2021 Annual INCOSE international workshop
Virtual Event
January 29 - 31, 2021

A Roadmap for MBSE Data Standards

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Boeing

AFFILIATIONS:
PDES MBSE WG
LOTAR MBSE WG
NAFEMS SMS WG
INCOSE TIMLM WG
A&D PLM MBSE WG

Why MBSE Data Standards?

- Data integration, preservation and reuse
- OEM – Supplier Design Development
- Collaboration opportunities
- MBE digital thread (traceability, exchange, integration, and synchronization)
- Foundation for standard process and procedures

Lots of MBSE data standards: but need forums/industry/consortia to create/validate standards, and recommend enhancements.

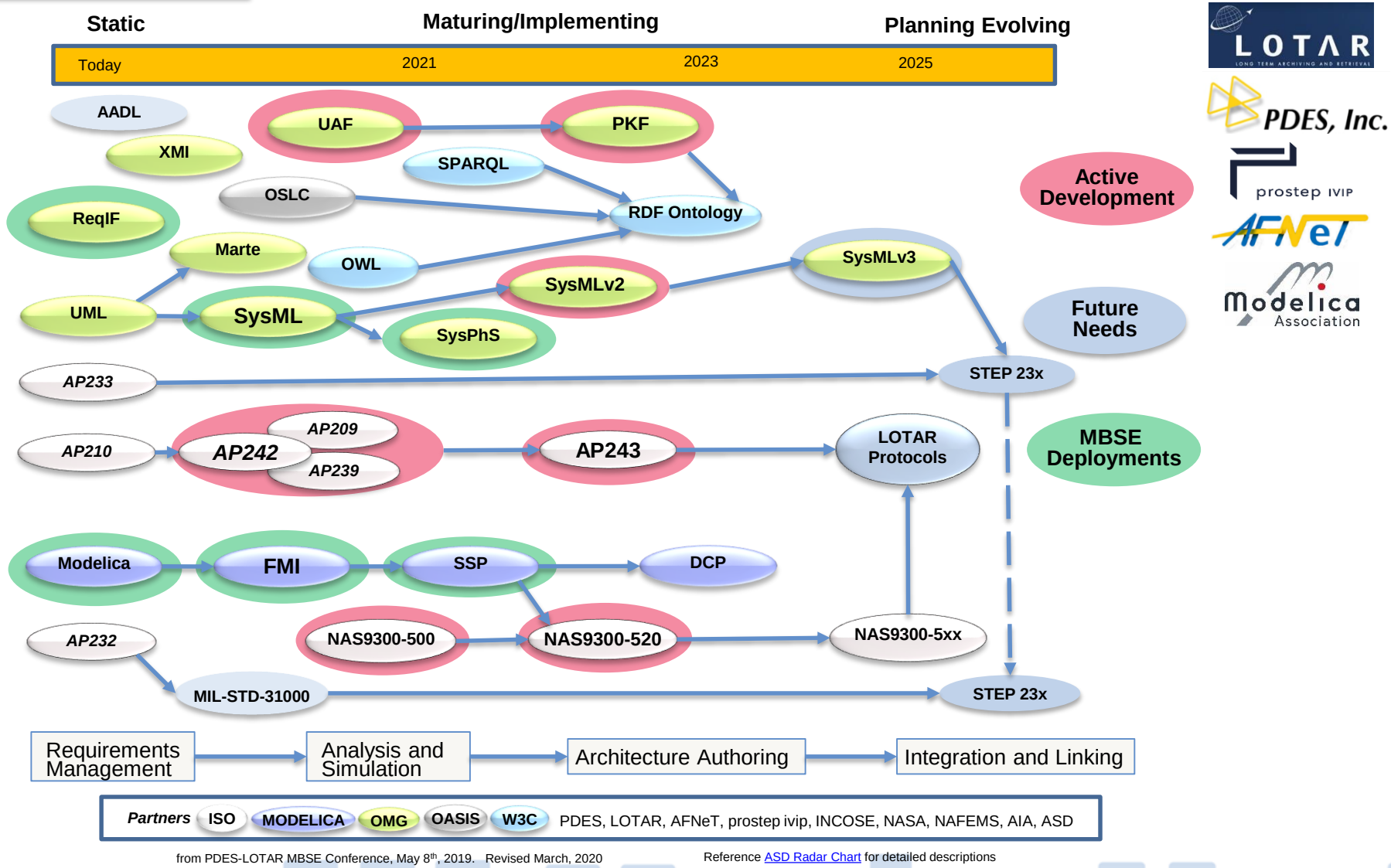
Your participation is needed!

(implementer Forums, industry groups, standard bodies)

Four categories of Standards?

- **Data and Interoperability Standards**: *includes modeling, exchange or language standards*
- **Process standards**: *specifications for methods, outcomes, compliance, lifecycle*
- **Procedural standards**: *for data measurement, testing and qualification*
- **Part/Product (Design) Standards**: *dimensional, material, operation, performance, protocols/specifications*

MBSE Data Interoperability Specifications



from PDES-LOTAR MBSE Conference, May 8th, 2019. Revised March, 2020

Reference ASD Radar Chart for detailed descriptions

Standards Bodies and Consortia

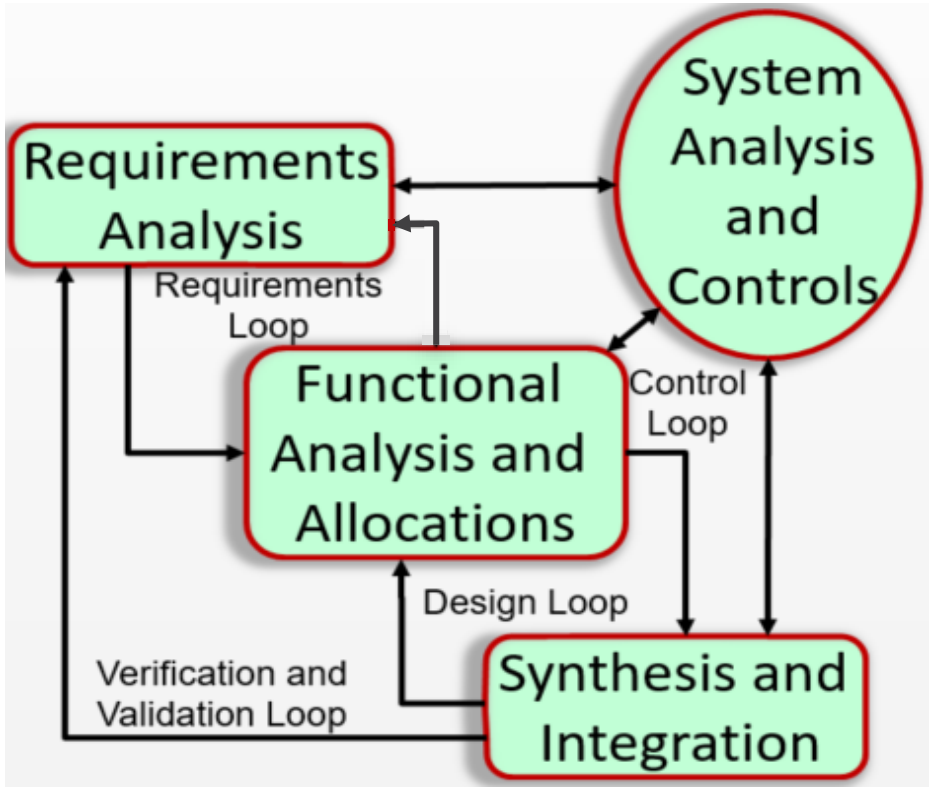
MBSE Standards Development

- PDES, MBSE WG (STEP, MoSSEC, INCOSE MoU)
- LOTAR, MBSE WG (data preservation and reuse)
- Modelica Association (MBD, language, FMI, SSP)
- NAFEMS (consortium, Systems Modeling & Simulation)
- SISO (consortium, modeling and simulation interoperability)
- AFNeT (consortium, digital transformation/stds)
- prostep ivip (consortium, industry best practices)
- AVSI (Academia, virtual integration, PBR/PMM)
- Others: W3C, OMG, OASIS, OAIS, INCOSE, Open Group

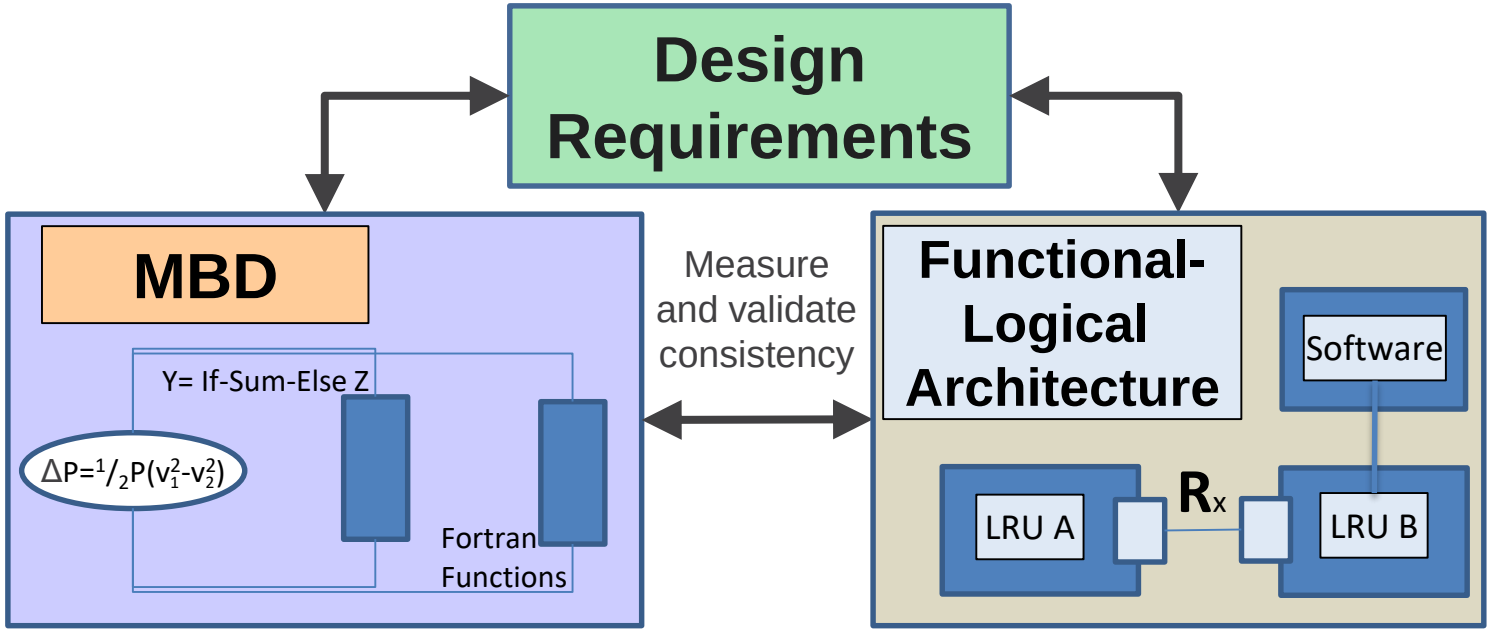
Industry and Governance

ISO, NASA, ASD, AIA, A&D PLM Action Group, GPDIS

MBSE Capabilities: Data Types



MIL-STD-499

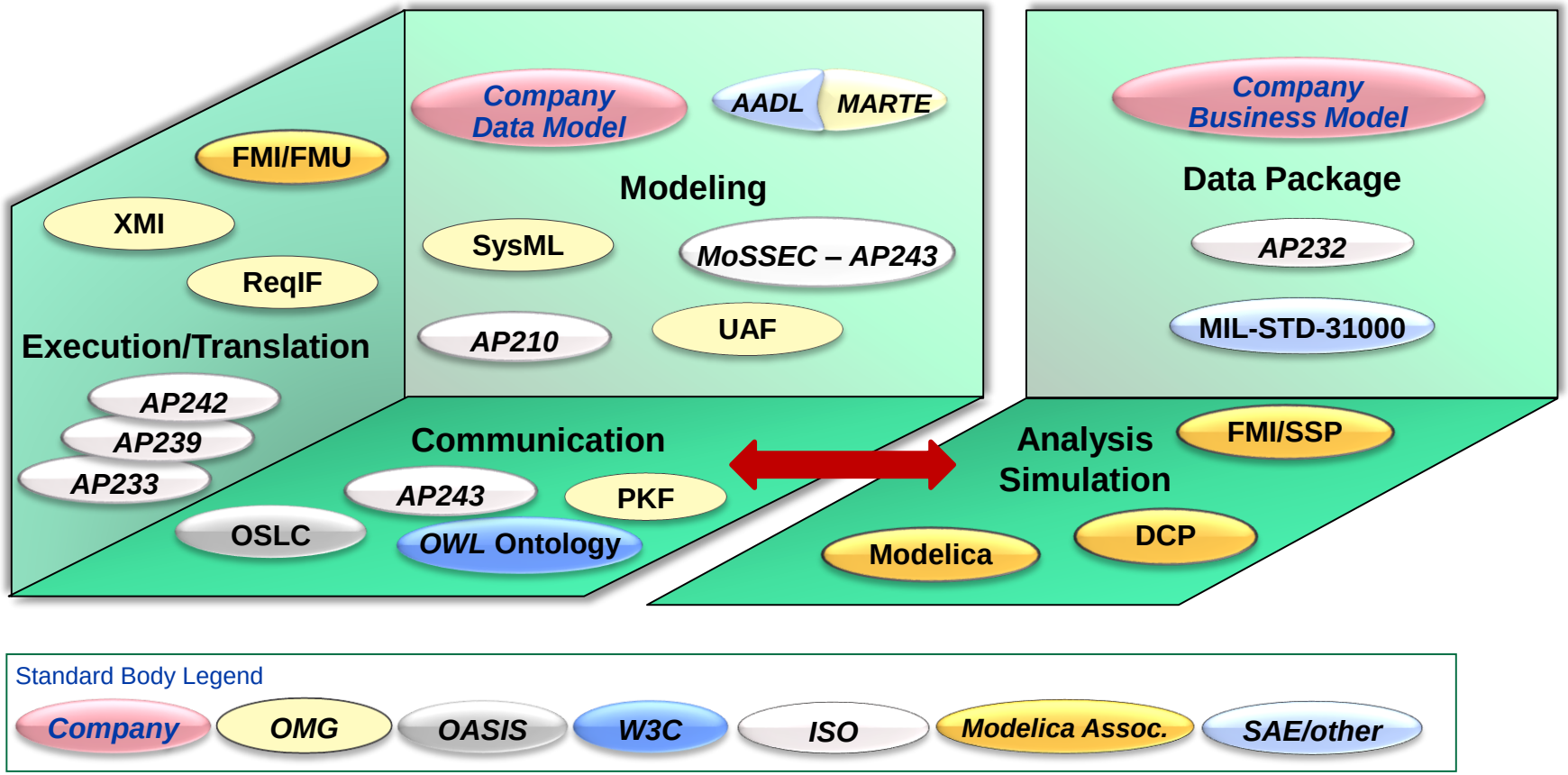


System Behavior, Performance, Controls, Code Generation, Acausal - Lumped Parameter models

System Architecture, Connectivity, Data I/O, Requirements Allocations, System Structure

MODELS

MBSE Data Standard Categories



CREDIT: Bill Chown, Mentor Graphics; MBSE Roundtable, 2015 GPDIS

Systems Behavior Model

The quantitative assessment of functional systems that represent the environment, System/Structural Plant architectures, and/or regulated Control Loop activities. They are defined as lumped parameter models representing physics based behaviors and control logic. They are constructed using complex mathematical equations, specifications or executable code, containing differential, algebraic and discrete equations.

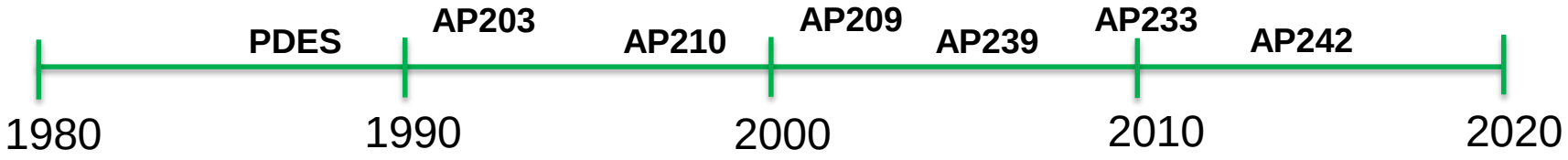
Model Based Design

MBD Standards Development

- PDES : Product Data Exchange Specification
  AP209 (FEM), AP243 (MoSSEC)
- LOTAR : LOng Term Archiving and Retrieval
  NAS9300-520, MoSSECC template
- Modelica Association : language, libraries, FMI, SSP, DCP
- NAFEMS : National Association of Finite Element Methods
  vocabulary, Engr Simulation Quality Standard
- SISO : Simulation Interoperability Standards Organization
  HLA for M&S, DIS (Dist SIM), DSEEP
- NASA : National Aeronautics and Space Administration
  NASA-STD-7009A, NASA-HDBK-7009A
- The Open Group : SOSA, Sensor Open Systems Architecture

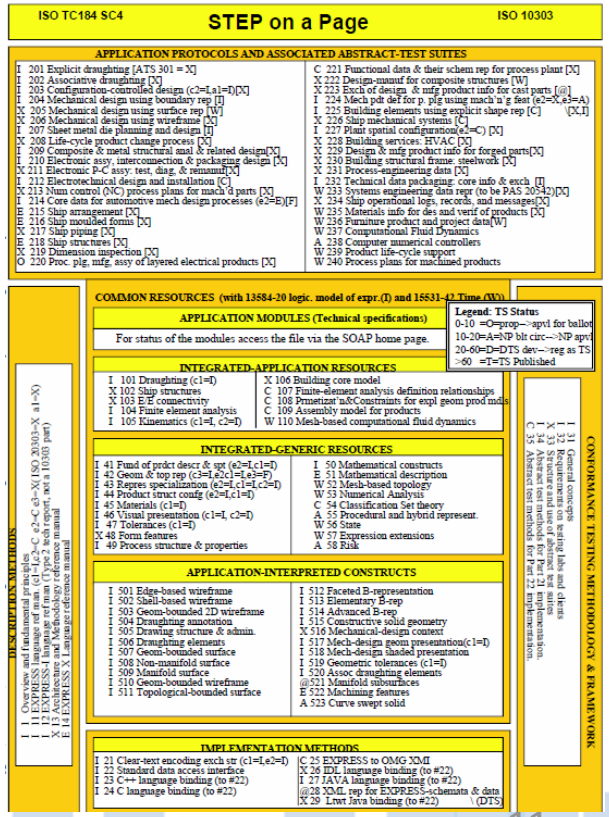
PDES, Inc.

PDES, Inc. is an international consortium joining industry, government and academia.



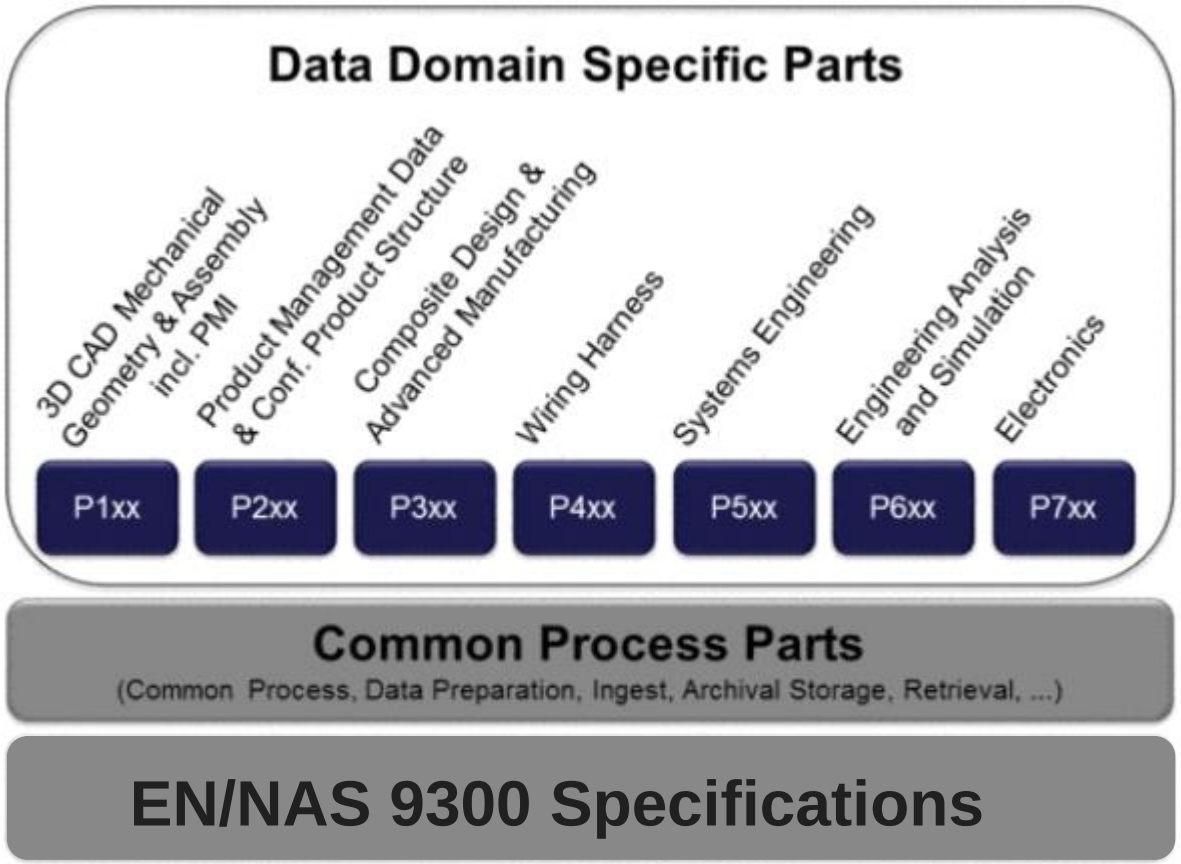
Formed in 1988 to standardized data exchange and accelerate the development and implementation of standards.

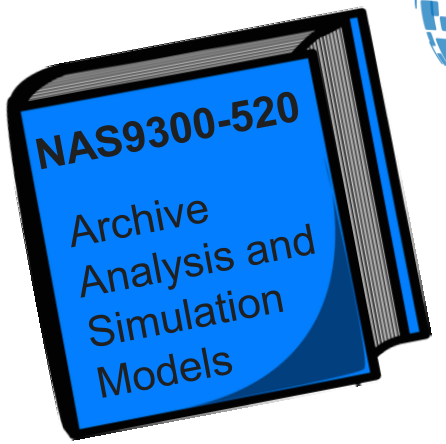
PDES = Product Data Exchange Specification
(Product Data Exchange using STEP)

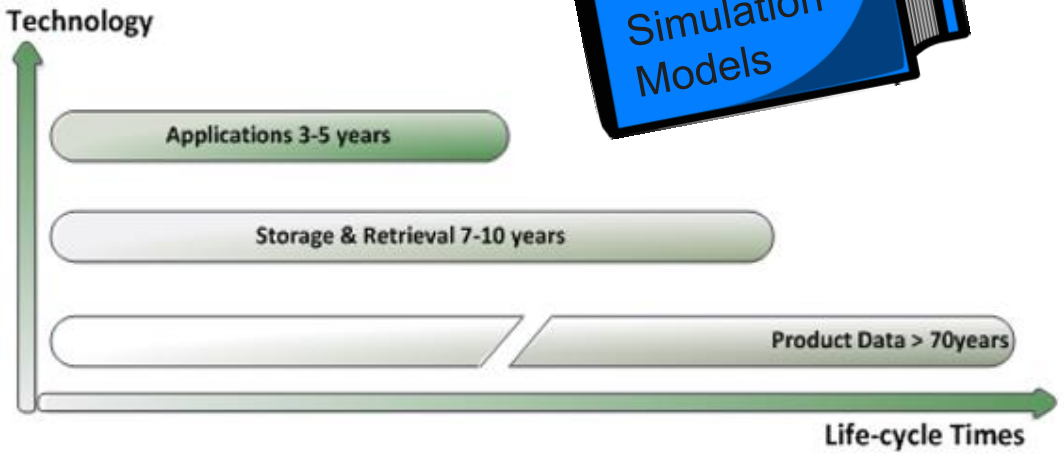


LOTAR Parts Structure

LOTAR International is supported by the AIA and PDES Inc. in the US, ASD-STAN and ProSTEP iViP in Europe







LOTAR is Enabled by Standards

- Data preservation, Reuse, Accident Investigations, Maintenance, Regulations, Obsolescence, Safety
- Assume Application versions 3yr; storage/access 10yrs; translate to stable formats for 50yr product cycles.

Collaboration Strategies

1. Share data/models without expectation of receiving model revisions
2. Share data/models using a drop-box technology with the expectation to make changes and iterate the sharing process. Must manage multiple versions.
3. Use a secured common repository, or interactive environment, where data/models from all parties are shared and executable. The shared models represent the latest version. Add additional controls to support model modifications, and sister repositories for comparative trade studies.

Modelica Standards: FMI, SSP, DCP

FMI: Functional Mock-up Interface

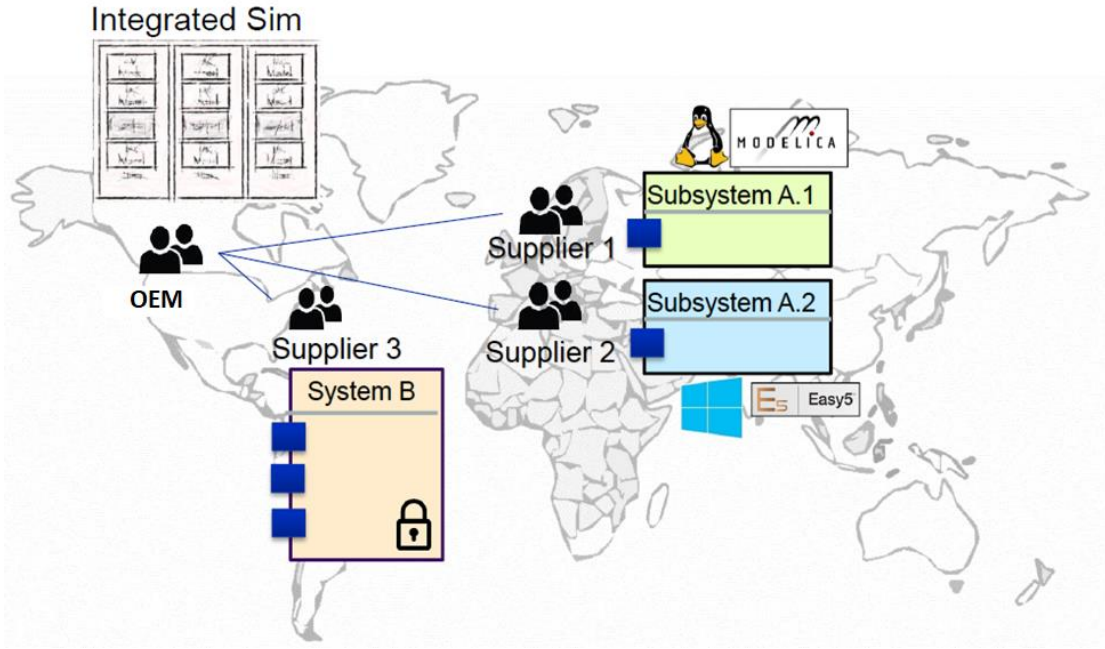
- ✓ **Supplier – OEM Model Exchange**
- ✓ **Early requirements validation**

SSP: System Structure and Parameterization

- ✓ **Supplier – OEM Simulation Exchange**
- ✓ **Traceability with Architecture definition**

DCP: Distributed Co-simulation Protocol

- ✓ **High fidelity, real time co-simulation**



End users have identified Improvement Areas

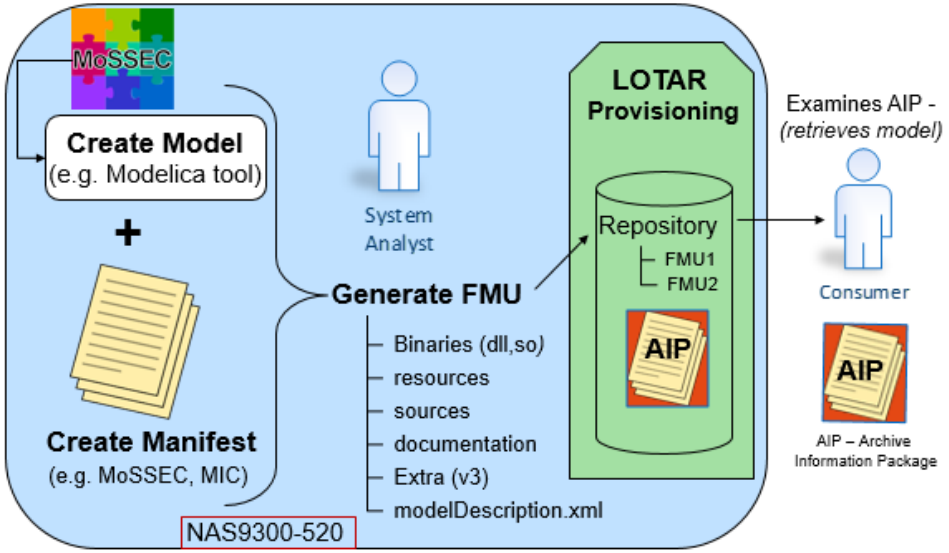
Juan Carlos Mendo,
Boeing Research & Technology - Europe

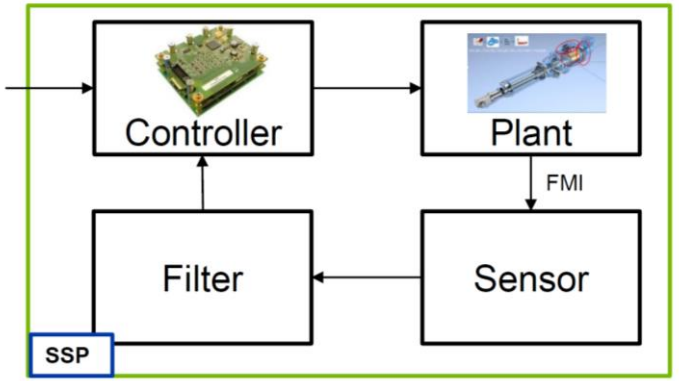
Industry Use Case: Reuse of FMI and SSP models

Industry collaborative prototype. LOTAR-PDES Activity.

Goals are:

- ✓ **Define the process to archive and retrieve behavioral/ executable models (particularly the MBSE use case).**
- ✓ **Define the process to archive and retrieve simulations**
- ✓ **Identify changes to the FMI and SSP Standards for Modelica.org**
- ✓ **Align and bring together AP243 and the concept of the Model Identity Card (MIC)**
- ✓ **Deliver a LOTAR prototype that can be reused for other MBSE model types**



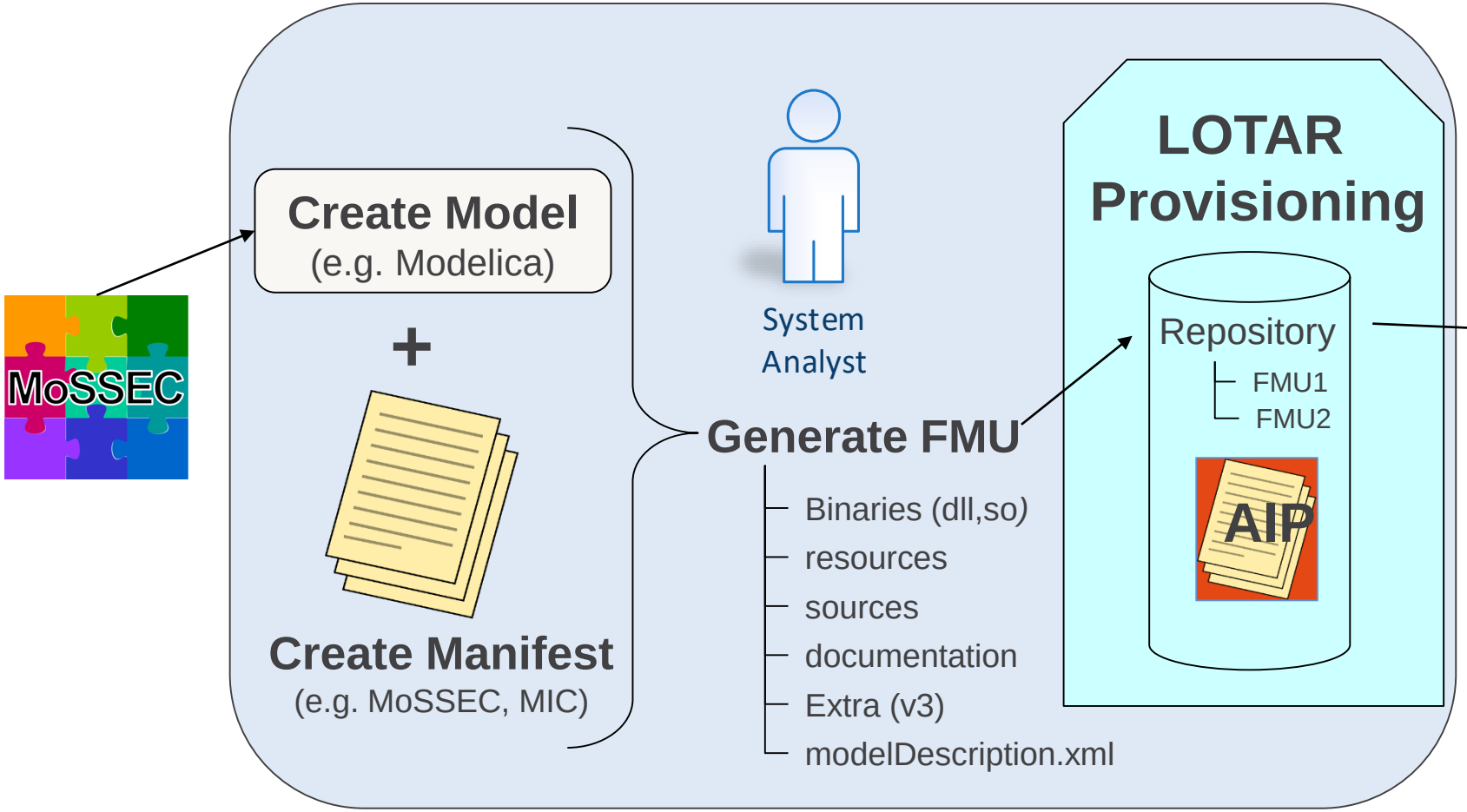


Closed loop Actuation Industry use case

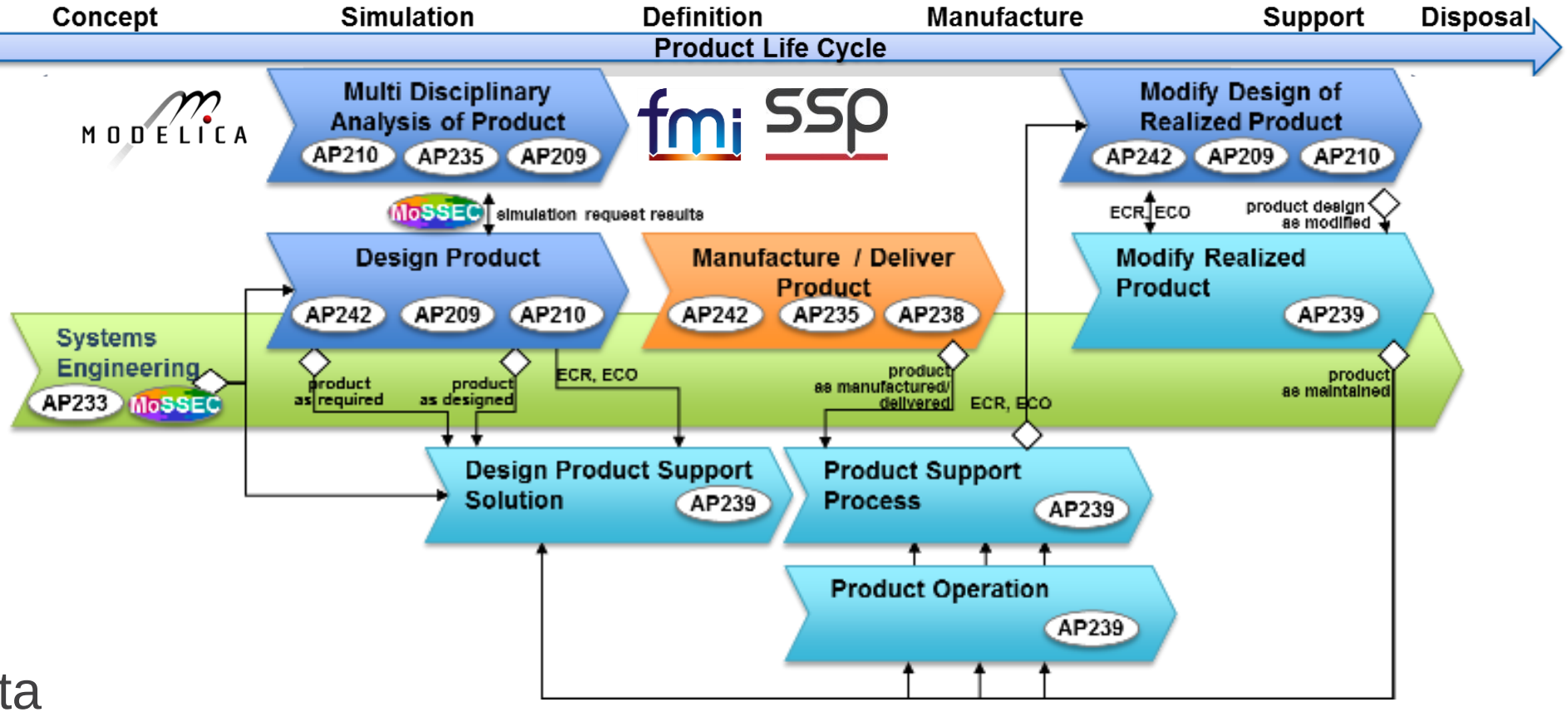
Juan Carlos Mendo,
Boeing Research & Technology

NAS9300-520 Process

Archiving a Simulation Model (FMU or SSP)



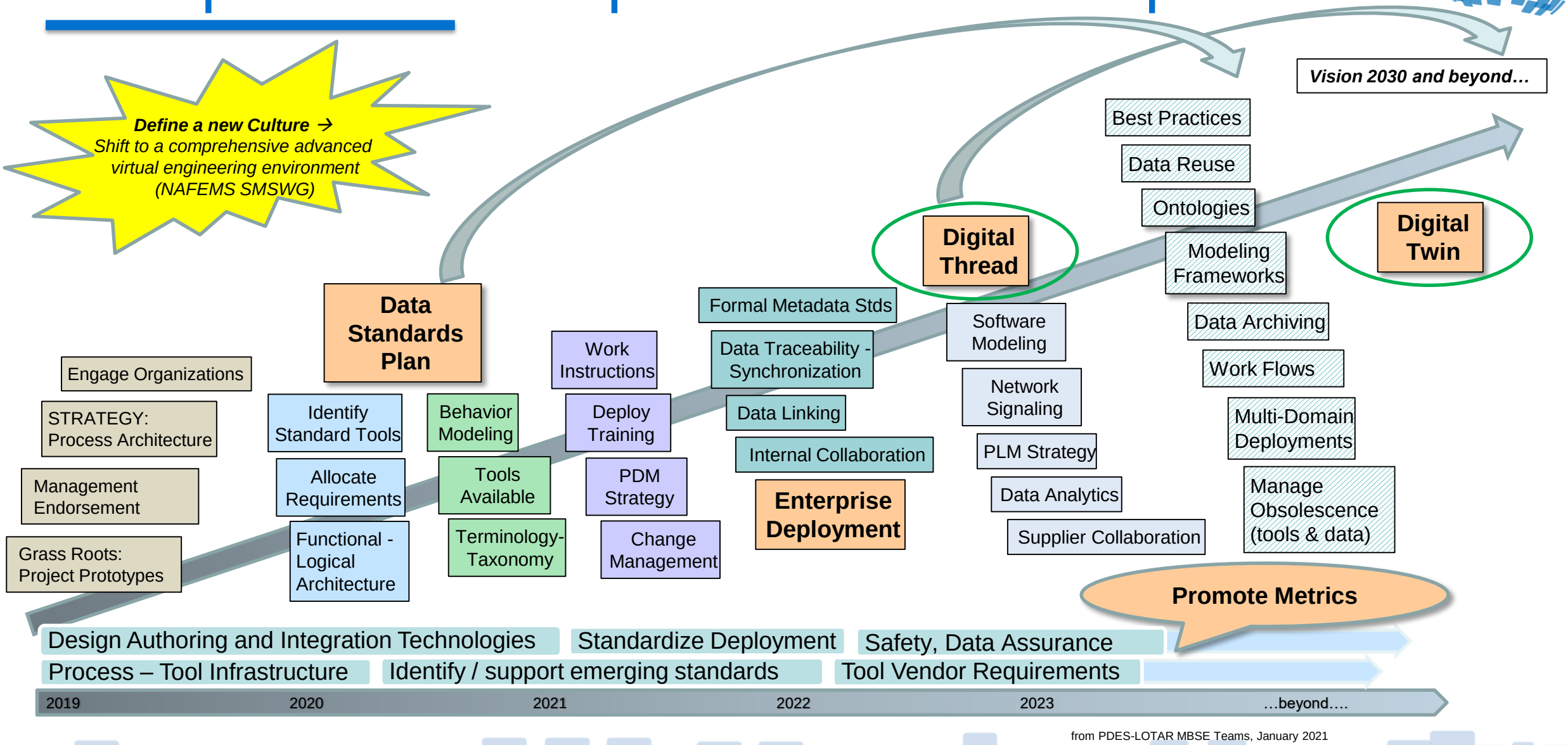
The path to integrating data



MoSSEC

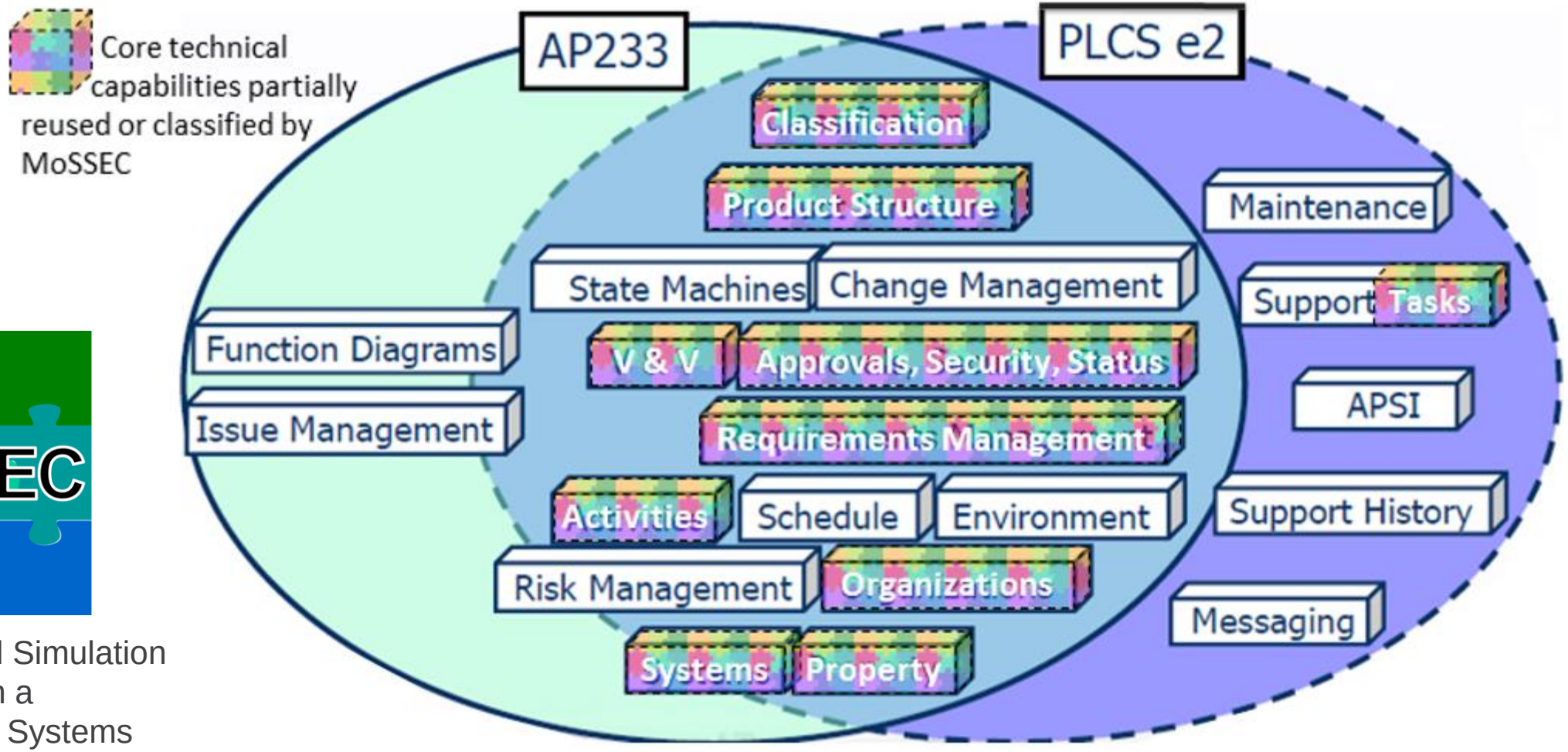
Model metadata
Scope, Pedigree, Provenance
Who, What When Where, Why, How

Sample MBSE Capabilities Roadmap



from PDES-LOTAR MBSE Teams, January 2021

AP233 + AP239 + AP243



MoSSEC

Modeling and Simulation Information in a Collaborative Systems Engineering Context

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www.incose.org/IW2021