Systems Engineering Standards landscape

Jay Ganguli Boeing



Agenda

- Context & approach
- The dimensions of analysis
- The sources of information
 - SEBok, NSF, INCOSE 2025 SE Vision
- Overlap of some standards.
- Implications of some current directions
 - FutureSTEP, MoSSEC, AP209
- Future influencers..disruptors..
 - BigData- Distributed Graph databases, InMemory computing
 - Research via NSF Systems Engineering grants.



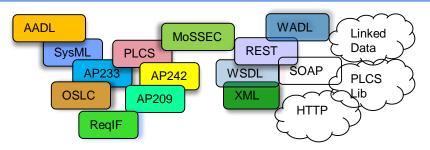




Context & Approach

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The problem...



Initial discussion at PDES Inc.

- PDES Sytems Engineering team
- Landscape....needs to show multidimensional data.
- Implementation techniques ... OSLC... REST, Linked Data
- **Product Life Cycle**
- SysML, AADL, MoSSEC, AP233, RegIF, FMI, Modelica.....etc
- Standards bodies...PDES..INCOSE, OASIS, ProSTEP..OMG
- How choosing one path...restricts/ opens up other options

Consultancy with Industry Subject Matter Experts

- Sandy Friedenthal- "Father of SysML"
- Axel Reichwein Koneksys
- Nigel Shaw Eurostep
- Garry Roedler- Lockheed Martin Fellow, INCOSE Fellow and Founder Recipient;



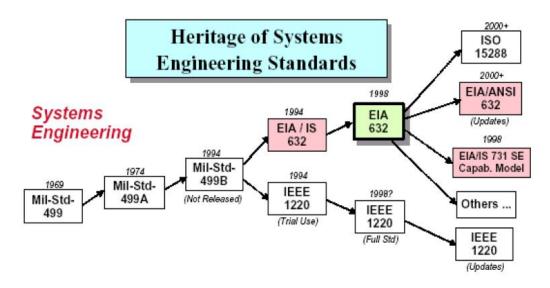






Dimension - Evolution over time

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A Review of Systems Engineering Standards and Processes (2008) by Guey-shin Chang, Horng-linn Perng, Jer-nan Juang











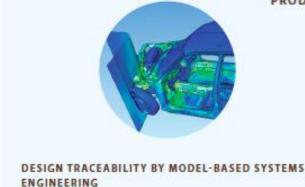
Dimension: The Use Case

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PRODUCT-FAMILY AND COMPOSABLE DESIGN





2025- Sys Engg Vision -INCOSE-S.Friedenthal et al..









Dimension: The Stakeholder view

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INTEGRATING STAKEHOLDER

VIEWS



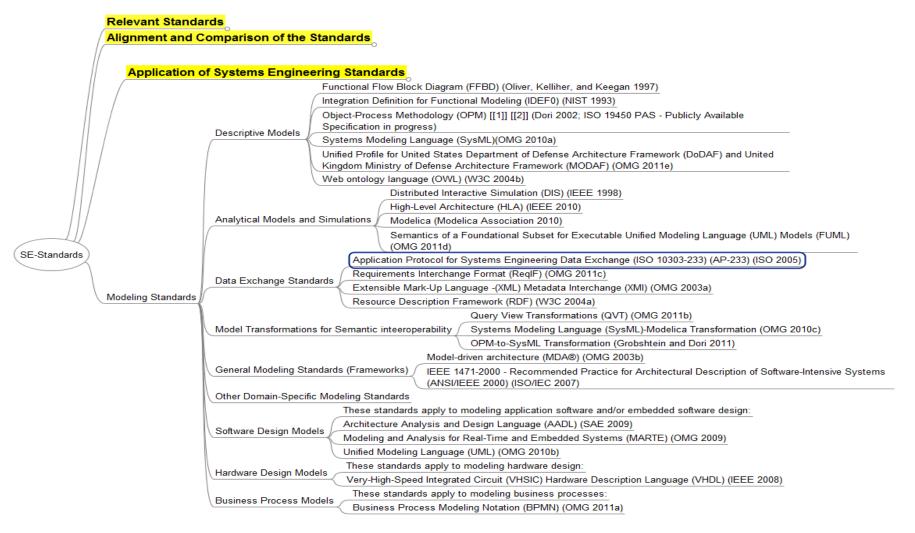




2025- Sys Engg Vision -INCOSE-S.Friedenthal et al..



Dimension: The SE Bok



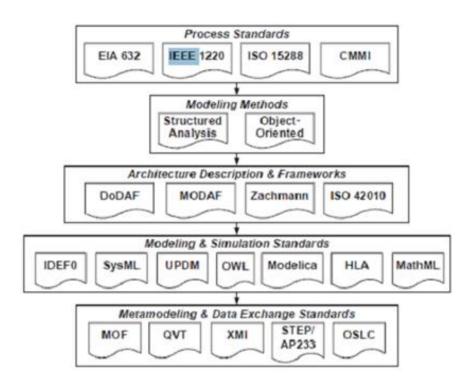








Dimension: Layered Standards



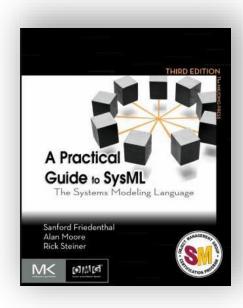


Figure 1.9 - from Sandy's Book



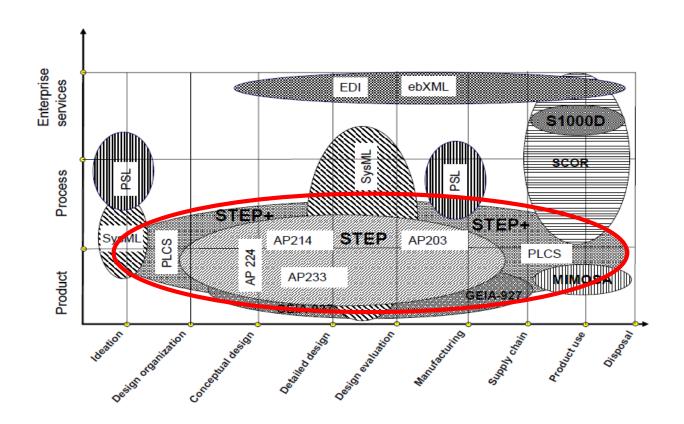






Dimension: Standards influencing each other

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SOURCE: Analysis of PLM Standards for US Army- NIST











Dimension: Theoretical foundations of Systems Engineering The INCOSE Vision

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iPad 令 6:08 PM Rigorous and Pragmatic Methods & Tools System Virtual Optimization Testing Modeling Visualization Composable Design Visual Modeling & **Analytics** Stakeholder Simulation Predictive **Analysis** Modeling System Architecting SHORING UP THE THEORETICAL FOUNDATION OF SYSTEMS ENGINEERING Ontology Knowledge Psychology **Physics** Representation Control Theory Decision **Behavioral** Chemistry Theory Complexity Game Biology Network Science Organizational Theory Earth **Probability** General Science **Systems Theory** Theory SYSTEMS SCIENCE MATHEMATICS AND THEORY **HUMAN SCIENCES** & INFO SCIENCE

2025- Sys Engq Vision-INCOSE -S.Friedenthal et al...







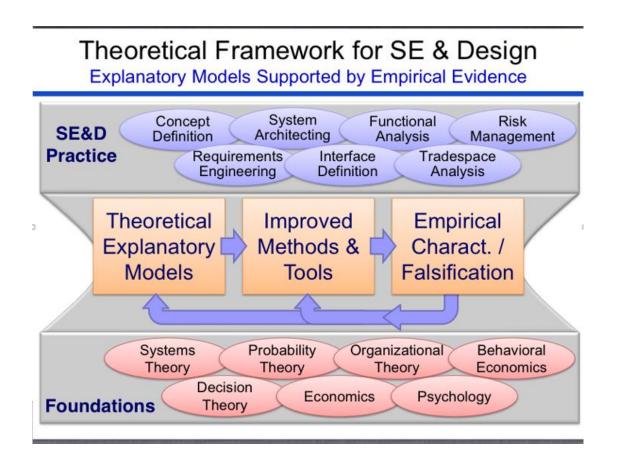


FOUNDATIONS

₿ 9% 🗀

Dimension: Theoretical foundations of Systems Engineering National Science Foundation –Systems Science

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NSF – Theoretical Framework for SysEng – Paredis





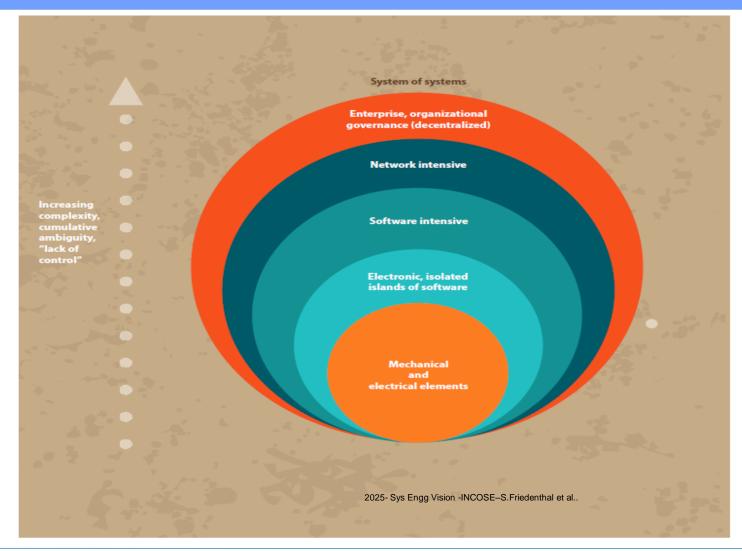




Dimension: Complexity...and its roots

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THE ROOTS FOR GROWING LEVELS OF SYSTEMS COMPLEXITY



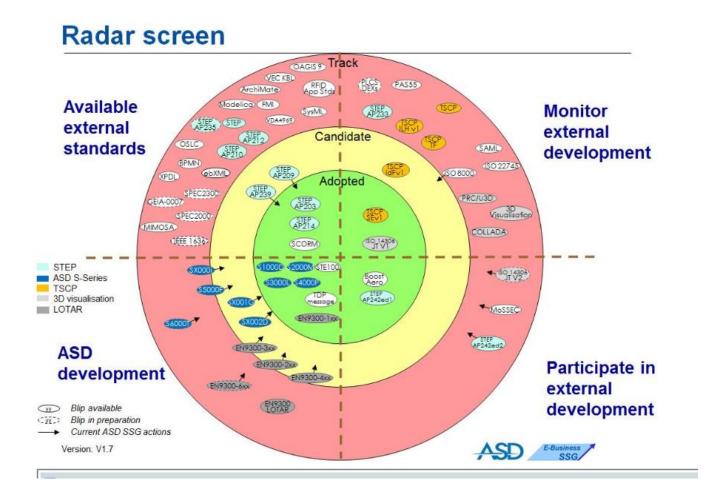








Dimension: Consortia / Business priorities and drivers





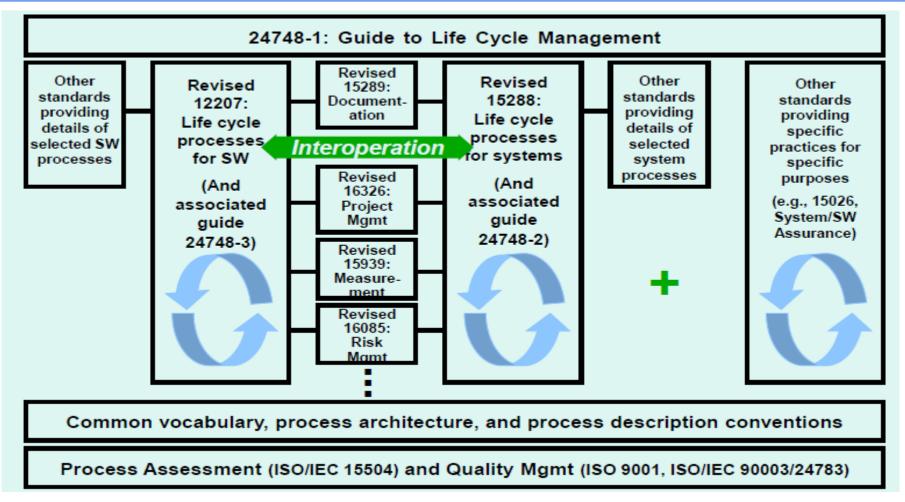






Intended Relationships of Key System & Software **Engineering Process Standards After Alignment**

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Used with permission from Garry Roedler, LM Fellow / Engineering Outreach Program Manager INCOSE Fellow and Founder Recipient: IEEE Golden Core



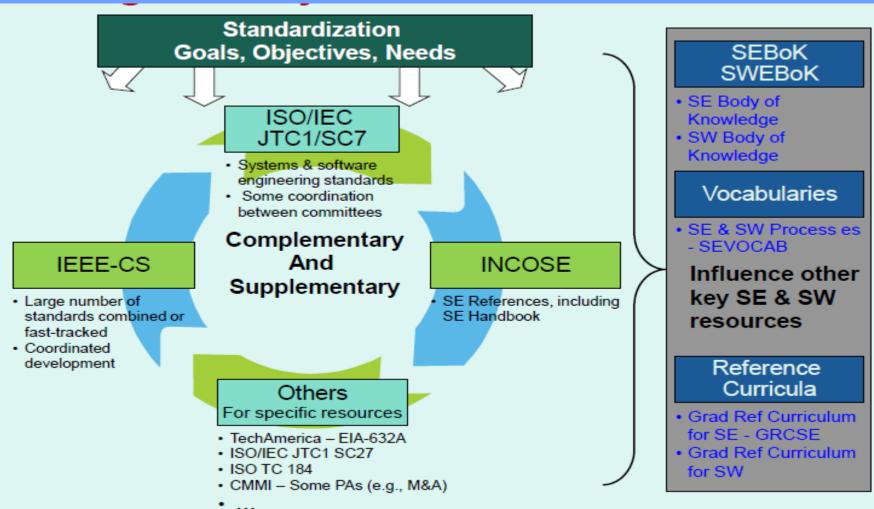






Growing collaboration

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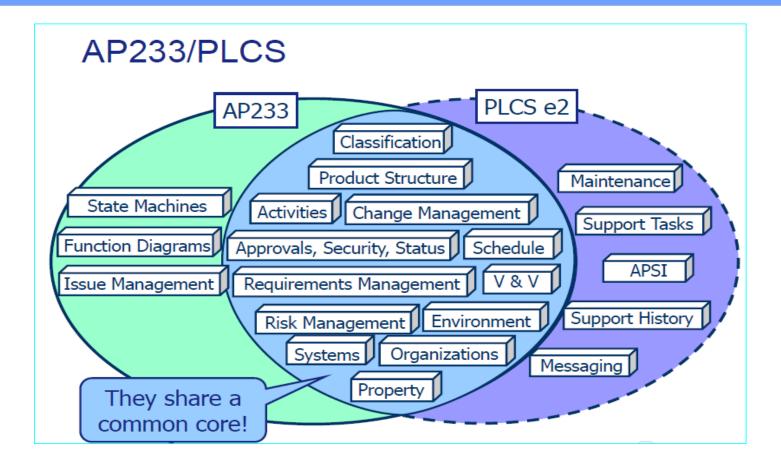








Dimension: Churn in STEP







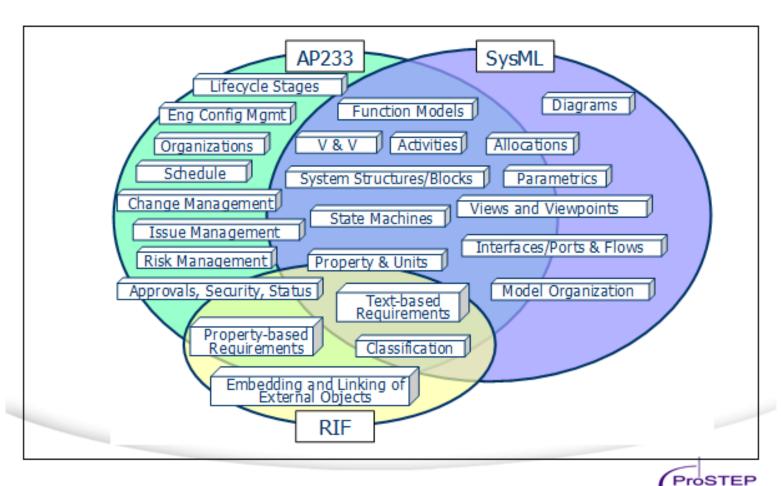




Dimension: Churn in STEP....Requirements domain

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Relationship of RIF to OMG Standards (Concepts)















iViP

STEP AP209 & MoSSEC

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AP209 and MoSSEC – Scope comparison Design and PLM Business Simulation Performance Simulation Management MoSSEC Study Model & Method Value **Key Question:** Model Networks Libraries I am an Architect. Management AP209 **Quality Gates** & Evaluation What data is available to Tracing support my decision and Product **Executed Models** Templates for where did it come from? Versions Analyses Requirements Quality reporting **Key Question:** Simulation Activity recording I am a Simulation Analyst. Execution Results What data is available to Geometry/ execute my simulation and Mesh Shape what results did it produce? Presentation Detail √ •eurostepshare space COPYRIGHT EUROSTEP GROUP









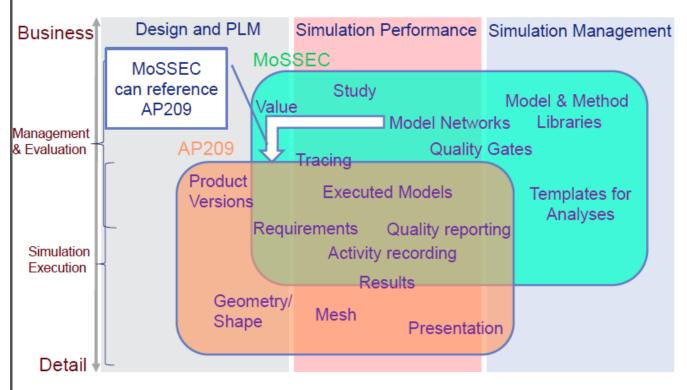




STEP AP209 & MoSSEC

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AP209 and MoSSEC – together



MoSSFC is analysis type agnostic and only records meta data about Models

The detail can be described using AP209 (and/or other formats including system specific formats)





Used with permission from Nigel Shaw, Director EuroSTEP









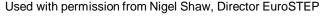


AP209 & MoSSEC

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The "Why" and the "What"

- » AP209 has no concept of why the analysis is being performed or even if it needs to be performed or not.
 - AP209 has all the details for What analysis is/was to be performed
- Mossec deals with recording everything is that has been or will be done and where the data used came from
 - Mossec has little of the details for What analysis is/was to be performed except by reference to associated documents
 - Which can be AP209 datasets











Challenges for distributed systems engineering: MoSSEC

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Distributed Infrastructure

- Secure Collaboration for:
 - Locations
 - Organisations
 - Software Platforms

Distributed Processes

 Multitude of Modelling and Simulation tools

Simulation driven design changes CAD traced and under PLM control

Distributed Data

- Modelling and Simulation data
- V-cycle meta-data
 - (who what when where how why etc)
- Efficient sharing, synchronisation and integration

Remain Compliant with existing Standards (e.g. AP233, AP239, AP242)

System Integration

Reats Mnami

Project

planning











Collaboration Services

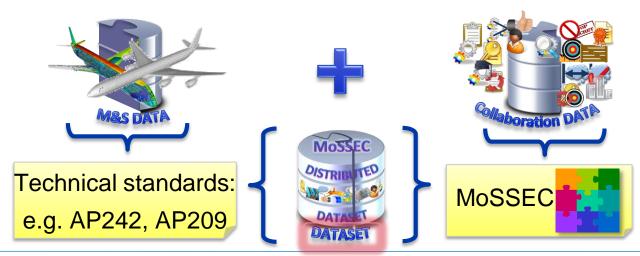
Collaboration Services

Mathematical

analysis

Collaboration vs Modelling & Simulation Data

- Modelling and Simulation data
 - Managed in the PLM/M&S systems
 - Exchanged with technical standards
- Collaborative SE context data
 - Managed by MoSSEC Compliant Tools
 - Exchanged with MoSSEC services
- Together they enable the distributed dataset











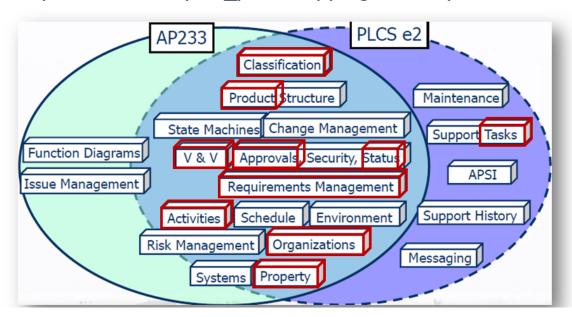


MoSSEC & AP233, and PLCS

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AP239 templates used

What templates used in <u>plcs_psm</u> mapping are for planned v1 of MoSSEC









Evolution of "interoperability" in the Product Data space (STEP context)

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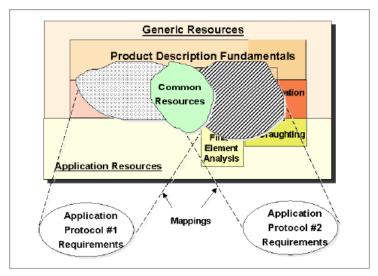


Figure 4-8: Mapping AP #1 requirements to AP #2 requirements

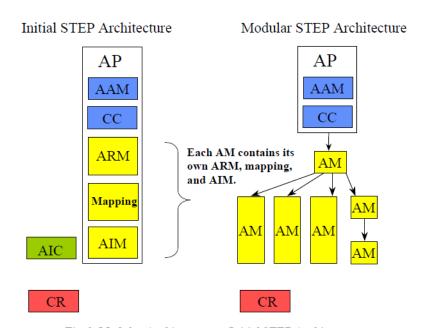


Fig. 2 Modular Architecture vs. Initial STEP Architecture

The primary driver for interoperability in the STEP world was aimed at building new APs faster.

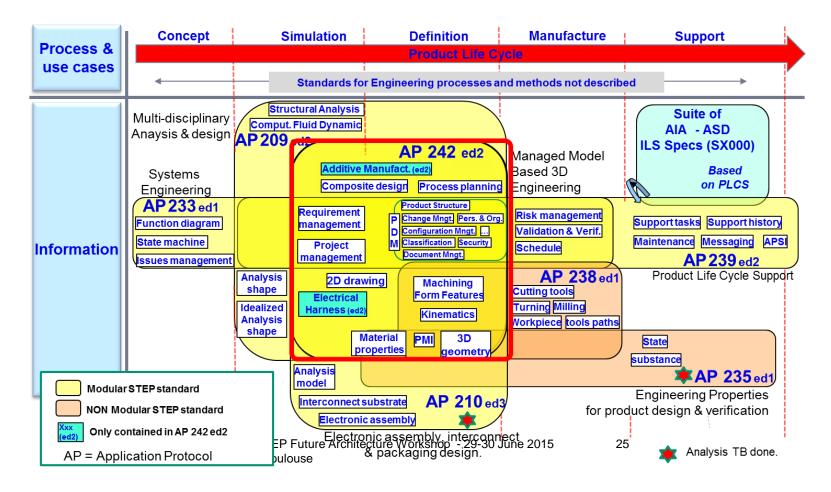






STEP on the Lifecycle



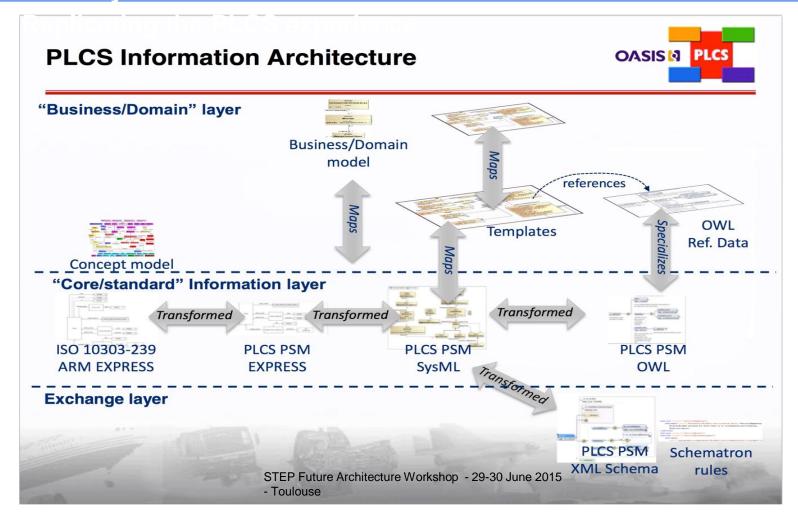








Global Product Data Interoperability Summit L 2015 Multi-layered information models..based on Standards —











FutureSTEP..recent developments

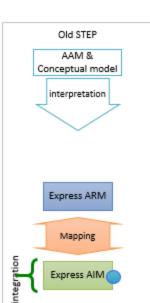
Integration layer

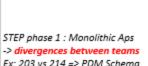
Model based

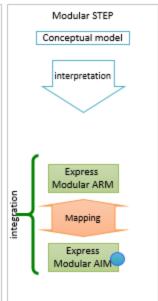
Implementation laver formal

TODAY

9

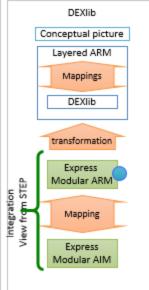






STEP modules: objectives : favour integration by reuse, speed up development & publication

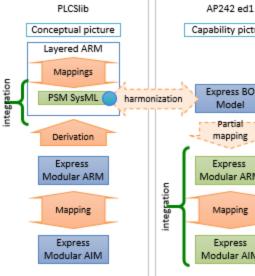
But Logic layer and implementation layer got more dependant



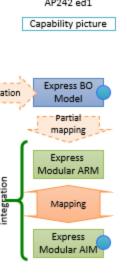
introduction of a higher level development framework with inputs from semantic web, based on the modular architecture but Inneficient XML implementation ARM implementation Underlying concepts of the PLCS framework are alianed with the STEP philosophy

PLCS version 1: new business needs on lifecycle, request for

XML implementation method,



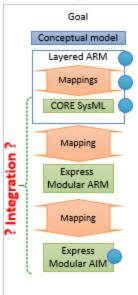
PLCS version 2: for PLCS stakeholders, difficulties to maintain strong integration with STEP modules. The SysML PSM is the integration layer



AP242 ed1 BO Model: requirements close from PLCS: XML implementations with associated documentation. Plus strong requireemnt of full integration to the modular architecture:

Fail to provide complete mapping from BO Model to Modules

Harmonization started between BO Model and PSM



Ensure consistency and integration on the whole stack and across AP

Model based

Allow extensions from other domains and technologies









FutureSTEP...recent developments

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Multi Information Model layer and associate stakeholders we have a global consistent information model Company specific Level 5 Aerospace & Defence The core model is one specific layer of the European OR American or Asian European OR American Or Asian information model shared Level 4 Aerospace & Defence Automotive by all the stakeholders International International ? ASD SX SERIES? Level 3 Aerospace & Defence Automotive Worldwide multisector AP 209 Level 2 AP 242 AP 239 ISO concensus Level 1 Core model simulation Elec PDM REQ ILS block block Geometry block ARM Example: MOSSEC would be a new information model at level 2 referencing the Core model objects AIM









Dimensions- what does a Pragmatic user need?

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- Scope of standards
- Ease of adoption by vendors + users + developers
 - Vendors attends standards mtgs...
- Existing tool support
- Existing adoption
- Alignment with technical trends Linked data. Is the std compatible with linked data, communication protocol
- Documentation quality, accessible, examples to get started
- Stds:
 - Std ways to access info: AP233, SysML, AADL, FMI, Modelica, Simulink,
 - Std protocol: OSLC is domain independent...
- Quantify the complexity...the number of relationships
- Assess the impact. is it in a domain used by 90% of engineers.
- W3C: Dublin Core, RDFontologies,

Courtesy: Axel Reichwein - Koneksys









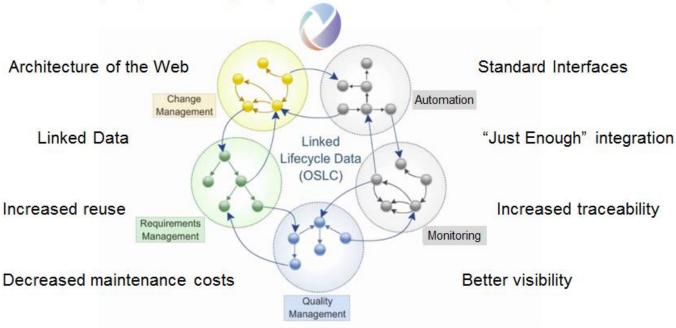


OSLC

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Users can work seamlessly across their tools

(complex and fragile synchronization schemes not required)





OSLC is an open and scalable approach to lifecycle integration. It <u>simplifies</u> key integration scenarios across <u>heterogeneous</u> tools

http://www.w3.org/DesignIssues/LinkedData.html











OSLC & STEP... possible patterns of interaction

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What co-existence may mean...

- Mapping conceptual notions of APs ARM (Application Reference Module) ,AM (Application Module) to linked data
- OSLC resource structure, maps to STEP notions of modularity?
- How does OSLC influence Future STEP architecture?
- Can OSLC domain linking features be used to test STEP AP modularity?
- - An example from the Library

• How have others traversed this path.. Preparing for the future: supporting the transition to Linked Data in Libraries

As a research assistant at OCLC, I have had the opportunity to be involved in a variety of industry initiatives to help modernize library infrastructure and prepare them for the eventual coming of Linked Data. Two of these projects help underscore the fundamental changes that the library industry needs to undergo in order to support the adoption of Linked Data. The first is the redevelopment of the MODS data model as an RDF ontology and the second is the conversion of the Getty vocabularies from a traditional controlled stringbased thesaurus into a Linked Data dataset that uses URIs as identifiers for people, organizations, places, concepts etc. The two projects each address different but equally important types of changes that will need to occur in order for libraries to create Linked Data and integrate it into their everyday workflows.

ars, Linked Data has been a buzzword or I brary conferences around the world. en the subject of paper presentations, nd project reports at conferences such SIS&T. The themes of these talks e discussion revolves around the d Data for libraries and how the Data will finally help facilitate the



the future soon / k rupp [Flickr]

Source: http://hangingtogether.org/?p=4096









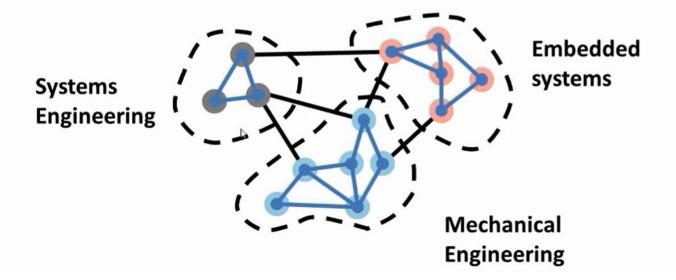


OSLC & SysML experience

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Interoperability beyond SysML

From linked Data user perspective: SysML concepts can be used to define cross-domain relationships



Courtesy: Axel Reichwein, Koneksys







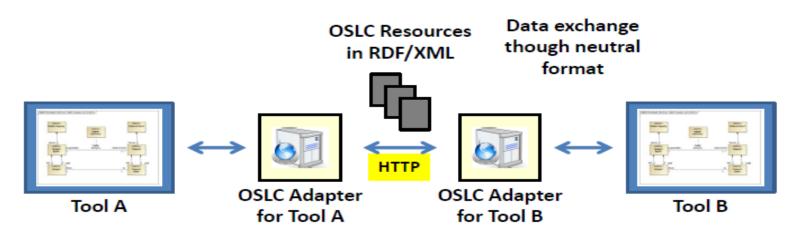


OSLC Tool Interoperability

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Tool Interoperability through Standardized RDF Vocabularies

- Interoperability between tools is based on common standards
- OSLC specifications provide RDF vocabularies for specific domains for the purpose of supporting interoperability



Courtesy: Axel Reichwein, Koneksys











OSLC Resource and Resource Shapes

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Additional RDF resources for defining constraints on RDF resources: OSLC Resource Shapes

- RDFS Vocabulary cannot define constraints on RDF data
- OSLC Core vocabulary includes additional RDFS classes and RDF properties for defining constraints on RDF data such as:
 - RDFS class oslc:ResourceShape
 - RDFS class oslc:AllowedValues
 - RDF property oslc:occurs
 - RDF property oslc:allowedValue
- OSLC resource shapes are RDF resources that define constraints on RDF data by using the OSLC Core vocabulary

Courtesy: Axel Reichwein, Koneksys



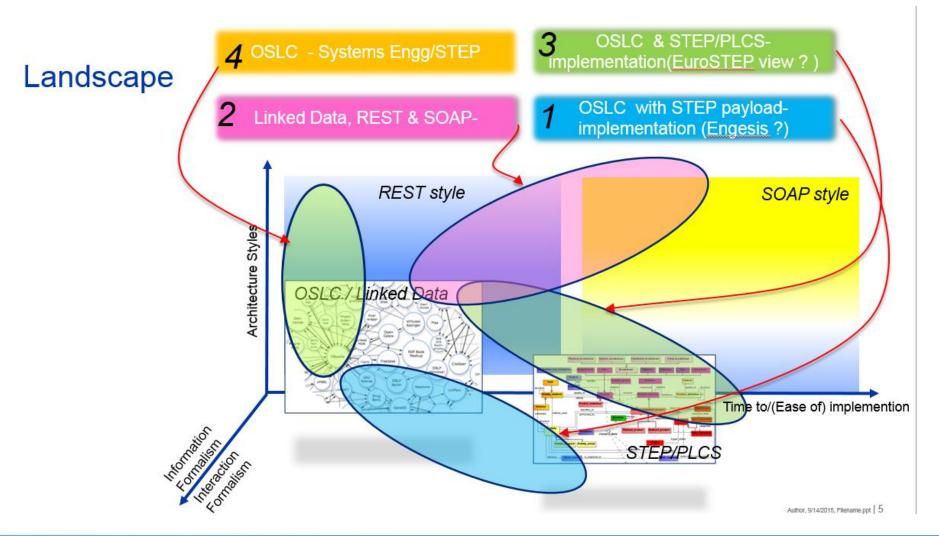








One way to think of the landscape











The Positive influence of Consortia Projects: UK's CONGA: PLCS/MoSSEC/OSLC

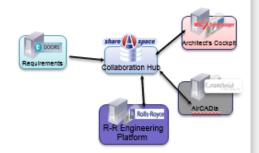
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Conga

Configuration Optimisation of Next Generation Aircraft

- OSLC supported Conga in the sharing of requirements in the Conga Tool Net.
- OSLC was demonstrated to work well with another standard (BDA) which was already being use for requirements.
- The delegated UI allowed other tools to access requirements in DOORS.







"

The aim was to identify how requirements in OSLC could be made available to other partners. The other tools in the tool net were already BDA compliant and so a re-work to OSLC consumers wasn't desirable . "

". The solution was to create BDA requirement objects on the collaboration hub and embed the link to the DOORS requirement inside. Using the link to the delegated UI it was possible for existing consumers of BDA resources to access the requirements in DOORS without having to develop their own OSLC consumer adapters. "

(Source: OSLC Community Update - OSLC with PLCS and MoSSEC (June 10,2015



INNOVATIONS

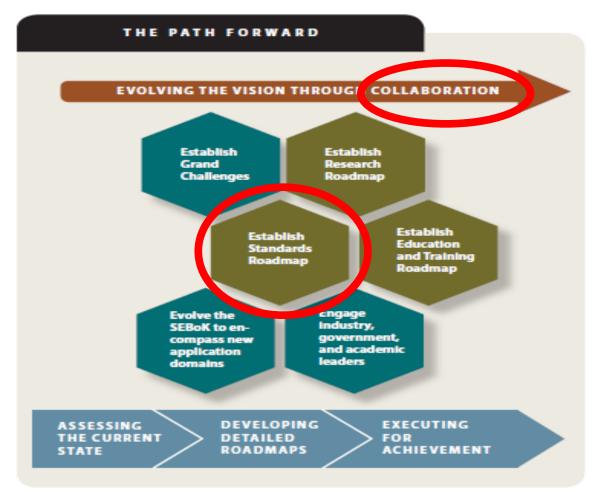






The need to Collaborate...

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I et al..

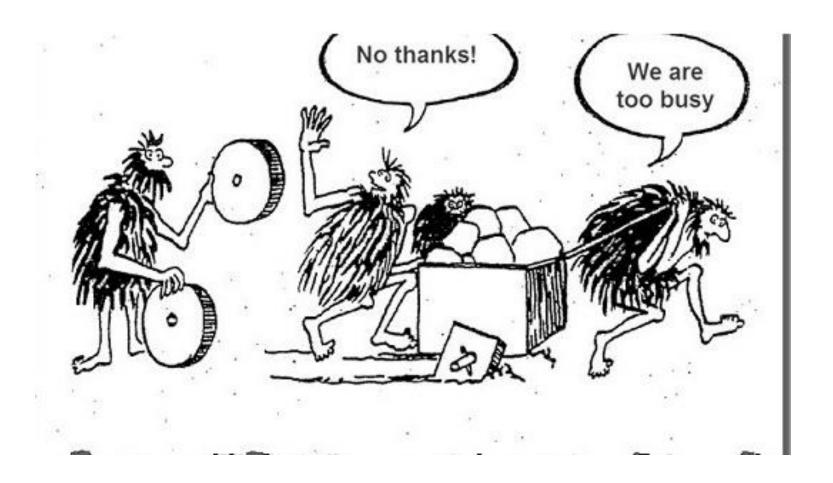








People...











People.... INCOSE & PDES

- Standards Lead At INCOSE(Ken Zemrowski) & Sandy Friedenthal working on 2 near term task
 - Focus on developing a domain specific SE vision for automotive
 - INCOSE will encourage other domains to do something similar.
 - NSF Theoretical Framework for SysEng engagement. The standards roadmap is critical here too.
- INCOSE engagement with standards bodies like PDES, OASIS- OSLC
 - 'MBSE for OSLC 'working group is working with OSLC. (Mark Sampson and Sandy F – Co-Chairs)
 - 'Tools Interop WG' is also collaboration on standards.
- INCOSE's new strategy 'Accelerate the Transformation to a MB Discipline' has a 'Technical objective that requires engagement with other standards bodies.
- MBSE wiki would be a good place to show links to other standards working groups









People ..FutureSTEP and OSLC-ALM-PLM

- ALM-PLM working group leaders invited to FutureSTEP sessions
 - Axel Reichwein to present OSLC view at PLCS meet.
- Importance of Standardizing Interaction patterns and Webservices
- Linked Data...Resource Shapes..
- Could provide early clues on Interoperability needs for STEP.









OSLC Community Update (June 10,2015)

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Collaboration with other Organizations

A cornerstone to make OSLC a success is to collaborate with other organizations

- Recently announced: Partnership with ProSTEP iViP (www.prostep.org)
- ProSTEP iViP Association is an international association committed to develop innovative approaches for modern standards for product data management and virtual product creation
- ProSTEP iViP has created the CPO initiative (Code of PLM Openness) to establish a common understanding on openness for IT systems in PLM between IT customers, IT vendors and IT service providers; OSLC and associated standards are seen as the approach to implement CPO
- Joint activities are planned, e.g. 1st ProSTEP iViP OASIS OSLC Conference October 20th, 2015 hosted by Daimler AG in Stuttgart http://www.prostep.org/en/events/topicspecific-events/oslc.html
- Relaunch of the ALM-PLM Interoperability Working Group on open-services.net http://open-services.net/workgroups/alm-plm-interoperability/









ProSTEP and OSLC

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ProSTEP iViP – OASIS OSLC Conference

Seamless Lifecycle Integration based on open Standards



Held jointly with: 4th Interoperability Conference

Location: Daimler Auditorium, Stuttgart-Möhringen

Epplestraße 225, 70567 Stuttgart Date: 20 October 2015 / 10:00 - 16:00

One day full of information under the lead-theme ALM - PLM Interoperabili Impulses for enabling information flows between different engineeri disciplines will be given. In industry-relevant talks possibilities of OSLC will discussed and demonstrated. Target-audience are people interested in solvi systems engineering challenges in smart ways - experts and new-comers.

The keynote will be held by Prof. Martin Eigner, TU Kaiserslautern.

Registration and more Information at http://www.prostep.org/en/events/topic-specific-events/oslc.html

Seamless Lifecycle Integration

20 October 2015

Time	Topic
10:00	Welcome Dr. Steven Veltermann, ProSTEP IVIP & Rainer Ersch, Siemens AG
10:15	OSLC: Introduction & Overview Reiner Ersch, OASIS-OSLC Steering Committee Member
10:30	Keynote: OSLC - Bridge between Model-based Systems Engineering and PLM? Prof. Dr. Martin Eigner, University Keiserlautern
11:15	OSLC as an Opportunity to Compose IT Solutions in an existing Application Landscape Frank Wagenknecht, Bombarder Transportation
11:45	Co-simulation in technical software development Gemot Egger, Philips Healthcare
12:15	Lunch Break
13:30	Aerospace: Industrial Use Case Demonstrator Andrews Kirls, Airbus
14:20	Coffee Break
14:40	Automotive: Industrial Use Case Demonstrator
15:30	Questions & Answers from the Audience Closing Remarks & Outlook Reiner Ersch, Siemens AG & Dr. Steven Vettermann, ProSTEP IVIP
16:00	Anticipated end







BACKUP









Transformation: SysML to/from AADL

- Ensures consistency between the system model and domain models
- AADL profile enables import of SysML elements into AADL model.

