



An Overview of AP233

STEP's Systems Engineering Standard

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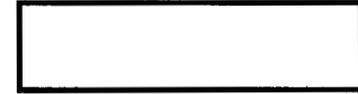
October 2, 2001



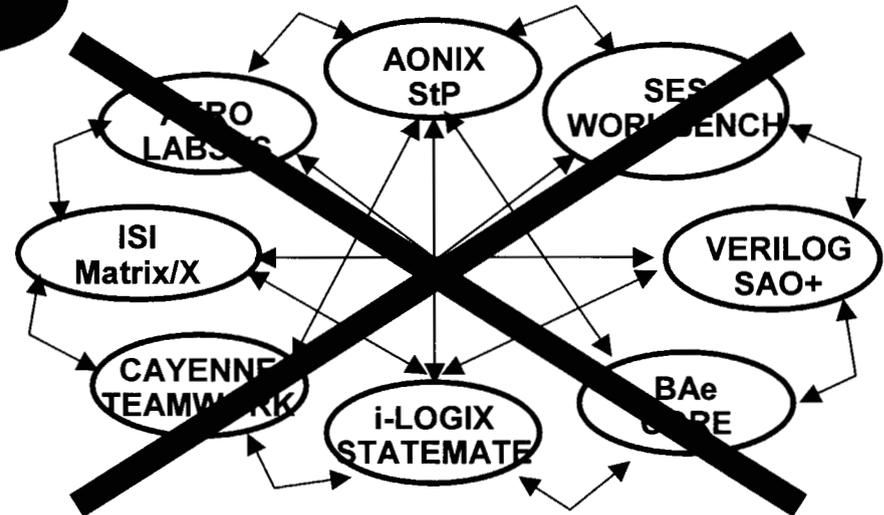
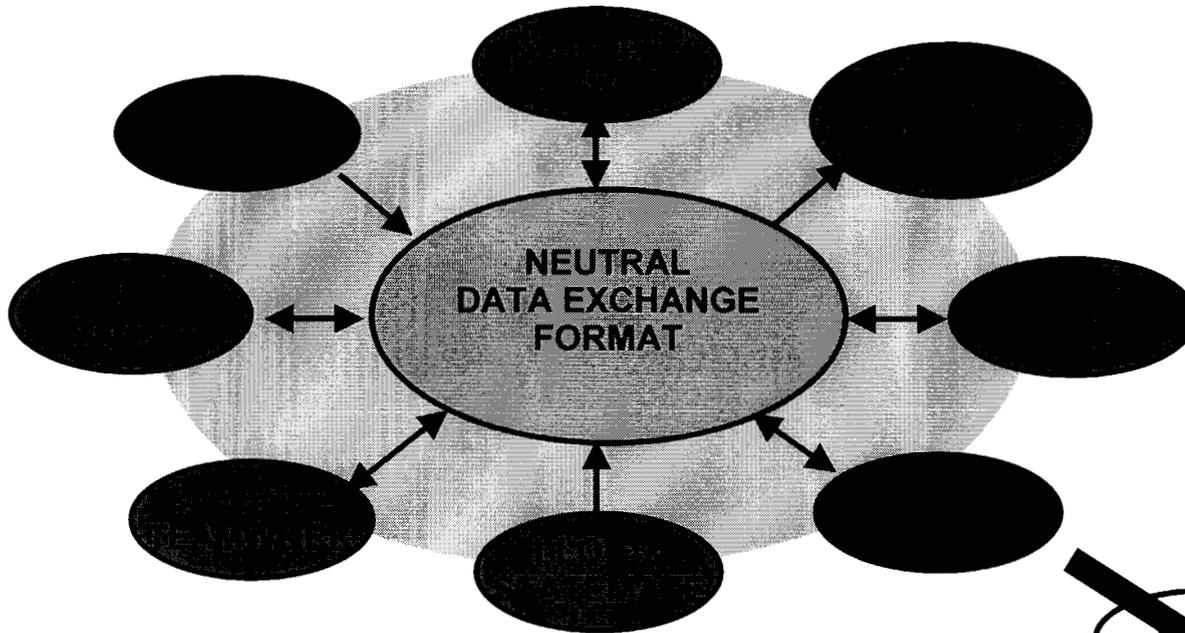
The SEDRES Project: The Roots of AP233

(Systems Engineering Representation and Exchange
Standardization)

- **SEDRES Project consists of European aerospace companies**
 - > **Aerospatiale, Alenia, British Aerospace (now BAE Systems),
DASA (now DaimlerChrysler), SAAB**
- **Joint projects**
 - > **Gripen**
 - > **Eurofighter (EF2000)**
- **Project focused on specific SE data exchanges**
- **SEDRES initiated NWI in TC184/SC4 in 1998 to provide
a means of publishing its work**



Primary Driver: Reduction in Tool Interfaces

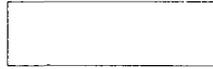




SEDRES Project Concludes

Deliveries:

- **Produce an EXPRESS data model**
- **Prototype data exchanges between commercial tools**
- **Initiated AP233 Work Item in TC184 / SC4**
- **Produce a ISO Publicly Available Specification - PAS 20542 (in work)**
- **SEDRES Project Final Review - December 2001 at BAE SYSTEMS (Warton, UK)**



AP233: The Next Development Wave

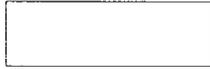
- **A change in scope - integration and communication of SE information**
- **PDES Inc., (with INCOSE and OMG) leads the next wave of AP233 development**
- **Using lessons learned from PLCS and other STEP initiatives, AP233 is planning a “fast moving” project that develops standards-based technology**



STEP Systems Engineering Project (AP233)

The STEP Systems Engineering Project is coordinated through the PDES Inc., a STEP consortium. Standards organizations collaborating with the Project are INCOSE (International Council for Systems Engineering) and OMG (Object Management Group).





Systems Engineering a “big picture” definition

“ An interdisciplinary collaborative approach to derive, evolve, and verify a life cycle balanced system solution that satisfies customer expectations and meets public acceptability.”

(IEEE 1220-1984)

Support a Range of Systems Engineering Views

- Requirement point of view**
- Functional structure point of view**
- Physical structure & allocation point of view**
- Configuration and traceability point of view**
- Project & data management point of view**

AP233

This slide provides high level information about STEP can be applied to engineering domains used to build spacecraft

STEP in Spacecraft Development

How the STEP Data Standard can be applied to Spacecraft Development

Fluid Dynamics

- Standard: STEP-CFD
- Software -
- Status: In Development
- Boeing,

Optics

- Standard: NODIF
- Software - TBD
- Minolta, Olympus

Structural Analysis

- Standard: AP209
- Software: MSC Patran, Thermal Desktop
- Status: In Production
- Lockheed Martin, Electric Boat

Thermal Radiation Analysis

- Standard: STEP-TAS
- Software: Thermal Desktop, TRASYS
- Status: In Production
- ESA/ESTEC, NASA/JPL & Langely

Machining

- Standard:: STEP-NC/AP224
- Software:: Gibbs,
- Status:: In Development / Prototyped
- STEP-Tools, Boeing

Propulsion

- Standard: STEP-PRP
- Software:-
- Status: In Development
- ESA, EADS

Mechanical Engineering

- Standard: AP203, AP214
- Software Pro-E, Cadds, SolidWorks, AutoCad, SDRG IDEAS, Unigraphics, others
- Status: In Production
- Aerospace Industry Wide, Automotive Industry

Electrical Engineering

- Standard: AP210
- Software Mentor Graphics
- Status: Prototyped
- Rockwell, Boeing

Cabling

- Standard: AP212
- Software MentorGraphics
- Status: Prototyped
- Daimler-Chrysler, ProSTEP

Software Engineering

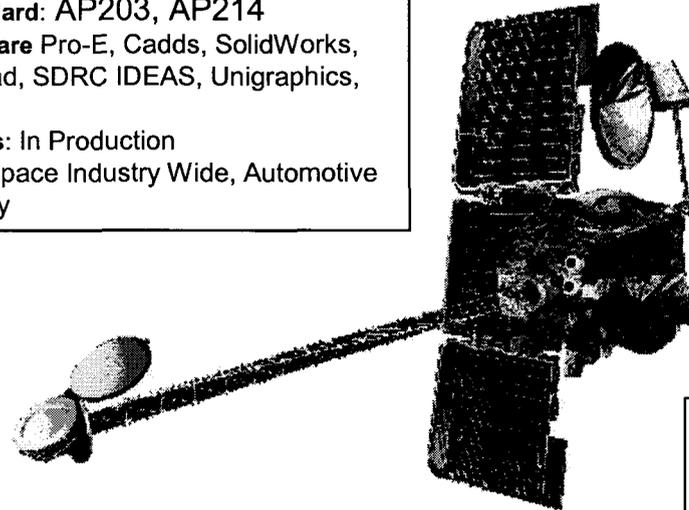
- Standard::UML - (AP233 interface In Development)
- Software:Rational Rose, Argo, All-Together
- Status: In Production
- Industry-wide

Systems Engineering

- Standard: AP233
- Software: Statemate, Doors, Matrix-X, Slate, Core, RTM
- Status: In development / Prototyped
- BAE SYSTEMS, EADS, NASA

PDM

- Standard: STEP PDM Schema/AP232
- Software: MetaPhase, Windchill, Insync
- Status: In Production
- Lockheed Martin, EADS, BAE SYSTEMS, Raytheon



Inspection

- Standard: AP219
- Software: Technomatics, Brown, eSharp
- Status: In Development
- NIST, CATIA, Boeing, Chrysler, AIAG

Life-Cycle Management

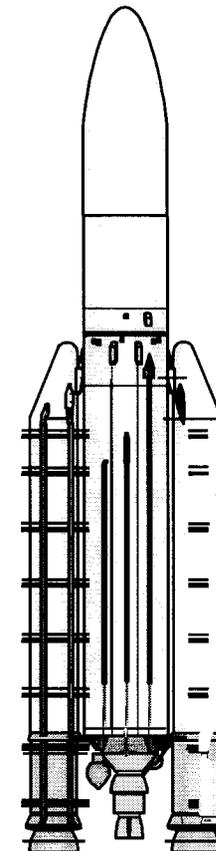
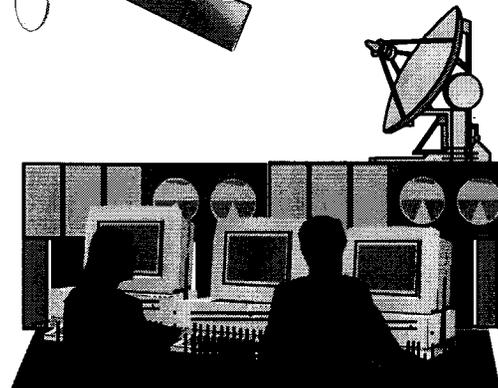
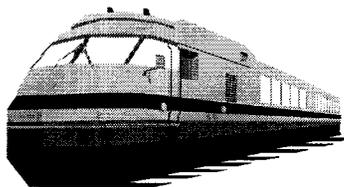
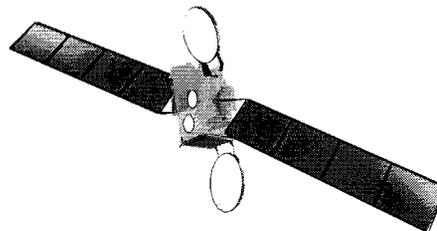
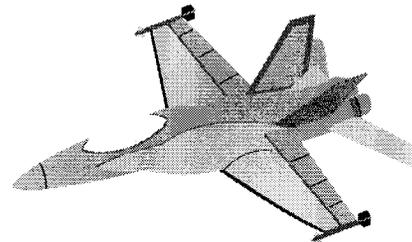
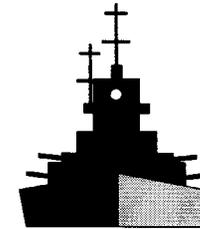
- Standard: PLCS
- Software: SAP
- Status: In Development
- BAE SYSTEMS, Boeing, Eurostep



Applicability

Target Industries:

- > Aerospace
- > Automotive
- > Transport systems
- > Telecommunication
- > Public Utilities
- > Civil engineering
- > C³I (Command, Control..)





Current Approach of AP233 Work

- **Modularization**
 - > **Avoids lengthy gestation of large AP efforts**
 - > **Allows frequent, sequential deliveries**
 - > **Provides on going evolutionary development environment**
- **Active Development Team**
 - > **Bi-weekly Telecons**
 - > **Web-based repository to collect, secure and publish work-in-progress**
 - > **Public website (in work)**
- **Collaboration with existing Industry groups**
 - > **INCOSE - International Council on Systems Engineering**
 - > **OMG - Object Management Group / SE Working Group**

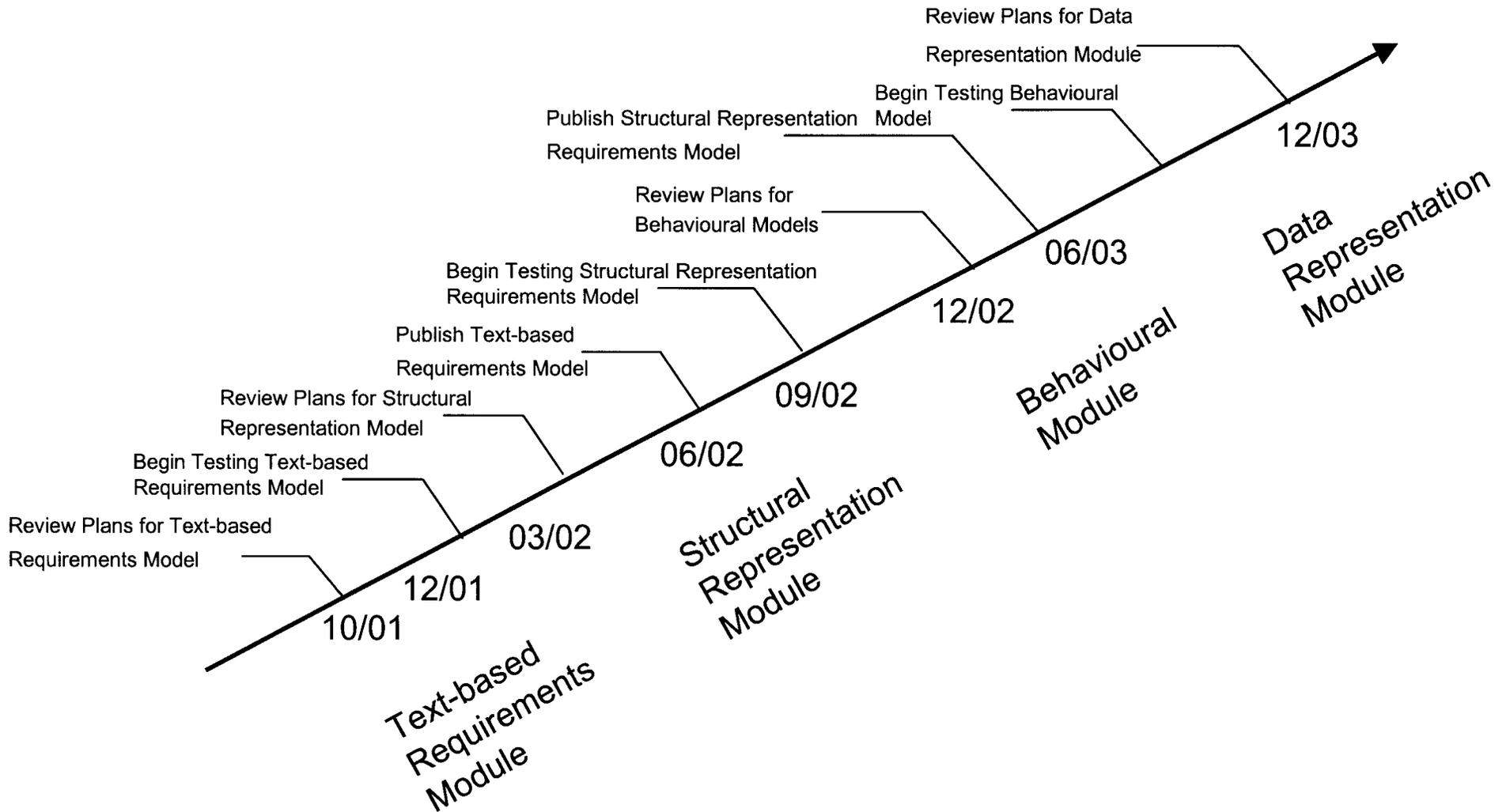


Status of Current Work

- **Creating the modular AP233**
 - > to provide “hooks” into neighboring APs
 - > reusing existing and creating new modules
- **Development of Semantic Data Dictionary**
 - > analysis of existing work
 - > reuse and harmonize terminology as possible
- **Analysis of current STEP standards for:**
 - > Interfaces
 - > Reuse
 - > Integration
 - > Harmonization
- **Develop preliminary 3 year project plan**
 - > draft plan published to Project Workspace (available on request)



Schedule of Deliverables STEP System Engineering Team

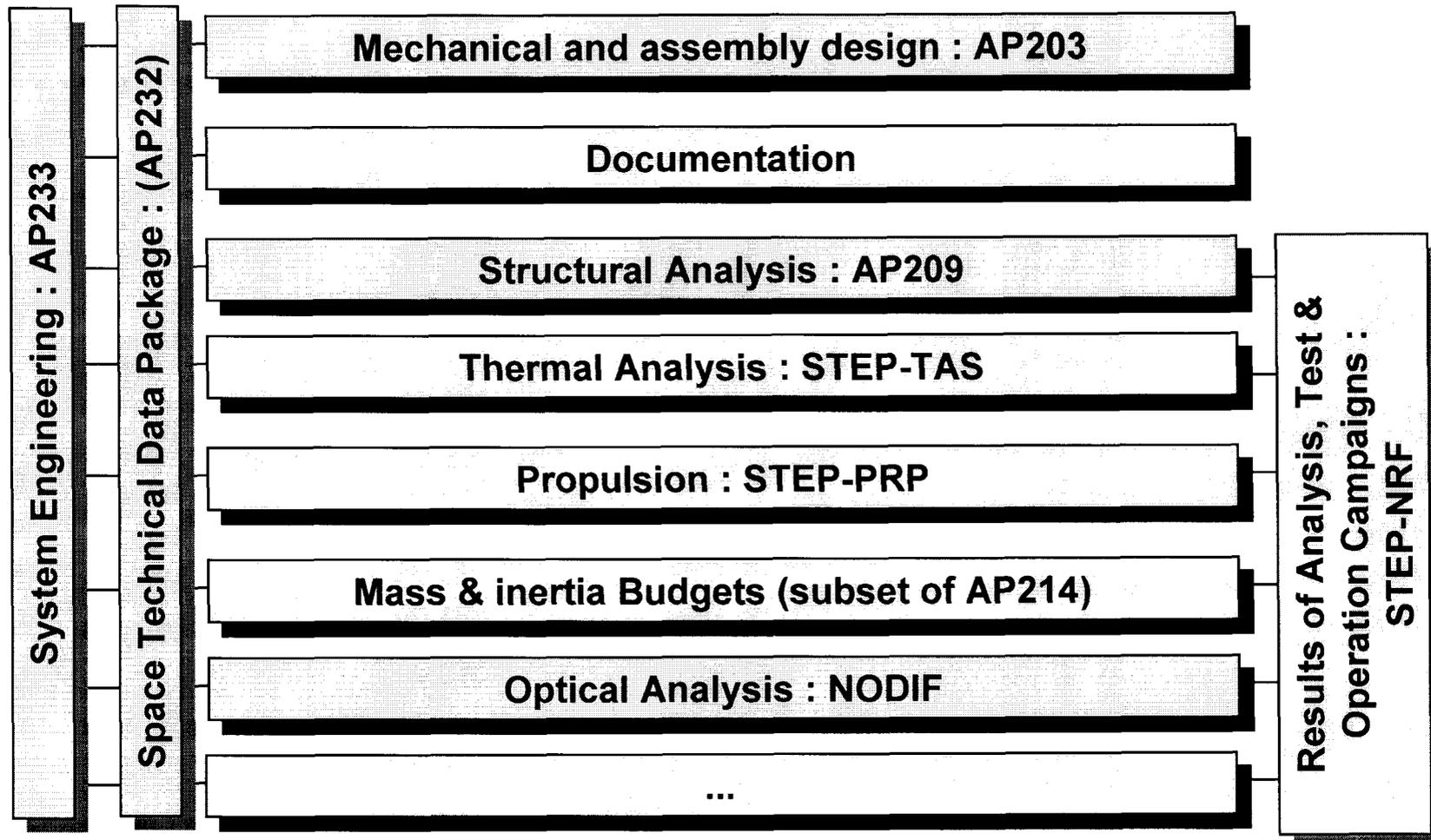




[Backup Slides]

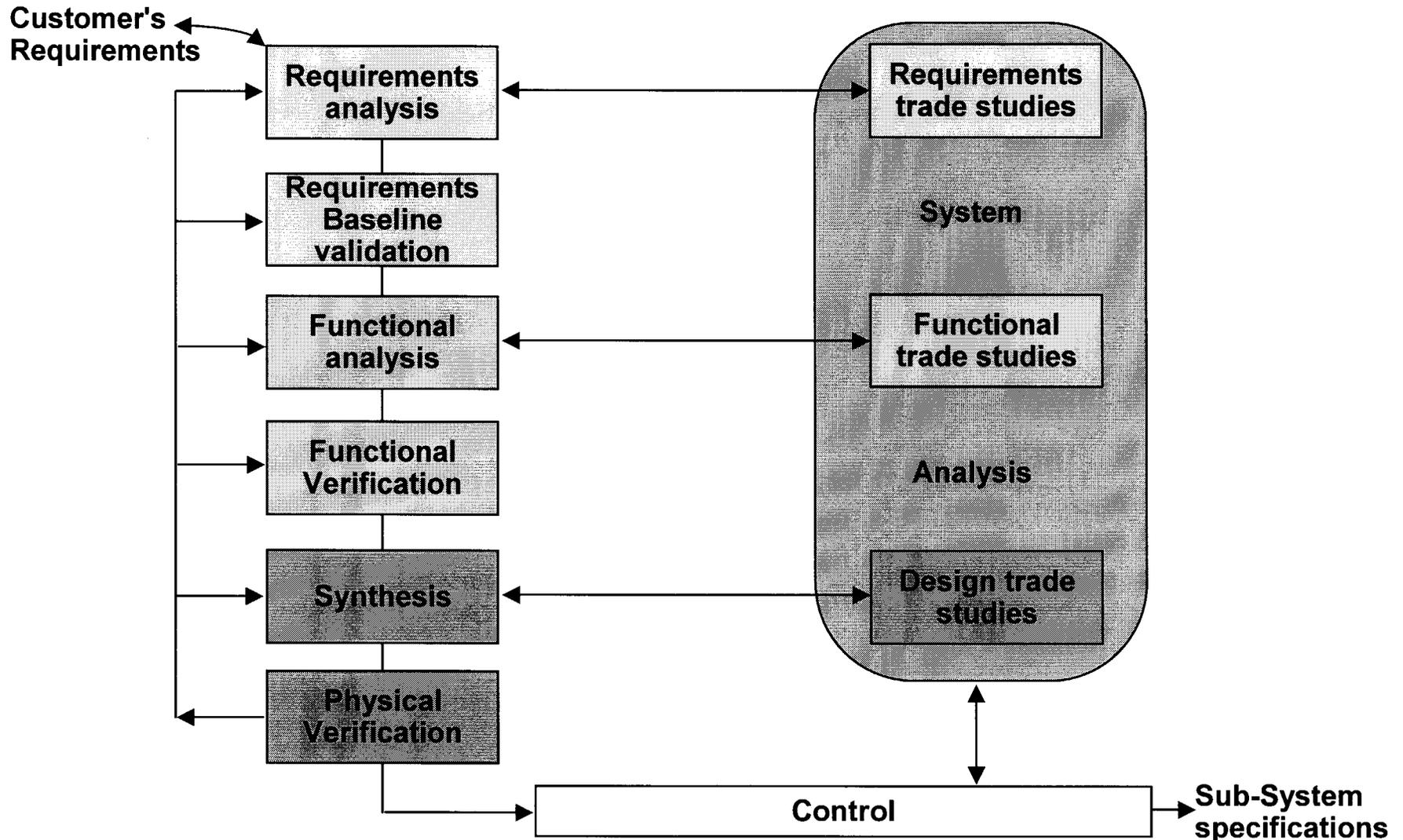


AP-233 and the STEP architecture



SYSTEM ENGINEERING PROCESS

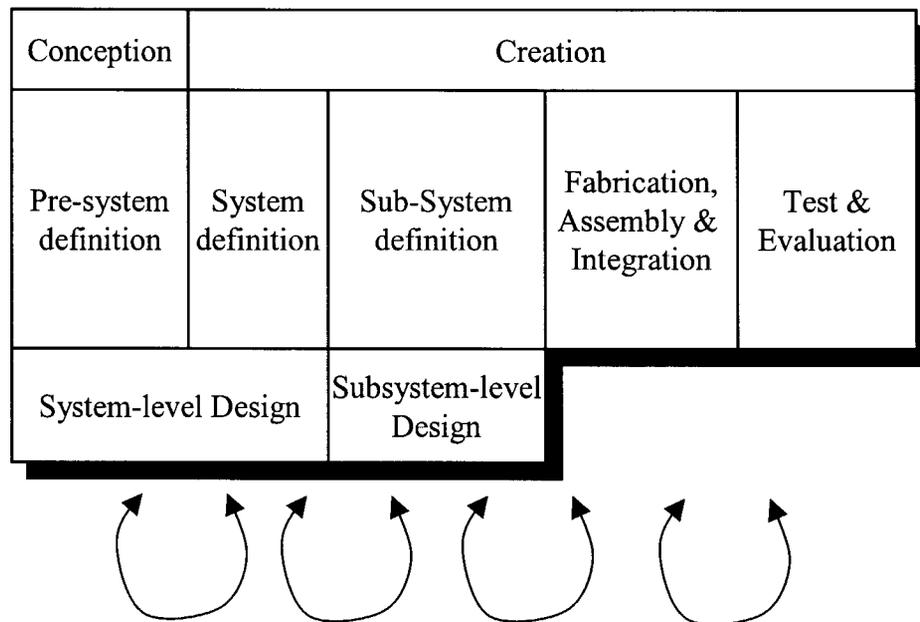
(this example from IEEE1220)



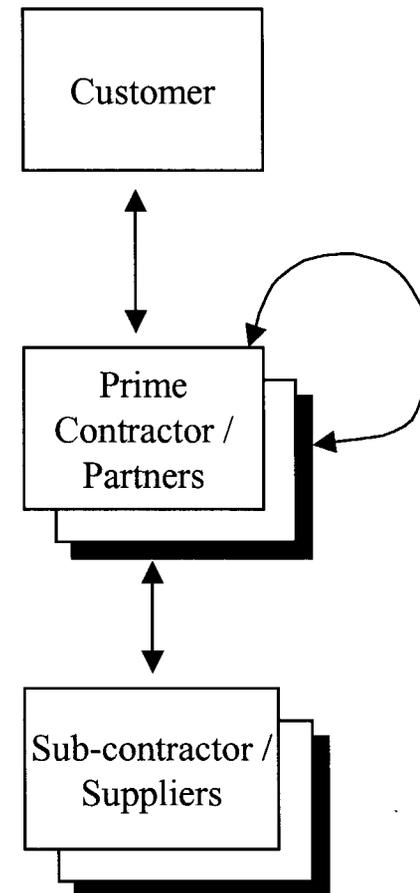


The situation... Data Exchanges in context

Development life-cycle phases

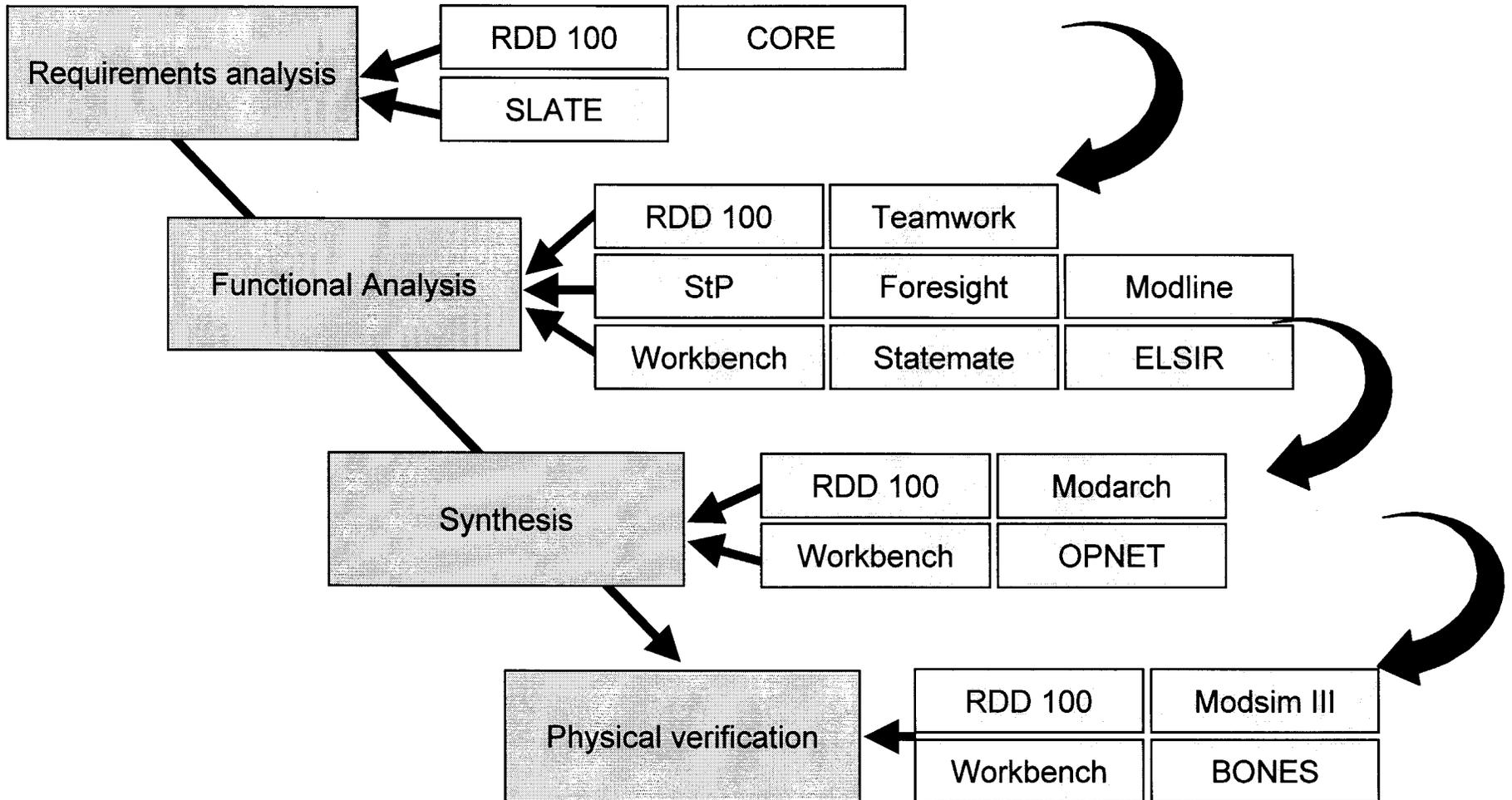


Fundamental Data exchanges





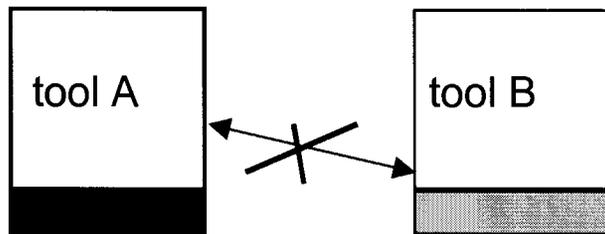
SE Process and SE Tools



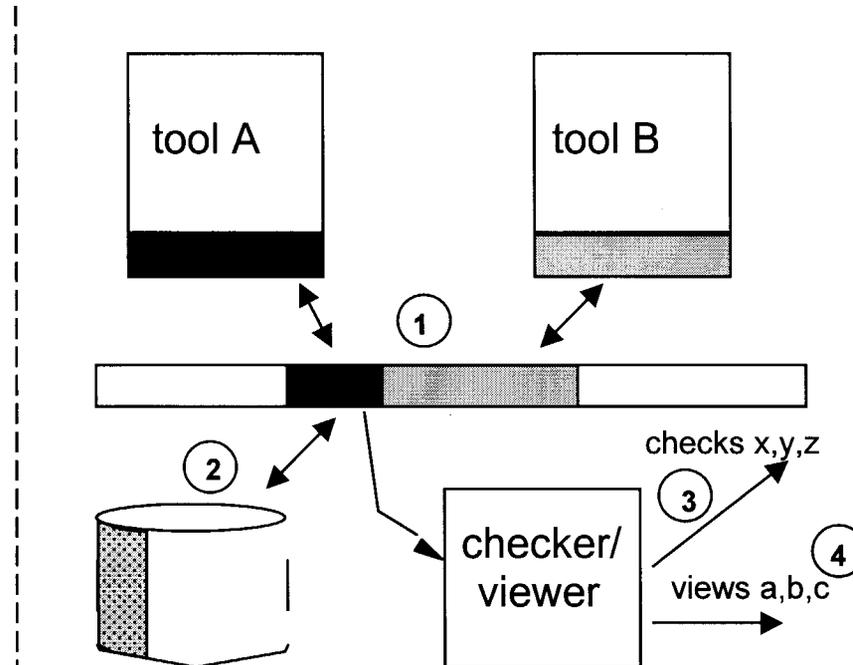


From isolation to inter-working

The Past



The Future



The consequences:

- Reduced benefits from each tool;
- Costs migrating to new tools/versions;
- Lack of an 'integrated' design dataset;
- Compromised success of partnerships

The benefits:

- Reduced costs to transfer & check data (1, 3);
- Better achieve a coherent design (3, 4);
- Facilitate Integrated Product Development (1, 3, 4);
- Facilitate documentation/ design data management (2, 4)

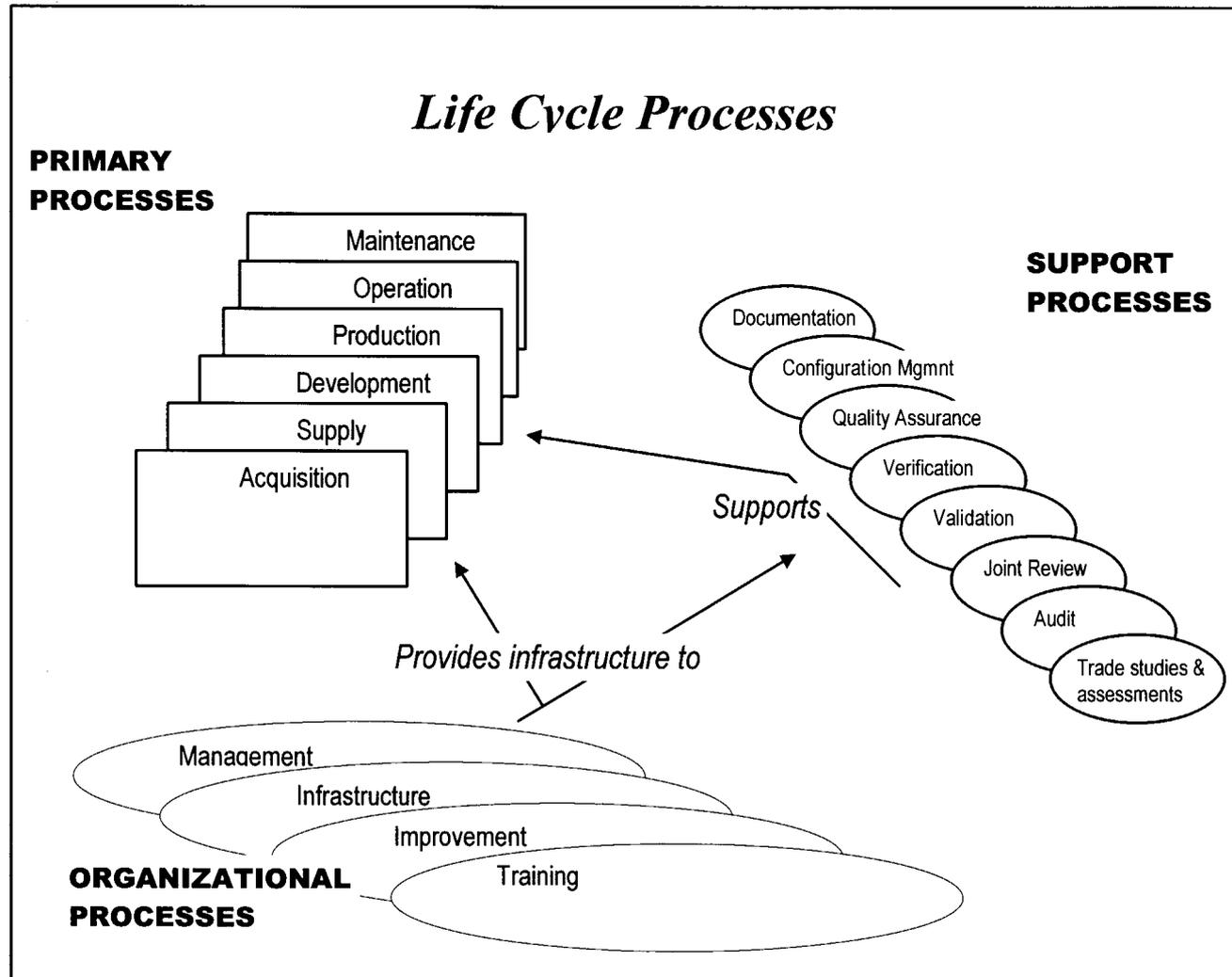


Requirements for a system engineering exchange standard

- **Shall be compliant with SE processes**
 - > **Support for primary, support & organisational processes**
 - > **From requirement elicitation to V&V**
 - > **Consistent with concepts of SEMP**
 - > **Through life cycle support**
- **Shall provide a tool independent representation**
- **Shall be compatible with industrial organisation**
- **Shall be implementable / adoptable by vendors**
- **Lead to a consequential reduction in number / variety of design tool interfaces**



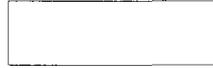
Requirements: Process compatibility





Requirements: Process - view points

- **Requirement point of view**
- **Functional structure point of view**
- **Physical structure & allocation point of view**
- **Configuration and traceability point of view**
- **Project & data management point of view**



Requirements: Process - Requirements

- **Requirements, categories and structure**
- **System context & operational modes**
- **System environment description**
- **Validation & verification information**
- **Implementation verification**
- **Requirement trade study information**
- **Links to:**
 - > **maturity, design phases, project control, project organisation, documentation support**



Requirements: Process - Functionality

- **Functional elements and child-parent hierarchy**
- **Requirement allocation**
- **Function inputs and function outputs**
- **Data description**
- **Behaviour description**
 - > **possible modelling paradigms: state machines, time lines, structured text, logic tables, mathematical, analytical..**
- **Links to:**
 - > **maturity, design phases, project control, project organisation, documentation support**



Requirements: Process - Physical structure

- **Component description**
- **Subsystem hierarchy definition**
- **Data links / Physical interface definition**
- **Information interface definition**
- **Performance allocation**
- **Function allocation**
- **Support for validation, verification, traceability**
- **Links to:**
 - > **maturity, design phases, project control, project organisation, documentation support**



Requirements: Process - Configuration and traceability

- **Item identification and version control**
- **Analysis iteration control with link to version**
- **Traceability management (upward / backward)**
- **Justification traceability**
- **Security management**
- **Link to full product management (consistency between real product and architectures)**
- **Trade-off & Justification support**
- **Exchange control**



Requirements: Process - Project & data management

- **Design process**
 - > **Support for work breakdown structure**
 - > **Support for a flexible process representation**
- **Partner organisation, stakeholders**
- **Design product packaging**
- **Work allocation**

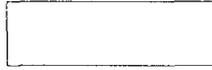


Requirements: Tool independence

- **Shall provide a tool independent representation**

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- > **Neutral format data exchanges**
- > **Neutral modelling paradigms**
- > **Flexible item representation and description**
- > **Extendibility**
- > **Long term design-data storage**
- > **Compatibility with several technology platforms**
 - Upward compatibility with new enabling technologies (distributed environments, distributed repositories...)
 - Backward compatibility with simple exchange techniques



Requirements: Organisation

- **Shall be compatible with industrial organisations**

==>

- > **Compatibility with industrial adopted technologies for data sharing & exchange**
- > **Support for organisation description and work allocation**
- > **User oriented / Usable**
- > **Supports both high / low data volumes; 'deltas'**
- > **Supports data exchange management**
- > **Compatibility with other techniques used in industrial domains (CAD systems...)**
- > **Extensible - evolving processes / data types**



Requirements: Vendor acceptance

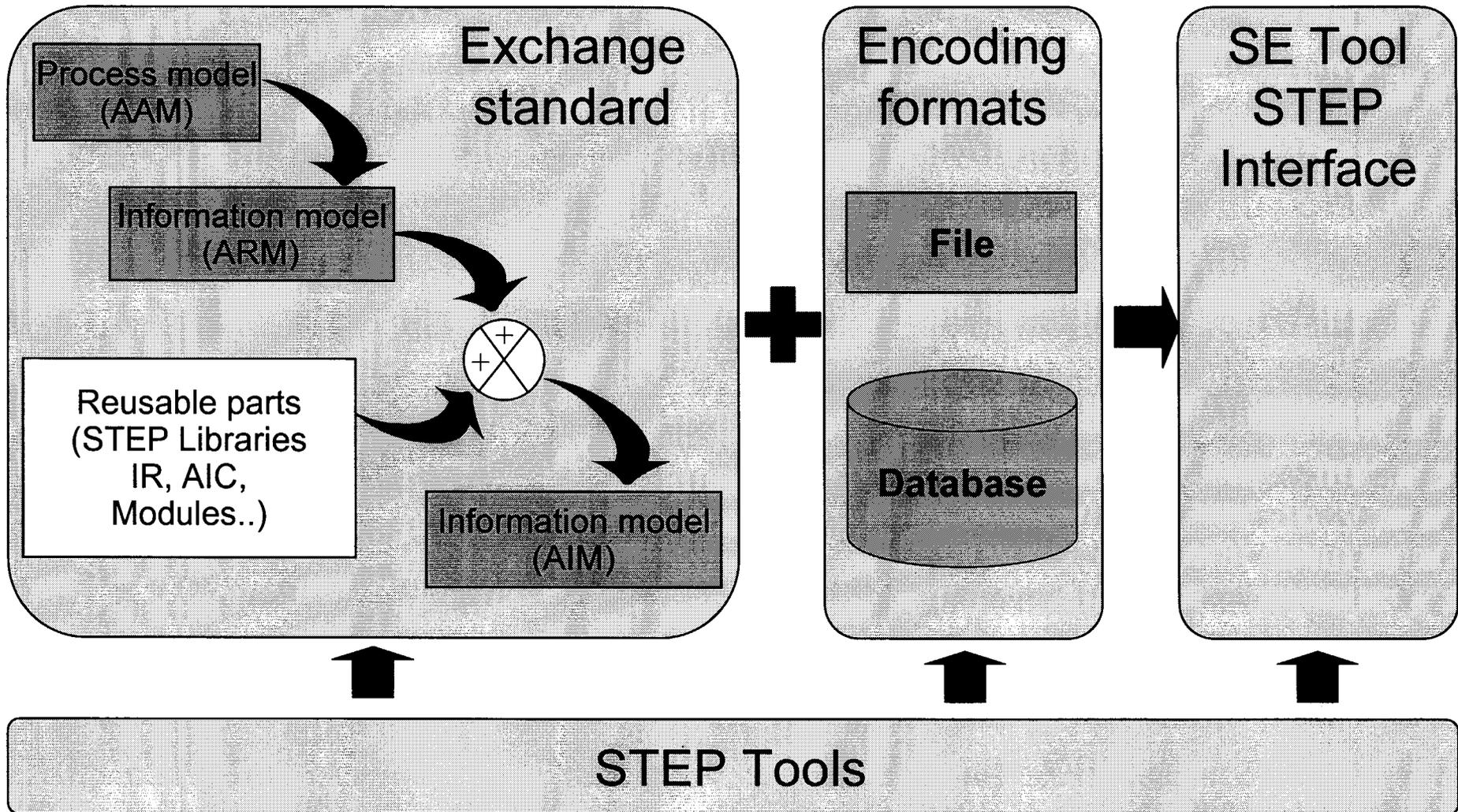
- **Shall be implementable / adoptable by vendors**

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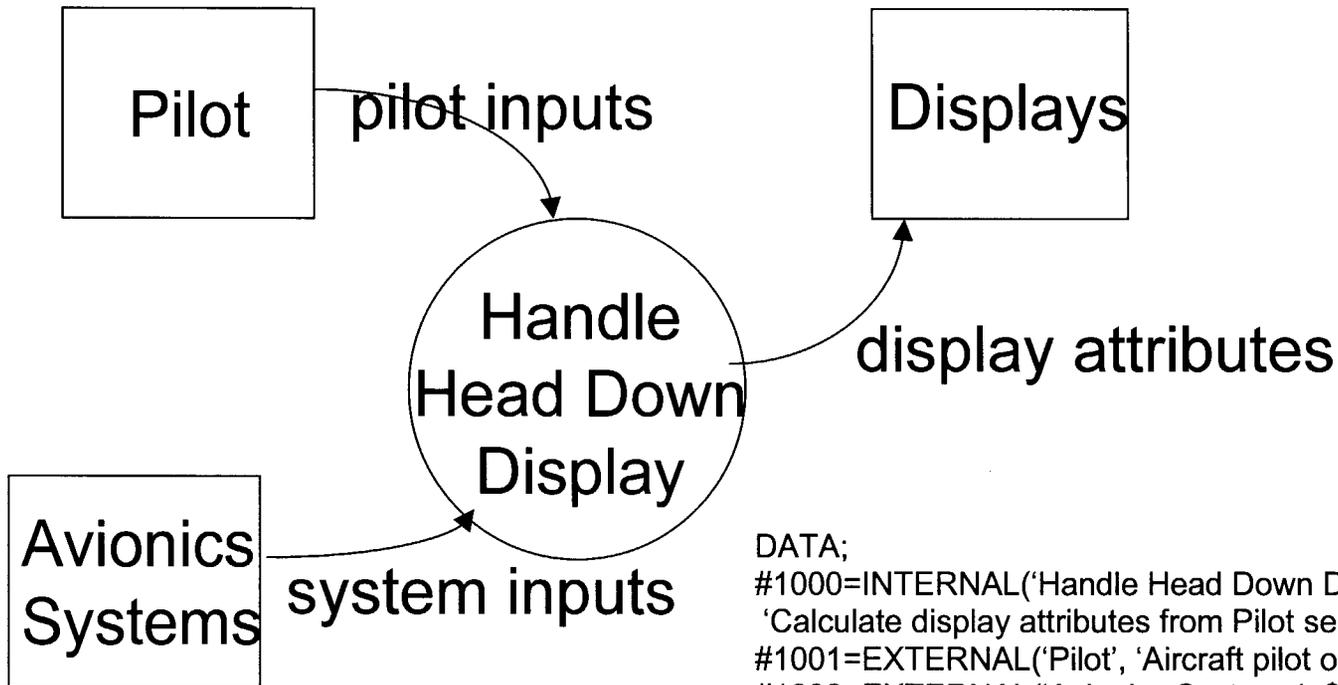
- > **Shown to be implementable**
- > **Feasible to support (effort / cost / ROI)**
- > **Tool neutral / vendor independent**
- > **Based on mature data exchange technology**
- > **Widely supported by tools & consultancy**
- > **Widely supported by tool market users**



Interface development process



Example design encoding (Part 21)



```
DATA;  
#1000=INTERNAL('Handle Head Down Display', $, (#1004, #1005), (#1006),  
'Calculate display attributes from Pilot selections and system inputs');  
#1001=EXTERNAL('Pilot', 'Aircraft pilot or navigator', (), (#1004));  
#1002=EXTERNAL('Avionics Systems', $, (), (#1005));  
#1003=EXTERNAL('Displays', 'Cockpit displays', (#1006), ());  
#1004=FLOW('pilot inputs');  
#1005=FLOW('system inputs');  
#1006=FLOW('display attributes');  
END_DATA;
```



AP233 Basic Philosophy & design principles

- **Focussed on semantic level information**
 - > **Graphics Unit of Functionality (UoF) is the exception**
- **Aspects of data model driven from principles**
 - > **Distinction between Instances and Definition**
 - > **Concept to support 're-use'**
- **Aspects driven by ease of model evolution**
 - > **Relationship entities**
 - > **Support of templates for textual descriptions**
- **Model not tool-specific**



Requirement UoF (1)

- **Related to Requirement elicitation phase**
- **Defines several kind of requirements**
 - > **Functional requirements**
 - > **Constraints**
 - > **Physical requirements**
 - > **Operational requirements**
- **Other categories can be added from**
 - > **ECSS 10A**
 - > **EIA632...**



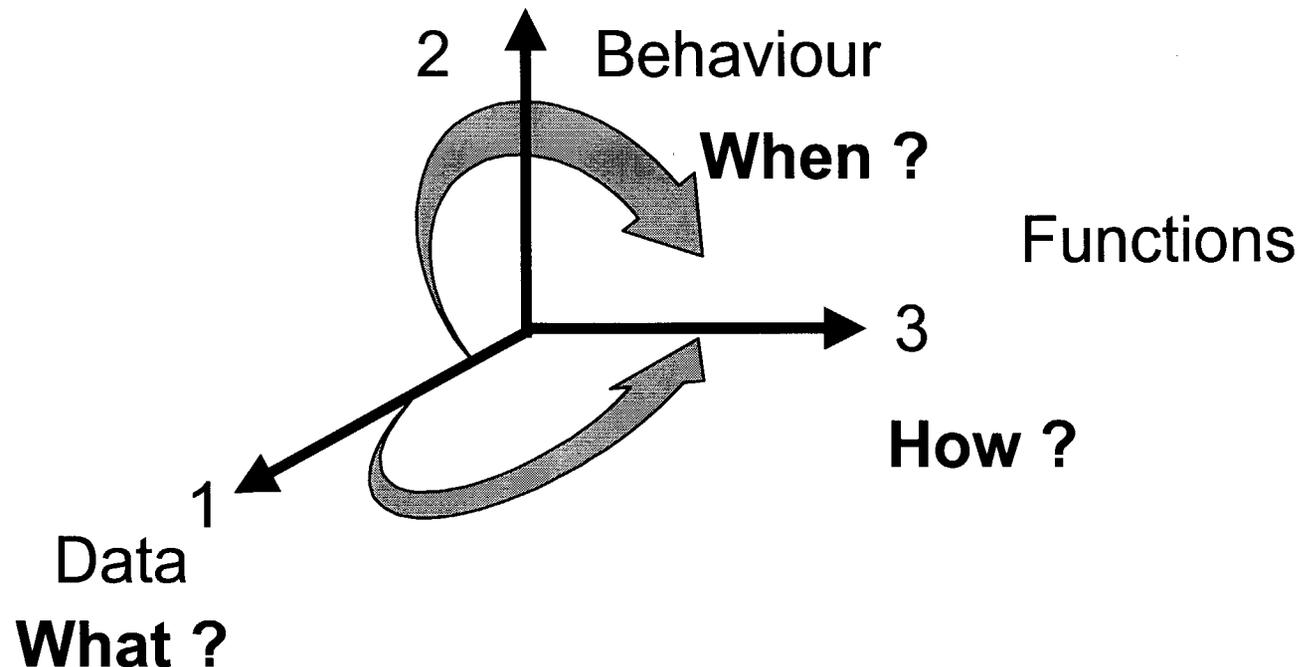
Requirement UoF (2)

- **Supports operational scenario definition**
- **Supports Derived requirements & composition relationship**
- **Defines the link between external entities and the system to be engineered**
 - > **Externals / functional context**
- **Concept of Traceability matrices support**
 - > **To functional breakdown structure**
 - > **To physical breakdown structure**



Functional UoF (1)

- **Not linked to a particular engineering methodology**
 - > SART style
 - > RDD style
 - > In-house...





Functional UoF (2)

- **Supports the functional breakdown structure**
 - > **Functions, instance & definition**
 - > **Hierarchical relationships**
 - > **Flows**
 - Flow groups
 - Stores
- **Data description**
 - > **Data structure**
 - > **Data types**
- **Links to Behavioural model**
 - > **Causal chain, Finite state machine, synchronous**



Behaviour UoF

- **Finite state machines (State chart style)**
 - > **State, instance & definition**
 - > **State hierarchies**
 - > **Transition**
 - > **Action on transition**
 - > **Events**
 - > **Control of functions**
- **Causal chains for safety critical systems**
- **Synchronous model (Clock driven behaviour)**



Physical UoF

- **Component definition and breakdown structure**
 - > **Product Breakdown Structure (PBS)**
 - > **Bill of Materials (BOM)**
- **Physical path description**
- **Functional/physical mapping**

Function <=> Physical component

Flows <=> Physical links



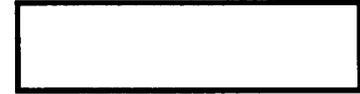
Graphics UoF

- **Objective:**
 - > ensure (where applicable) that designs on receiving tool can bear 'similarity' in layout to original
- **Visual Elements**
 - > Nodes, links that appear on SE diagrams
 - > Association to semantic elements
 - > Graphics points (nodes, links, link path) for diagram layout
- **Is this the most appropriate approach?**



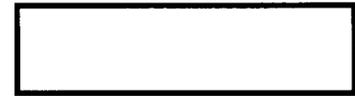
System configuration management UoF (1)

- **Configuration Management Item & Item Id**
- **Traceability matrices support**
 - > From requirements through to physical components
- **Documentation support ('Package')**
- **Support for version control**
 - > release / approval
 - > versions
 - > variants
 - > workspace revision

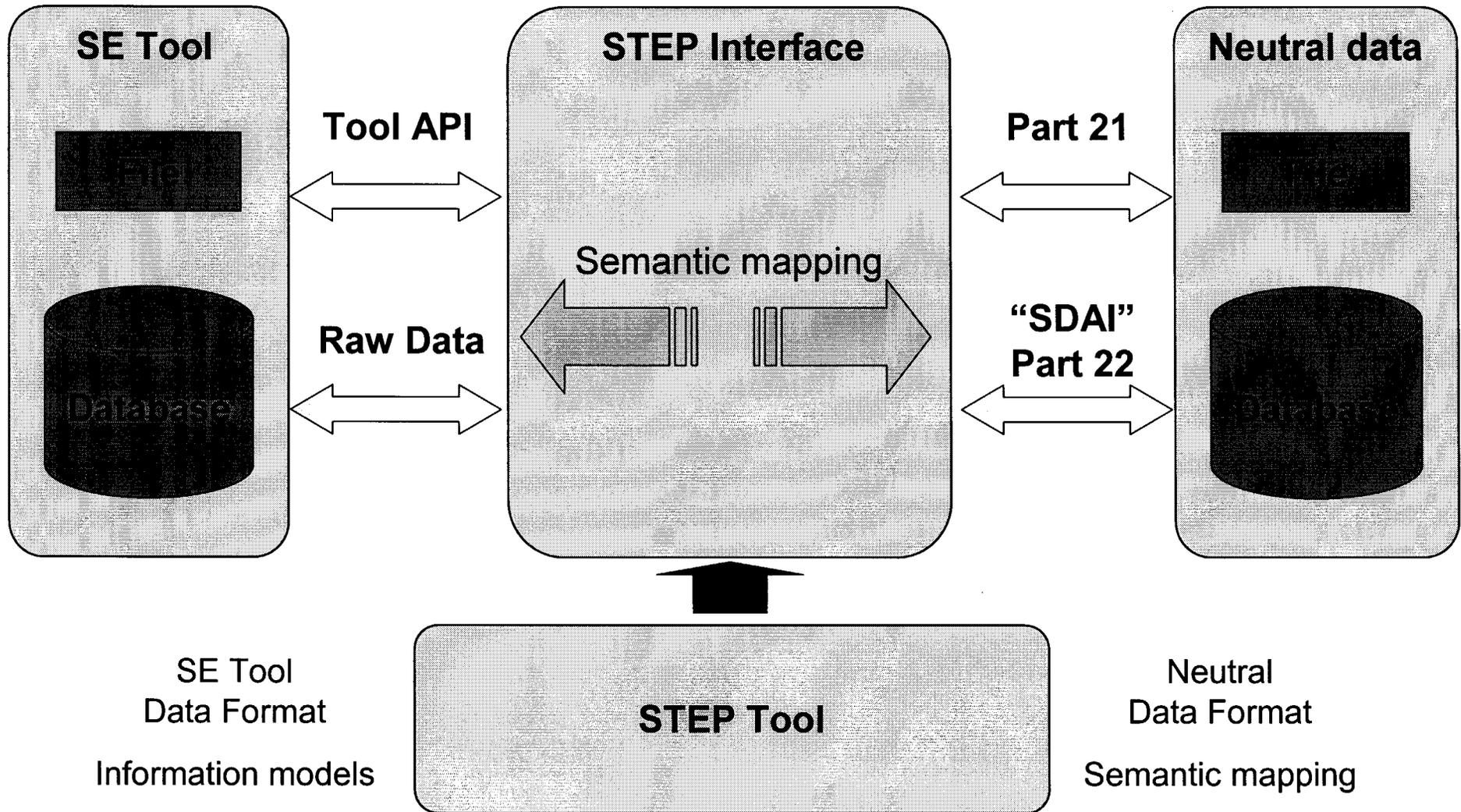


System configuration management UoF (2)

- **Support for justification and maturity indices**
- **Relationships to process**
 - > work breakdown, activities & products
- **Support for industrial schema**
 - > *“Who does what and where”*
 - > Project
 - > Company Id
 - > Person Id
- **Convergence with STEP Product Data Mgmt (PDM) Schema**



STEP Interface usage w.r.t SE Tools





Test & Evaluation: 'the bottom line'

- Actual measurements of limited exchanges capture how time spent
- Simple analysis indicates projected times
- Note several activities currently due to prototype technology:
 - > Produce Part21 file..
 - > Manage & transfer..
 - > Prepare for import
 - > ..are likely to go to zero in industrial implementation

