



AeroSpace and Defence
Industries Association of Europe



Through Life Cycle Interoperability

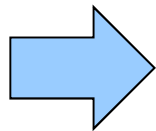
and the multidisciplinary
simulation challenge

Presented by Yves Baudier,
ASD SSG Chairman
Airbus Group Innovations

NAFEMS SMSWG call, 26/05/2015



Contents



A) ASD SSG and the challenge of Through Life Cycle Interoperability

1. The role of the ASD SSG within the e-business standard governance
2. The challenges of Through Life Cycle interoperability
3. The ASD SSG recommendations

B) Multidisciplinary Simulation Interoperability

ASD

E-Business
SSG

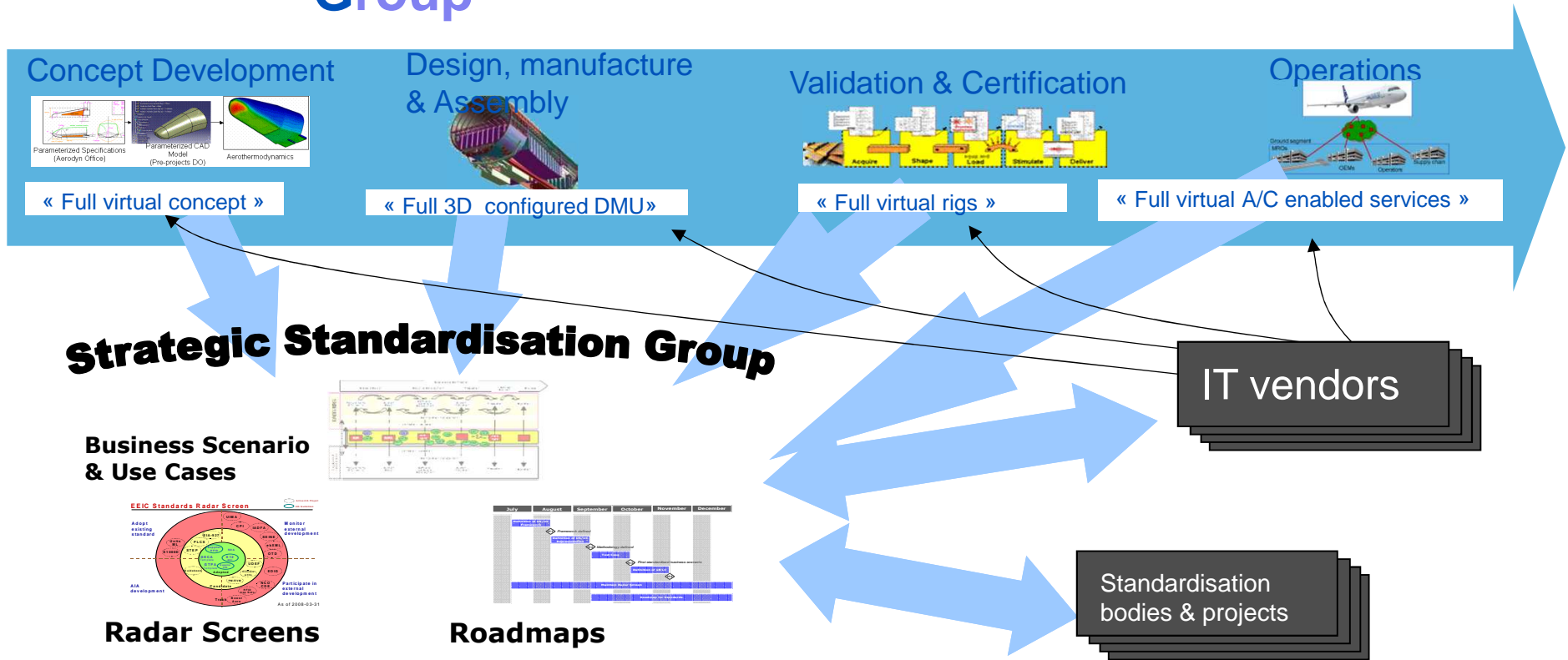
ASD association





Strategic Standardisation Group

Standards Governance





E-Business
SSG

ASD SSG members and links



Product developpt requirements

3D Mechanical interop. WG
 3D Composite interop. WG
 Electrical Harness interop. WG
 PDM interop. WG
 Multi-disciplinary simul. interop. WG

Through Life requirements

Through Life-cycle interop. WG

Product support requirements

Link with the *ASD ILS Council* driving the ILS suite of specifications: STE100 , S1000D , S2000M, S3000L, S4000P, S5000F, S6000T, SX000i, SX001D, SX002D

Supply Chain requirements

Supply Chain interop. WG

Data Quality requirements

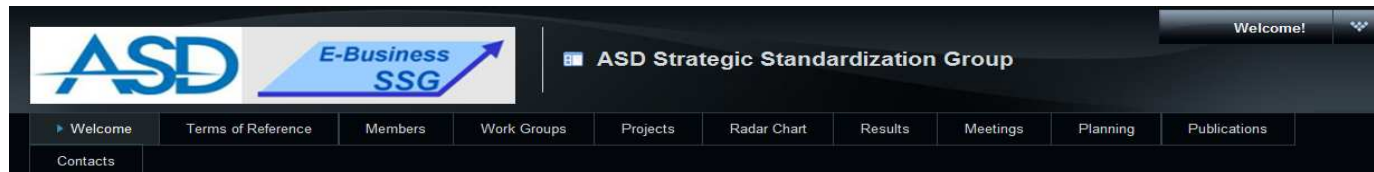
Data Quality WG

Collaboration with
AIA (USA)



ASD SSG public web site

<http://www.asd-ssg.org/>



Parent organisations

ASD www.asd-europe.org

ASD-STAN www.asd-stan.org

Web Content Display

New!!

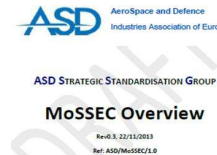
ASD SSG leaflet now available for download:

About ASD Strategic Standardization Group

The ASD Strategic Standardization Group (SSG)

Overview

The Strategic Standardization Group (SSG) was set up in October 2008 by a group of European manufacturers, A&D associations and military governmental agency in order to share efforts of development of common A&D e-Business standards and associated harmonized European policies for operational use.

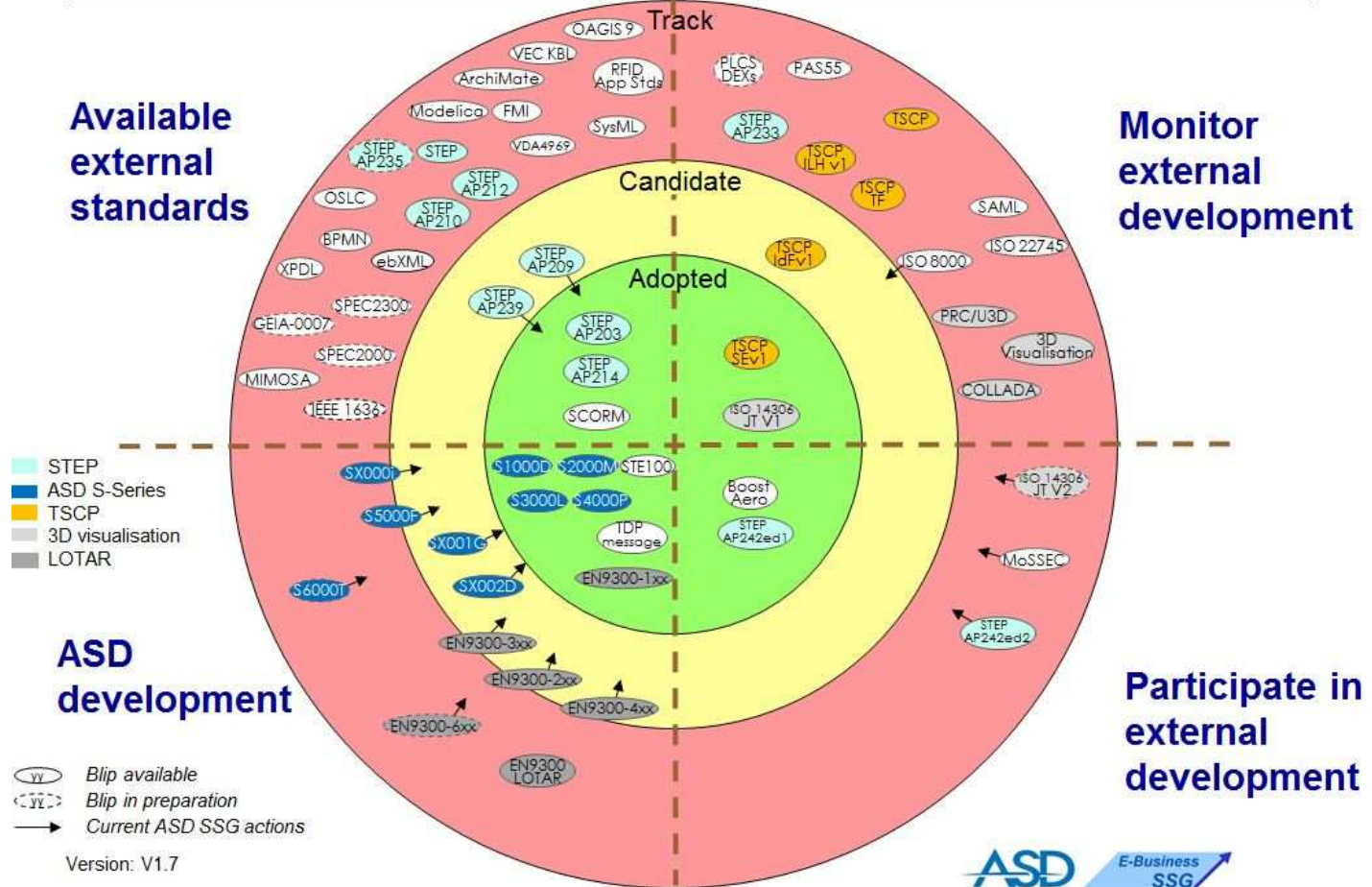


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Slide 6



Radar screen

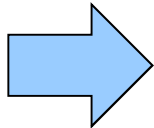




Contents

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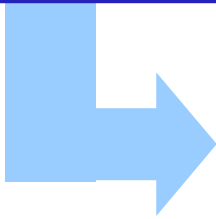


B) Multidisciplinary Simulation Interoperability



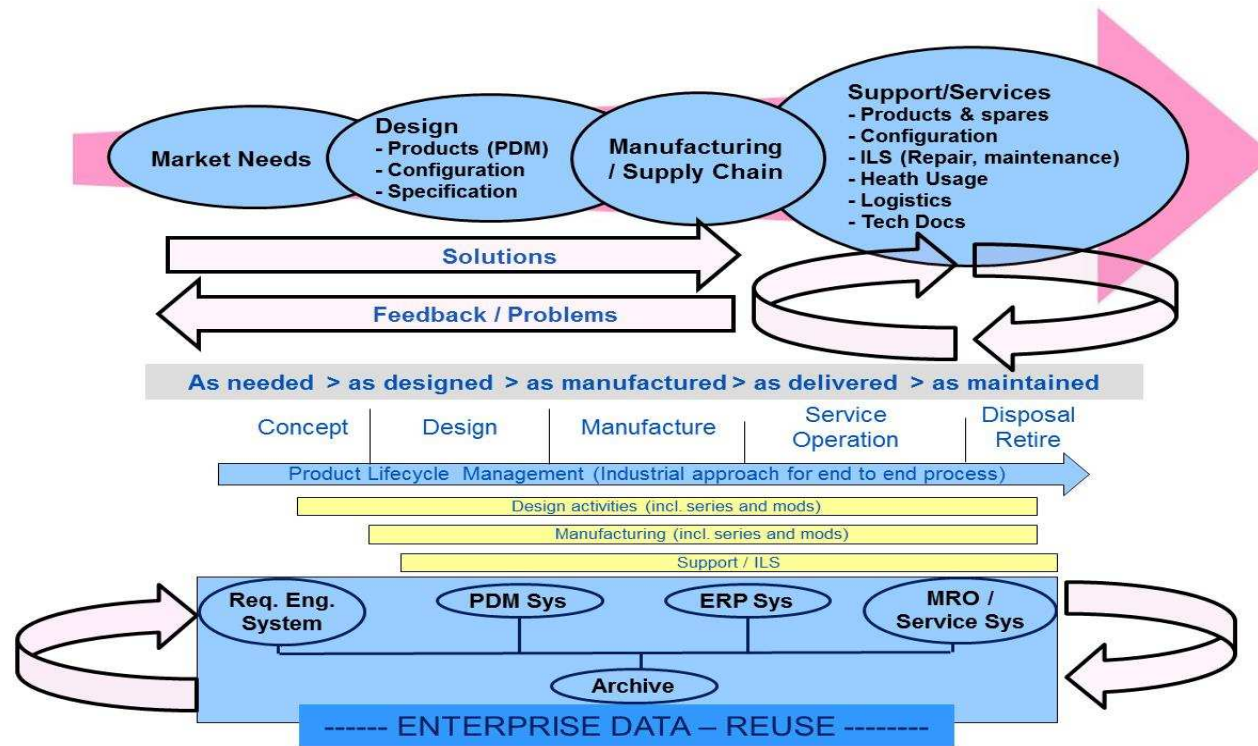
Aerospace and Defence Industry characteristics

- Small number of large prime contractors,
- Global marketplace,
- Large global supplier network shared among primes and other industries with an average supplier size of 20-50 employees,
- Long product and service life cycles that far exceed the life of software, equipment and people,
- Continuous innovation in products, processes and services for new capabilities and for regular technology upgrade programmes.
- In many cases this is also subject to rigorous certification requirements.
- The Industry has also seen the development of new service contract models that include electronic customer services, management of the in-service phase and feedback from service into the design phase.

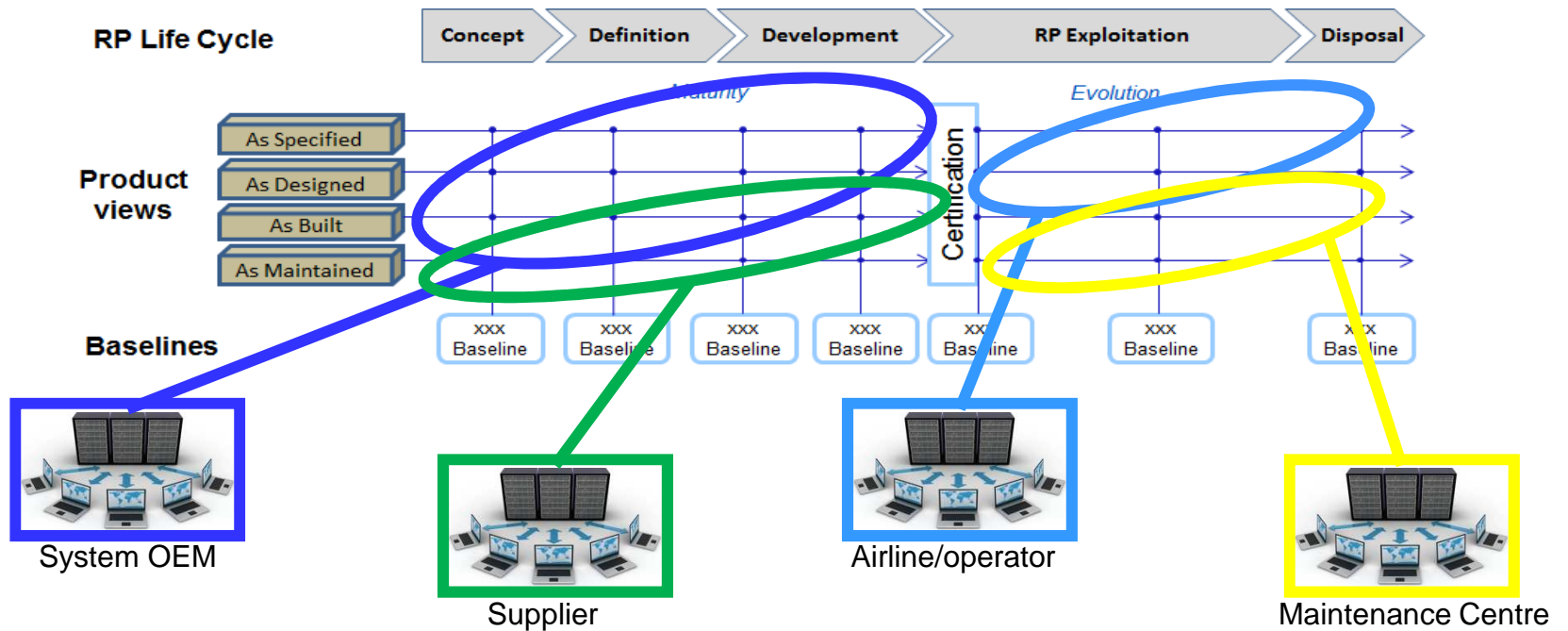


Need to manage design, product and service information throughout the product lifecycle, including rigorous configuration management and the long term retention of information, where the **data is 'created once and used many times'**.

Data explosion through the life cycle



Shaping the PLM Platform of the Future



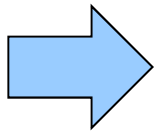
The PLM Platform of the Future will be **federative** and PLM Interoperability will be enabled by standards



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B) Multidisciplinary Simulation Interoperability



ASD SSG “Through Life Cycle interoperability” report

A critical strategic lever for competitiveness

*The objective of this document is to develop a vision of Through Life Cycle Interoperability for Aerospace & Defence and to **propose recommendations**.*



Executive Summary:

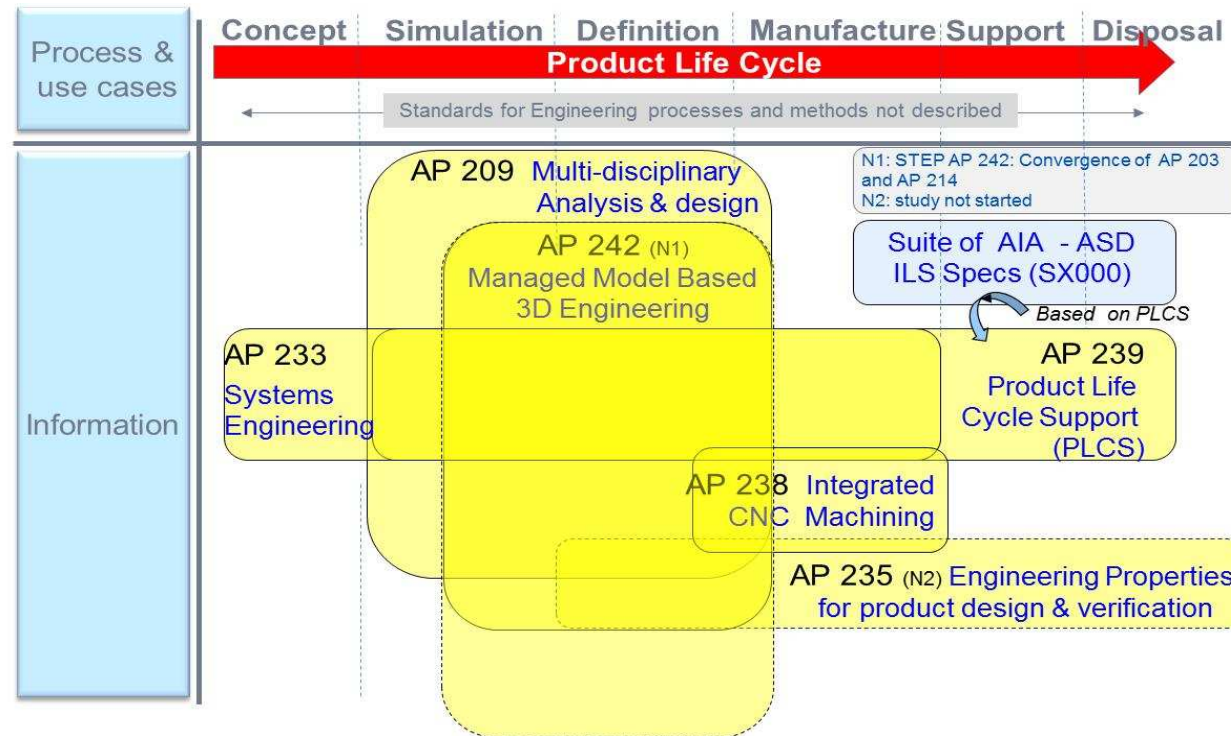
- Vision
- The business challenge
- Benefits
- ASD SSG answer

Table of content

1. Introduction
2. The interoperability challenge
3. Status of interoperability standards
4. Required standards architecture
 - 4.1 Global requirement
 - 4.2 Interoperability Framework
 - 4.3 Envisioned standards backbone
 - 4.4 Proposed recommendations



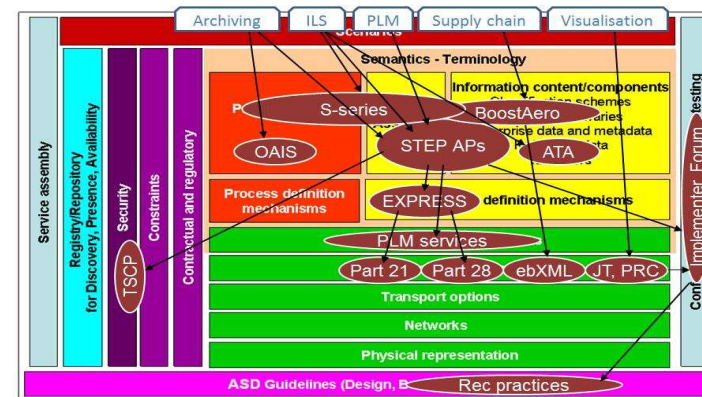
The core suite of STEP standards for PLM interoperability





Proposed recommendations

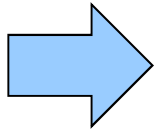
1. **Strengthen the STEP architecture approach** to 1) ensure interoperability between STEP standards and 2) provide unambiguous implementation methods (including for new information technologies, e.g. OSLC).
2. Ensure that **3D visualisation format standards** used in the industry are **consistent with STEP standards**
3. Ensure the **common data model** for the **ILS specifications** is **consistent with STEP AP239**.
4. Promote the **ASD-AIA ILS suite of specifications** and seek to manage **coherence with ATA specifications** where needed by the industry.
5. Participate in the development, and interoperability testing of the **next generation of PDM/PLM web services**.
6. Facilitate **data interoperability in the Aerospace and Defence Supply Chain** and align business process between Supply Chain stakeholders.
7. Supports the setting-up of **implementer forums** (e.g. PDM implementer forum) to test and validate the implementation of the standards-based solutions.





Contents

A) ASD SSG and the challenge of Through Life Cycle Interoperability



B) Multidisciplinary Simulation Interoperability

1. Overview of candidate standards
2. Vision, next steps



Multidisciplinary simulation - Scope

“Multi-disciplinary simulation” refers to the many “Law of physics” disciplines:
aerodynamics, structure analysis, thermal, electromagnetics, acoustics, vibration, etc

One energy, several forms.

The challenge is to ensure an accurate view on A/C physics from concept definition (incl. architect trade-offs) up to certification (and operations).

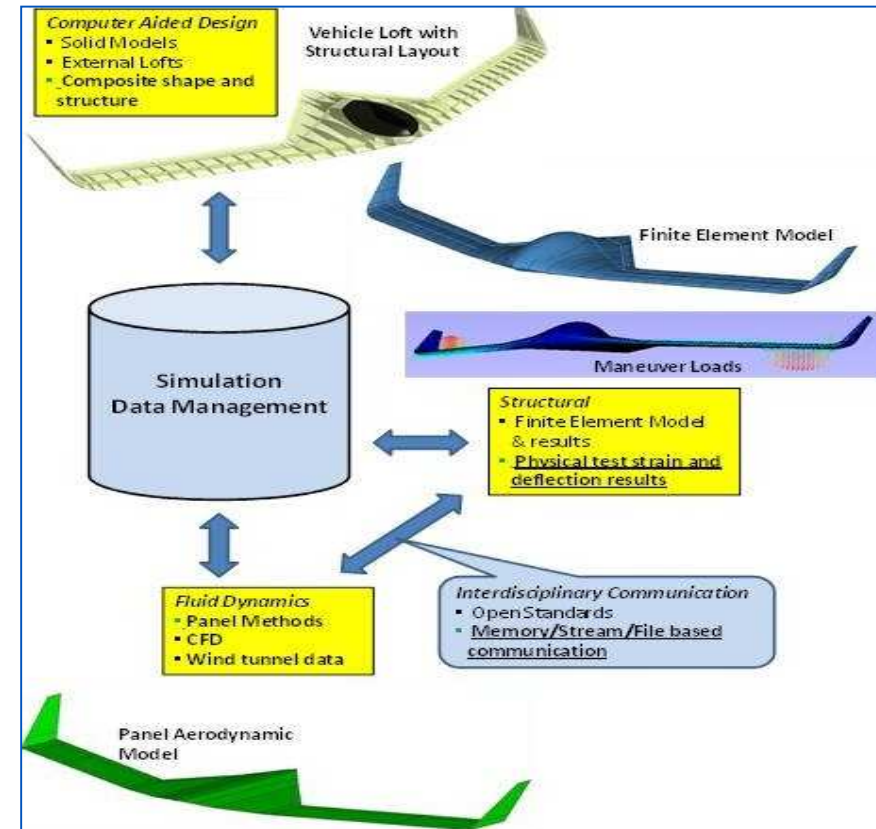
- High challenge for future vehicles (eco-efficiency, hybrid, more electrical)
- Link with classical Systems Engineering
- From architecture views to simulation chains

Out of scope (but interfaced!): design/CAD, Command/Control, SW engineering, electrical system and in general on-board system engineering – and related simulations (operational simulation, virtual iron bird).

STEP AP209: Multidisciplinary analysis and design (1/2)

Scope

- Finite Element Analysis (FEA)
- Computational Fluid Dynamics (CFD)
- Kinematics Analysis
- Product definitions
 - Product structure, including composites
 - Product shape: nominal design shape, idealized analysis shape(s), analysis shape(s)
- Configuration control: design and analysis
- Material properties
- Generic structured and unstructured analysis and mesh capabilities
- Meshless numerical analyses
- Complete discrete/continuous mathematical field representation capability

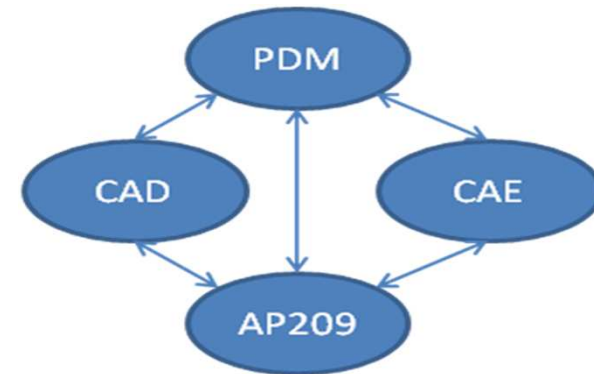




STEP AP209: Multidisciplinary analysis and design (2/2)

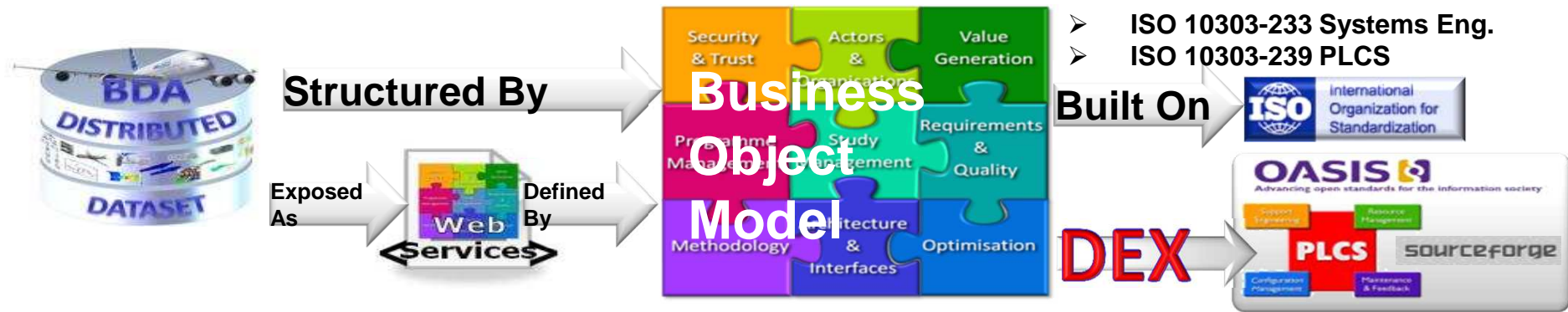
Highlights

- STEP AP 209 ed2 is implemented at 3 different levels:
 - **Mono disciplinary simulation tools**
 - **Simulation Data Management**
 - **CAE Services.**
- Complementing AP235 (Engineering properties for product design and verification), AP209 ed2 offers functions related to engineering materials database for simulation.
- AP209 has migrated to a modular architecture → increased integration with other parts of ISO 10303
- STEP AP209 website : <http://www.ap209.org>



AP209 links with 3 domains:
CAD, CAE and PDM (SDM included)

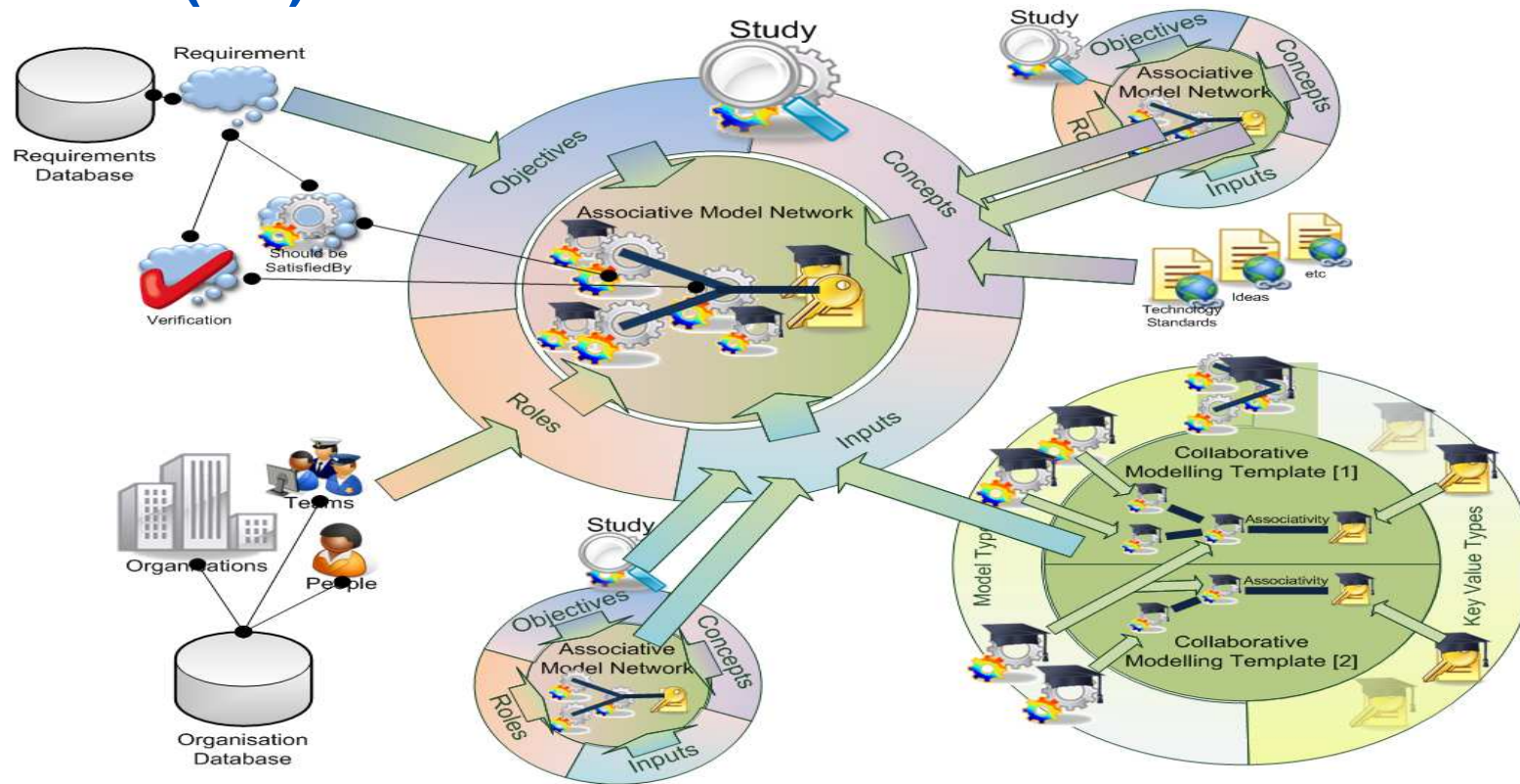
MoSSEC (1/2)



Common Approach: Standardised, Supported & Secure

- Elaboration of MoSSEC DEX specifications is in progress
- **MO**delling and **Si**mulation in collaborative **S**ystem **E**ngineering **C**ontext
 - Each BDA BOM Class → Template in a DEX (Data Exchange specification) defined using OMG SysML
 - Associative Model Network and Model Instance DEX defined
 - The key elements for Collaborative Modelling and Simulation.

MoSSEC (2/2)



Combined view of commonly used objects

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VDA CAE Services (1/2)

From a ProStep iViP project.

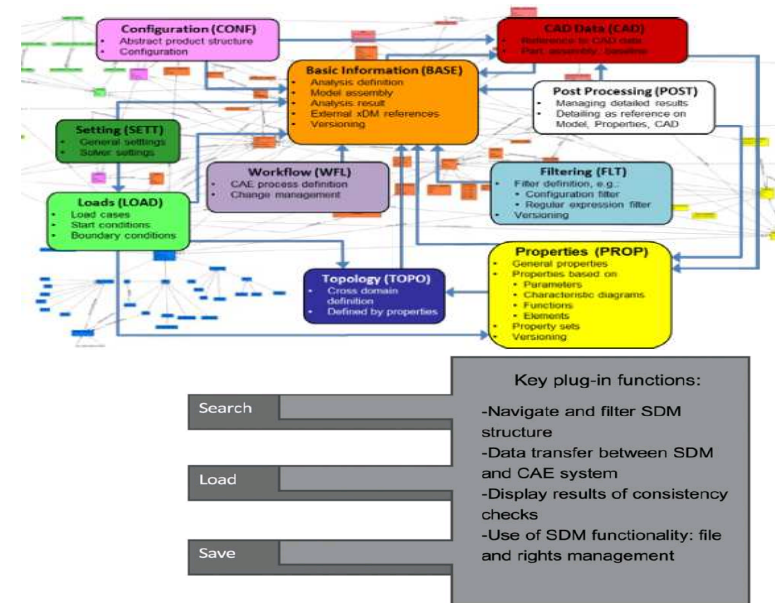
Objectives

- Integrate the Simulation and Calculation processes in the overall enterprise PLM backbone.
- Provide functions for the CAE engineer to access PDM data as simple as on the file system.
- Provide a possibility to work with PDM information without leaving the CAE systems environment.
- Provide a solution to handle the variety of CAE-tools with a “standardized” data exchange specification and not with many proprietary interfaces.
- Provide solutions to stay independent from a CAE vendor and to choose the best-in-class CAE tool for an existing problem.



VDA CAE Services (2/2)

1. Specification to integrate CAE-Systems into a PDM-Environment: data model, CAE functionalities, use cases, CAE-PDM processes.
2. Definition of xDM (PDM, SDM...)-based process chains.
3. Use cases for the handling of CAE data between companies (collaborative) and between domains (CAD/CAE integration)
4. C3I Data Model refined and mapped towards STEP AP209 and Siemens PLMXML formats.
5. Generation of a system specification for the usage of CAE services.
6. Demonstrator for a "C3I plugin" developed.





CGNS (1/2)

- The CFD General Notation System (CGNS) provides a general, portable, and extensible standard for the storage and retrieval of CFD analysis data.
- The system consists of 2 parts:
 - **a standard format for recording the data,**
 - **software that reads, writes, and modifies data in that format.**
- The CGNS system is designed to facilitate the exchange of data between sites and applications, and to help stabilize the archiving of aerodynamic data.
- The CGNS project originated in 1994 as a joint effort between Boeing and NASA, and has since grown to include many other contributing organizations worldwide. In 1999, control of CGNS was completely transferred to a public forum known as the CGNS committee, made up of international representatives from government and private industry.
- CGNS was "STEPified" in STEP AP209
- Website: <http://cgns.sourceforge.net>





CGNS (2/2)

- General, portable, and extensible standard for the storage and retrieval of CFD analysis data
- Collection of conventions, and free and open software
- Designed to facilitate the exchange of data between sites and applications, and to help stabilize the archiving of aerodynamic data
- Platform independent API for implementation in C, C++, Fortran and Fortran90
- Principal target is compressible viscous flow (i.e., the Navier-Stokes equations), and subclasses such as Euler and potential flows
- HDF5 is the default (official) data storage mechanism to enable parallel I/O

Source: "What is CGNS?," <http://cgns.sourceforge.net/WhatIsCGNS.html>



NASTRAN Data Deck

- De facto standard for structural FEA model transfer
- Bulk data deck is declarative definition
 - Node ID, location, degrees of freedoms
 - Element ID, nodes, property ID
 - Loads and boundary conditions
- Case control deck is process parameter definition
 - Organization of loads, sequences, parameters
- Good commonality still remains
 - Divergence between MSC and SPLM since 2004 divestiture
 - Exchange participants do need content agreement



HDF5

- Data model, library, and file format for storing and managing data
- Flexible and efficient I/O
- For high volume and complex data
- Completely portable file format
- High-level API with C, C++, Fortran 90, and Java interfaces
- Range of computational platforms, from laptops to massively parallel systems
- Commercial software supporting HDF5
 - Matlab, EnSight, ParaView, ...

Source: “HDF Group – HDF5, What is HDF5?,” <http://www.hdfgroup.org/HDF5/whatishdf5.html>



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Modelica

- The goal of Modelica is to model the dynamic behavior of technical systems consisting of components from, e.g., mechanical, electrical, thermal, hydraulic, pneumatic, fluid, control and other domains in a convenient way.
- Modelica is a free, non-proprietary, object-oriented, declarative, equation based language
- Models are described by differential, algebraic, and discrete equations.
- 3D simulation based on partial differential equations (e.g. FEM, CFD) is not supported, but results of such simulations can be integrated (e.g. using surrogate models).
- Beyond the textual description, there are graphical editors for Modelica models, which can be translated into in C-Code for simulation; interactive scripting (plot, frequency response, ...) is also possible.
- Modelica is designed to be domain neutral and, as a result, is used in a wide variety of applications. such as:
 - fluid systems
 - automotive applications
 - mechanical systems: multi-body systems, mechatronics, etc.
- **Modelica association website: www.modelica.org**
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FMI (1/2)

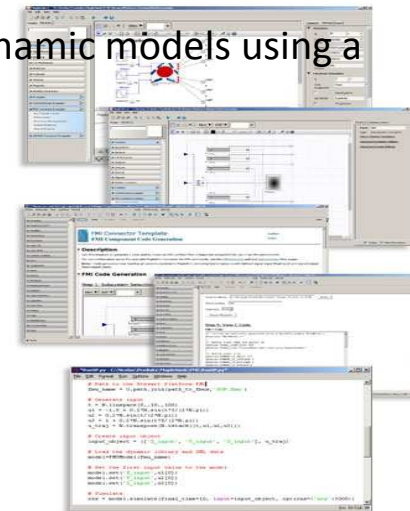
- Functional Mock-up Interface (FMI) is a tool independent open source standard designed to enable links between disparate simulation programs
- A component which implements the interface is called Functional Mockup Unit (FMU).
- An FMU may contain models, model description, source code, and shared libraries for multiple platforms.
- FMI supports both model exchange and co-simulation of dynamic models using a combination of xml-files and compiled C-code.
- Website: <https://www.fmi-standard.org>



functional mockup interface for model exchange and tool coupling

courtesy Daimler

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Slide 29



FMI (2/2)

The FMI standard consists of 3 parts:

1. FMI for Model Exchange

- Objective: **generate C-Code of a dynamic system model** that can be utilized by other modelling and simulation environments.
- Models are described by **differential, algebraic and discrete equations** with time-, state- and step-events.

2. FMI for Co-Simulation

- Characteristics of co-simulation:
 - Coupling of several simulation tools
 - Each tool treats one part of a modular coupled problem
 - Data exchange is restricted to discrete communication points
 - Subsystems are solved independently between communication points
- Objective: **provide an interface standard for coupling two or more simulation tools** in a co-simulation environment.

3. FMI for Product Lifecycle Management (PLM)

- Objective: **provide a generic way to handle all FMI related data** needed in a simulation of systems in a PLM system
- Generic processes are defined, as well as a format description to communicate between the PLM system and the authoring tools.



Synthesis: simulation-related interoperability standards

STEP AP209

- Exchange of FEA/CFD models & results managed in configuration
- SDM functionalities
- Edition 1 in production; Edition 2 Published

CGNS

- Exchange of CFD models
- Included in STEP AP209 ed2
- In production

MoSSEC

- Collaboration
- Model Network
- In development

CAE Services

- Standardized connection between SDM and CAE system
- Synchronization and connection between SDM systems
- In development

Modelica

- Modelling the dynamic behaviour of technical systems
- Equation based language
- Developments to enlarge the current scope

FMI

- Model exchange: operational
- Co-simulation: in development

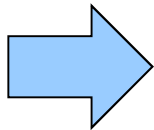


Contents

A) ASD SSG and the challenge of Through Life Cycle Interoperability

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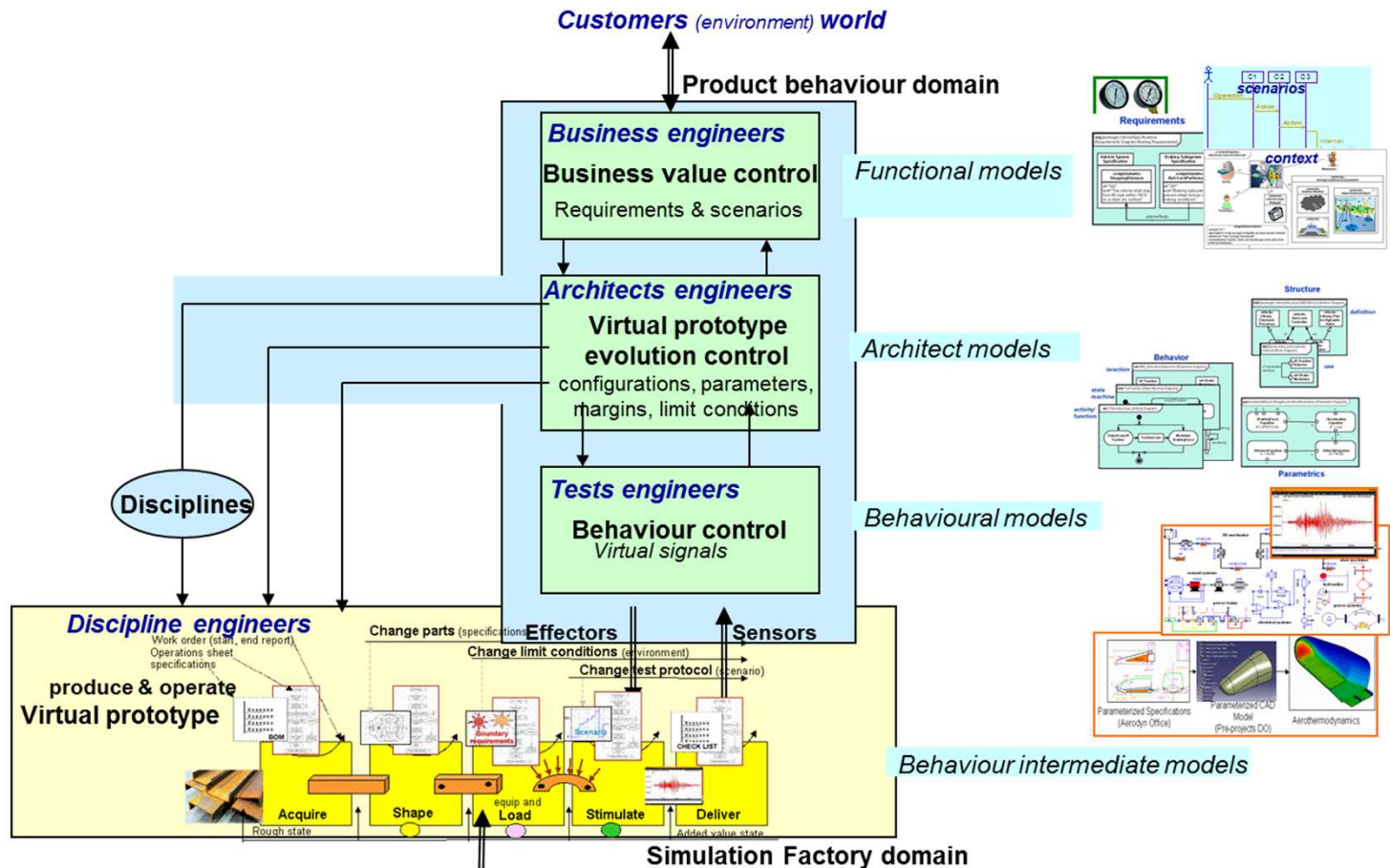
1. Overview of candidate standards
2. Proposed vision, next steps





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From architect views to simulation chains





Open questions

- Your approach for discipline-specific workbench integration, weak coupling, strong coupling/cosimulation?
- Your vision of multi-disciplinary integration?
 - Role of SLM (= SDM here)
 - Role of STEP AP209, MoSSEC
 - Role of cosimulation frameworks
 - Linking Systems Simulation and CAE
- Your vision of the linkage between simulation chains and architect views
 - How to specify behaviour models?
 - How to link with functional models
 - Role of SysML, Modelica, FMI
- How to progress on these issues?
 - Industry roadmap



Conclusion

Industry performance will rely more and more on Through life cycle interoperability

PLM must be seen as a federation of PLM platforms

A coherent set of standards is needed to enable interoperability

The ASD SSG intends to influence the emergence of this set of standards

Multidisciplinary simulation is an emerging domain, where standards are maturing

Your support and contribution is needed!

Thank you!

Questions?

