Challenges and Benefits of Applying ISO STEP

Stuart T. Booth
Systems Engineering Directorate
Office of the Director, Defense Research and Engineering

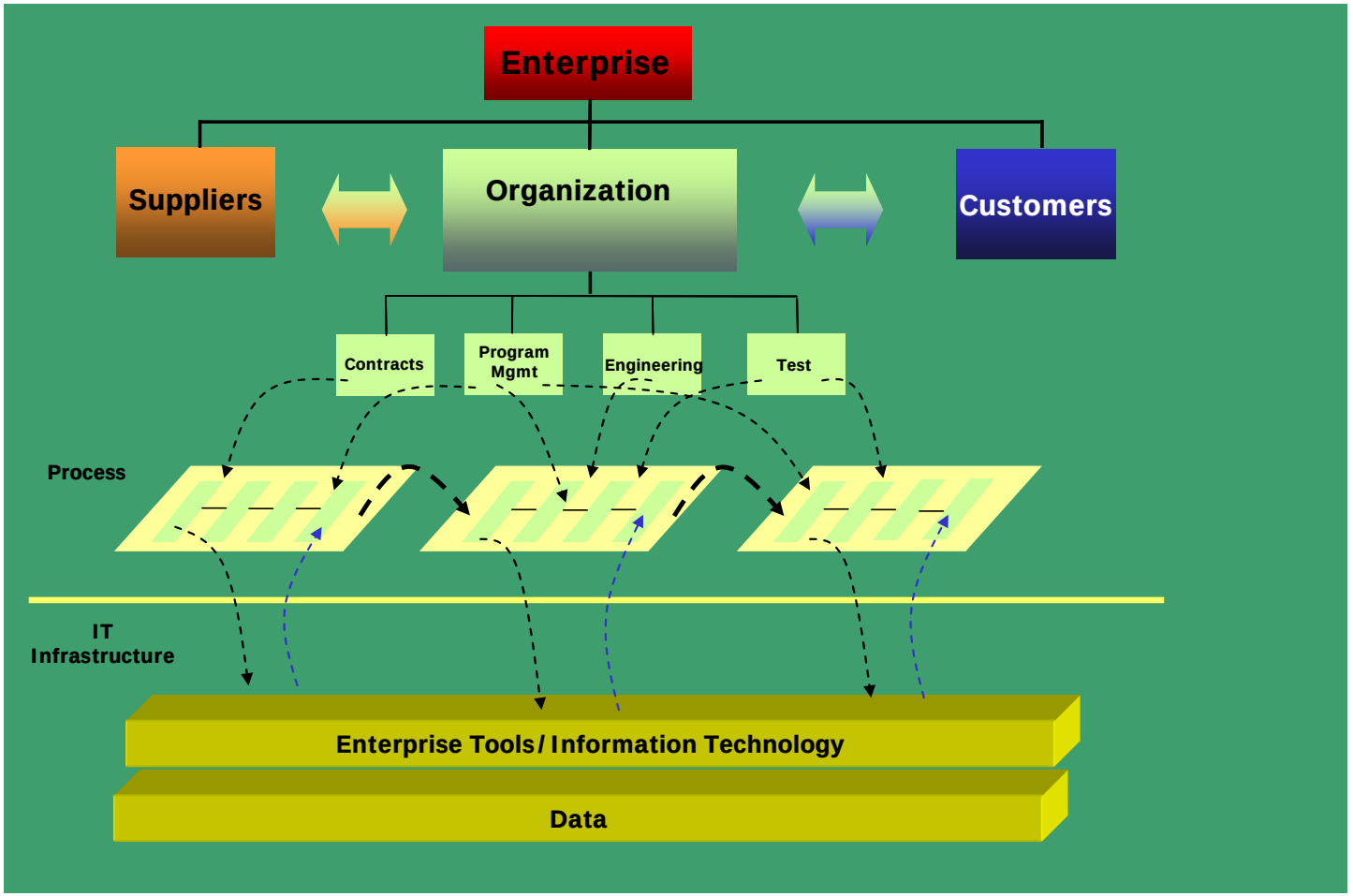
Charlie Stirk
PDES Inc.
Technical Advisory Committee Chairman

12th Annual NDIA Systems Engineering Conference
October 29, 2009

Outline

- **Overview of the Enterprise Challenge**
- **Tool Vendor and Data Management Challenges**
- **OSD Path forward on a Common Data Exchange Approach**
- **Overview of APs**
  - AP-233 and AP-239
  - Status of AP-233
- **AP Architecture**
- **AP Methodology for implementation**
- **Summary**

Notional Enterprise View "Synchronizing the Layers"

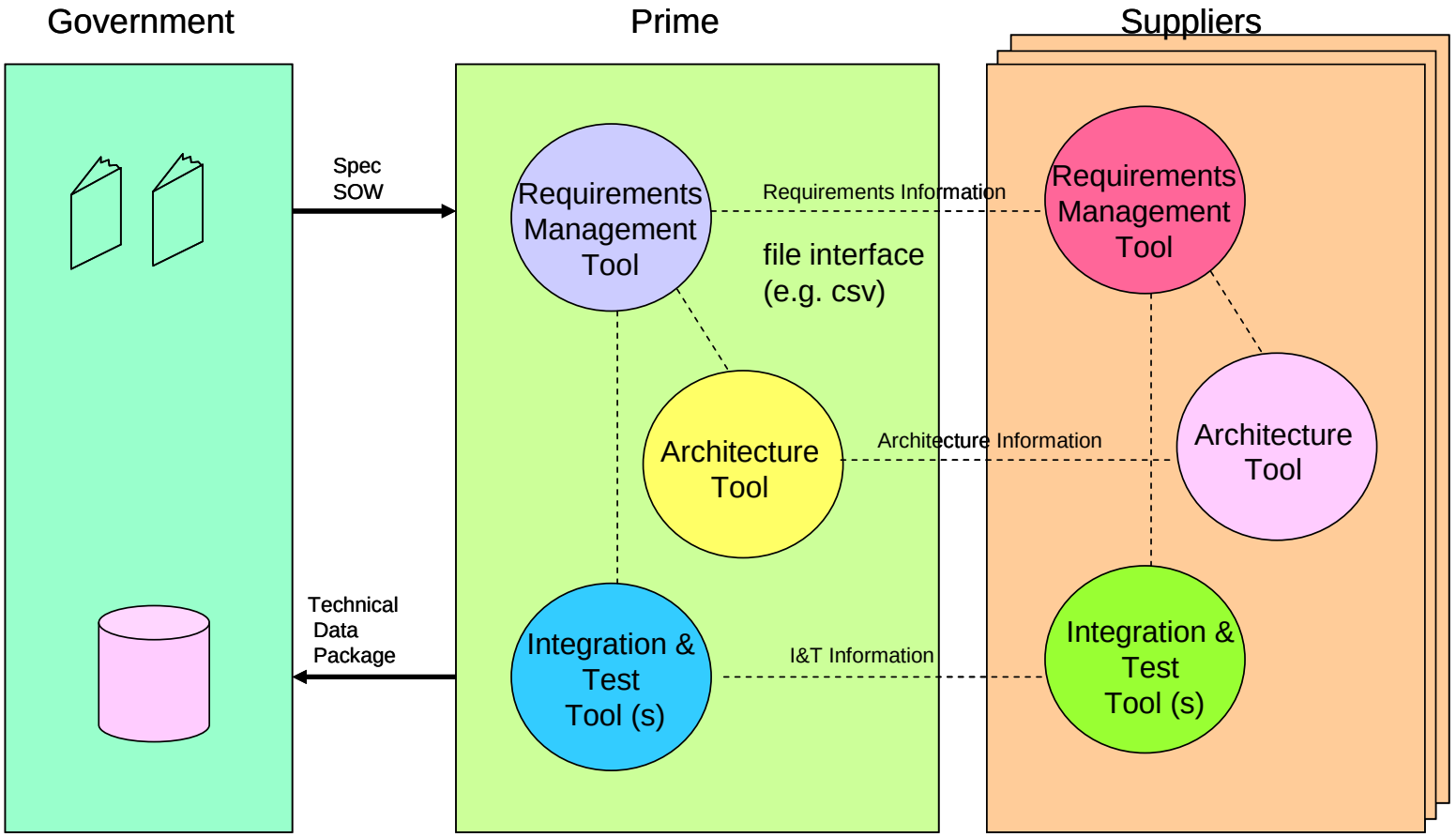


Tool Vendor and Data Management Challenges

- **Tool vendors are in competition resulting in no incentive to integrate tool capabilities…creating "islands of automation"**
  - Proprietary Data Interfaces
  - Proprietary Data Model
- **The tool customer must invest in tool integration to overcome the tool interface challenges**
  - Point to Point tool interfaces…custom scripts
- **Typical SE tools consist of:**
  - Requirements Management
  - Architecture
  - Integration and Test
  - Risk Management
- **All stakeholders suffer due to poor data integration and synchronization and consistency problems.**

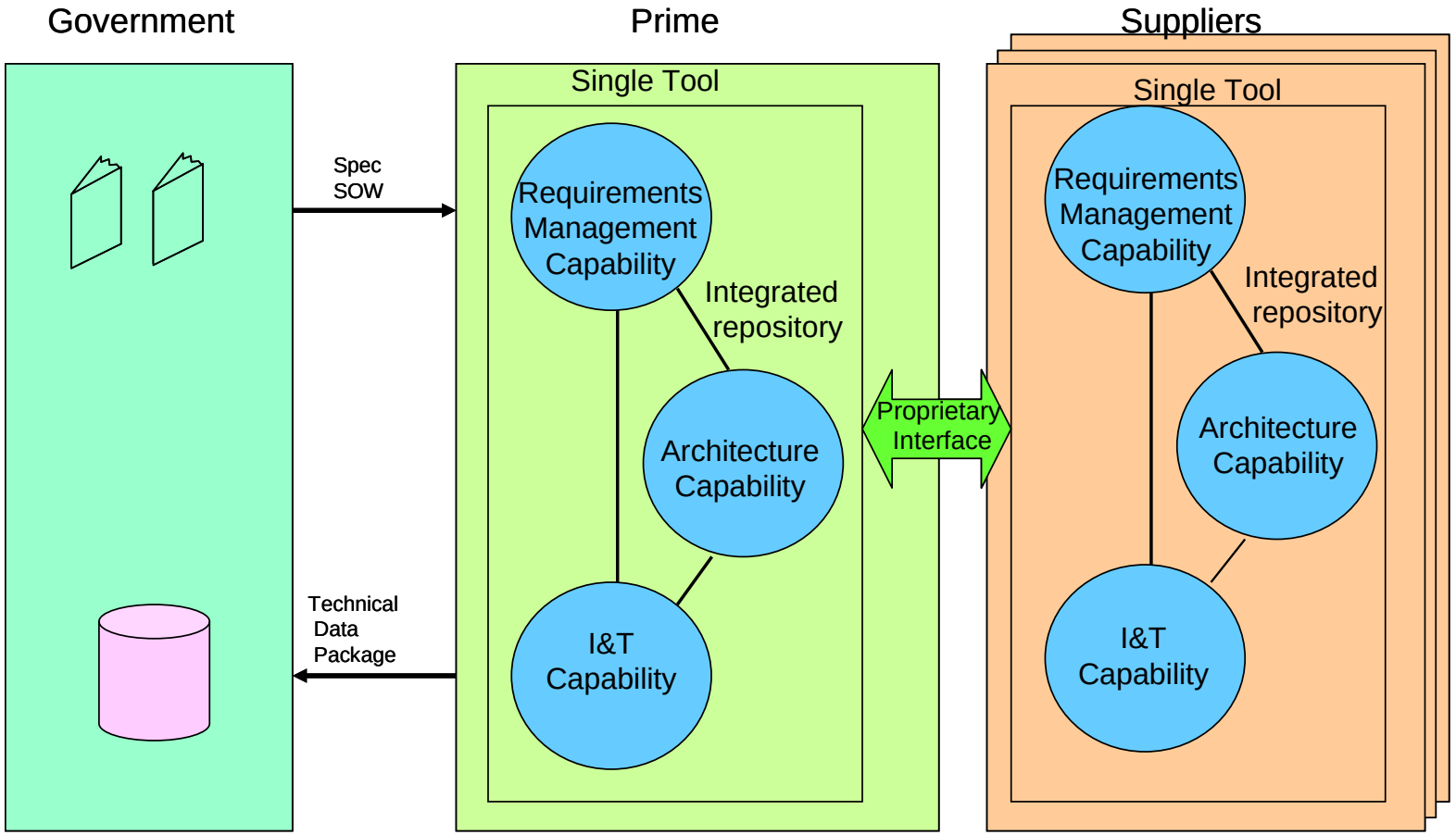
Need another approach….
Common Data exchange protocol that facilitates data integration.

Notional Multi-Tool Vendor Typical Consequences



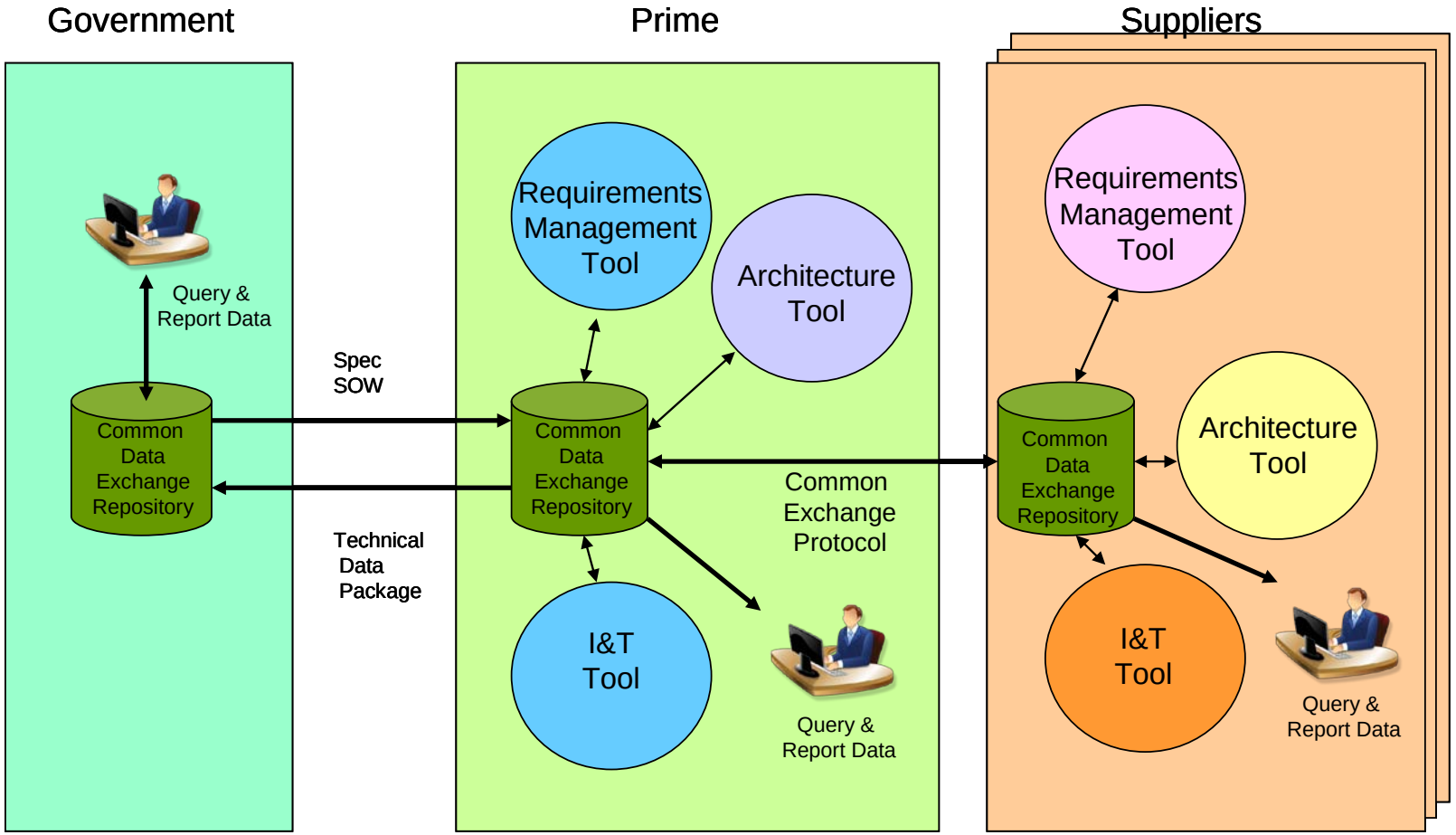
- Engineers must query multiple databases to get a full picture; painful process with temporary value
- Maintaining synchronization and consistency is nearly impossible
- Expert tool staff is needed to develop custom scripts to support point to point data exchanges

Notional Single Tool Vendor Typical Consequences



- Engineers can easily query data…data is synchronized and consistent
- Program is dependent on a single vendor
- Tools have proprietary interface and not easily integrated with other tools

Notional Multi Tool Environment with Common Data Exchange and Repository



- Supports multi-tool environment….One size does not fit all
- Data Synchronization and consistency is achieved.
- Non proprietary data exchange interface facilitating ease of sharing data
- Engineers/Users can query and report data

DoD Approach Going Forward

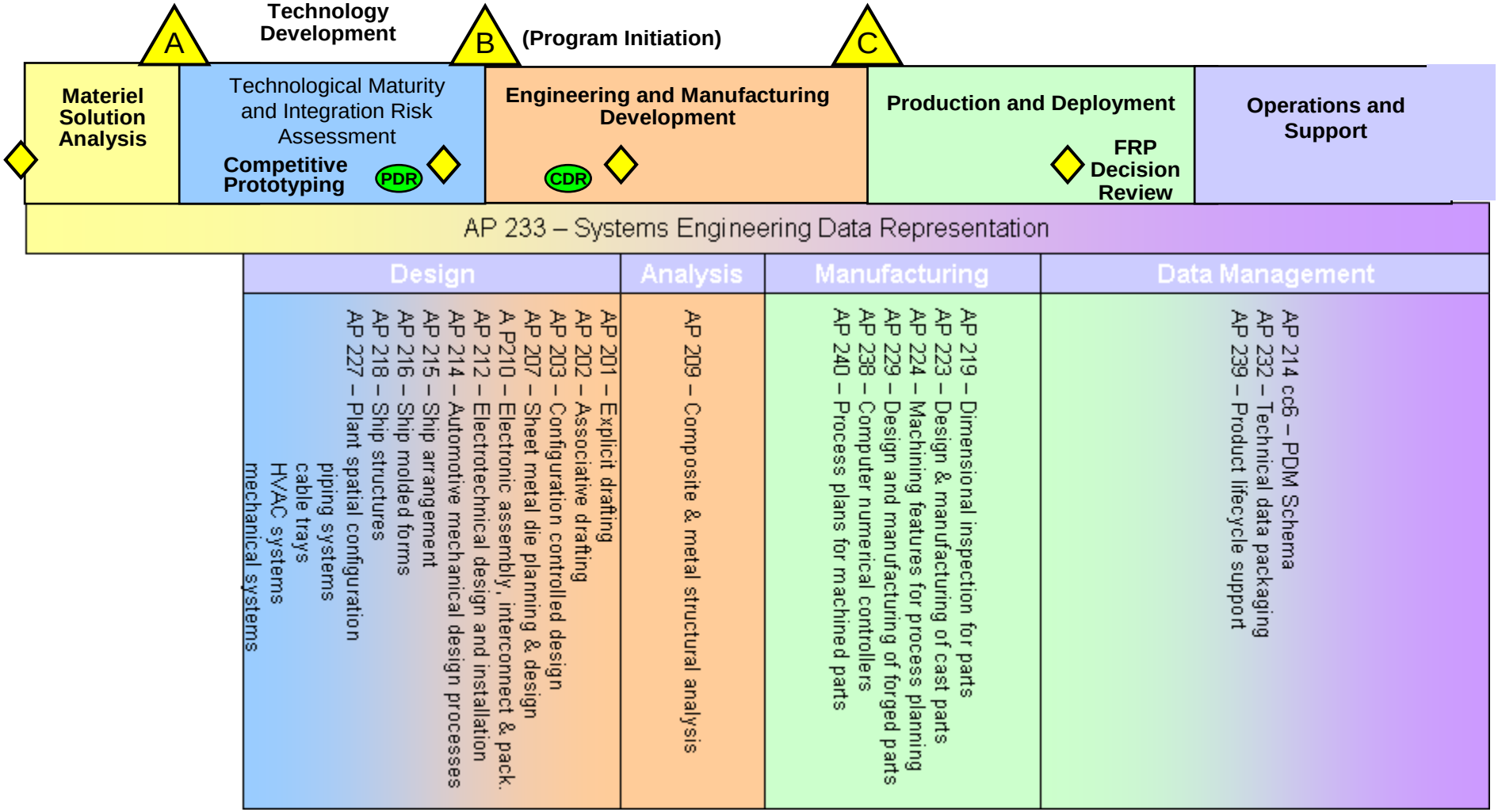
- **Investigating Common Data Exchange Approach**
  - ISO STEP AP-233 (For Systems Engineering)
- **This has its challenges**
  - Developing a robust data model to support systems engineering
  - Applying AP-233 in a commercial environment (flexibility and ease of implementation)
  - Getting the vendors to work with you
- **OSD Systems Engineering is funding a study through the Systems Engineering Research Council (SERC) to investigate the maturity of AP-233. This study will:**
  - Evaluate the current AP-233 (systems engineering) and AP-239 (for logistics) data models for compatibility.
  - Implement a working prototype of AP-233 with market leading systems engineering tools.
  - Adapt AP-233 to selected specialty systems engineering tools.
  - Adapt AP-233 to capture, maintain and export cost & schedule (EVM) data
  - Assess the ease of use and competencies needed to apply AP-233 for commercial application
  - Make recommendations on a path forward.

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

STEP for DoD Acquisition Cycle



Mandates for ISO 10303 STEP

- requirement for Computer-Aided Engineering, Design and Manufacturing systems used by NASA to have interchange tools that support ISO 10303
  - NASA-STD-2817 Chief Information Officer (1999)
- "procure all product/technical data in attachment (1) digital formats and ensure product model data meets ISO/STEP requirements specified in attachment (1)."
  - ASN RDA Memo by John Young, Oct. 23, 2004, STEP for 2-D and 3-D CAD
- "implement a similar approach that adopts ISO 10303 to enhance interoperability" as described in Young memo above
  - OSD ATL Memo by Ken Krieg, June 21, 2005, STEP for UID
- "Ratifying nations agree to apply ISO 10303-239 for product data management in cooperative NATO acquisition programs."
  - NATO STANAG 4661, ratified by US
- "The PM shall require the use of International Standards Organization (ISO) 10303, Standard for Exchange of Product (STEP) Model Data, AP239, Product Life Cycle Support, for engineering data "
  - AFI 63-101 , April 17, 2009, PLCS for engineering data

Modular STEP AP's

- **Application Protocol (AP) Modularization Benefits**
  - Faster revision process (months rather than years)
  - 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)

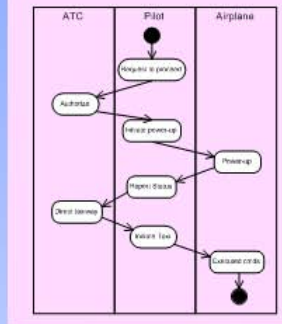
AP233 is One Enabler of INCOSE 2020 Vision

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.

INCOSE International Council on Systems Engineering

SE Practice Transitioning from Document centric to Model centric

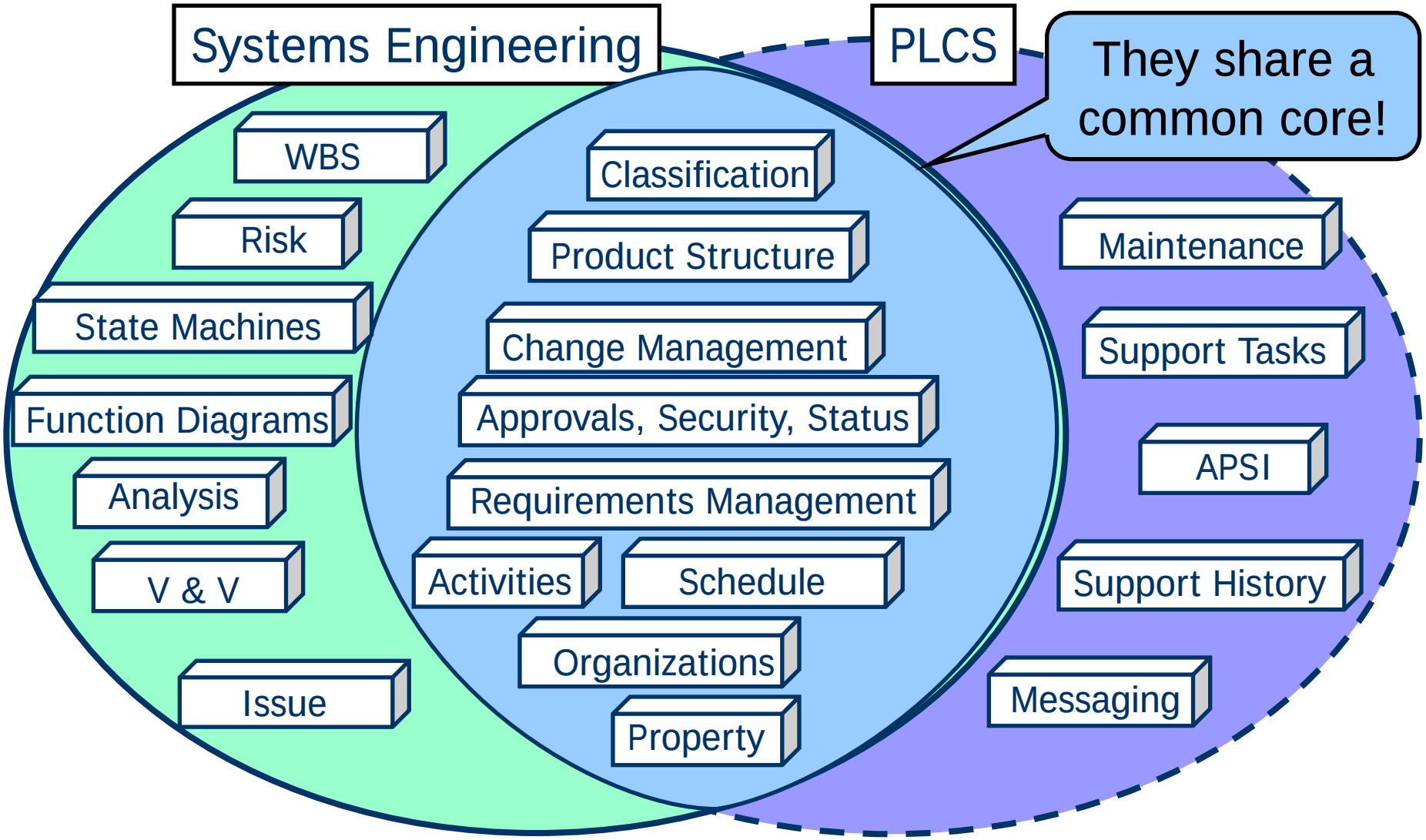
SE and PLCS

- **PLCS shares over 80% of models with AP233 SE**
- **Implementations of PLCS**
  - Pilots at NAVAIR, NAVSEA & Electric Boat
  - Production use at US Army TARDEC & contractors
  - US Army LOGSA developing PLCS DEX's
  - Extensive use by NATO allies for ships, aircraft, land vehicles
- **PLCS Edition 2 in ISO standardization process**
  - Fixes issues found in implementations
    - Incorporated into 233 through common modules
  - Incorporates new capabilities from AP233 SE
    - Risk, Decision Support, V&V

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

SE/PLCS Overlap



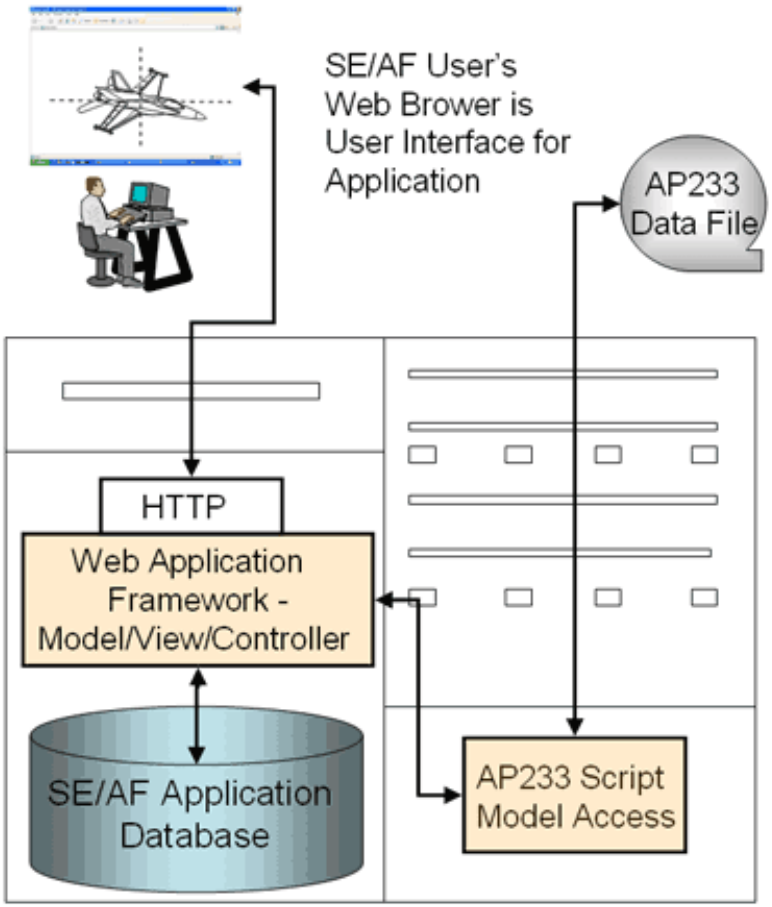
AP233 Implementations

- **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 DoDAF views
- **Multi-domain simulation management**
  - Requirements through analysis – EU Vivace & MBEST
- **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

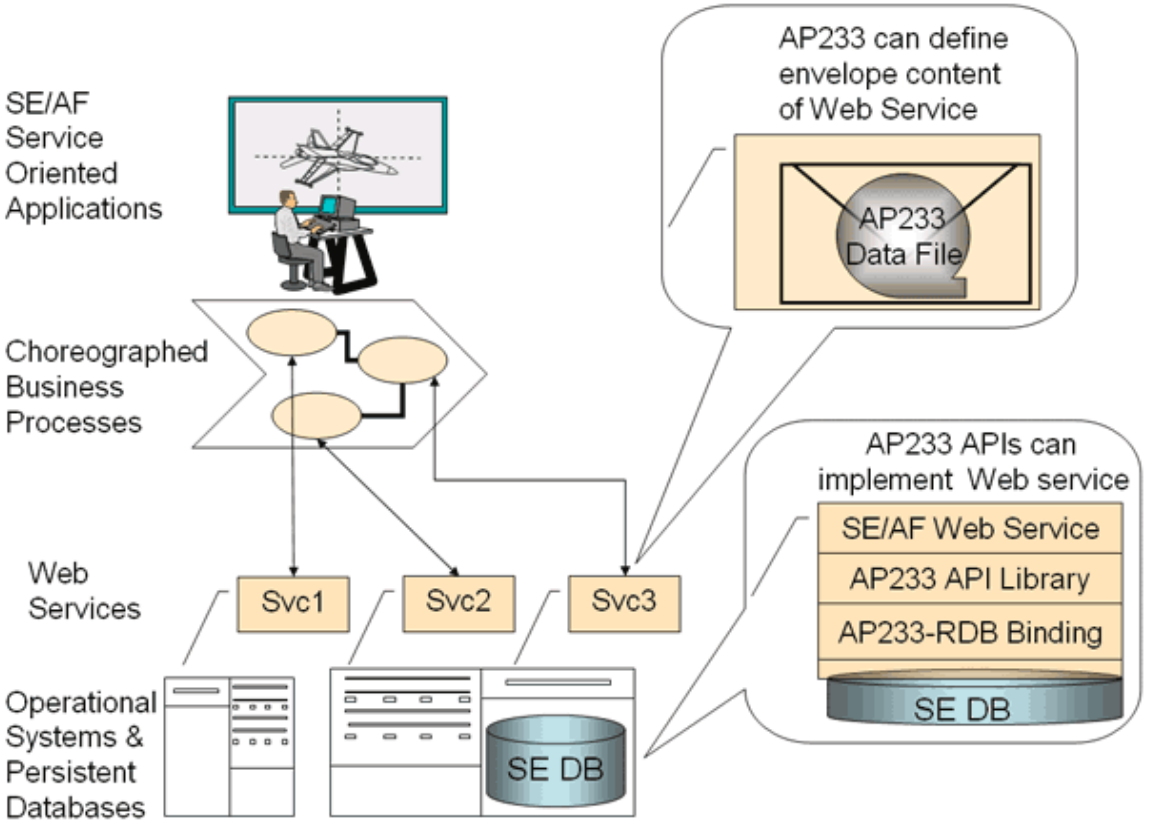
Scripting API Implemented

- **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**

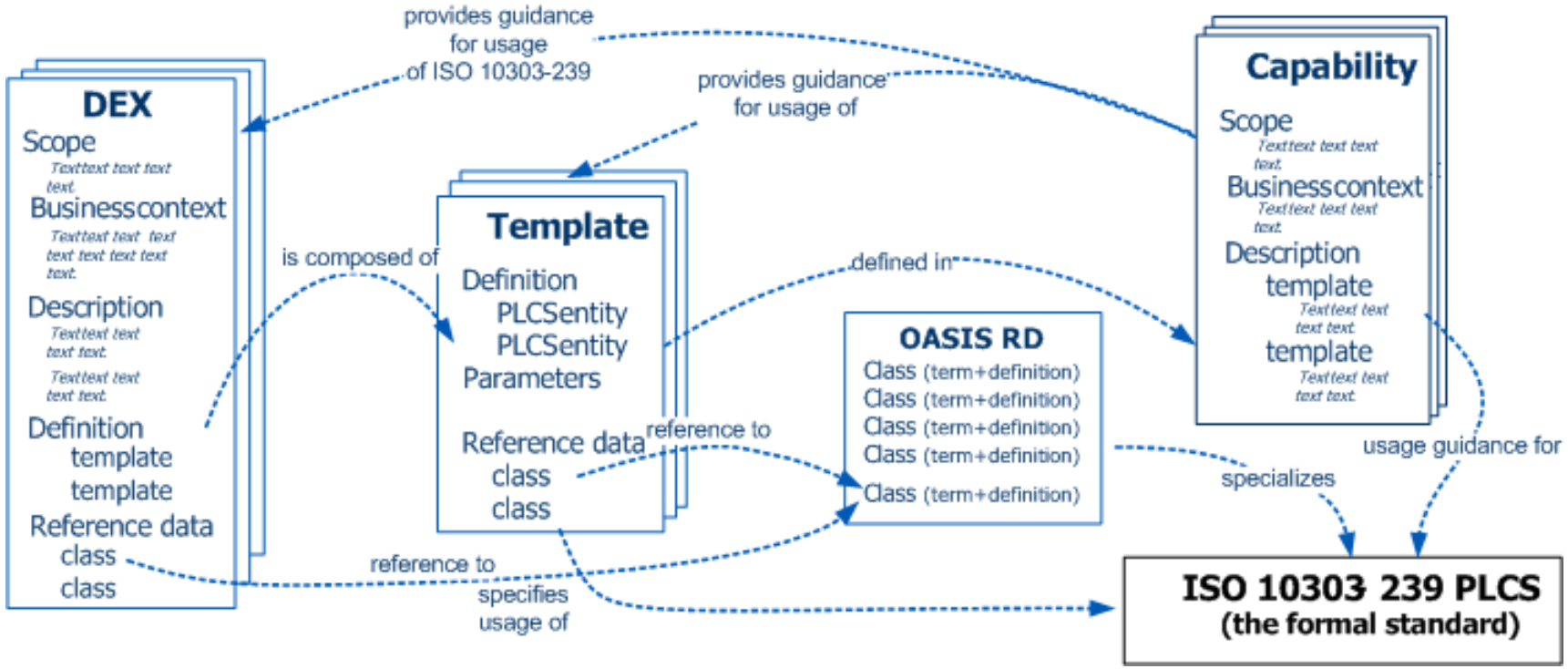


Proposed High Level API

- **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**



Extending 233/239 with Domain Semantics



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

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 NIST FutureSTEP project
  - Need to map UPDM extensions to SysML

SysML Issues

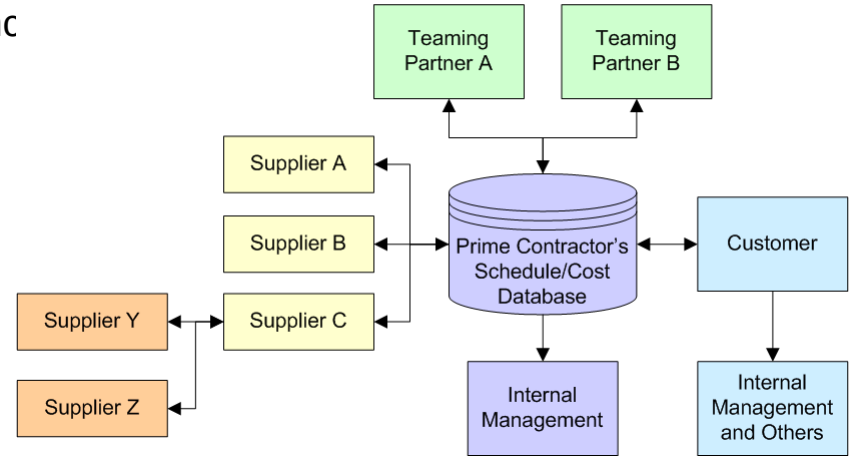
- **XMI – XML Metadata Interchange**
  - For UML and others expressed in OMG Meta Object Facility (MOF)
  - Vendor implementations currently incompatible
  - OMG Model Interchange Working Group to improve interoperability
  - Expect will be solved and XMI will serve for most inter-SysML tool exchange
- **Model configuration and other management aspects out of scope for SysML, but provided by AP233**

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

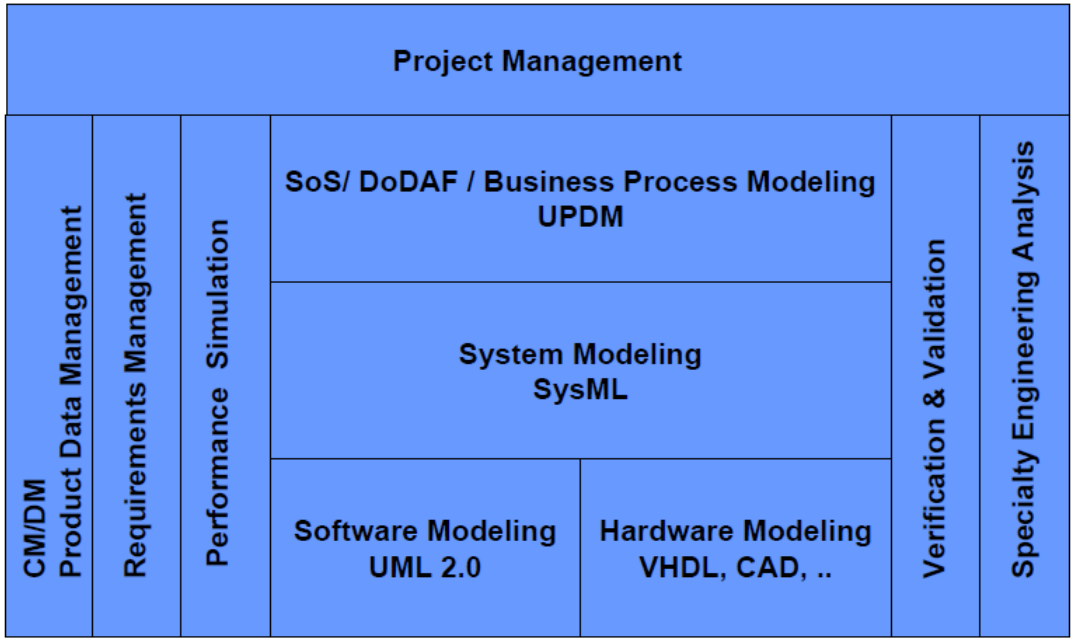
Earned Value Management

- **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 Agenc
- **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**



AP233 is designed to

- Capture system requirements, design and analysis data over the life cycle
- Support interoperability and 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 and UPDM for DoDAF
- Enable INCOSE’s vision of Model-Based Systems Engineering

For Additional Information

Stuart Booth

stuart.booth.ctr@osd.mil

Charles Stirk

stirk@costvision.com