

Applications of the STEP AP 233 Systems Engineering Information Model

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Outline

- STEP & AP233
- SysML and 233
- DoDAF and 233
- EVM and 233

Industrial Data Standards

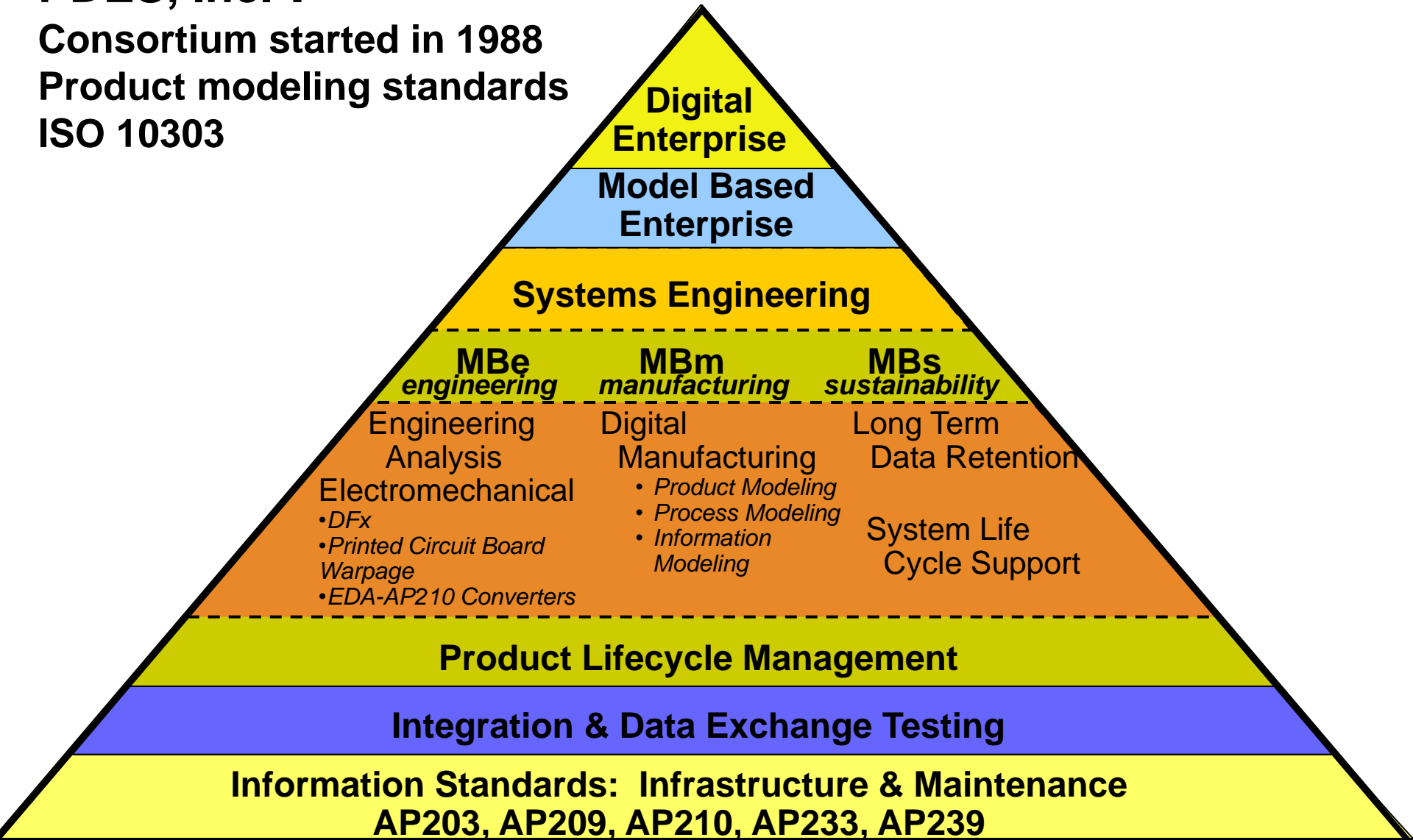
- International Organization for Standardization (ISO) Subcommittee TC184/SC4
 - Describe and manage industrial data through product life
 - 2007 ISO Eicher Leadership Award
 - For reusable information model building blocks to enforce interoperability and simplify implementation
 - Past winners include MPEG & ISO 9000
- Areas from product design, analysis & manufacture
 - STEP- Standard for the exchange of product data
 - MANDATE – Industrial manufacturing management data
 - PSL – Process specification language
 - PLIB – Parts library
 - Process Plants including Oil and Gas facilities lifecycle data
 - eOTD – electronic open technical dictionary for catalogs

PDES, Inc. :

Consortium started in 1988

Product modeling standards

ISO 10303





Requirements/Concept

Conformity to the concept of a system
System definition data and configuration control
Requirements, requirement analysis, and functional allocation
Functional, functional analysis, and functional behaviour
Physical architecture and synthesis
Trade studies for decision support

AP233, Systems engineering data representation

Analysis

Shape Associated Finite Element Analysis
Analysis results material properties

AP209:2001, Composite and metal structural analysis and related design

Detailed Design/BoM

Equipment Coverage • Power-transmission • Power-distribution • Power-generation • Electric Machinery • Electric Light and Heat • Control Systems	Electrotechnica Systems • Buildings • Plants • Transportation Systems	Data Supporting • Terminals and Interfaces • Functional Decomposition of Product • 3D Cabling and Harnesses • Cable Tracks and Mounting Instructions Electrotechnical Plant • Plants, e.g. Automobile • Units, e.g. Engine Control System • Subunits, e.g. Ignition System
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AP212:2001, Electrotechnical design and installation

Manufacturing

Components Assemblies

Administration Planning Execution Archiving

Geometry Dimensions Tolerances Inspection processes

AP219, Dimensional inspection

Lifecycle Support

Work activities and resources -define -justify -approve -schedule -feedback	Configuration -design requirements -design configurator -as-built -as-maintained	Operating states Behavior Usage	Support facilities -personnel -equipment -diagnostics
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AP239, Product lifecycle support

Cross Process Utility

Configuration Management of Product Structure
Versioning and Change Tracking
Bill of Materials

Edition 2
Tolerances
Construction History
Colors
Layers

AP203, Configuration Controlled 3D designs of mechanical parts and assemblies

Related Standards

The library: When they are placed in the product model additional information is provided about the specific instance.

Attribute	Value
Equipment:	Pump
Type:	Vertical
Centrifugal:	Cast Iron
Casing:	Bronze
Impeller:	Stainless
Shaft:	Aluminum
Mfg:	
Marine:	
Q:	200 m ³ /h
P:	3 bar
RM:	1720
Power:	23 kw
Tmax:	250

ISO 13584 (Parts Library Exchange)

Physical layout of the circuit card assembly
Description of logical connections among the functional objects
Packaged parts
Physical interconnections
Configuration management
Parameters for parts and functional objects

Edition 2 in process

AP210:2001, Electronic assembly, interconnect, and packaging

Configuration controlled exchanges between Product Data Management (PDM) systems
Links multiple formats
Design Analysis Manufacturing Support

AP232:2002, Technical data packaging: core information and exchange

Components Assemblies

Machining features
Assembly information
Explicit geometry
Tolerances

Edition 3 in process to add gear features

Make or buy
Micro process planning

AP224:2001, Mechanical product definition data for process planning using machining features

Micro Process Planning Automated NC generation

Mechanical parts machining
-milling
-turning
-electro discharge machining
Sheet metal bending
Pipe bending

AP238, Computer numerical controllers

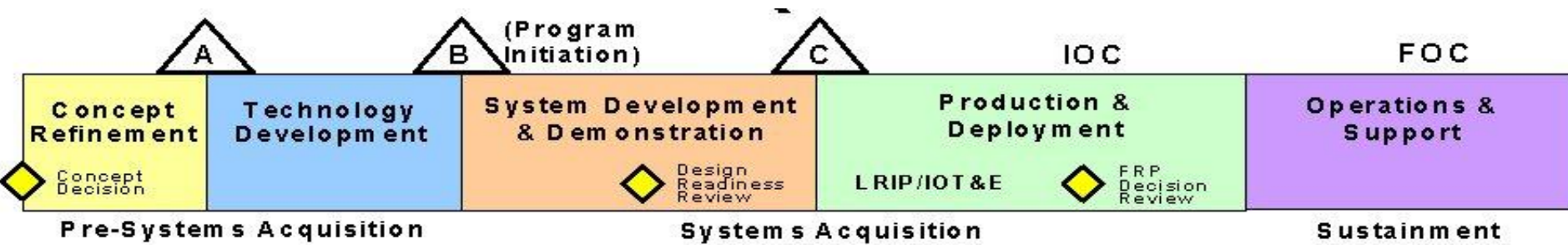
Components Assemblies

Macro Process Planning
-machining
-fabrication

Mechanical parts
Structural steel
Sheet metal bending
Pipe bending

AP240, Process plans for machined products

STEP for DoD Acquisition Cycle



AP 233 – Systems Engineering Data Representation				
Design	Analysis	Manufacturing	Data Management	
AP 216 – Ship molded forms AP 218 – Ship structures AP 227 – Plant spatial configuration piping systems cable trays HVAC systems mechanical systems	AP 209 – Composite & metal structural analysis	AP 219 – Dimensional inspection for parts AP 223 – Design & manufacturing of cast parts AP 224 – Machining features for process planning AP 229 – Design and manufacturing of forged parts AP 238 – Computer numerical controllers AP 240 – Process plans for machined parts	AP 214 cc6 – PDM Schema AP 232 – Technical data packaging AP 239 – Product lifecycle support	

Modular STEP AP's

- Application Protocol (AP) Modularization Benefits
 - Faster revision process
 - Interoperability of implementations thru reuse
- Modular AP Domains
 - AP203 Mechanical CAD (parts & assemblies)
 - AP209 CAE (FEA and CFD)
 - AP210 EDA (aka ECAD, components to racks)
 - AP233 Systems Engineering
 - AP239 Product Life Cycle Support (PLCS)

Background on AP233 Systems Engineering

- Endorsed by DoD, INCOSE, OMG
- Mappings of SysML and DoDAF proven
- PLCS shares 70% of models with AP233
 - Pilot at NAVSEA & Electric Boat
 - Production use at US Army TARDEC & contractors
 - Extensive use by NATO allies for ships, aircraft, land vehicles
- Multiple vendor and third party involvement & support
- NIST SE plug-fest to test tool interoperability
- Scheduled for publication as technical standard in Q2 2008

STEP AP 233 Systems Engineering

integration and data exchange approach

- DoD mandates that technical data must be delivered in STEP
 - Eg. AFI63-101 April 17, 2009, PLCS for engineering info
- Restructured early SE specification based on STEP modular architecture through ISO process
 - Flexible, extensible, integrated, & interoperable
 - Traceability from concept, development, manufacturing, O&S through other modular STEP Application Protocols
 - Shared modules with AP 239 PLCS widely implemented
 - New Capabilities: Risk, Issue, Decision Support
- Open standard with wide support by industry, tool vendors, other DoD components, NATO partners

AP233 is one enabler of INCOSE 2020 Vision

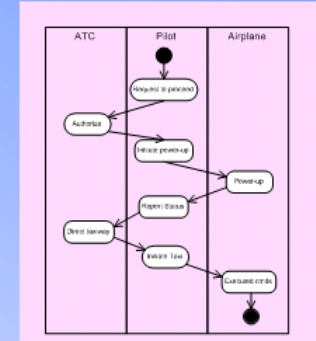
Model based systems engineering (MBSE)

Past



- Specifications
- Interface requirements
- System design
- Analysis & Trade-off
- Test plans

Future



- MBSE is the formalized application of modeling to support system requirements, design, analysis, verification and validation beginning in the conceptual design phase, and continuing throughout development and later life cycle phases.

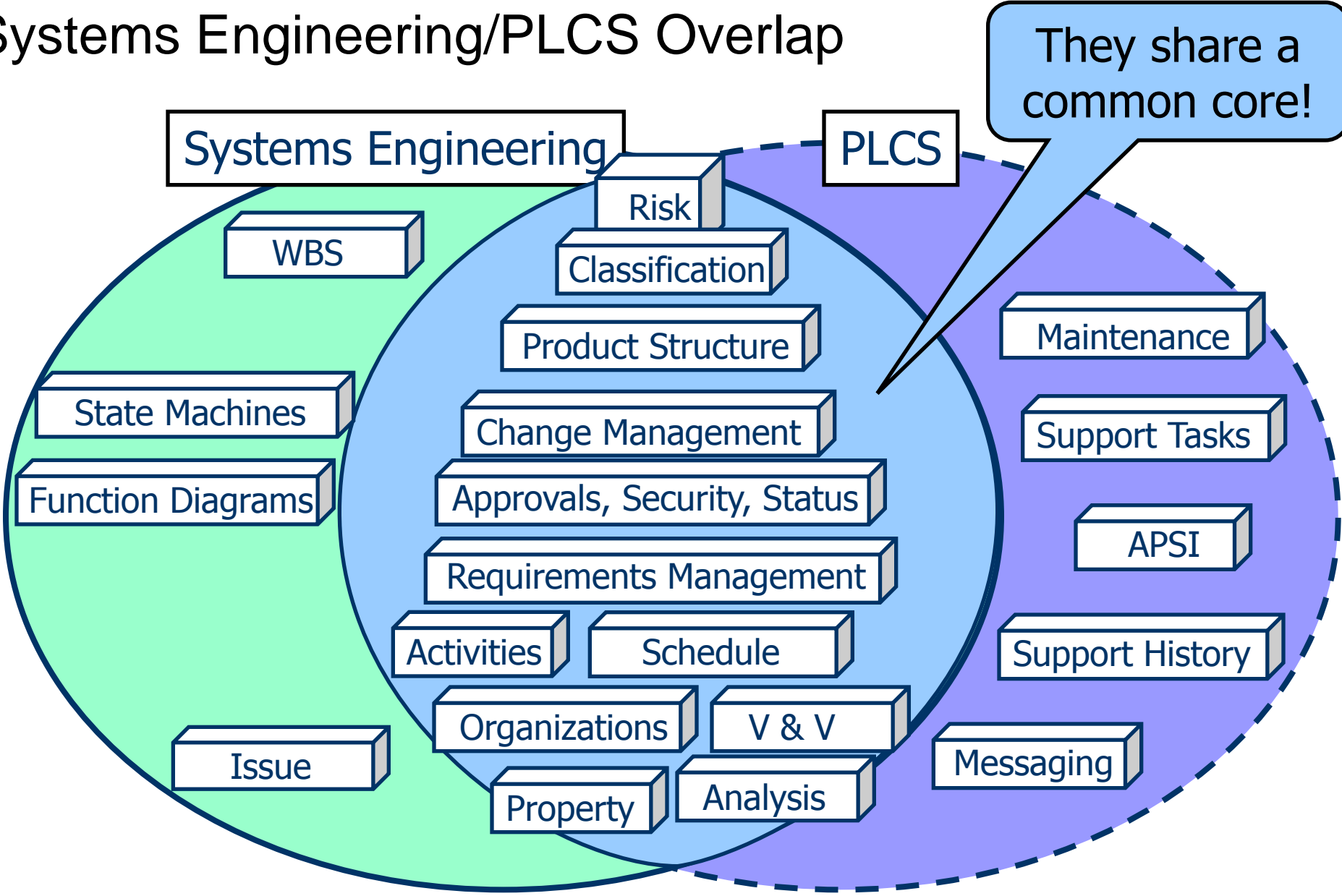
AP233 History and Current Status

- *1996-2001*: European SEDRES/SEDRES2 projects
 - Delivered validated SE information model
 - SESRES2 result submitted as ISO PAS 20542
 - INCOSE and EU project results got AP233 project initiated
- *2000*: STEP Modular architecture approved
- *2004*: Modular PLCS AP239 completed
- *2008*: AP233 passed ISO ballot on new capabilities, built over existing PLCS and PLM capabilities
- *Now*: AP233 Draft International Standard publication
 - Aligned with new PLCS AP239 Edition 2

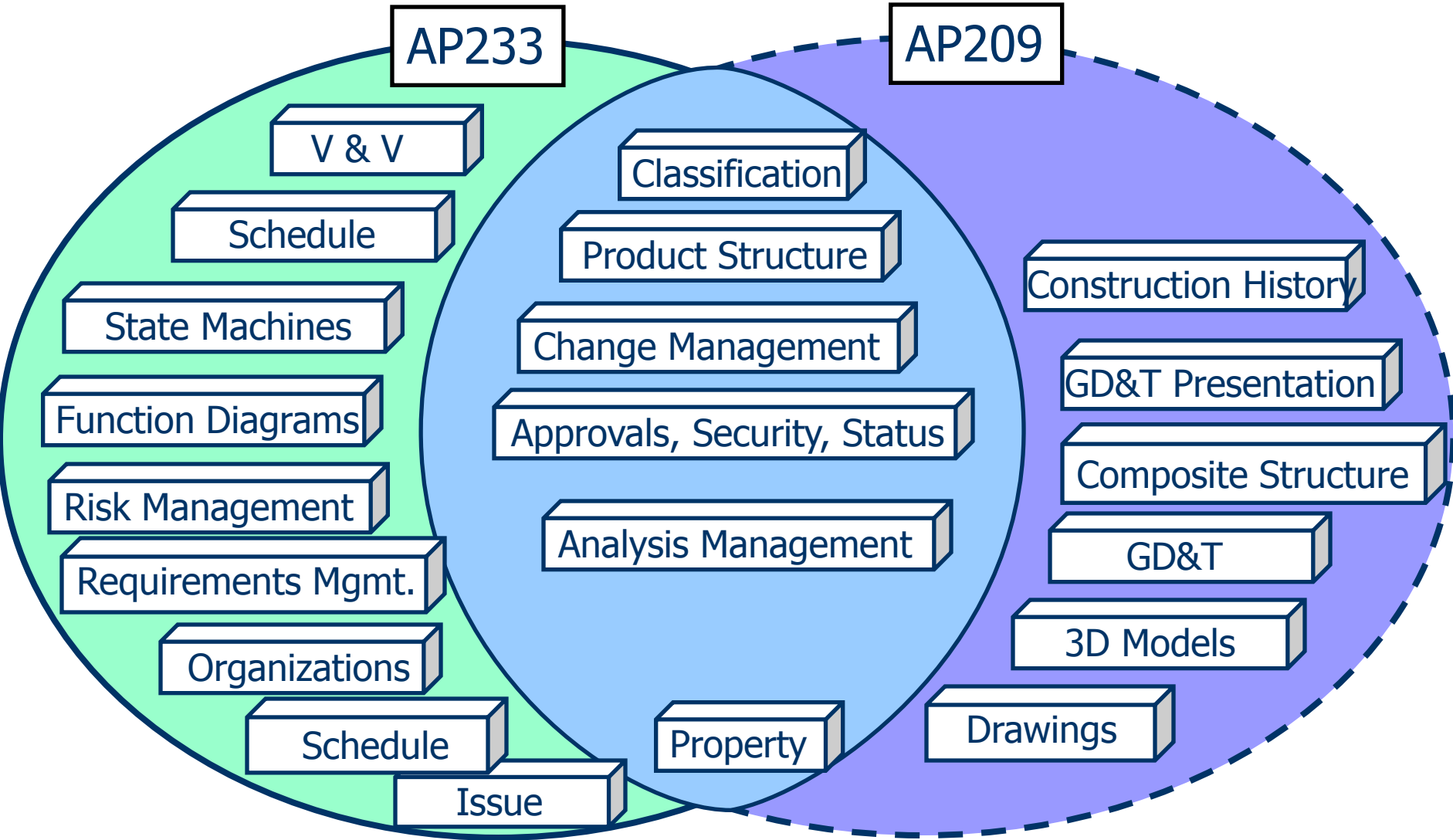
What Does AP233 Enable?

- Program management
 - Issue
 - Activities
 - Approvals
 - Risk
 - Probability & Consequence
 - Source & Impact
 - Contingency plans
 - Project
 - Organizational structure
 - Project breakdown
 - Schedule
 - Work structure
 - Management information resources
- System modeling
 - Decision support
 - Requirements management
 - Measures of effectiveness
 - Analysis interface
 - Verification & Analysis
 - Justification
 - System structure
 - Product data management
 - Breakdown
 - Interface
 - System behavior
 - Function based behavior
 - State based behavior

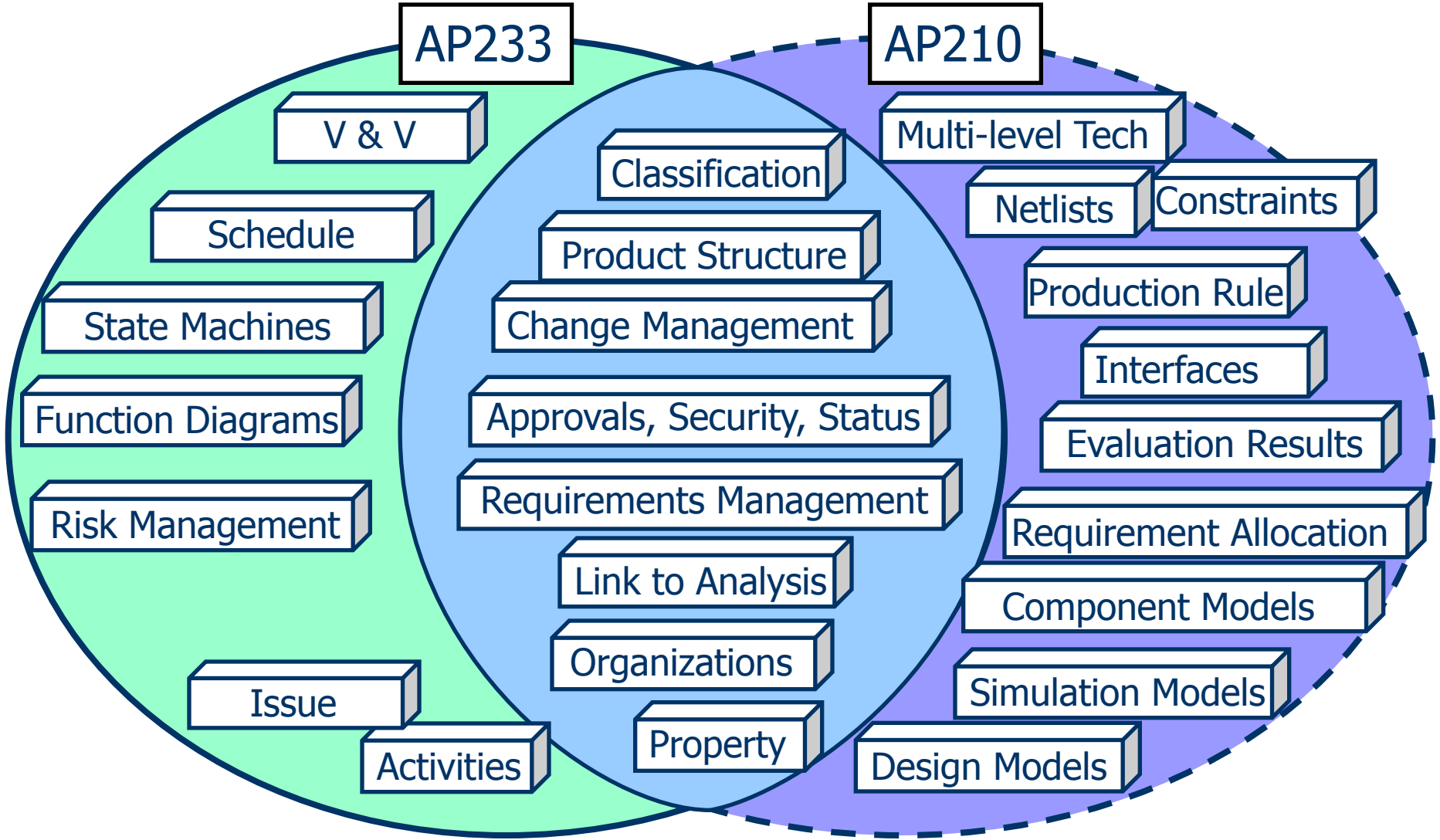
Systems Engineering/PLCS Overlap



AP209 Engineering Analysis Relationship



AP210 Electromechanical Relationship



Testing and Implementation

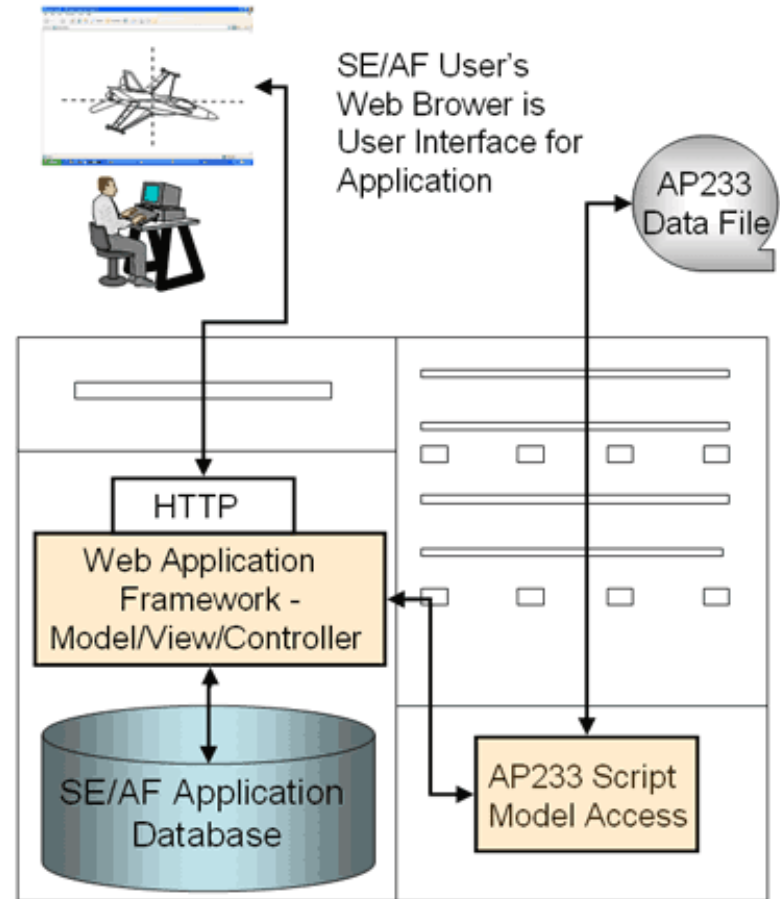
- Aspects of AP233 are in production use today
 - 60 % of AP233 standardized in 2004 as PLCS
- New AP233 capabilities being prototyped
 - NIST-funded Enterprise Integration project (e.g. SysML/AP233 converter)
- NIST/OMG Model Interchange Validation
 - supports conformance testing, including alignment with UML, SysML and AP233

AP233 Implementations

- Migration between versions of SE tools
 - UGS Slate to UGS Systems Engineering
 - Exchange between Requirements Management tools
 - IBM Requisite Pro and Telelogic DOORS
 - Model management of SysML and interoperability with other domains
 - i.e. Risk, Program/Project, downstream CAD/CAM, PLCS
 - DoDAF to AP233 for exchange and archive
 - CADM representation of views
 - Multi-domain simulation management
 - Requirements through analysis – EU Vivace & Crescendo
 - Earned Value Management XML Schema mapping into 233 reference data
 - Associate cost & schedule with systems engineering
- .. And remember PLCS implementations **are** AP233 implementations where they overlap

Scripting API Implemented

- Application Programming Interface (API) in simple and accessible language
- Programmer must know concepts, attributes and relationships in AP233
- Ruby API code generated from AP233 EXPRESS ARM
- Available as open source from www.exff.org

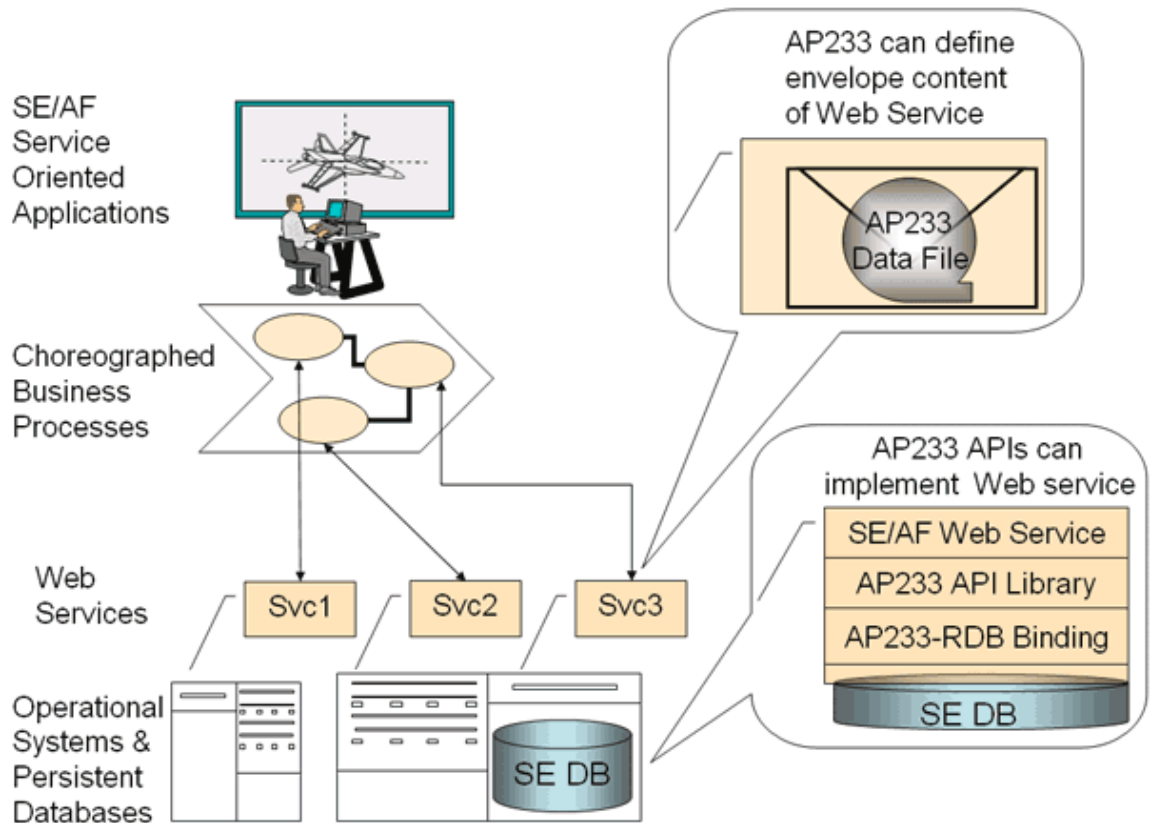


SOA and Web Services

- No standard services exist today for SysEng (or PLCS)
 - Prototype PLCS services in-work in OASIS
 - Create, Read, Update, Delete, Where-Used
 - Tested in Aerospace supply chain
 - OMG PLM Services exist but are not harmonized
 - Alignment with OAGIS services underway
 - NIST project will look at SE Web services
- PLCS Technical Data Package (TDP) Messaging
 - Envelope not the models
 - Message types: send, acknowledge

Proposed High Level API

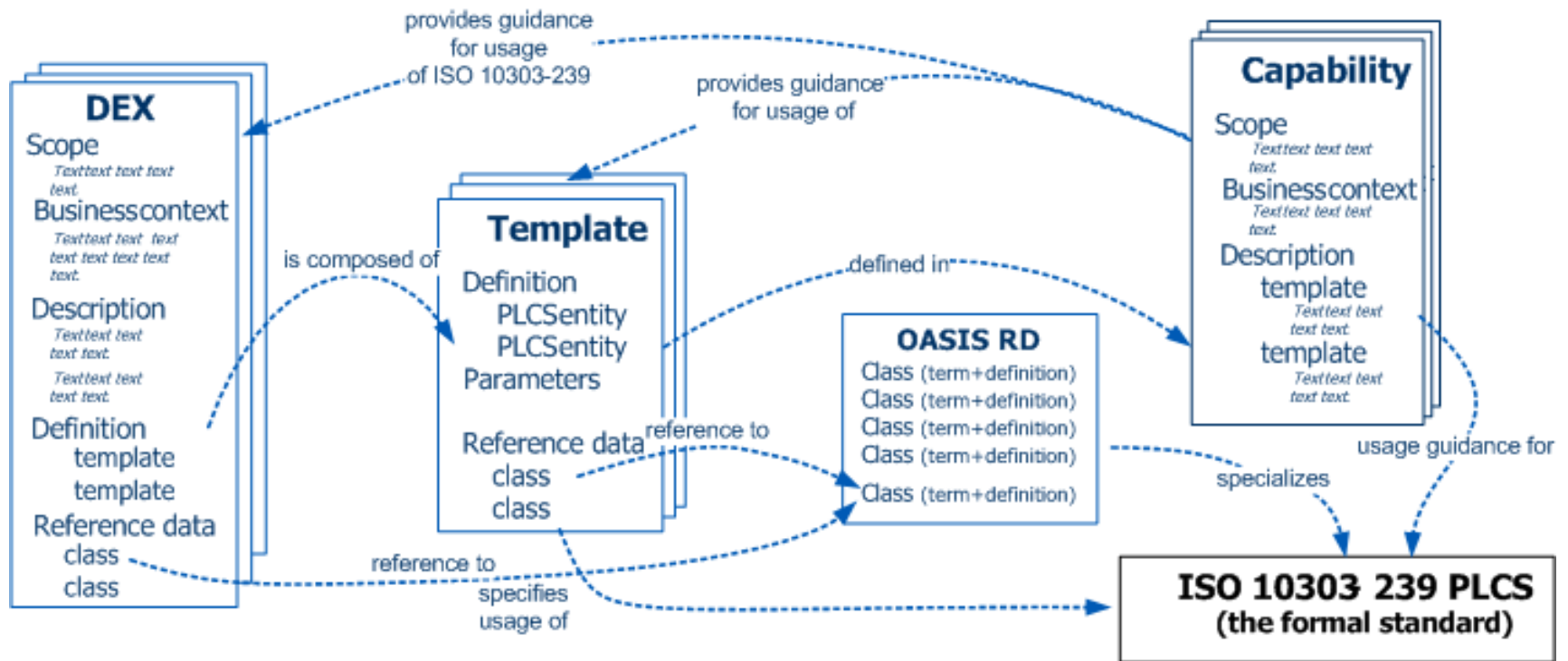
- Efficient Access: classes group objects that are create or destroyed simultaneously
- Business Objects: at level of SE domain concepts for mapping to software tools
- Web Services: functions of SE domain separate from data structures for integration



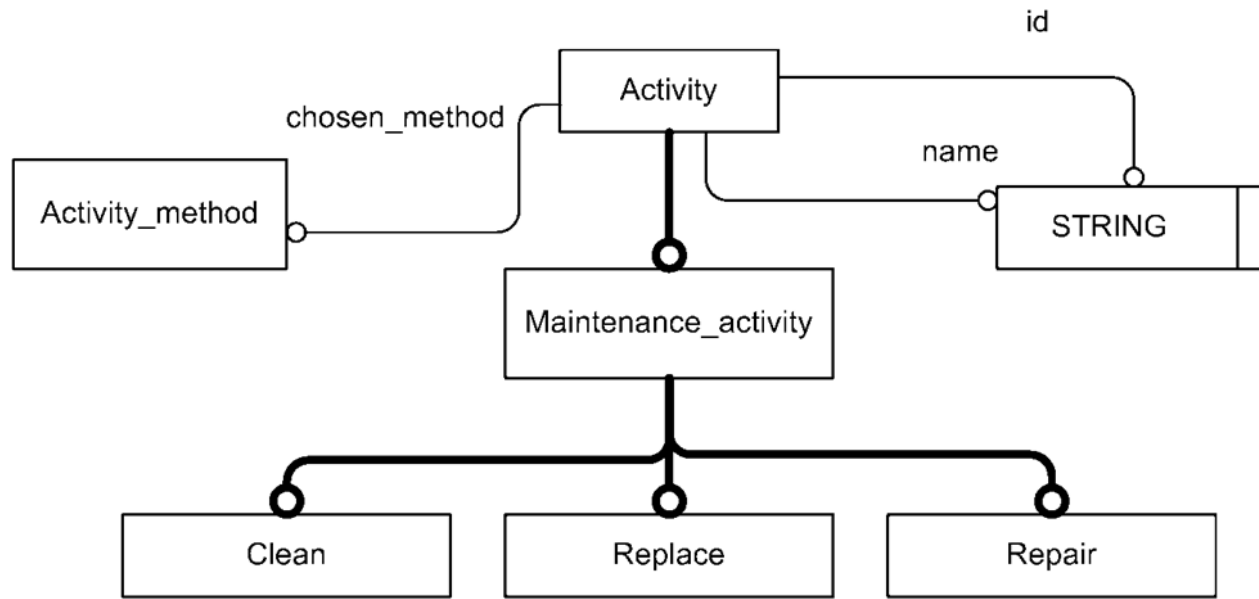
Mapping with Reference Data

- Entities/relationships 233/239 are general
 - E.g. Product, Activity, Product_relation
 - Most things are subtypes of Product
 - Requirement, Part, Interface, ...
- Other subtyping is by classification assignment
 - Specialization of entities/relationships/attributes
 - External classes of reference data
 - E.g. INCOSE subtypes for requirement_version
 - Functional, Performance, Reference, Validation, ...

OASIS DEX Architecture

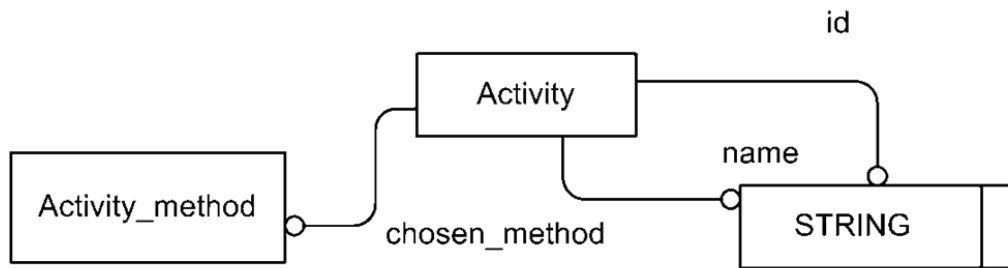


- Reference data in Web Ontology Language (OWL) tailors to domain
- Templates are assembled into Data EXchange Specification (DEX)

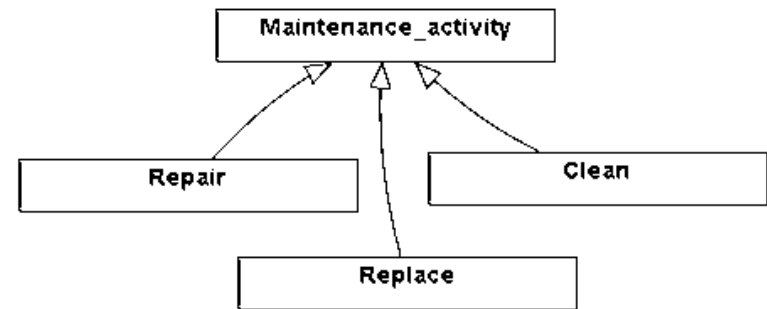


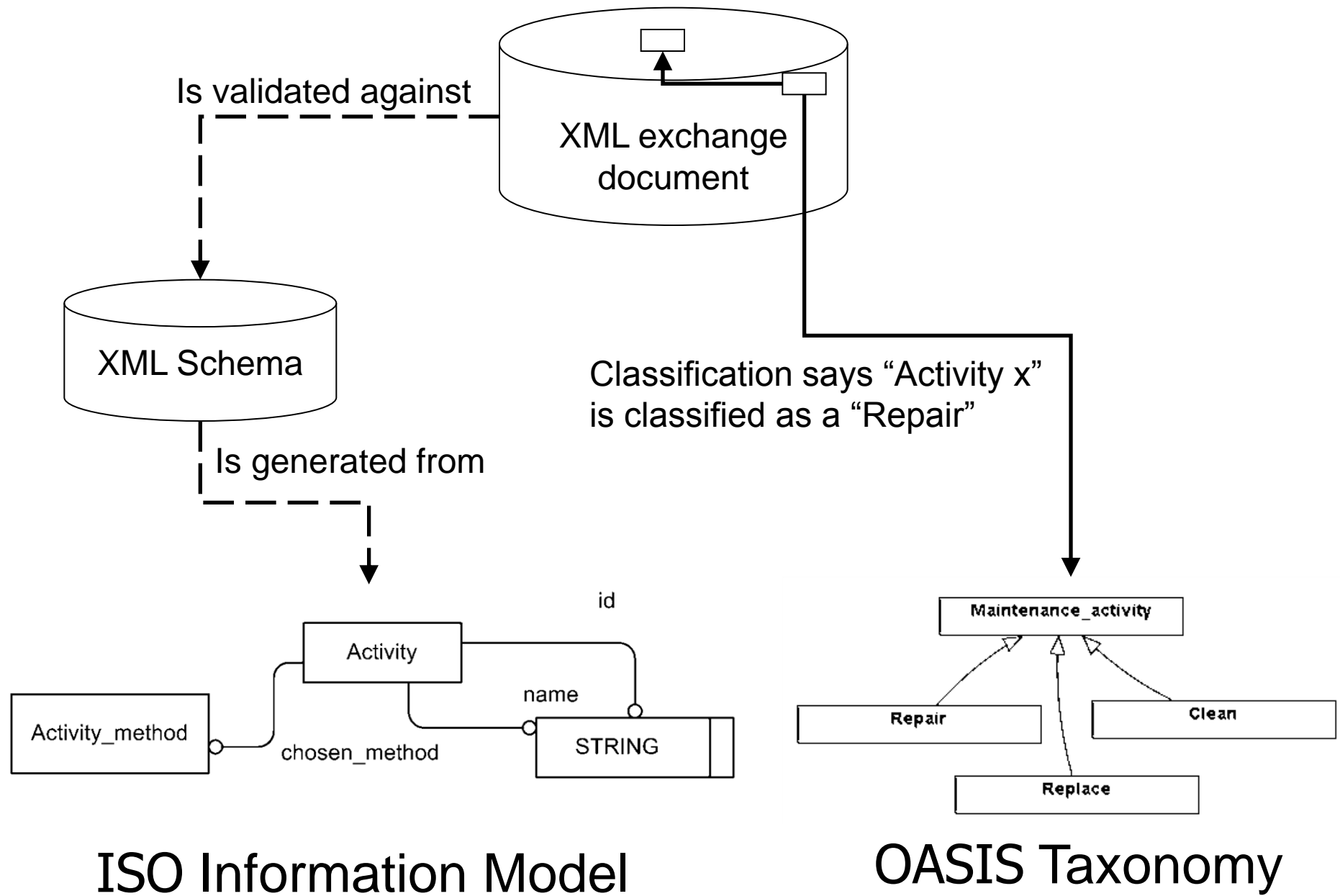
Extension by Subtyping

ISO Information Model



OASIS Taxonomy

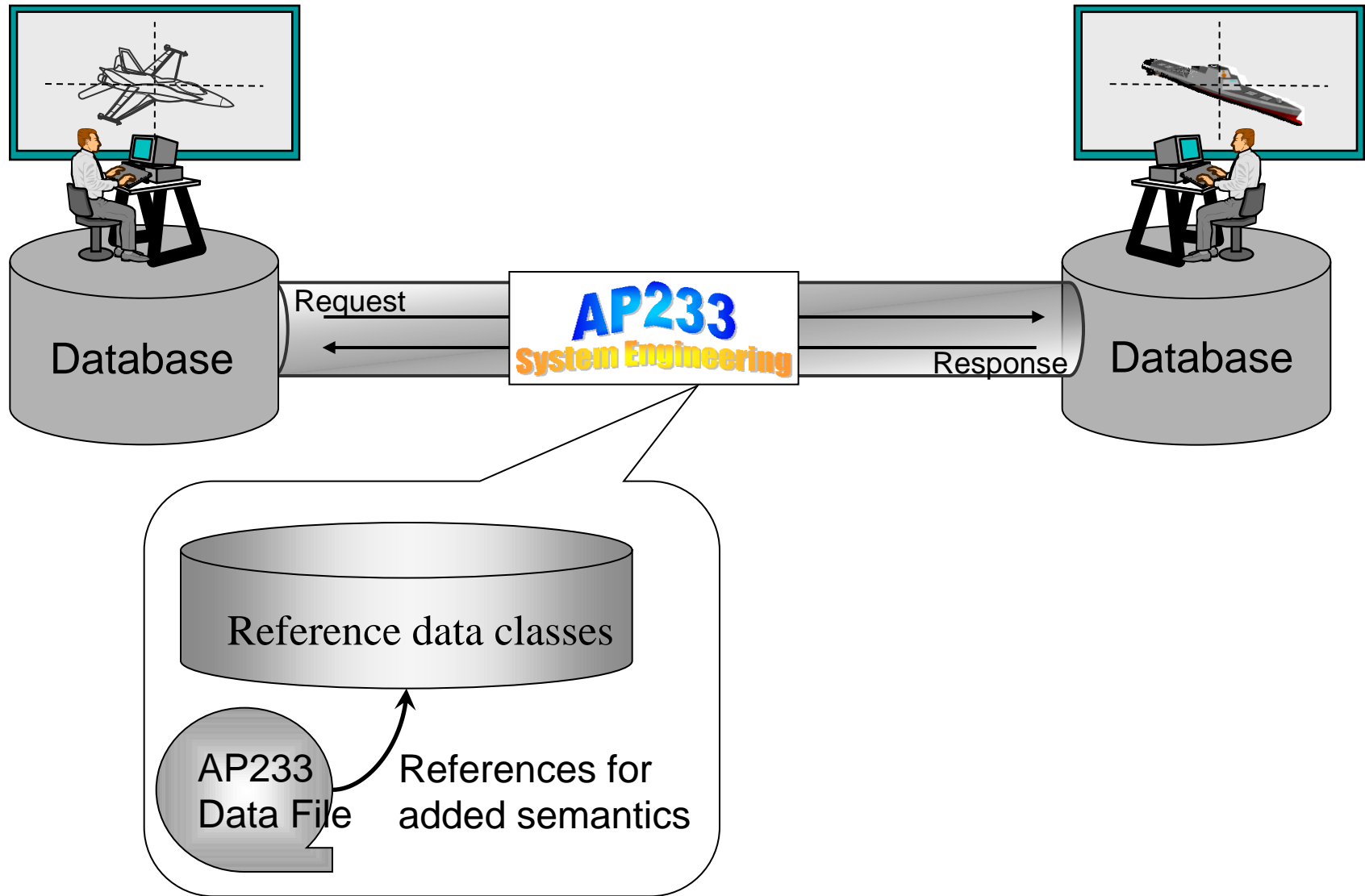




ISO Information Model

OASIS Taxonomy

AP233 designed with extensibility in mind



Reference Data Issues

- Need expert knowledge of STEP information models to properly subtype with reference data
- Many potential sources of reference data from different domains (need domain experts involved)
- Basic set theory used to classify reference data
- Potential for other uses of OWL e.g. semantic web, reasoning

DoDAF and AP233

- There exists a CADM-AP233 OWL representation (www.exff.org)
 - Used AP233 WD2 version with fixes, CADM 1.02
 - Need to update to current version of AP233 and newer versions of CADM (1.5)
 - For legacy program analysis and data migration
- Need to map UPDM with AP233
 - SysML portions from FutureSTEP project
 - Need to map UPDM extensions to SysML

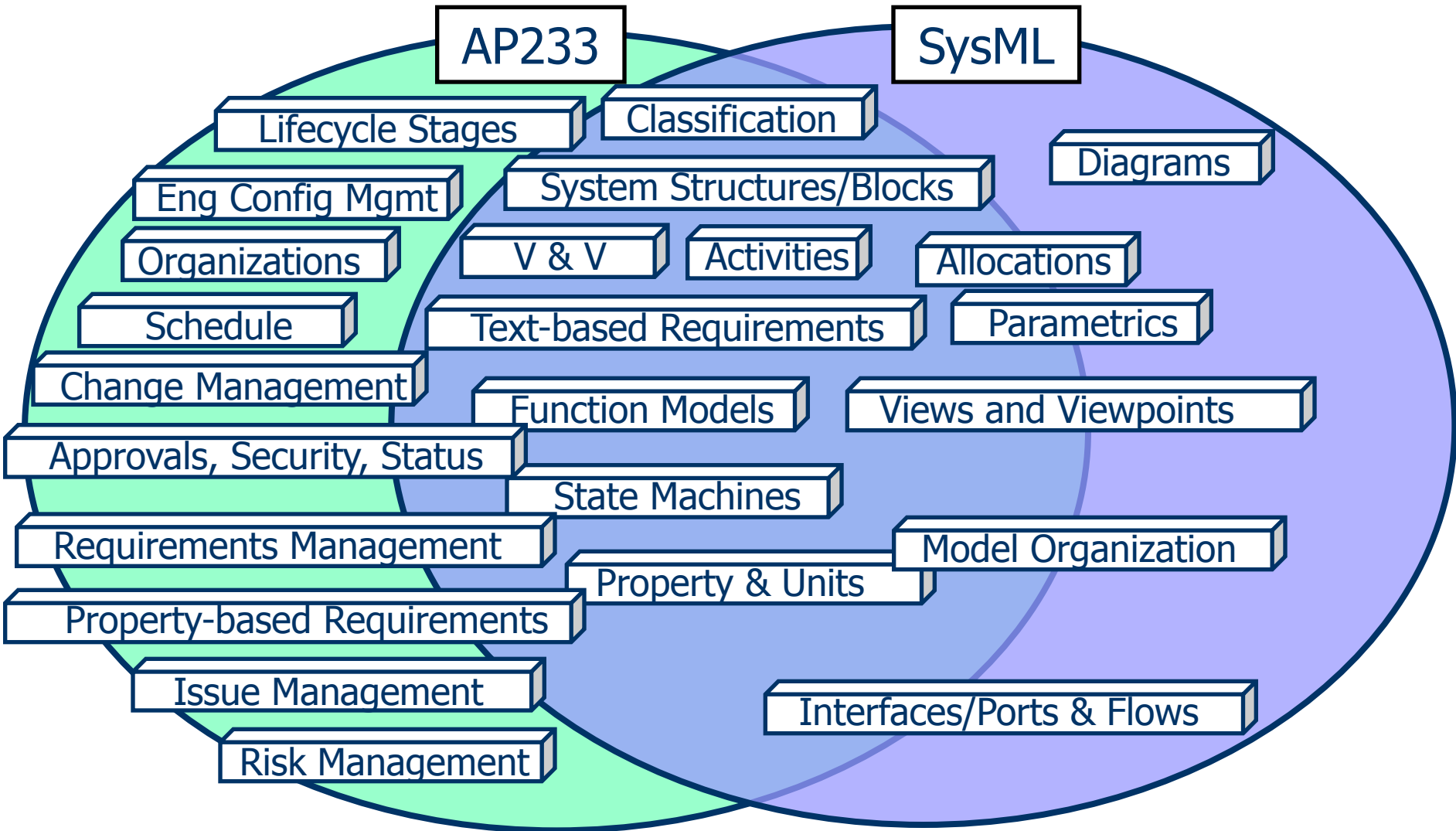
SysML Issues

- XMI – XML Metadata Interchange
 - For UML and others expressed in OMG Meta Object Facility (MOF)
 - Vendor implementations currently incompatible
 - OMG Model Interchange Working Group to improve interoperability
 - Expect will be solved and XMI will serve for most inter-SysML tool exchange
- Model configuration and other management aspects out of scope for SysML, and provided by 233

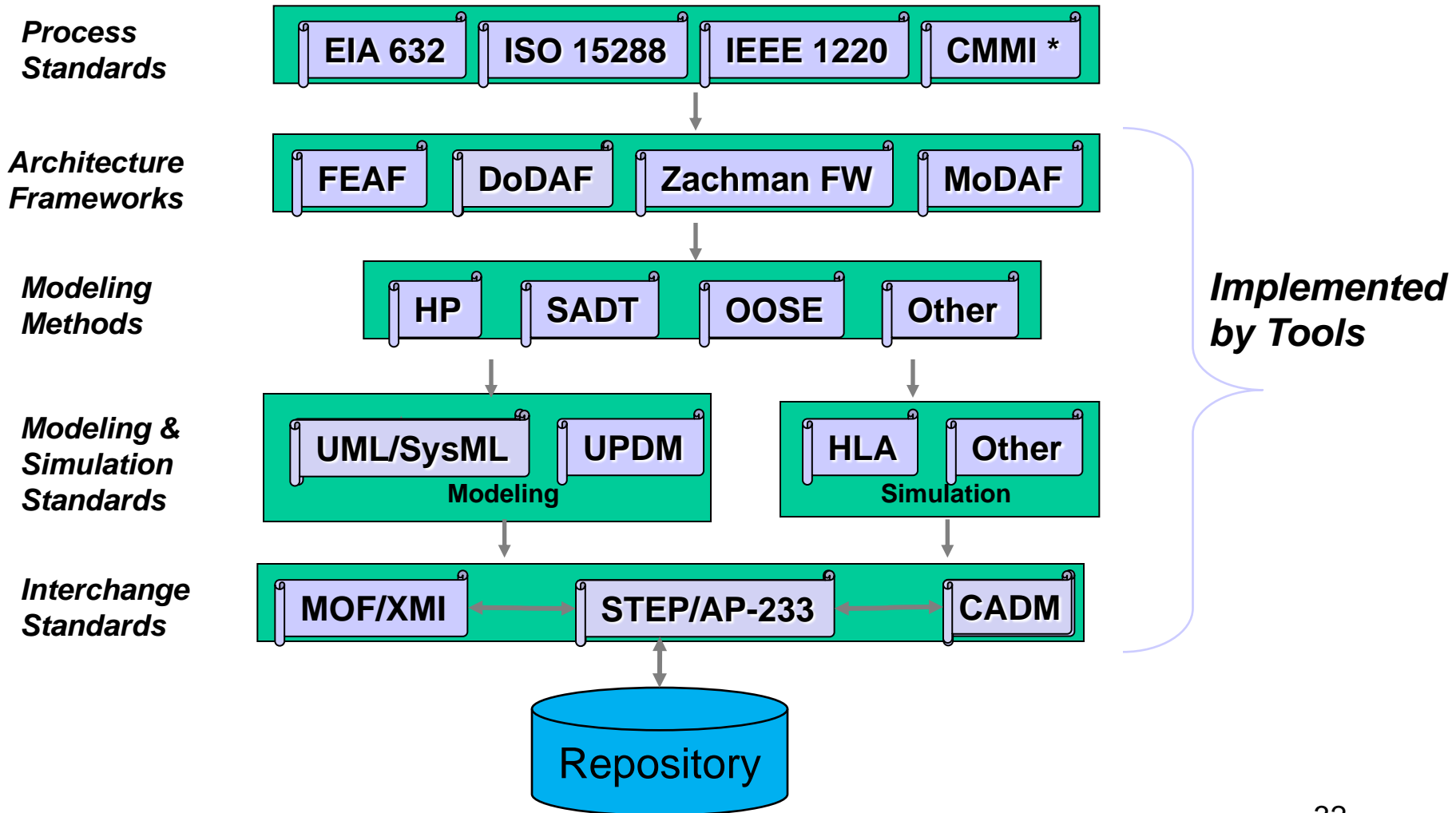
SysML and AP233

- SysML to AP233 mapping underway
 - Both based on INCOSE concept model
 - Creating reference data for SysML
 - Consensus is SysML info a subset/subtype of AP233
- 233 enhances SysML by
 - Management and representation of
 - Risk, Analysis, Fine-Grained Configuration, Program/Project ...
 - Linking to downstream CAD, CAE, CAM, PLCS
- EXPRESS meta-model now in MOF
 - 233 first test case of bringing STEP AP into OMG MDA

SysML/AP233 Data Overlaps



Context Diagram for Architecture & Systems Engineering Standards



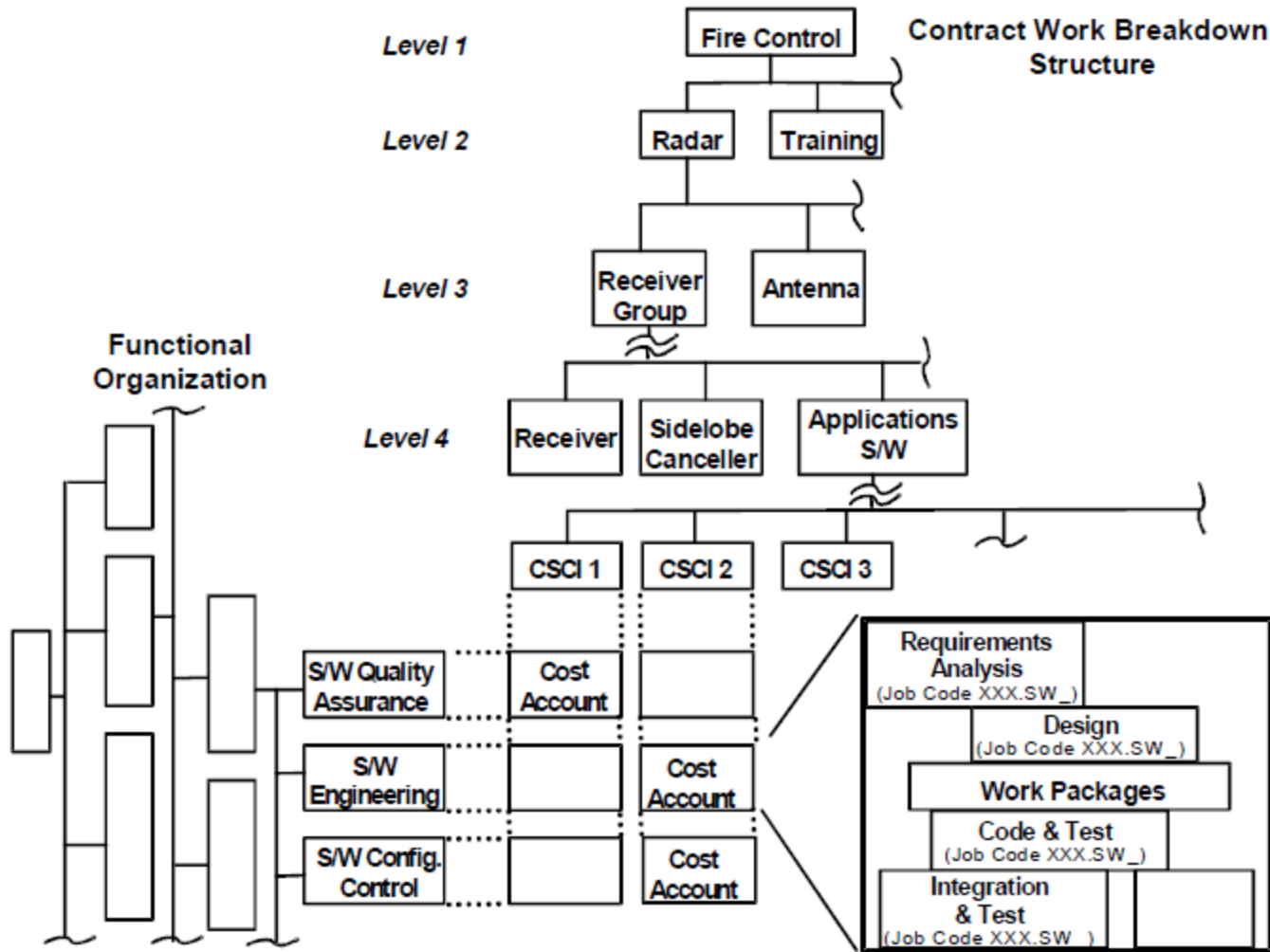
Earned Value Management

- Government contract cost and schedule performance reporting
- Standards for EVM Systems
 - ANSI/EIA-748-A EVMS Guidelines
 - XML Schema based on ANSI X.12 806 & 839
 - NDIA Program Management Systems Committee XML Working Group
 - Defense Contract Management Agency

Work Breakdown Structure (WBS)

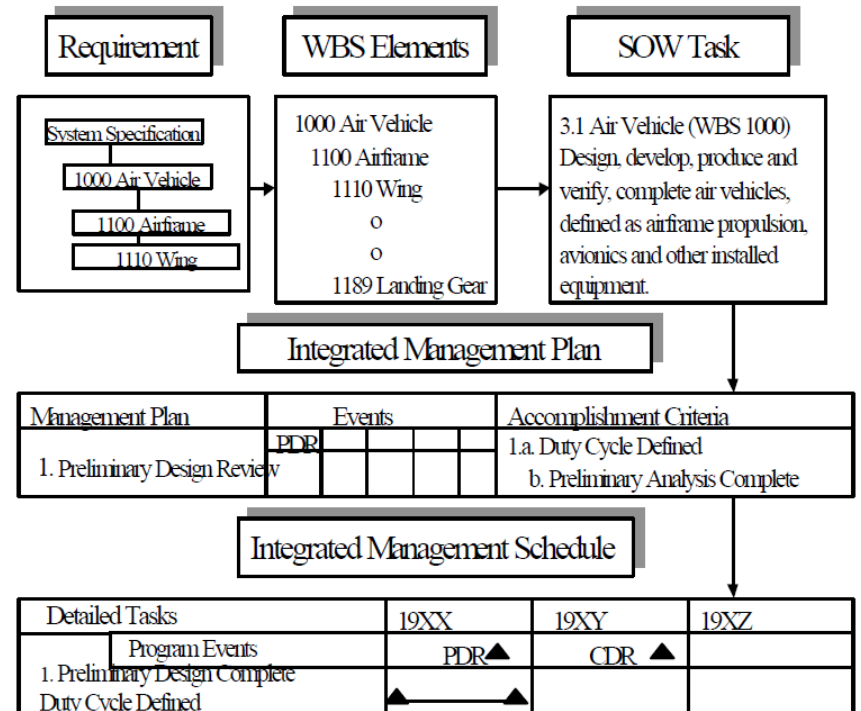
- MIL-HDBK-881 standard 3-level for weapon systems
 - E.g. Missile System/Air Vehicle/Propulsion
 - Allows trade-space
 - Contractor tailors to deeper levels for program
 - Some contractors standardizing lower WBS levels
- New Operations & Support WBS
- WBS codes in Integrated Master Schedule (IMS) and cost accounting system

Breakdowns & Cost Accounts



WBS Integration

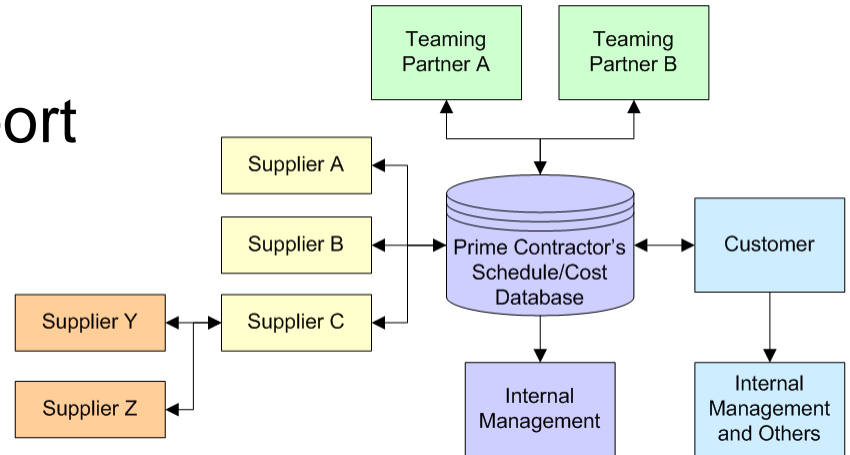
- Requirements and specifications by WBS
- IMS uses WBS to code tasks in SOW
- Contracts report task cost by WBS



EVM Status

- EVM Central Repository
 - Required for major programs
 - Used for analysis
 - PM software vendors support

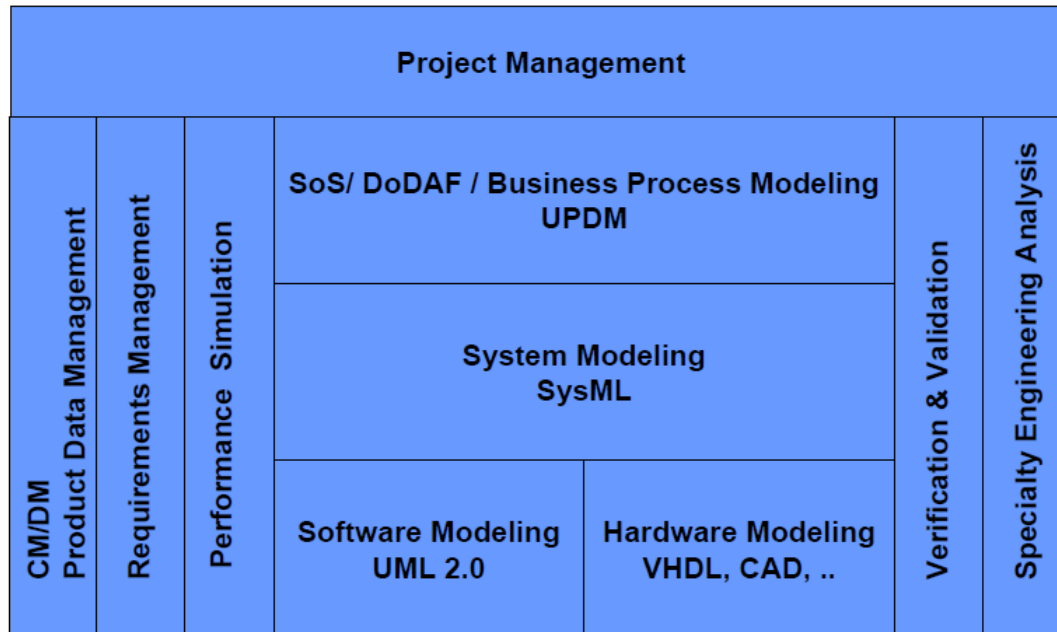
- Mapping EVM into 233
 - OWL Reference Data



- Need to map EVM Schema and 233-based Schema
 - Maintains upward compatibility

233 Pulls it All Together

- STEP AP233 can integrate cost, schedule and systems engineering
- Models can be managed, inter-related, and linked to specialty engineering domains



Summary

- AP233 is designed to
 - capture system requirements, design & analysis data over the life cycle
 - support interoperability & integration of Systems Engineering tools
 - provide a “front end” to PLCS-based Support Engineering tools
 - link with detailed design, PDM, analysis, etc. tools through other STEP protocols
 - align with OMG SysML
 - enable INCOSE vision of Model-Based Systems Engineering

In Conclusion

- STEP AP233 Systems Engineering can
 - Input and integrate cost, schedule, and engineering models
 - Manage models through changes, lifecycle, and supply chain
 - Provide a basis for program baseline, reporting, analysis, and management
- Stable for implementation by tool vendors