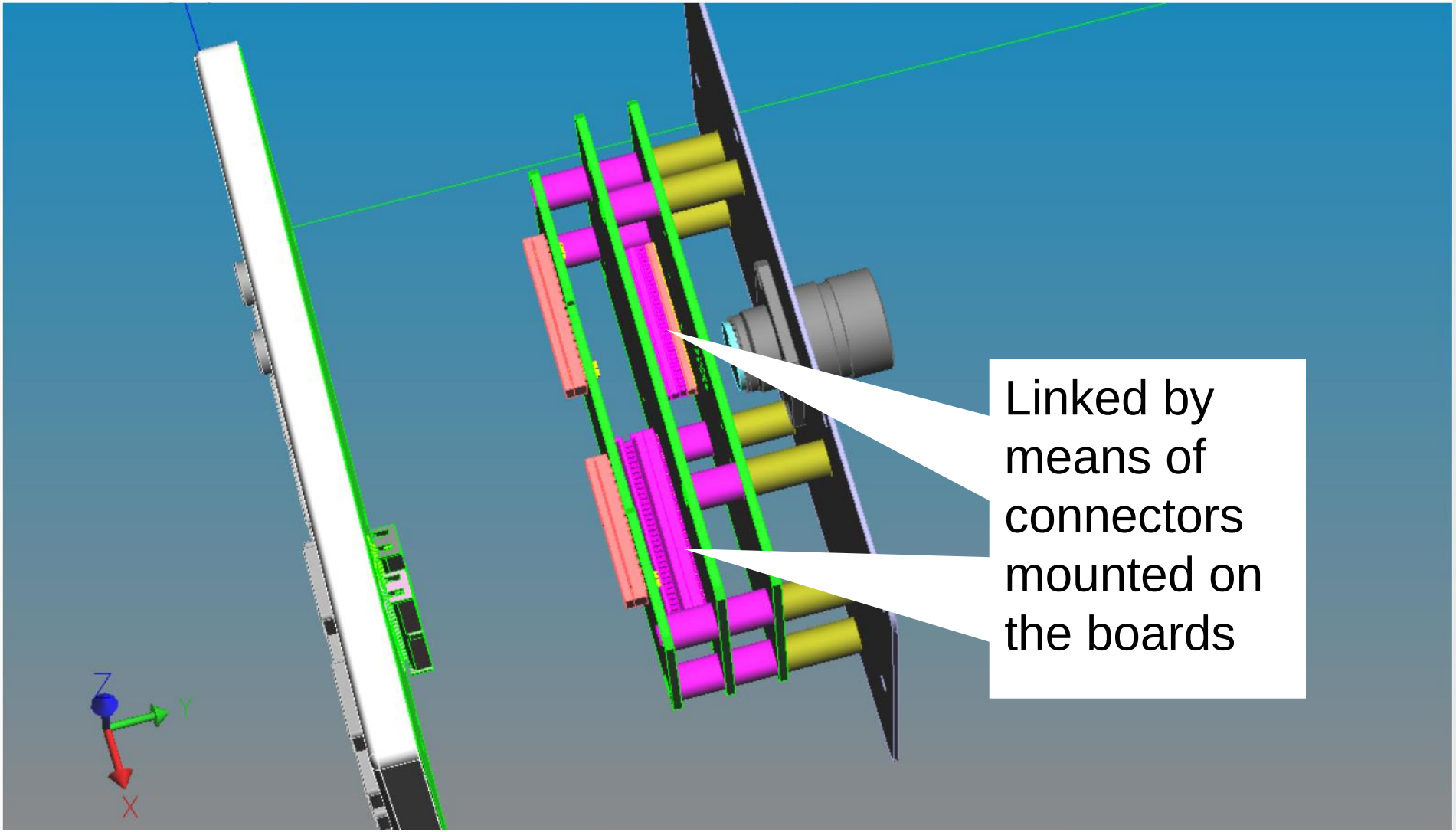


A SAVI Use Case for Consistency Checking (cont'd)

Look under the covers



A SAVI Use Case for Consistency Checking (cont'd)



Multiple Sources of Truth for the One System

- **There are multiple sources describing the product that are developed in independent domains using different tools that do not communicate well**
  - **The assembly is defined in MCAD**
  - **Each board is developed independently**
    - **ECAD to ensure board functionality**
    - **MCAD model used in the assembly**
  - **The architect for the assembly specifies the connections that link the boards**
    - **Signals across connectors specified as Excel**
  - **A specialist package is used to create connector seating and mating points**
    - **To ensure physical fit both on board and out-of-the-board**

Multiple FORMATS of Truth for the One System

- **There are multiple sources describing the product that are developed in independent domains using different tools that do not communicate well**
  - **The assembly is defined in MCAD in STEP AP214 (inches)**
  - **Each board is developed independently**
    - **ECAD to ensure board functionality in STEP AP210 (nanometres)**
    - **MCAD model used in the assembly in STEP AP214 (inches)**
  - **The architect for the assembly specifies the connections that link the boards in "Publish Subscribe table" – Excel**
    - **Signals across connectors specified as Excel**
  - **A specialist package is used to create connector seating and mating points PackageWright – produces csv files (cm)**
    - **To ensure physical fit both on board and out-of-the-board**

Multiple Sources of Potential Inconsistency

- **The 13 source files that describe the assembly and its components have overlapping content:**
  - **Shape between MCAD and ECAD**
  - **Signals between ECAD and the publish/subscribe tables**
  - **Positioning information across ECAD, MCAD and PackageWright**

- **To determine if the different models are consistent we need to bring them into a common environment:**
  - **Using a single geometric space**
    - **With correct positioning**
  - **One query space**
    - **To allow comparison**

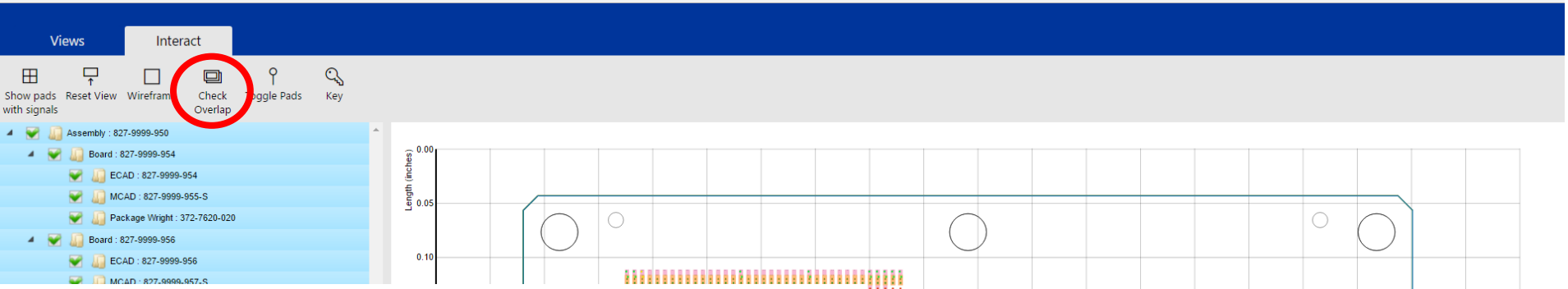
Using a SAVI Model Repository

- **A key concept for SAVI is the idea of a Model Repository with data extraction capabilities**
  - **The repository may store a model or link to it**
  - **The repository shall store metadata concerning each model**
  - **The repository may store data extracted from models such as is required to allow consistency checking across models**
  - **The repository shall keep records of groups of models for which consistency checking is performed**

- **Eurostep have configured their ShareAspace InReach collaboration hub to act as a SAVI model repository**
  - **Consistency checks specific to assemblies such as the system presented here have been implemented as an app running on the Model Repository**

Comparison of Board Profiles

Q1: How well do the MCAD and ECAD boards match up?



comparing points between MCAD and ECAD profiles on the same board

…

checking board : MCAD : **827-9999-957-S**

checking board: ECAD : **827-9999-956**

Both the MCAD & ECAD are the same sized shape

…

checking board : MCAD : **827-9999-959-S**

checking board: ECAD : **827-9999-958**

Both the MCAD & ECAD are the same sized shape

…

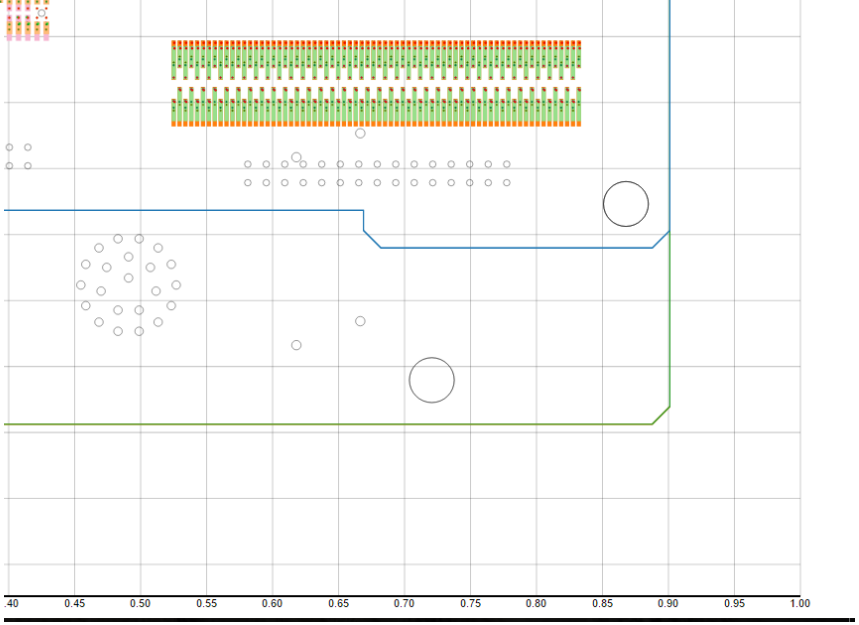
checking board : MCAD : **827-9999-955-S**

checking board: ECAD : **827-9999-954**

Both the MCAD & ECAD are the same shape but different sizes

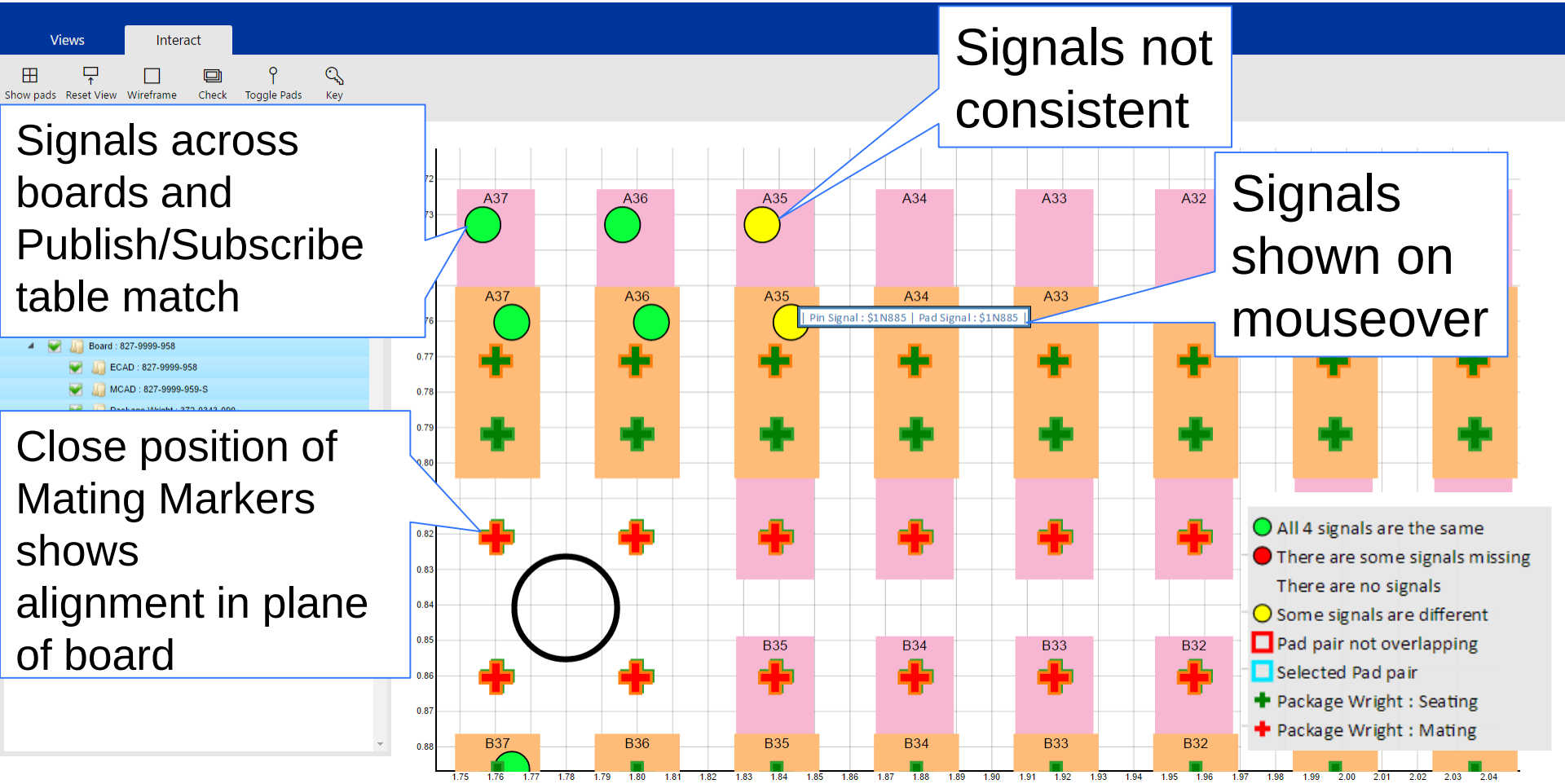
Total difference in X : **0**

Total difference in Y : **0.0010000000000012221**



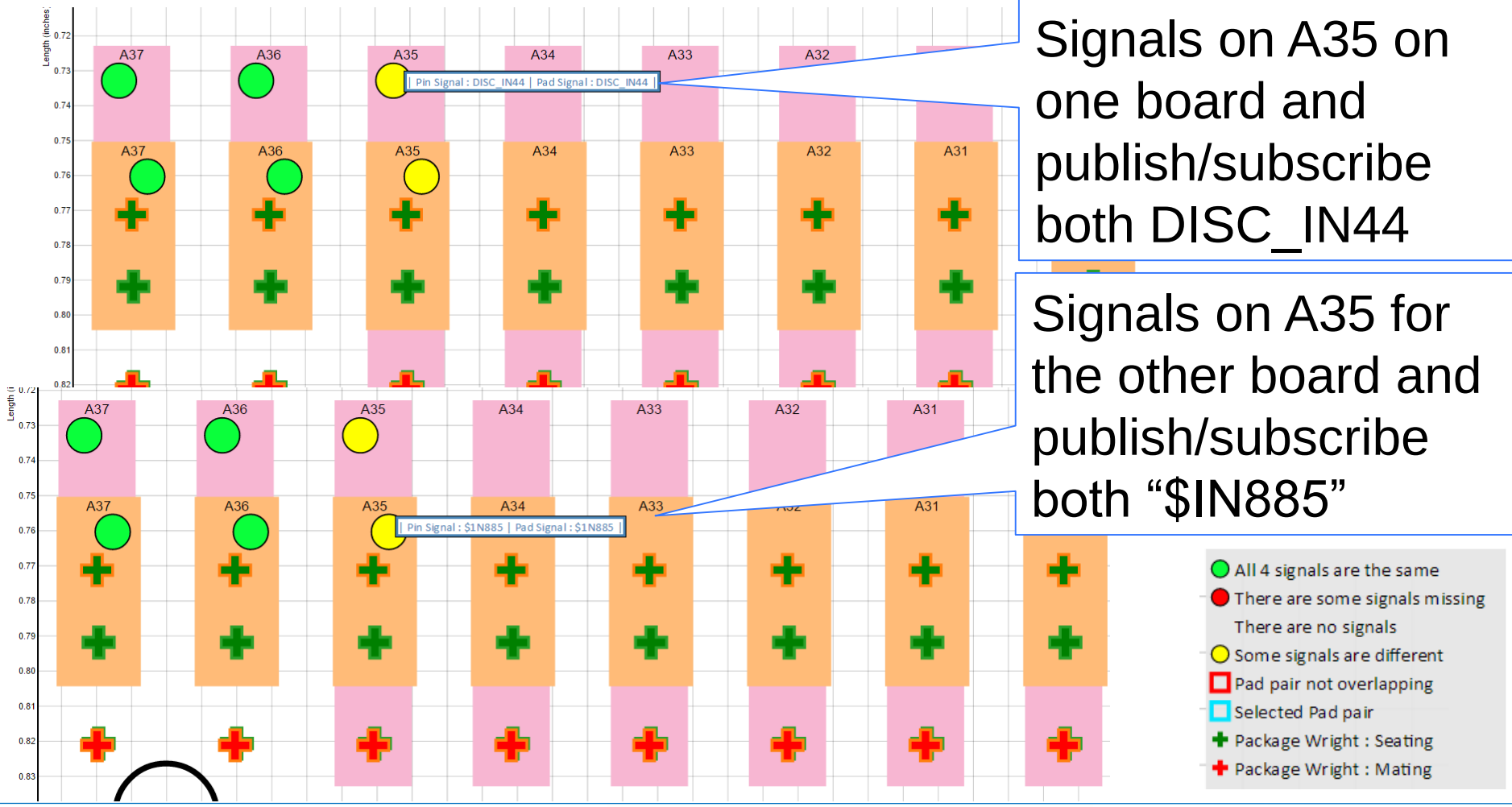
Will the Assembly Connect Up (cont'd)?

Q2: How well do connectors align? Q3: Are the signals consistent?



Check Signal Consistency Across Connectors

Inconsistent Signals - need engineer to determine if this really is an issue!



Signals on A35 on one board and publish/subscribe both DISC_IN44

Signals on A35 for the other board and publish/subscribe both “$IN885”

Show as Table for Connectors Between Boards

Views

Pad Front View | Pad Side View | Pad Top View | P2 : J2 | J3 : P3

Can view as extended Publish/Subscribe Table

Connector A								Connector B							
Part				372-7550-150				372-0343-090				Part			
Connector Ref Designator	Pad X Pos	Pad Y Pos	Pad X Dim	Pad Y Dim	Pad Signal Name	Pin Signal Name	Pin #	Pin #	Pin Signal Name	Pad Signal Name	Pad X Pos	Pad Y Pos	Pad X Dim	Pad Y Dim	Connector Ref Designator
P2	2.1643149606299215	0.257	0.022	0.08	DIGITAL_GND	DIGITAL_GND	A1	A1	DIGITAL_GND	DIGITAL_GND	7556614173228346	0.222	0.024	0.054	J2
P2	2.203685039370079	0.257	0.022	0.08	+28VDC_IN	+28VDC_IN	A2	A2	+28VDC_IN	+28VDC_IN	291338582677	0.222	0.024	0.054	J2
P2	2.2430551181102363	0.257	0.022	0.11	+28VDC_IN	+28VDC_IN	A3	A3	+28VDC_IN	+28VDC_IN	1.67 98425196	0.222	0.024	0.054	J2
P2	2.2824251968503937	0.257	0.022	0.11	N12VDC	N12VDC	A4	A4	N12VDC	N12VDC	1.63755 622	0.222	0.024	0.054	J2
P2	2.321795275590551	0.257	0.022	0.11	RSTF	RSTF	A5	A5	RSTF	RSTF	1.5981811	0.222	0.024	0.054	J2
P2	2.361165354330709	0.257	0.022	0.11			A6	A6			1.558811023	0.222	0.024	0.054	J2
P2	2.4005354330708664	0.257	0.022	0.11			A7	A7			1.51944094488		0.024	0.054	J2
P2	2.4399055118110238	0.257	0.022	0.11			A8	A8			1.4800708661417		0.024	0.054	J2
P2	2.479275590551181	0.257	0.022	0.11			A9	A9			1.446				
P2	2.5186456692913386	0.257	0.022	0.11			A10	A10			1.401				
P2	2.558015748031496	0.257	0.022	0.11			A11	A11			1.36				
P2	2.597385826771654	0.257	0.022	0.11			A12	A12			32				
P2	2.6367559055118113	0.257	0.022	0.11	DIGITAL_GND	DIGITAL_GND	A13	A13	DIGITAL_GND	DIGITAL	83220472440945	0.222	0.024	0.054	J2
P2	2.676125984251969	0.257	0.022	0.11			A14	A14			8503937007874	0.222	0.024	0.054	J2
P2	2.715496062992126	0.257	0.022	0.11			A15	A15			8031496063	0.222	0.024	0.054	J2
P2	2.754866141732284	0.257	0.022	0.11			A16	A16			3362204724	0.222	0.024	0.054	J2
P2	2.794236220472441	0.257	0.022	0.11			A17	A17			7480315	0.222	0.024	0.054	J2
P2	2.8336062992125988	0.257	0.022	0.11			A18	A18			401576	0.222	0.024	0.054	J2
P2	2.872976377952756	0.257	0.022	0.11			A19	A19				0.222	0.024	0.054	J2
P2	2.9123464566929136	0.257	0.022	0.11			A20	A20			425	0.222	0.024	0.054	J2
P2	2.951716535433071	0.257	0.022	0.11			A21	A21			5	0.222	0.024	0.054	J2
P2	2.991086614173229	0.257	0.022	0.11	DIGITAL_GND	DIGITAL_GND	A22	A22	DIGITAL_GND	DIGITAL_GND		0.222	0.024	0.054	J2
P2	3.030456692913386	0.257	0.022	0.11			A23	A23				0.222	0.024	0.054	J2
P2	3.0698267716535437	0.257	0.022	0.11			A24	A24							J2
P2	3.109196850393701	0.257	0.022	0.11			A25	A25							J2
P2	3.1485669291338585	0.257	0.022	0.11			A26	A26							J2
P2	3.187937007874016	0.257	0.022	0.11			A27	A27							J2
P2	3.2273070866141738	0.257	0.022	0.11			A28	A28							J2
P2	3.2666771653543307	0.257	0.022	0.11			A29	A29							J2
P2	3.3060472440944886	0.257	0.022	0.11			A30	A30							J2
P2	3.3454173228346455	0.257	0.022	0.11			A31	A31							J2
P2	3.3847874015748034	0.257	0.022	0.11			A32	A32							J2
P2	3.424157480314961	0.257	0.022	0.11			A33	A33							J2
P2	3.4635275590551187	0.257	0.022	0.11			A34	A34			0.45644881889763783	0.222	0.024	0.054	J2
P2	3.5028976377952756	0.257	0.022	0.11	DISC_IN44	DISC_IN44	A35	A35	$1N885	$1N885	0.41707874015748037	0.222	0.024	0.054	J2

Signal from ECAD

Signal from Publish/Subscribe Table

Next Step - SAVI Near Term Demonstration

- **WBS (Wheel Brake System)**
  - **OEM System Architecture Model (SysML)**
  - **Supplier Detailed Model (AADL) – Architecture Analysis Design Language**
  - **Safety Analysis (OCRA) – Othello Contracts Refinement Analysis**
  - **3D Geometry (SolidWorks)**
  - **Publish-Subscribe Model**

- **In tying the information model together in a publish-subscribe architecture with a solid STEP AP239 semantic architecture there is improved assurance in the consistency across the multiple model systems for the same aircraft.**

Conclusions

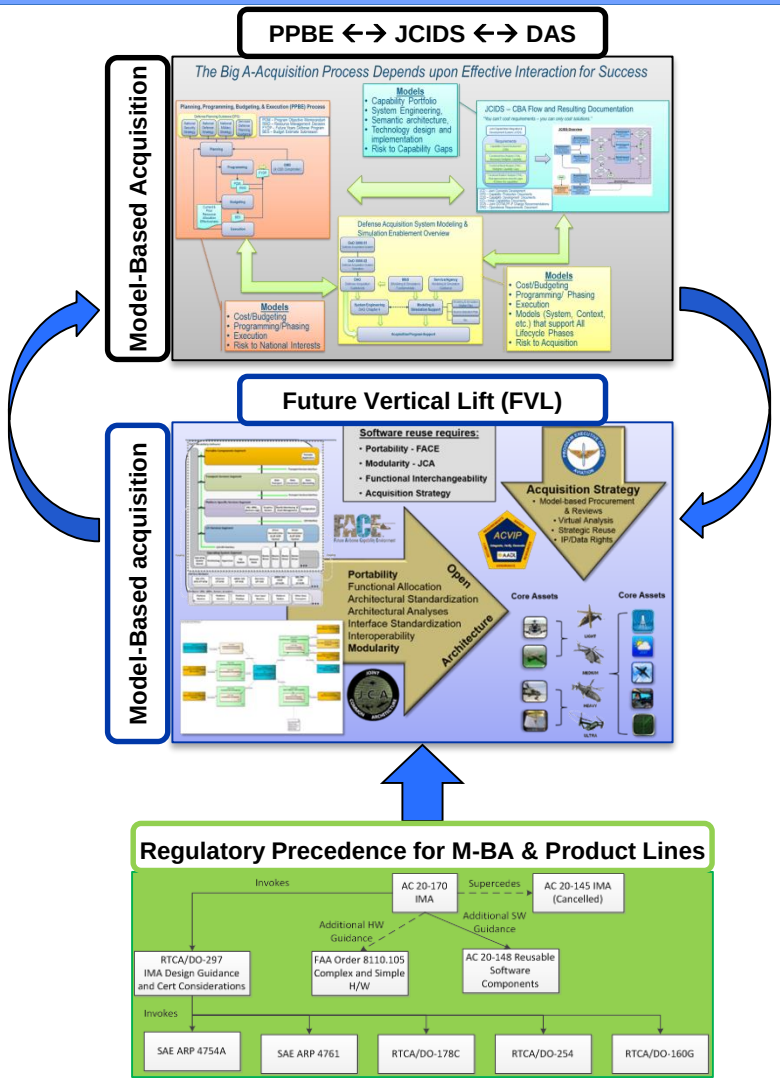
- **STEP AP239 affords a community to unambiguously capture, catalog, communicate, preserve, and interoperably exchange semantics of their architectures and data, thus making architecture descriptions true assets.**
- **AP239 enables MBSE checking, analysis, and error discovery.**
- **The application allows discovery of consistency issues much earlier than physical verification/test.**
- **The approach is feasible through the use of standard formats**
- **The overall capability performs a "system architecture virtual integration" much earlier in the lifecycle.**

Acknowledgements

- **The capability presented here has been developed by Eurostep Limited under contract to Rockwell Collins as a contribution to the SAVI project**

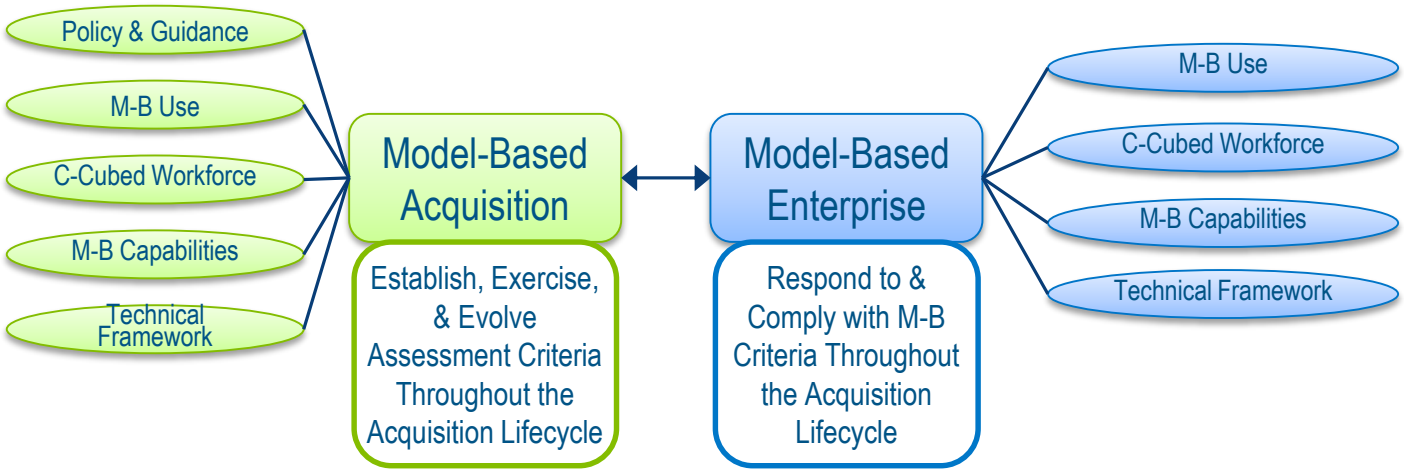
STEP AP239 Edition 3 Aerospace & Defense Context

- Update the current AP239 edition 2 information model to support **<u>Aerospace & Defense business requirements and specifications</u>**, and in particular from:
  - AIA/ASD ILS Spec suite
  - UK MoD requirements
  - US DoD requirements
  - GEIA STD 0007
  - LOTAR International PDM WG.
- Ensure **<u>interoperability</u>** between AP239 ed3 and other related STEP APs, by ensuring the compliance with existing ISO STEP modular standards and the future modular STEP architecture (new framework, new SMRL…) initiated by AP242 ed2. The common modules (PDM and Requirement Management identified to date) will be harmonized between AP242 ed2 and AP239 ed3.
- Support web services.



Model-Based Acquisition

Acquisition innovation to address the challenges of increasingly complex systems and to improve the early and ongoing assurance of the program validity & integrity in the interest of the most judicious consumption of resources.



C-Cubed – Competency, Capability, Capacity

Model-Based Acquisition – Exploiting Modeling & Simulation (M&S) in the Acquisition Communities

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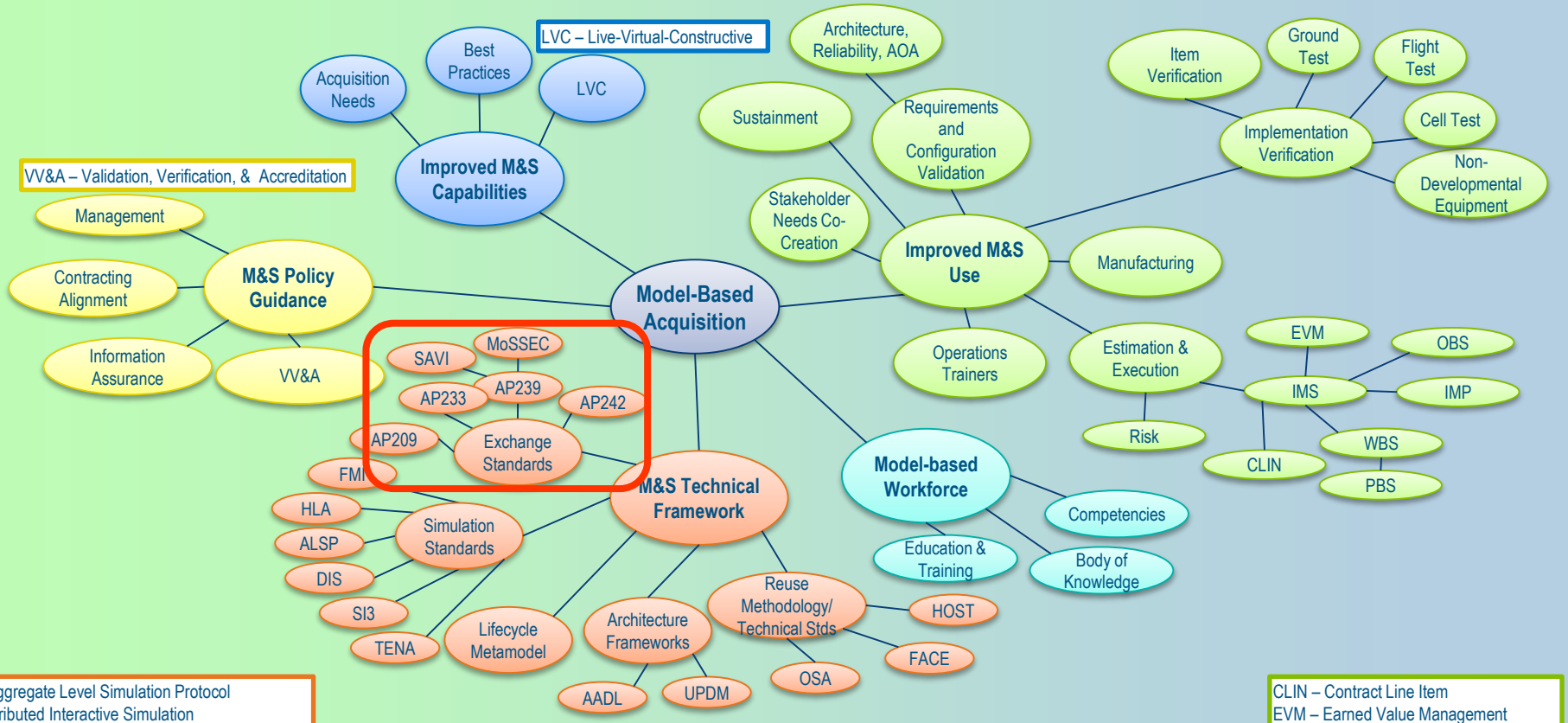
DOD Acquisition Community

Industry Prime Supplier Community

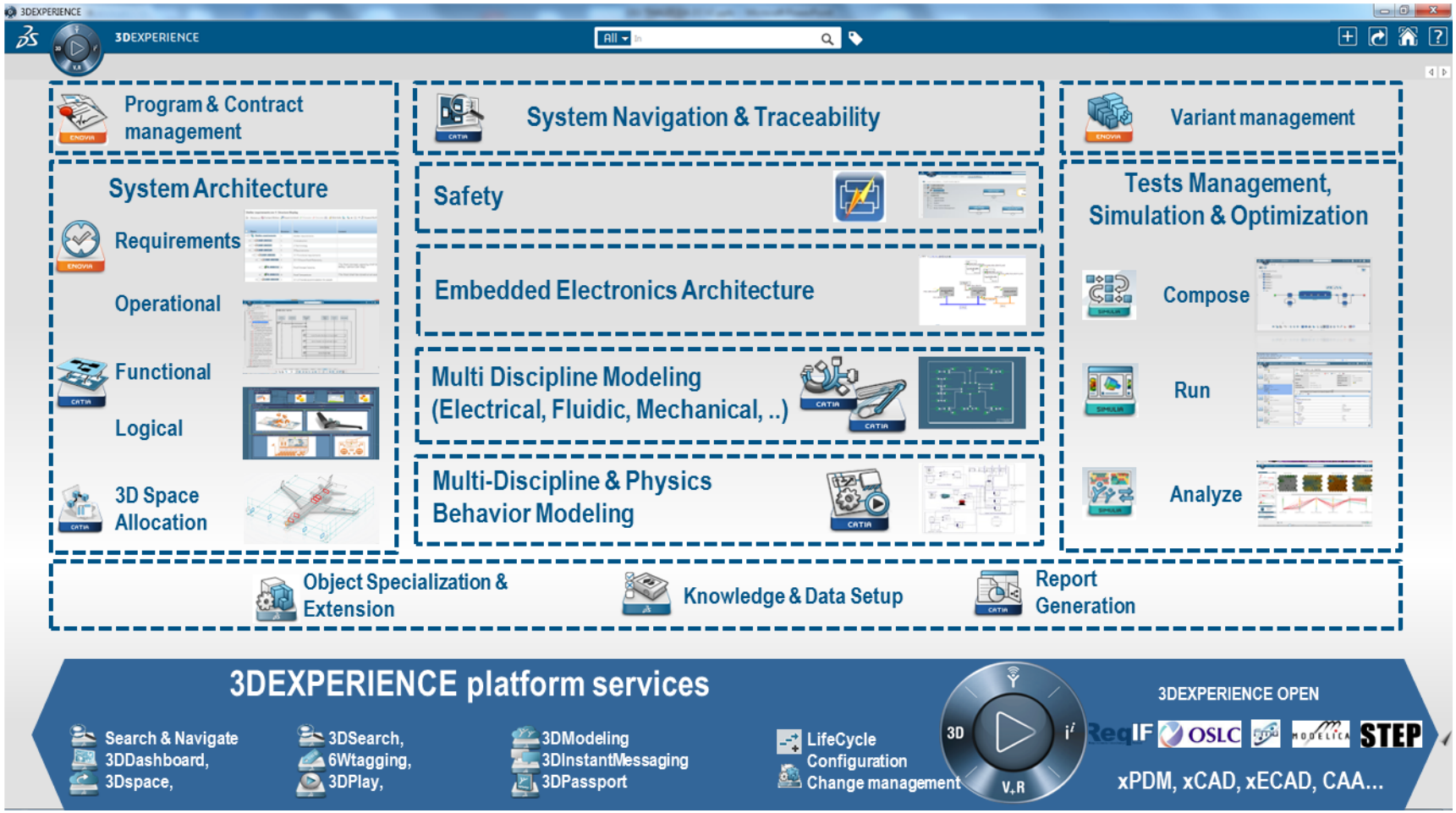


ALSP – Aggregate Level Simulation Protocol
DIS – Distributed Interactive Simulation
FMI – Functional Mockup Interface
HLA – High Level Architecture
SI3 – Simulation Integration/Interoperation Infrastructure
TENA – Test & Training Enablement Architecture
VV&A – Validation, Verification, & Accreditation

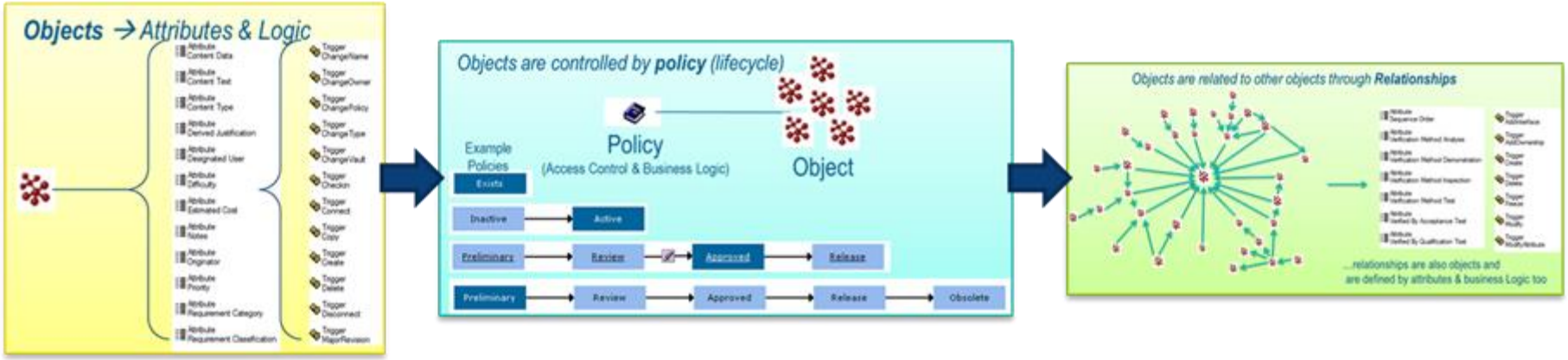
CLIN – Contract Line Item
EVM – Earned Value Management
IMP – Integrated Master plan
IMS – Integrated Master Schedule
OBS – Organization Breakdown Structure
PBS – Product Breakdown Structure
WBS – Work Breakdown Structure

Enabling Platform

3DEXPERIENCE platform for MBSE



Configurable Attributes & Logic, Policies, & Relationships



Recall the elements from STEP AP239 Program Management Considerations

- User-defined attributes
- Document order
- Work breakdown
- Binary representation items
- Textual expression representation
- Security & information rights
- Product as released
- Risk analysis,…

Highly Configurable Platform

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Data Schema
- Attributes
- Types
- Relationships
- Number Generators

Access Control
- People
- Organizations
- Roles
- Policies
- Rules
- Masks
- IP Export Controls

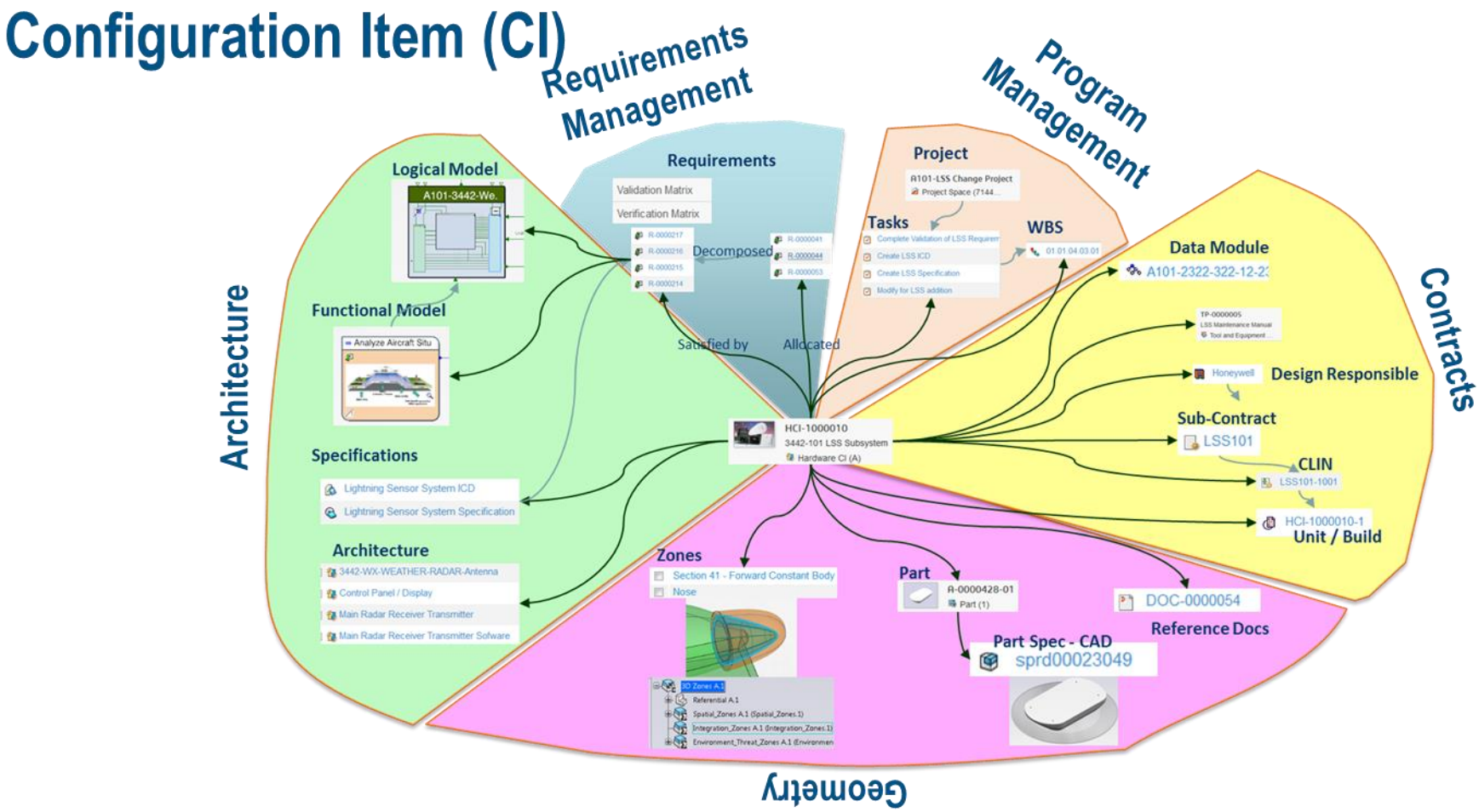
Business Rules
- Lifecycle
- Workflow
- Triggers
- Routes
- Business Logics
- Web Services
- Java Program Objects

User Interface
- Commands
- Configurable Pages
- Menus
- Web Tables
- Web Forms
- Widgets
- Queries
- Localization

Data
- Definition
- Extraction
- Import
- Validation

Administration
- Users
- Licenses
- 6WTag Vocabularies
- File Synchronization
- Collab Spaces
- Index Management
- Maintenance
- External Integration
- Communities

Applications Provide Multi-Perspective Information Access



3DEXPERIENCE Target Coverage

Chief Engineer **Aircraft Architects**

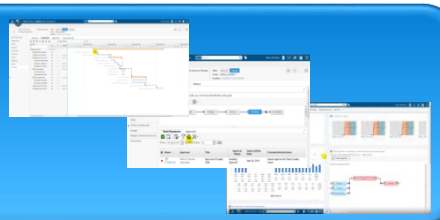
Architecture & Decisions

- Define aircraft architecture alternatives
- Define & drive trade-off studies
- Review & analyze results
- Take decisions

Study Leaders

Collaborative Studies

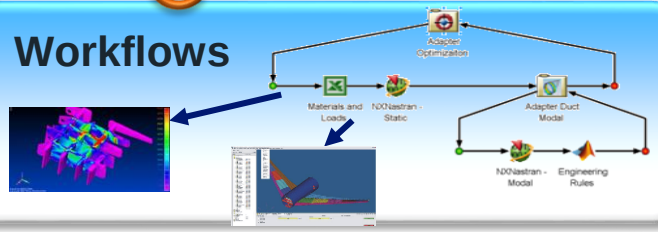
- Orchestrate modelling & simulation activities
- Leverage extended enterprise collaborations
- Organize collaborative reviews & quality gates



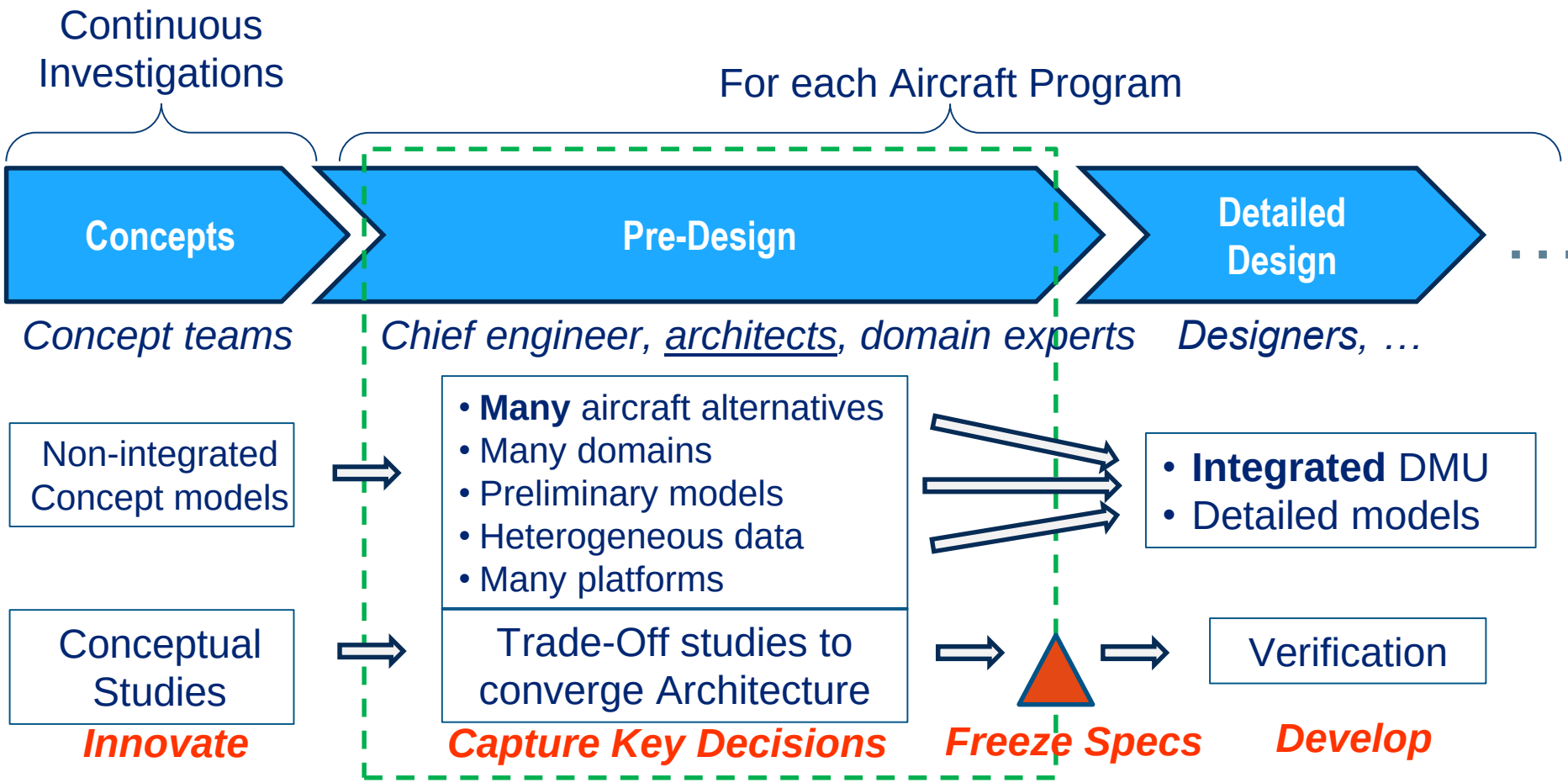
Domain Experts

Multi-Disciplinary Simulation Workflows

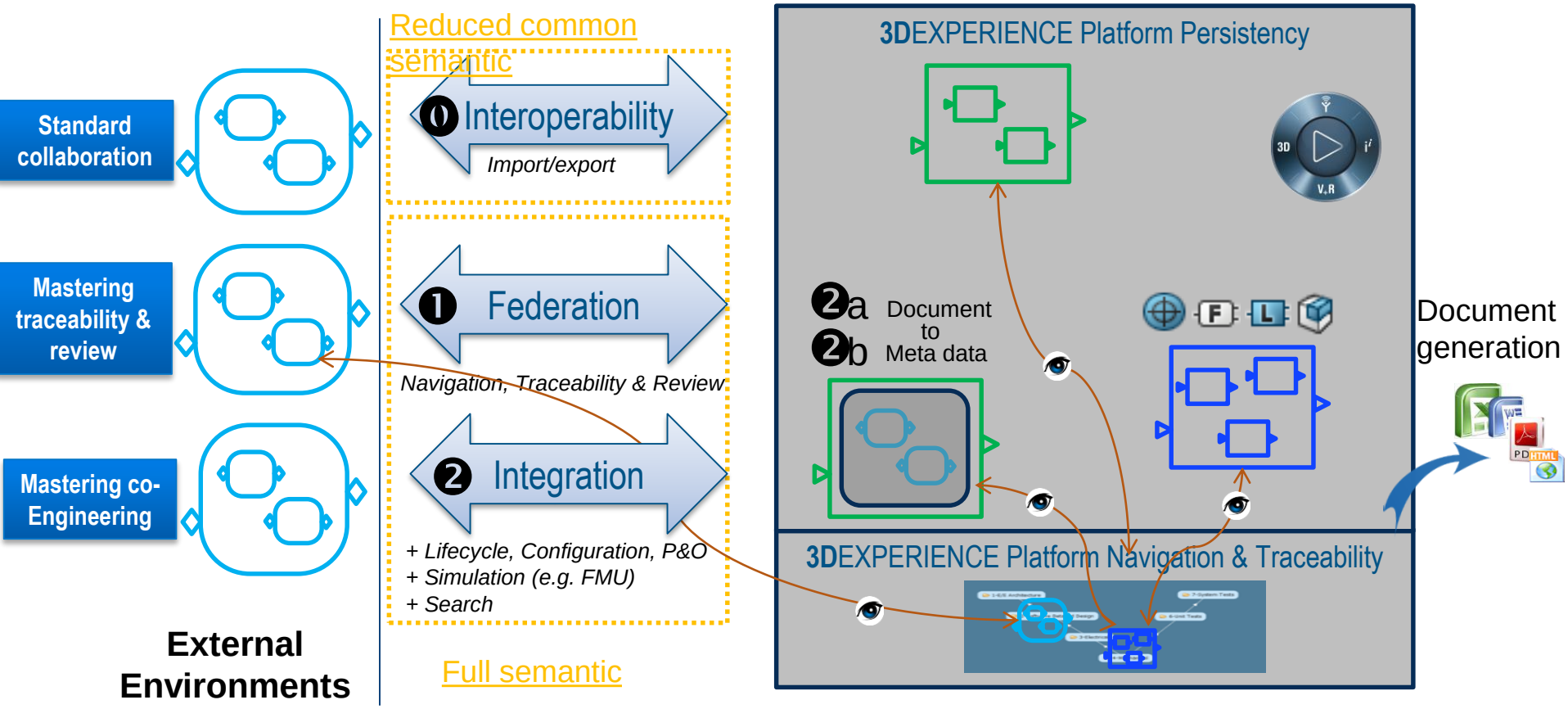
- Connect & run CAE applications
- Exchange between domains
- Capitalize, re-use & automate processes



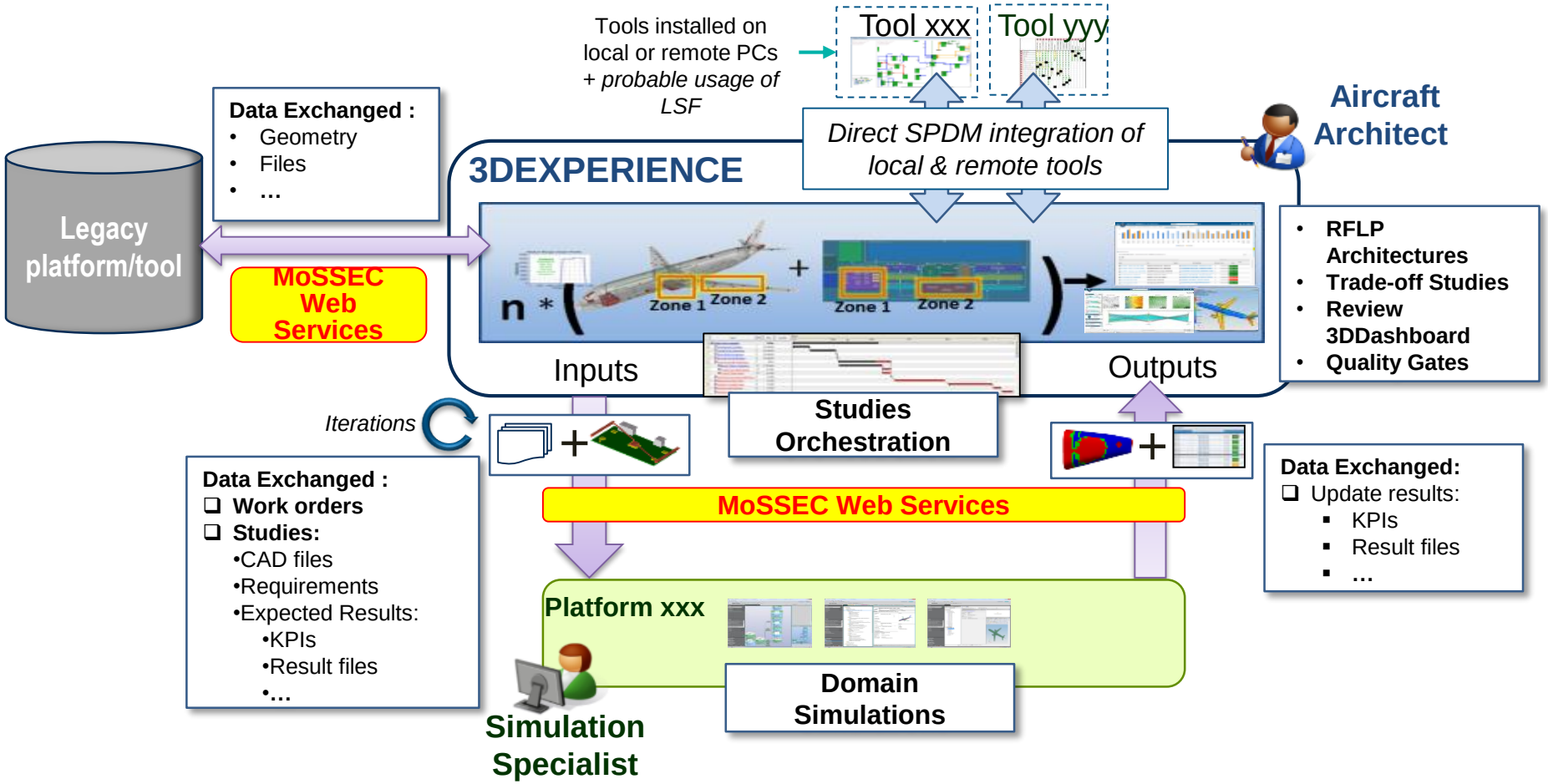
Increased Rigor on Model and Simulation Management in PBS and Requirements Context



Collaboration in 3DEXPERIENCE platform for Systems Engineering



Generic Collaborative Scheme



Questions?