

MBSE Standards Collaboration for Interoperability and Integration - i.e MBSE 101

John Nallon and Greg Pollari

GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2023



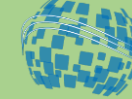
John Nallon

- John has over 40 years of product development, systems engineering and PLM consulting experience in the Aerospace & Defense, Automotive, Semi-Conductor and Government markets.
- John has been a member of the INCOSE (International Council on Systems Engineering) since 1993 and is the current chairman of the INCOSE TIMLM (Tools Integration and Model Lifecycle Management) Working Group and the SE Tools Database Working Group.
- John is a U.S. Navy veteran and an Electrical Engineering graduate of Old Dominion University.

Greg Pollari

- Greg is a co-chair of the INCOSE TIMLM working group and is a retired Associate Director of Systems Engineering at Collins Aerospace with design and management experience in ASIC, electrical, systems, and production for navigation systems.
- Greg holds a B.S. Physics, M.S in Electrical Engineering, and an MBA

TIMLM



PDES, Inc.



LOTAR

TIMLM - PDES - LOTAR MBSE

Projects Overview and Team History

May 10th, 2023



PDES Inc. Public Information

Not subject to U.S. Export Administration Regulations (EAR), (15 C.F.R Parts 730-774)
or U.S International Traffic in Arms Regulations (ITAR), (22 C.F.R Parts 120-130)

TIMLM-PDES-LOTAR MBSE 101 - Terms

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- **What is MBSE?** - *the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.*
- **What is TIMLM?** - INCOSE Tool Integration and Model Lifecycle Management Working Group
- **What is PDES?** - *an international industry, government, and university consortium committed to accelerating the development and implementation of standards for product data exchange in the Digital Enterprise.*
- **What is LOTAR?** - *an international consortium of Aerospace manufacturers, jointly facilitated by [AIA](#), [ASD-Stan](#), [AFNeT](#), [prostep ivip](#) and [PDES, Inc.](#)*

Visibility Materials for TIMLM-PDES-LOTAR 101

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- **What is SAVI?** - *a collaboration between aerospace system development stakeholders whose goal is to lower development costs of complex aerospace systems by enabling model-driven virtual integration of complex systems across multiple development environments. (AVSI)*
- **What is MoSSEC?** - *an ISO STEP (AP243) standard enabling the sharing and exchange of Modelling and Simulation contextual metadata.*
- **Various Project Deliverables – Standards and Trial Results**

Group History

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- **PDES Inc. , INCOSE, and LOTAR Collaboration**
 - **PDES and INCOSE working together since 1996!**
 - **Operating with INCOSE under an MoU championed by the TIMLM WG , PDES MBSE WG, and LOTAR for MBSE**
 - **Other Collaboration: ESPRIT, SAVI, OSLC, OMG, GPDIS, ISO, prostep ivip, Eurostep....**

The INCOSE TIMLM WG Profile

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**Chair,
Co-chairs,
Project
Leaders**

John Nallon: Chair

**Co-Chair: Mark Williams
MBSE for PDES/LOTAR Project Lead**

**Co-Chair: Gregory Pollari
MoSSEC Project Lead**

**INCOSE
Web
Pages**

[Tool Integration and Model Lifecycle
Management \(incose.org\)](https://incose.org)

[INCOSE SE Tools Database](#)

**138 Members in the TIMLM WG
39 Members MBSE for PDES and LOTAR
330 Members of the SETDB WG**

**Yammer
Communities**
www.yammer.com/incose.net

[TIMLM WG](#)

[MBSE for PDES and LOTAR](#)

[SETDB WG](#)

MOU Alliances: PDES Inc., LOTAR, and PPI

Tool Integration and Model Lifecycle Management WG

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- **The INCOSE TIMLM WG Primarily Focuses On:**
 - The *integration and interoperability of tools, data, models and processes* as they relate to **Systems Engineering processes** throughout acquisition and product life cycles.
 - **Collaboration with PDES Inc., ISO and STEP standards organizations**, the INCOSE Standards Development Department and other INCOSE Working Groups to improve the *exchange, archival and retrieval of digital artifacts produced by the systems engineering processes.*



TIMLM WG Activities for 2023

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- **Development and Publication of the INCOSE Model Portfolio Management Guide (Wiley Publications)**
- **Regular Joint Working Sessions**
 - *Every Wednesday 09:30 am to 11:00 am EST USA – PDES/LOTAR/INCOSE*
 - *Every Thursday Afternoon (times vary) – INCOSE SETDB WG and PPI*
 - *Annual INCOSE International Workshops*
 - *Quarterly PDES-LOTAR Workshops (2 Virtual, 2 Virtual and in person)*
- **Frequent Collaboration Participants:** (Example Listing)
 - *INCOSE DEIX Working Group,*
 - *INCOSE MBSE Initiative Teams,*
 - *INCOSE NAFEMS-SMS Working Group,*
 - *INCOSE Standards Department (ISO 10303-AP243 and ISO/IEC_CD_24641)*
 - *CIM Data (A&D PLM), OSLC, and the OMG*
 - *Tool Vendors, Tool Users and Standards Developers*

PDES/LOTAR/INCOSE Joint Activities

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- **LOTAR for MBSE Standards in Work: (European Norm/National Aerospace Standards)**
 - **EN/NAS9300-500**: Common concepts for Long term archiving and retrieval of Model Based Systems Engineering information 
 - **EN/NAS9300-510**: MBSE Requirements Archiving Fundamentals
 - **EN/NAS9300-515**: Model Verification and Validation
 - **EN/NAS9300-520**: How to Archive System Behavior and Simulation Models
 - **Others**: Architecture (530), LBOM (540)
- **How to Exchange MBSE Technical Data Packages (position paper)** 

PDES/LOTAR/INCOSE Joint Activities

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- **Interoperability Standards:**

- **ISO 10303-AP233 Systems Engineering Data Exchange**



- **ISO 10303 - AP243 Modeling and Simulation information in a collaborative Systems Engineering Context (MoSSEC)**

- **Our Activities Support: prototypes, vendor implementations, knowledge dissemination to the engineering community, relationships with other standards and leading the formation of an *Implementor/User Forum***

- ***INCOSE Systems Engineering Tools Database (SETDB) WG – tool, vendor, category and process mapping recommendations***



PDES/LOTAR/INCOSE Supporting Consortia

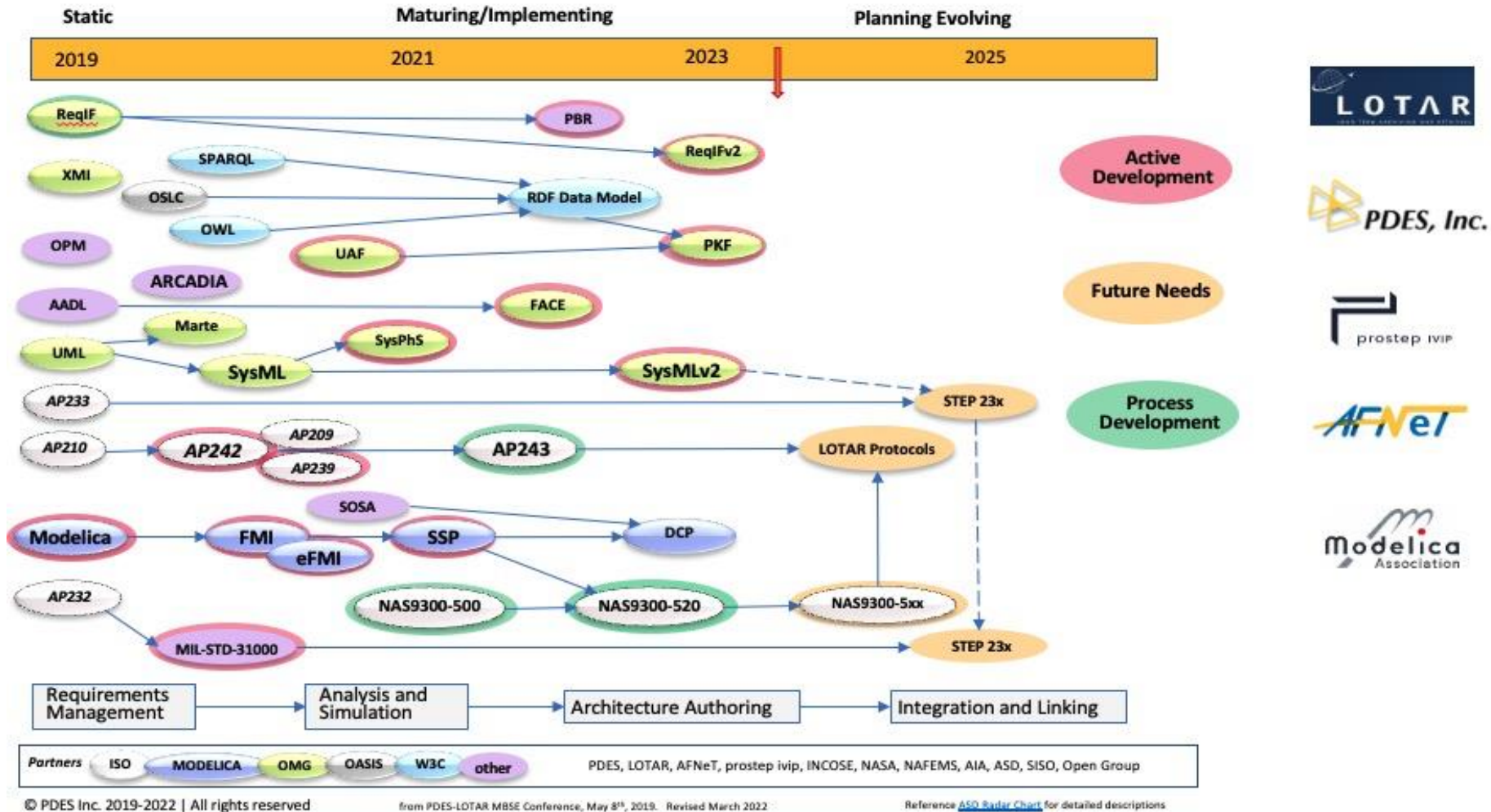
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ISO
INCOSE
Prostep ivip
NAFEMS
AFNeT
Modelica
Assoc.
A&D PLM AG
ASD-STAN
AIA



MBSE Data Interoperability Specifications

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PDES Requirements Traceability Project

Project Manager John Russel – 2010 to 2017

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Systems Engineering Requirements & Traceability – 2012

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Scope:

- Pilot requirements management and impact analysis within multi-tiered supply chains; identify gaps and best practices
- Use STEP AP233 exchange standards and common tools for pilot with industry use cases
- Investigate fidelity for traceability in STEP models and exchanges.
- Harmonize use cases involving AP233 and ReqIF exchanges

Participants:

- Rockwell Collins
- Honeywell
- Airbus
- Boeing
- Eurostep
- Engisis
- ProSTEP iViP
- OSD

Non – PDES Participants

Objectives:

- Align PDES use cases and activities with SAVI, INCOSE, and MoSSEC/CRESCENDO
- Develop higher fidelity System Engineering tool exchanges
- Identify metrics to assess ROI of requirements & traceability exchange practices to encourage translator development
- Document translation best practices for AP233

Deliverables:

- Functional demonstration involving 3 levels that focus on:
 - Text-based requirements exchange in MBE environments
 - Impact Analysis
 - Traceability Analysis
- STEP AP233 – ReqIF proof of concept translator
- White paper on results and ROI
- Review with INCOSE, SAVI, INCOSE, MoSSEC, and selected vendors on exchange scenarios

Project Test Case

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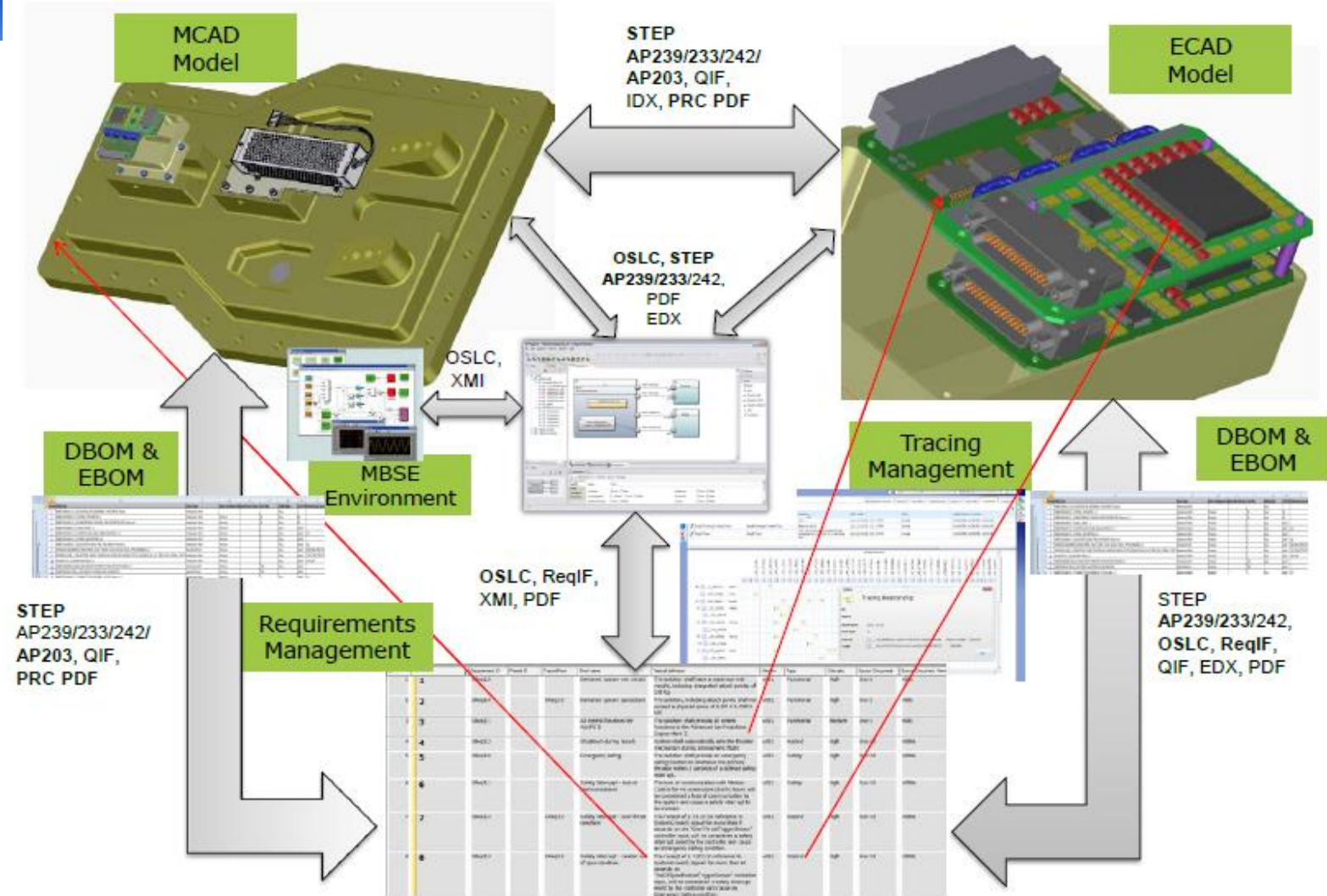
Tools Used

- Share-A-Space
- Doors
- Enterprise Architect
- Mentor Graphics
- Creo
- NX
- PRO-R / ReqIF Studio
- Teamcenter
- Anark

Model Sources

- MCAD: NIST MBE
- ECAD: Mentor HI library
- Requirements: INCOSE contribution (XML, Excel / ReqIF)
- EBOM: Teamcenter

Requirements Traceability Test Case



Project Summary – 2017

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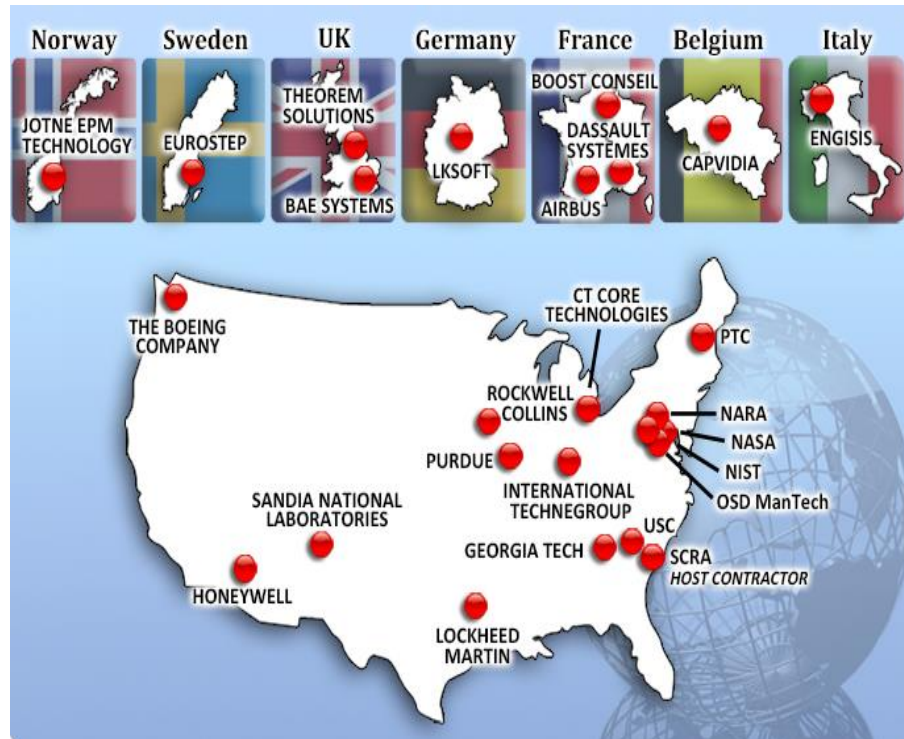
- **ALM –PLM Exchanges**
 - Metadata is easy
 - Artifact features are difficult once we go past basic access to individual files
- **MCAD and ECAD Tracing to PMI or Model Features Possible If Model Based Design Practices Are Followed**
 - Drawings Are NOT Models
 - Very few pure MBE MCAD environments in large supply chains
- **Publicly Available Test Cases Were Critical to Project**
 - Need work on high priority use cases and test elements for software
 - Control of test artifacts by central organization preferred
- **Maintaining Detailed Tracing Throughout Lifecycle Requires ALM and PLM Discipline**
 - Scenarios critical to business and process must be identified and supported for PMI traces – doesn't happen automatically (yet)
 - ALM - PLM likely to work more reliably than tool to tool situations

SAVI (Systems Architecture Virtual Integration)

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Joint PDES – SAVI Presentation

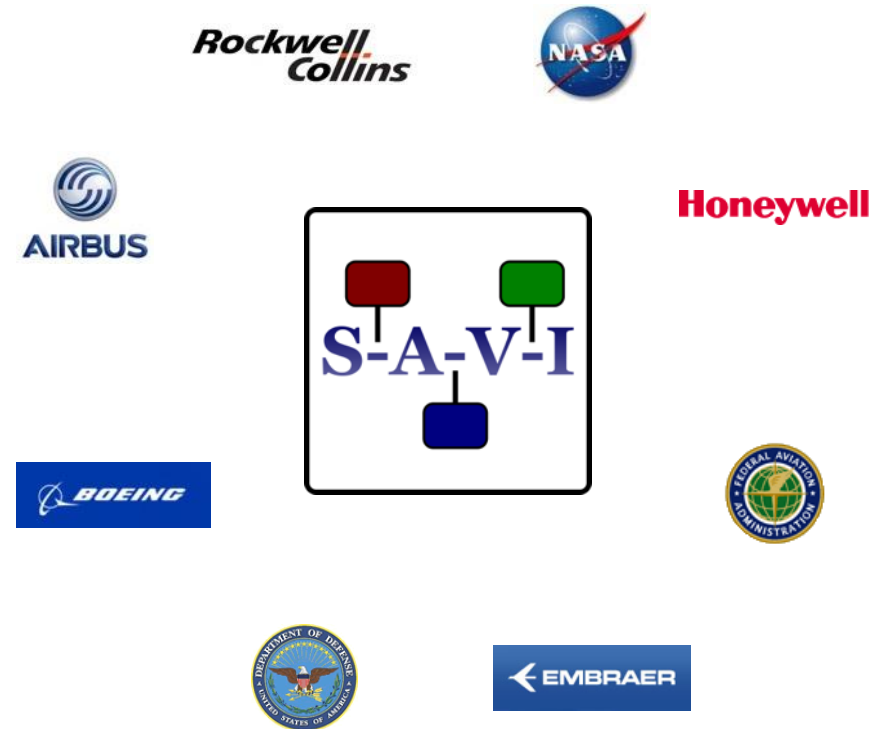
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PDES, Inc. is an international industry/government/university consortium committed to accelerating the development and implementation of standards enabling enterprise integration and PLM interoperability for its member companies.

Systems Engineering Interoperability

www.pdesinc.org/



The AVSI SAVI Program was a collaboration between aerospace system development stakeholders that aimed to advance the state of the art of technologies to enable virtual integration of complex systems.

“Integrate, Analyze, then Build”

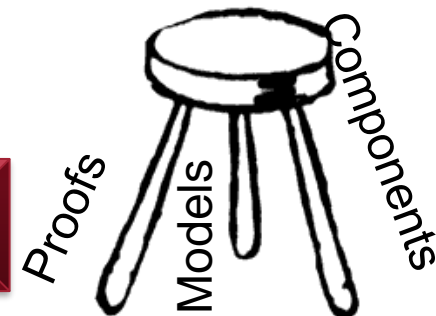
<http://savi.avsi.aero/>

SAVI Objective and Themes

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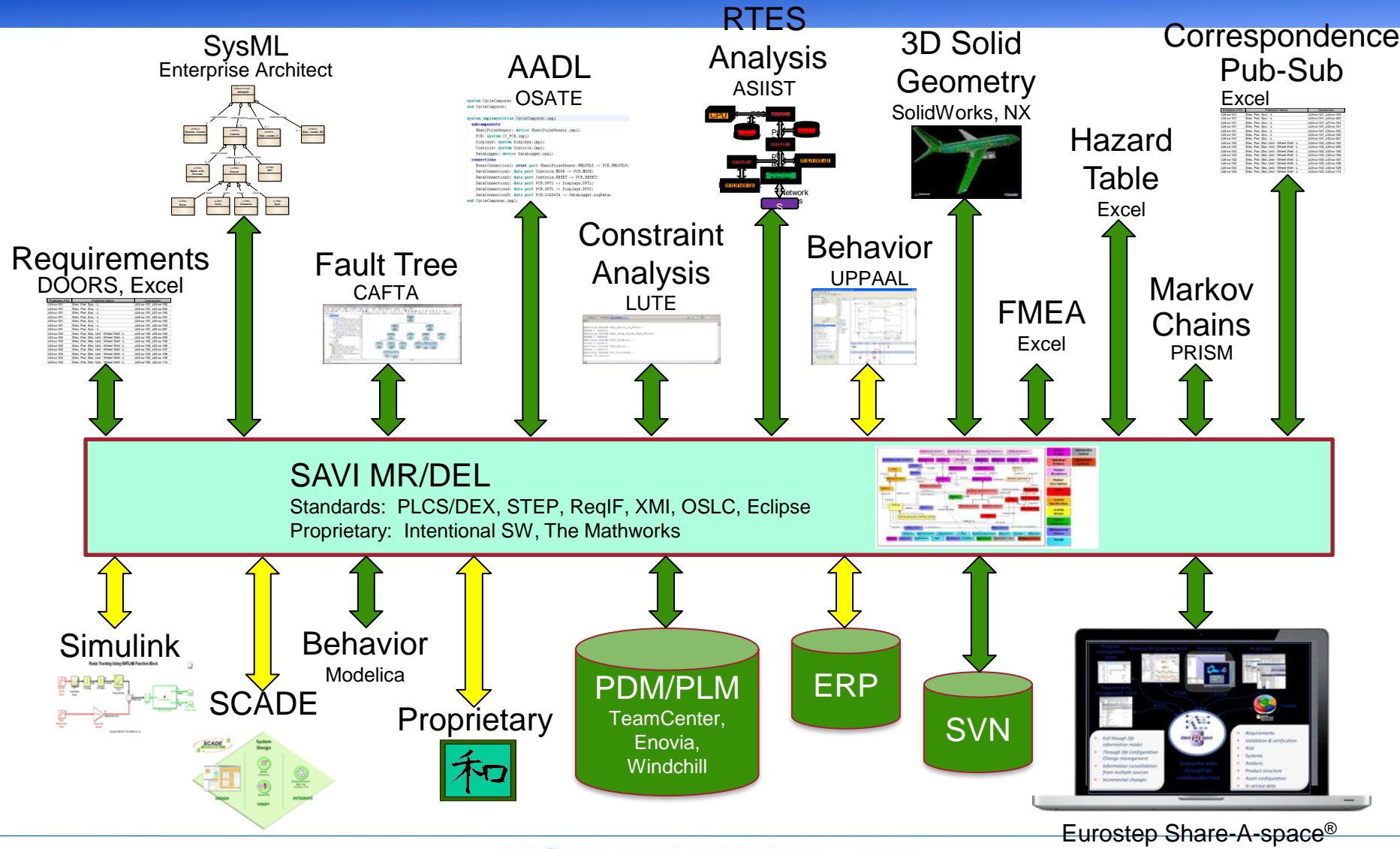
- **Reduce costs/development time through early and continuous model-based virtual integration**
 - ***Shift to new paradigm – integrated models rather than documents***
 - ***Architecture-centric approach – start with models, but more***
 - ***Virtual Integration – early and continuous integrated analysis***
 - Proof-based (consistency checked – but not all with formal models)
 - Component-based (hierarchical models)
 - Model-based (annotated models)

Integrate, analyze ... then build”



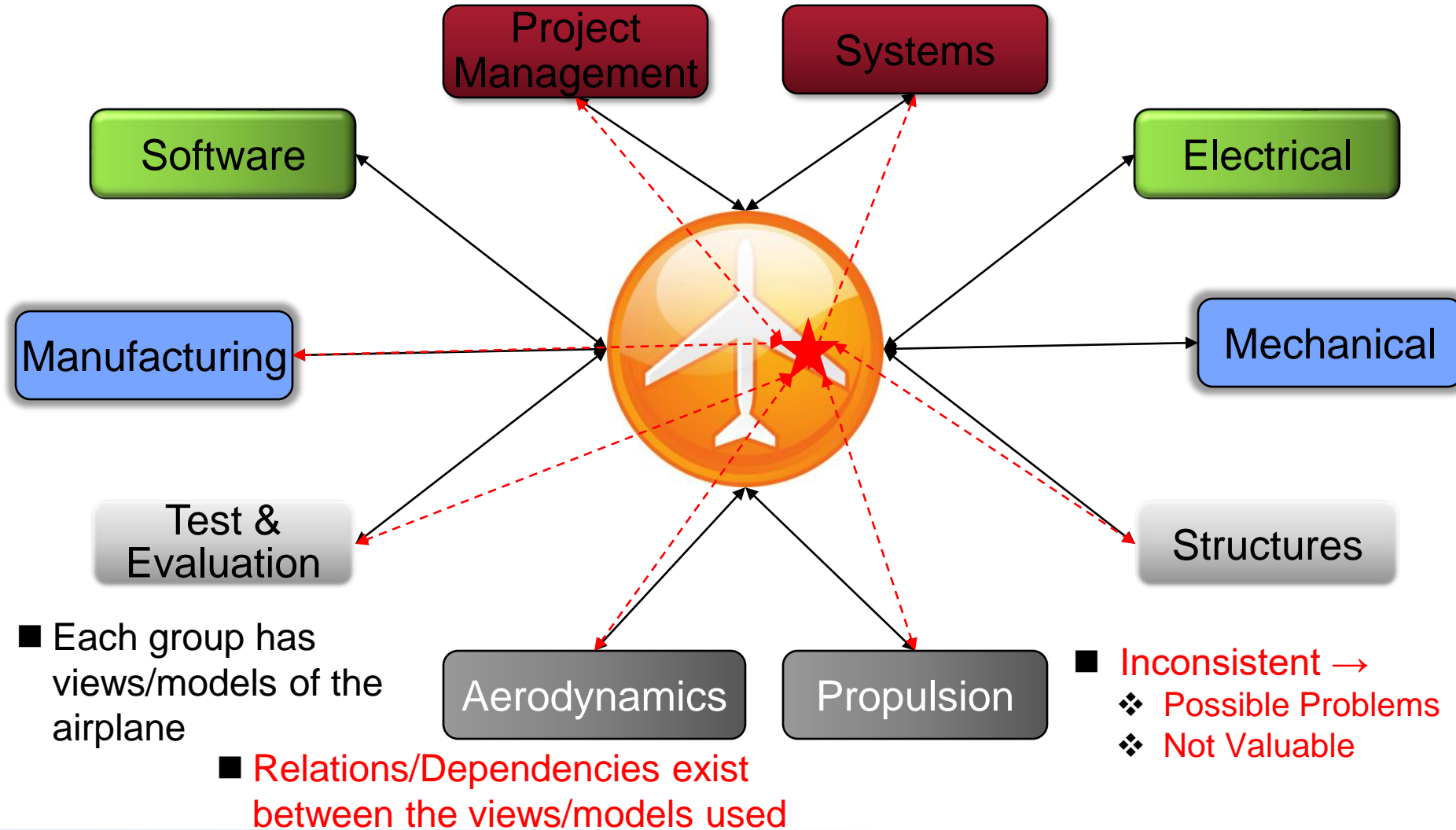
Models Across the Supply Chain

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Inter-Model Consistency

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Inter-Model Consistency Checking

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- **Consistency between two models exists when the dependence relations between those two models are satisfied**
 - **Some dependence relations can be detected automatically**
 - **Some tools are using patterns to assist**
 - **Some dependence relations will (always) require manual identification**
 - **Fidelity of consistency is proportional to the effort put into consistency modeling**
- **Dependence relations exist between entities and attributes**
 - **The output of one parameter in a model is the input for another model**
 - **IEEE floating point radar altitude in feet**
 - **NOT radar altitude on one side and barometric altitude on the other**
 - **NOT feet on one side and meters on the other**

Key Takeaways

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- **Systems Engineering use cases expose a new layer of complex interoperability requirements**
 - Multi-domain
 - Subsets of shared properties data exchange
 - Relationships (not exchange) of dissimilar properties
 - Consistency
 - Traceability
 - Dependency
 - Association
- **Not a “zero sum game” for tool providers**
 - Interoperability is the opportunity to participate

SAVI Summary

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- **Systems Engineering Model Set**
 - **Highly complex**
 - **Cross domain**
 - **Linked subsets of model properties**
- **Standards based**
 - **Process and tool independent**
 - **Protect Intellectual Property**
- **PDES & SAVI research and demonstrations**

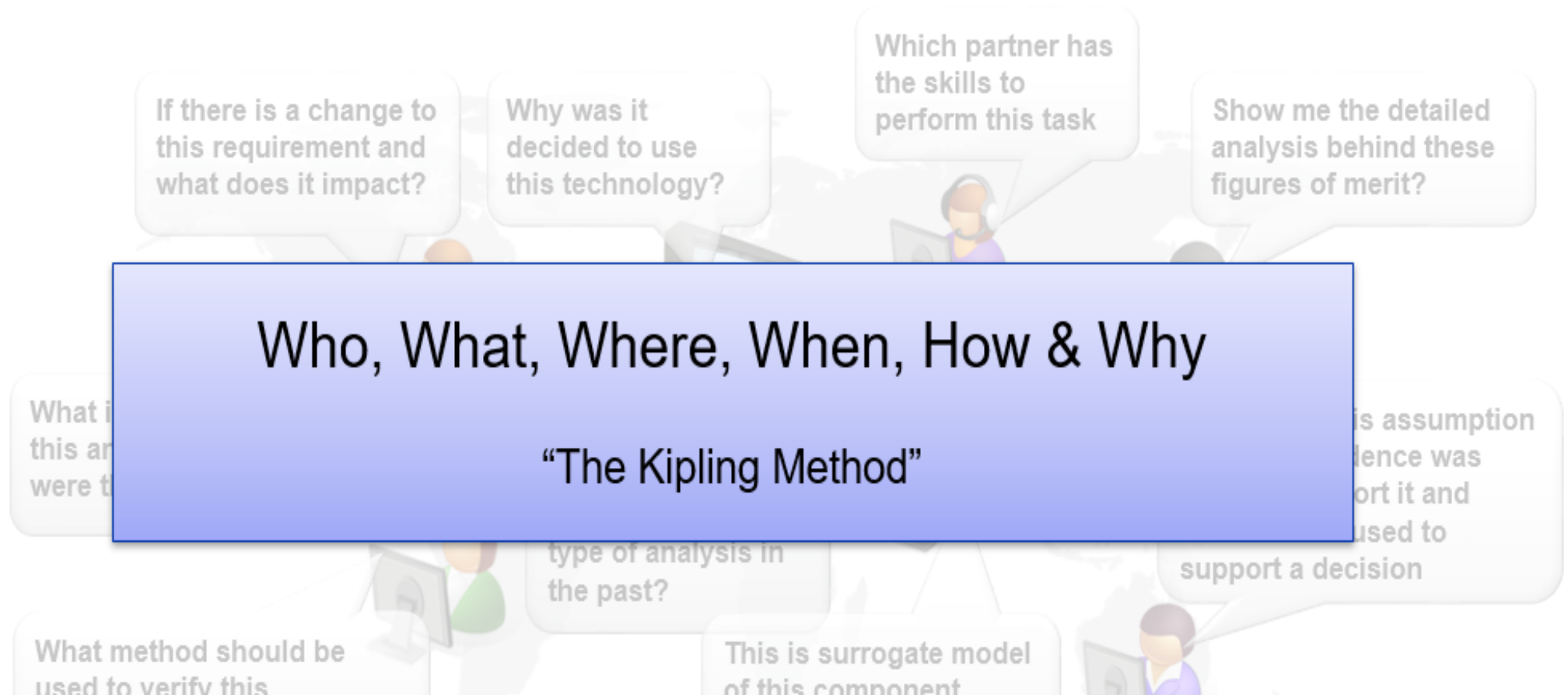
MoSSEC (Modeling & Simulation information in a collaborative System Engineering Context)

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Why Do I Need MoSSEC?

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Lifecycle Model-Based Enterprises: Typical decision making questions



Why Do I Need MoSSEC (cont'd)

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Combining Modelling and Simulation Data with Collaboration Data

Modelling and Simulation data

- Managed by PLM/SPDM tools
- Exchanged with technical standards



Collaboration data

- Managed by MoSSEC Compliant Tools
- Exchanged with MoSSEC standard

Together this supports a lifecycle model-based enterprise

MoSSEC Summary – A Unique Combination of Features

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- Links **Modelling and Simulation** to the **Systems Engineering Context**
 - Uses objects at a business level
- Efficiently shares context information
 - Uses **web services** defined using the business object specification
- Builds on existing standards
 - Uses **STEP Extended Architecture** mapping to AP239 and the **Core Technical Capabilities**
 - Exploits AP239 usages such as Long-Term Archiving and Retrieval (LOTAR)
- Supports lifecycle model-based enterprises

MoSSEC: An ISO Standard

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- **ISO 10303-243 STEP standard**

Check out other GPDIS 2023 presentations/sessions on MoSSEC

MBSE Represents a Huge Investment

MBSE LOTAR 101

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- **LOTAR MBSE SCOPE**

- **Capture requirements in models, including contributions from the sub-suppliers, and how they were allocated and validated**
- **Preserve behavior and simulation models, that were used to verify the design alternatives and decisions**
- **Easily identify what architectures were evaluated during the design process and the links to the supporting information**
- **What requirements are driving the physical design (CAD), purchasing, and manufacturing process?**

- **MBSE LOTAR Process Planning**

- **Use LOTAR Part 5xx documents to standardize the long-term archival and retrieval of your essential model assets, including requirements, behavior and architectural models; Logical BOM; and links between MBSE artifacts**
- **Develop robust methodologies for capturing model information, such as performance, integration dependencies, pedigree, and model credibility data**
- **Develop processes for assuring reconstituted models, extracted years from now, faithfully replicate their original features and behavior**

PDES MBSE WG Part 500 Deliverables – NAS9300

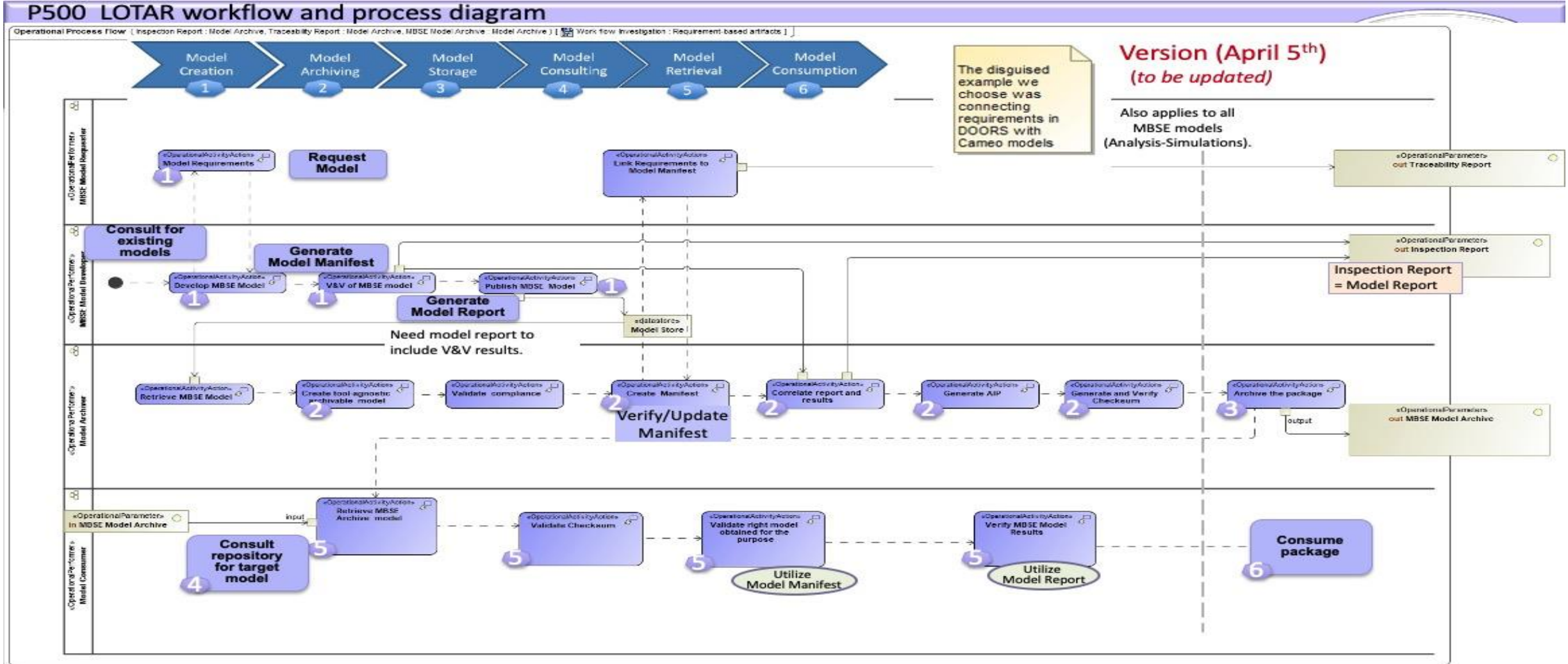
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- **Part 500:** Fundamentals and Concepts for long term archiving and retrieval of Model-Based Systems Engineering information
- **Part 520:** Analytical behaviour models described by specification or executable code, containing differential, algebraic and discrete equations
- **Part 510:** Requirement management “text, graphics, tables”, models, and “parameter based” information
- **Part 515:** Validation and Verification “text based” and “parameter based” information (expanding Part 510)
- **Part 530:** Architecture descriptions and architecture description languages (ADLs)
- **Part 540:** The Logical Bill of Materials (LBOM)
- **Part 550:** Digital or relational links specifying interrelated elements across numerous tools.

LOTAR P500 Workflow and Process Diagram – WIP

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PDES-LOTAR-INCOSE

MBSE Standards Collaboration for Interoperability and Integration

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- **Developing standards for systems engineering model exchange, interoperability, integration**
- **A Long History of collaboration**
 - **Model linking and data exchange**
 - **Requirements traceability**
 - **SAVI integration**
 - **MoSSEC model context**
 - **LOTAR model archiving**
- **Opportunities to Participate as a PDES/LOTAR Member or INCOSE Member**

THANK YOU!

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- **Questions?**