Space System Engineering Database

Integration and Collaboration Platform for the Engineering Domains in the Space Industry

Hans Peter de Koning (ESA)
Niklas Lindman (ESA)
Harald Eisenmann (EADS Astrium)
Matthias Grau (PROSTEP)

Outline

- Requirements arising for engineering data management in the space industry
- ECSS ETM-10-23
- Overview SSRM Project
  - Introduction
  - Platform Architecture
  - MDA, SOA, BPEL
  - Demo Scenarios
- Conclusions ans Outlook

Engineering Database Current situation (1)

- In a spacecraft project, many engineering databases do exist, ...
  - well designed for their domain
  - only fragments
  - made for a small section of the space system life cycle
  - own database
  - no data exchange (time-consuming, error-prone)
- ... otherwise standard office products are used
  - covering a significant part of the space craft design and verification information

Engineering Database
Current situation (2)

- Consistent data management is hard to achieve
  - inconsistencies between the databases
  - manual work to transfer data between the databases
  - difficult to get a consistent data sets needed for simulation tasks from data of more than one database
  - no data life-cycle defined
    - change process
    - Identification of incomplete/valid data
  - validation of data is difficult, often manually
  - redundancy

Why "ready-to-use" Data Management Systems would not solve the Problem

- Option 1: Document Management Systems
  - DMS "think" document based ...
  - integration required on user data level rather than on administrative level only
- Option 2: PDM Systems
  - PDM Systems can support workflows ...

    → process level integration
  - wrt. data management they function like DMS
- Option 3: DBMS
  - DBMS alone would not resolve the data integration issue – semantic transformation needed between to-be-connected tool and DMBS
  - DBMS are not process-aware

Consequence

An "Integration Platform" is needed that has the following characteristics:

- DBMS to store user/admin information in a tool-independent syntax and semantics
  - capable to cover both, engineering data and process information
  - database structure under control of DB owner
- Network-distributed environment as the basis for tool adoption
  - but also the capability for a file-based exchange
- Platform independent integration architecture
  - centrally manageable and conforming to industry standards
- Workflows to control exchange and communication processes from the user perspective
  - flexible and configurable – not hard-wired

ECSS ETM-10-23 Rationale and Goals

ECSS-E-10 Part 1B (System engineering - Requirements and process) states:

"System Engineering Integration and Control shall establish and control a database as a repository for engineering data from trade-offs, risk assessment, requirements, analysis, design, and verification"

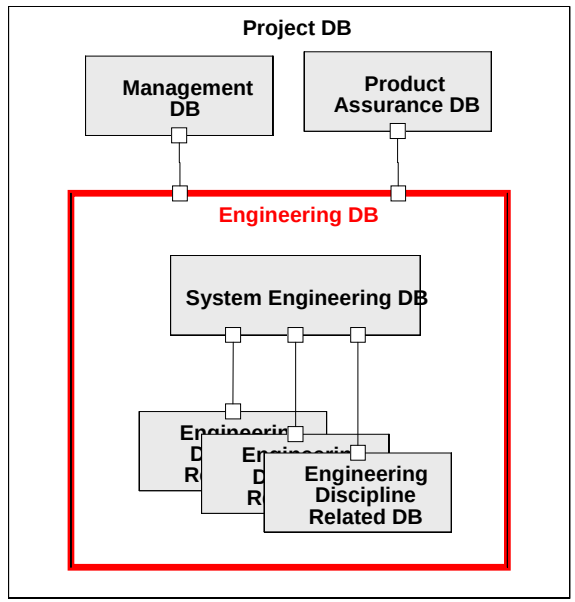
Enable efficient access of project teams to project information

Reduction of overall project investment in data base systems

Ensure compatibility between the different phases and activities in a project: Engineering, Testing and Operations

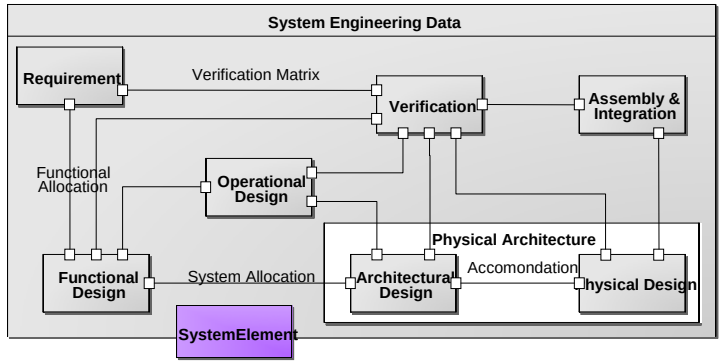
Allow project data exchange across company boundaries

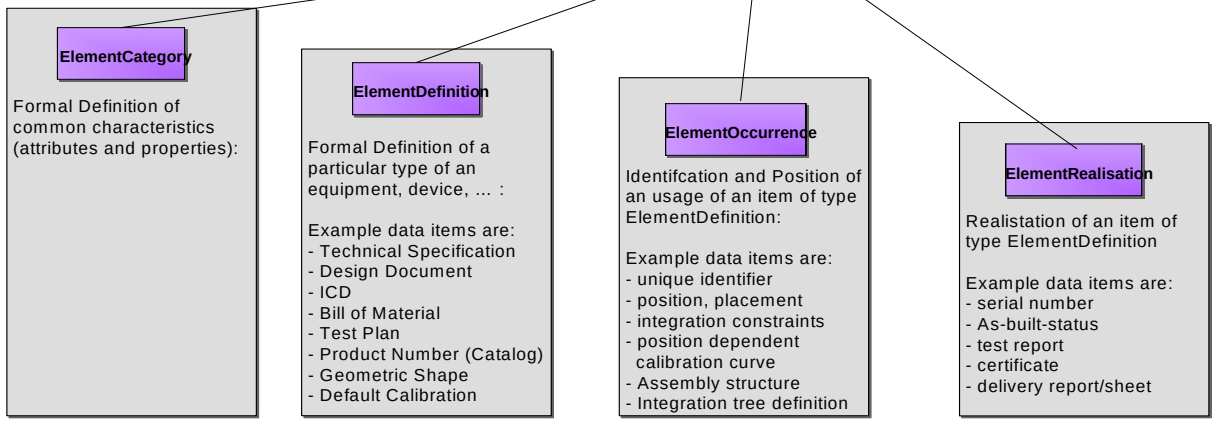
Support implementation of modern system engineering approaches including integrated project teams, distributed collaborative engineering, use of product data management systems etc.



ECSS ETM-10-23
Top-level Data Model

- System Engineering Data
  - Requirements, Functional, Architectural and Physical Design
  - AIT Data (procedures, logistics, …)
  - Verification Data (description, procedures, reports, …)
  - Operations Data (TM/TC Data, Planning, Operational Procedures, Bus Data, …)
- Engineering Discipline Related Data
  - Kept as references its primary data store





Space System Reference Model (SSRM)

esa

Responsible Contracts Officer: L van Hilten (RES-PTE)
Telephone (+31) 71-565 4544
Fax (+31) 71-565 5773

Subject: Invitation to Tender AO/1-5199/06/NL/LvH
Space System Reference Model

Reference: ESA/IPC(2004)11, item number 04.1EM.04
Budget reference 061 (TRP)

Dear Sirs

The European Space Agency (ESA) hereby invites you to submit a tender for the above subject.

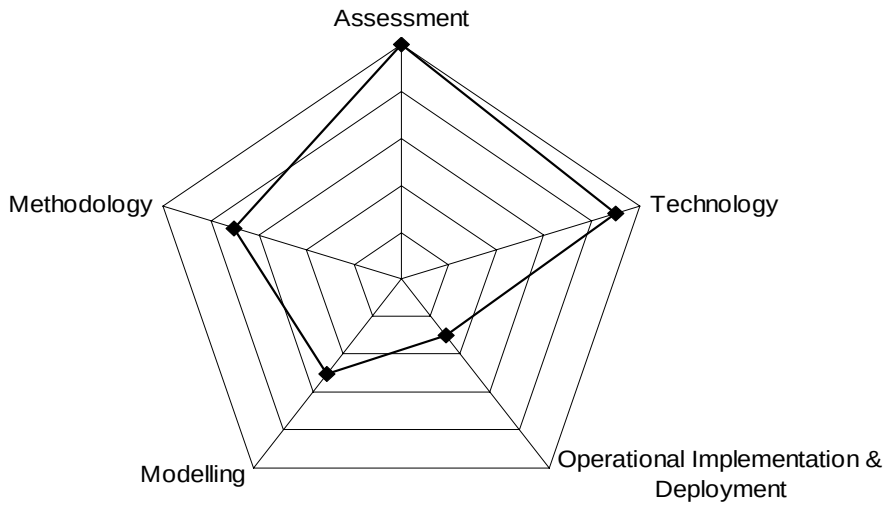
Please note that the abovementioned invitation to tender has been published on EMITS on
2nd August 2006

- Consortium consisting of
  - EADS Astrium
  - EADS ST
  - PROSTEP

awarded contract January 2007

SSRM – Study Focus

- Assessment of the ETM-10-23 approach
- Definition of a methodology for the description of the data model
- Selection of a feasible technology for the transformation of the data model
- Elaboration of a data model for a central engineering database
- Validation of the deployment and usage in an operational context

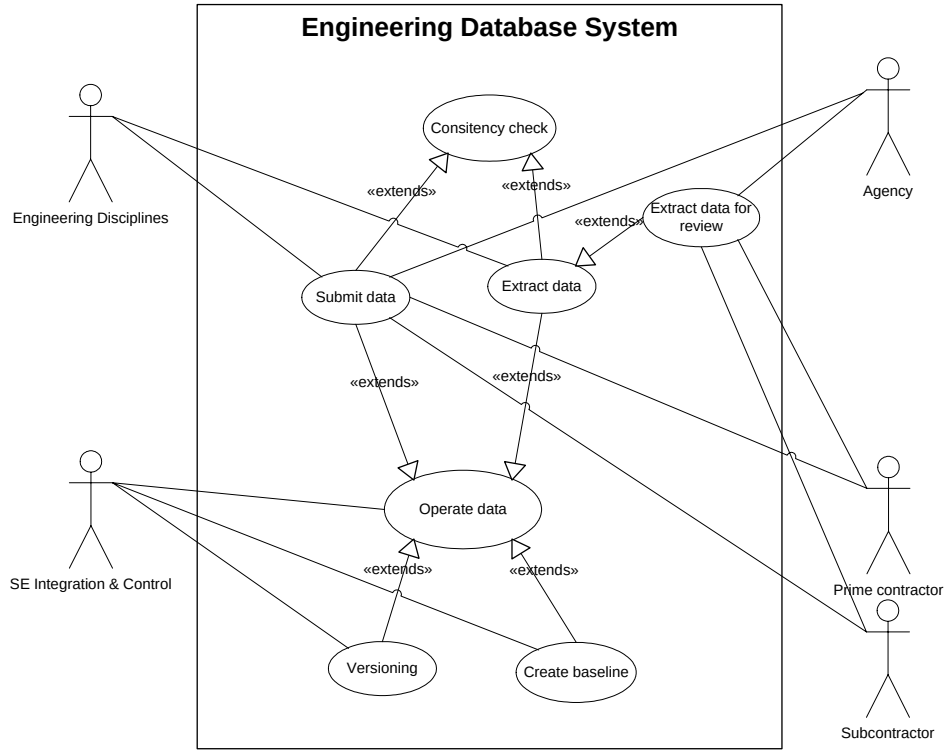


SSRM – Timeline

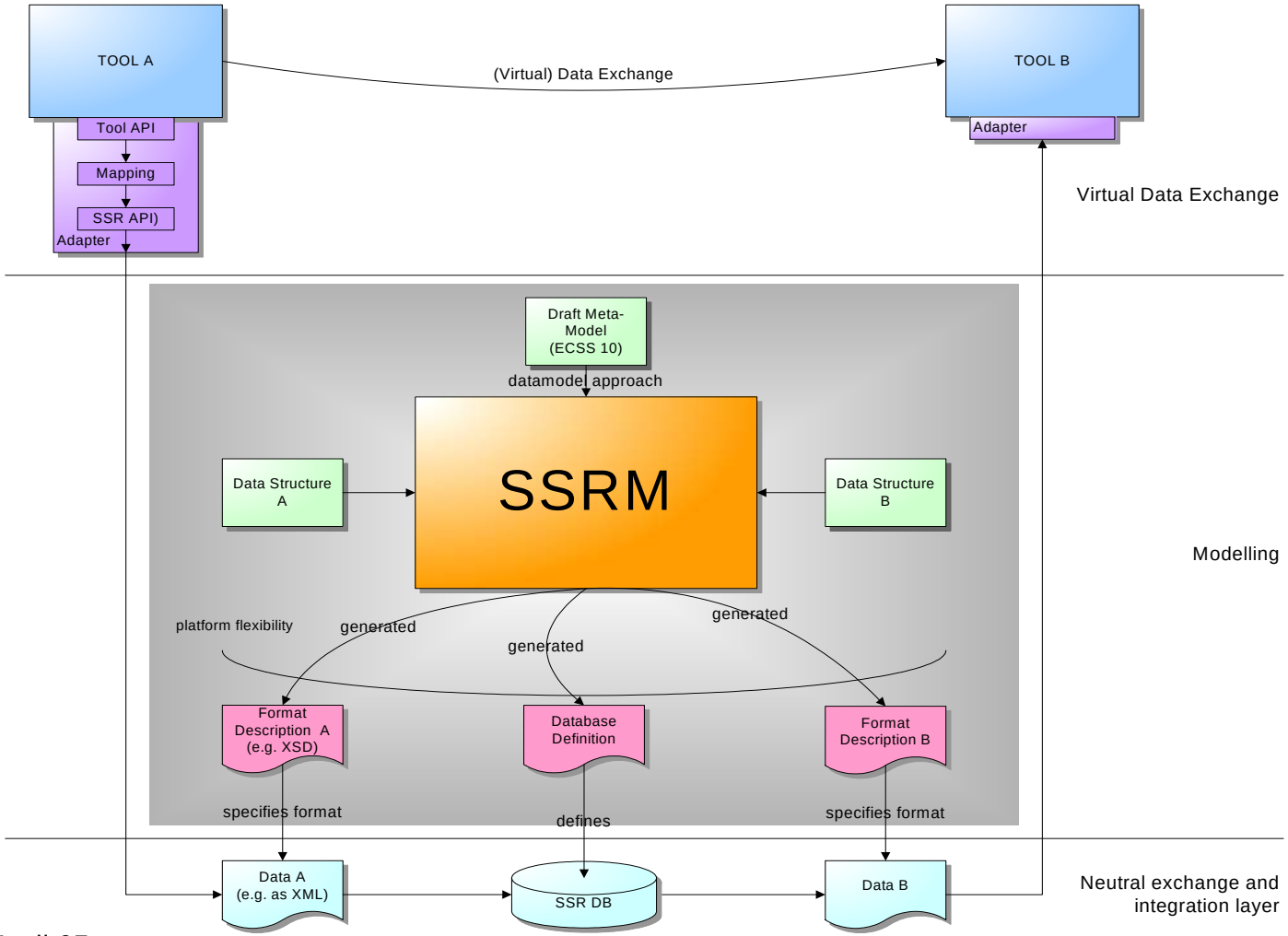
Use Cases for an Engineering Database (examples)

- Submit data
- Prepare data for review
- Extract data
- Consistency check
- Operate data
- Versioning
- Create baseline

- Actors (Roles)
  - Agency
  - Prime contractor / Subcontractor
  - Engineering disciplines
  - System Engineering Integration & Control

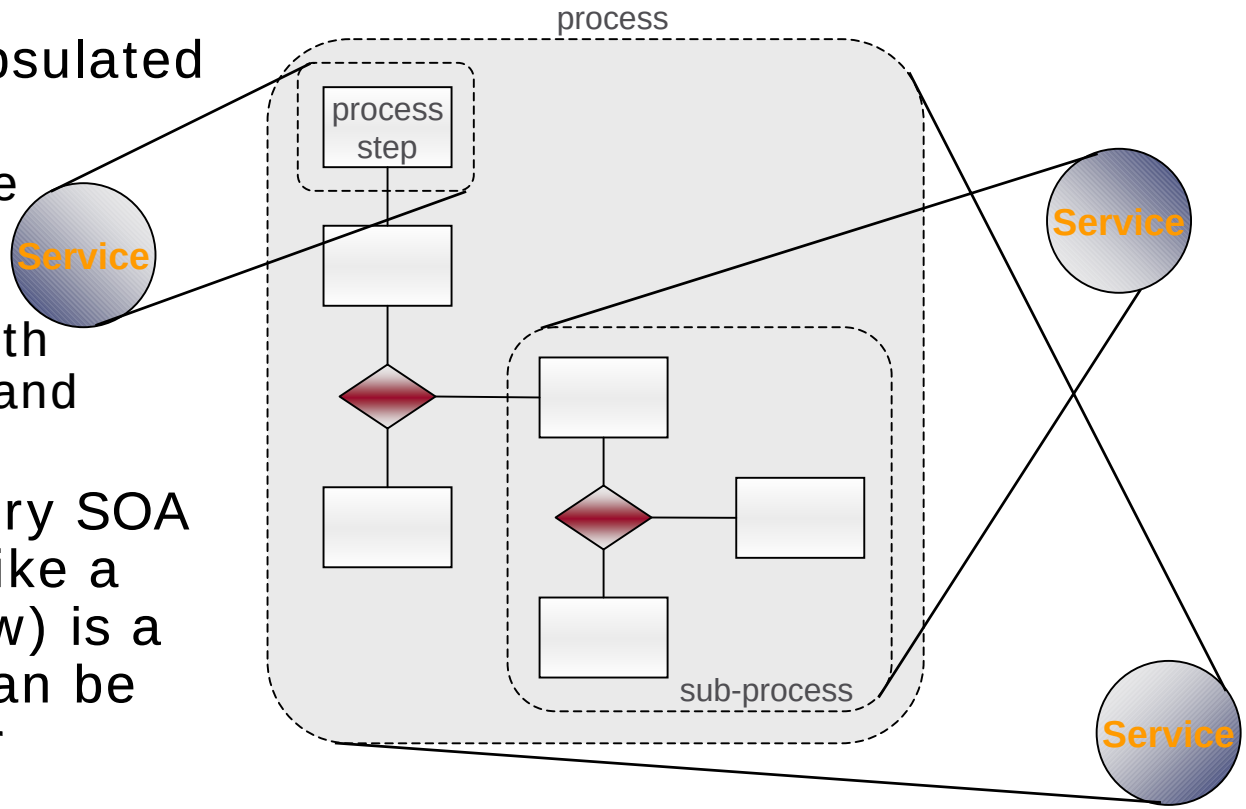


Overview of the Technical Solution



Architectural Basis
Service Oriented Architecture (SOA)

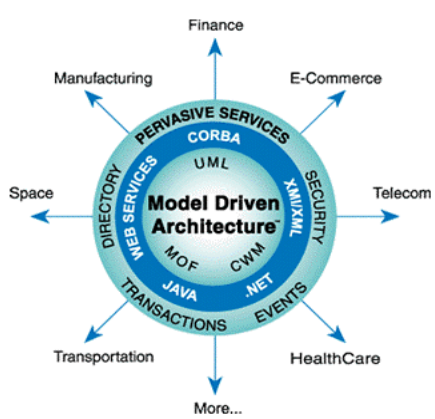
- Logic is encapsulated by services
  - each service has a public interface with operations and parameters
- Typically, every SOA component (like a BPEL workflow) is a service and can be used by other components

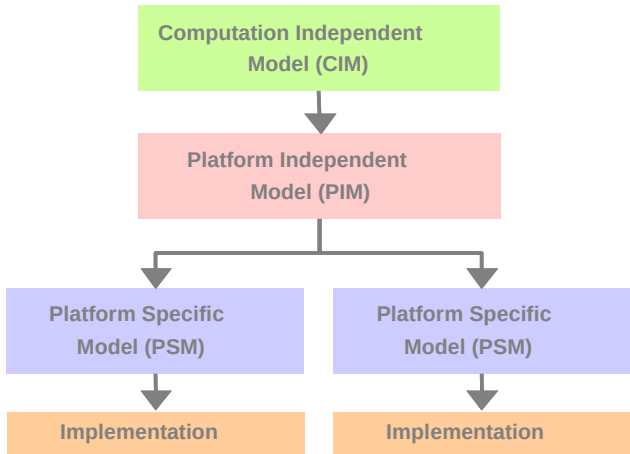


Encapsulate logic with services

Architectural Basis
Model Driven Architecture (MDA)

- The Model Driven Architecture approach, defined by OMG
  - enables the formal specification of a discipline-independent and neutral data model
  - supports the ability to apply state-of-the-art development methods and technologies
  - enables the transformation of a data model into several platform specific implementations

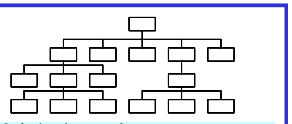




Everything is a Model

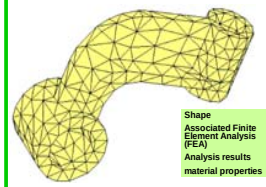
Basis for the Data Model

Requirements/Concept → **Analysis** → **Detailed Design/BoM** → **Manufacturing** → **Lifecycle Support**



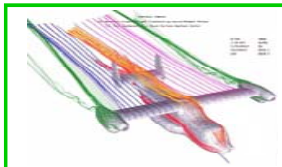
Conformity to the concept of a system
System definition data and configuration control
Requirements, requirement analysis, and functional allocation
Functional, functional analysis, and functional behaviour
Physical architecture and synthesis

AP233, Systems engineering data representation



Shape
Associated Finite Element Analysis (FEA)
Analysis results
material properties

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



Digital flow field data
Surface data
Analysis and computation

Future Editions
Ground test analysis and results
Flight test analysis and results

AP237, Computational fluid dynamics

Equipment Coverage
- Power-transmission
- Power-distribution
- Power-generation
- Electric Machinery
- Electric Light and Heat
- Control Systems

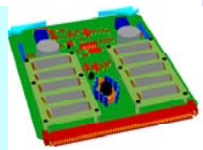
Electrotechnical Systems
- Buildings
- Plants
- Transportation Systems

Data Supporting
- Terminals and Interfaces
- Functional Decomposition of Product
- 3D Cabling and Harnesses
- Cable Tracks and Mounting Instructions

Electrotechnical Plant
- Plant, e.g., Automobile
- Unit, e.g., Engine Control System
- Subunit, e.g., Ignition System

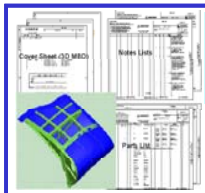
AP212:2001, Electrotechnical design and installation

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

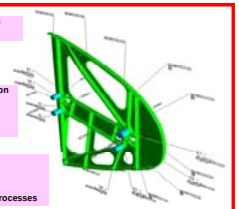


Configuration controlled exchanges between Product Data Management (PDM) systems
Links multiple formats

Design
Analysis
Manufacturing
Support

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

Components
Assemblies

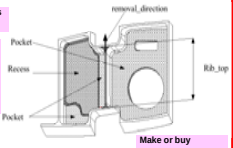


Administration
Planning
Execution
Archiving

Geometry
Dimensions
Tolerances
Inspection processes

AP219, Dimensional inspection

Components
Assemblies



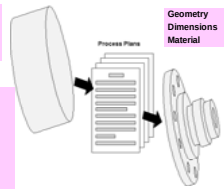
Machining features
Assembly information
Explicit geometry
Tolerances

Edition 3 in process to add gear features

Make or buy
Macro process planning

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

Mirco process planning
Automated NC generation



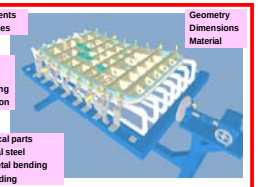
Geometry
Dimensions
Material

Mechanical parts machining
- milling
- turning
- electro discharge machining

Sheet metal bending
Pipe bending

AP238, Computer numerical controllers

Components
Assemblies



Geometry
Dimensions
Material

Maco process planning
- machining
- fabrication

Mechanical parts
Structural steel
Sheet metal bending
Pipe bending

AP240, Process plans for machined products

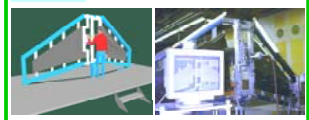
Lifecycle Support

Work activities and resources
- define
- justify
- approve
- schedule
- feedback

Configuration
- design requirements
- design configuration
- as-built
- as-maintained

Operating states
Behavior
Usage

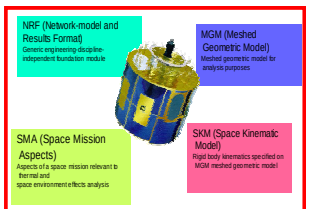
Support
- facilities
- personnel
- equipment
- diagnostics



AP239, Product lifecycle support

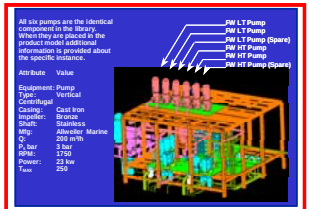
Cross Process Utility

AP203:1994, Configuration controlled 3D designs of mechanical parts and assemblies
AP 214:2001, Core data for automotive mechanical design processes



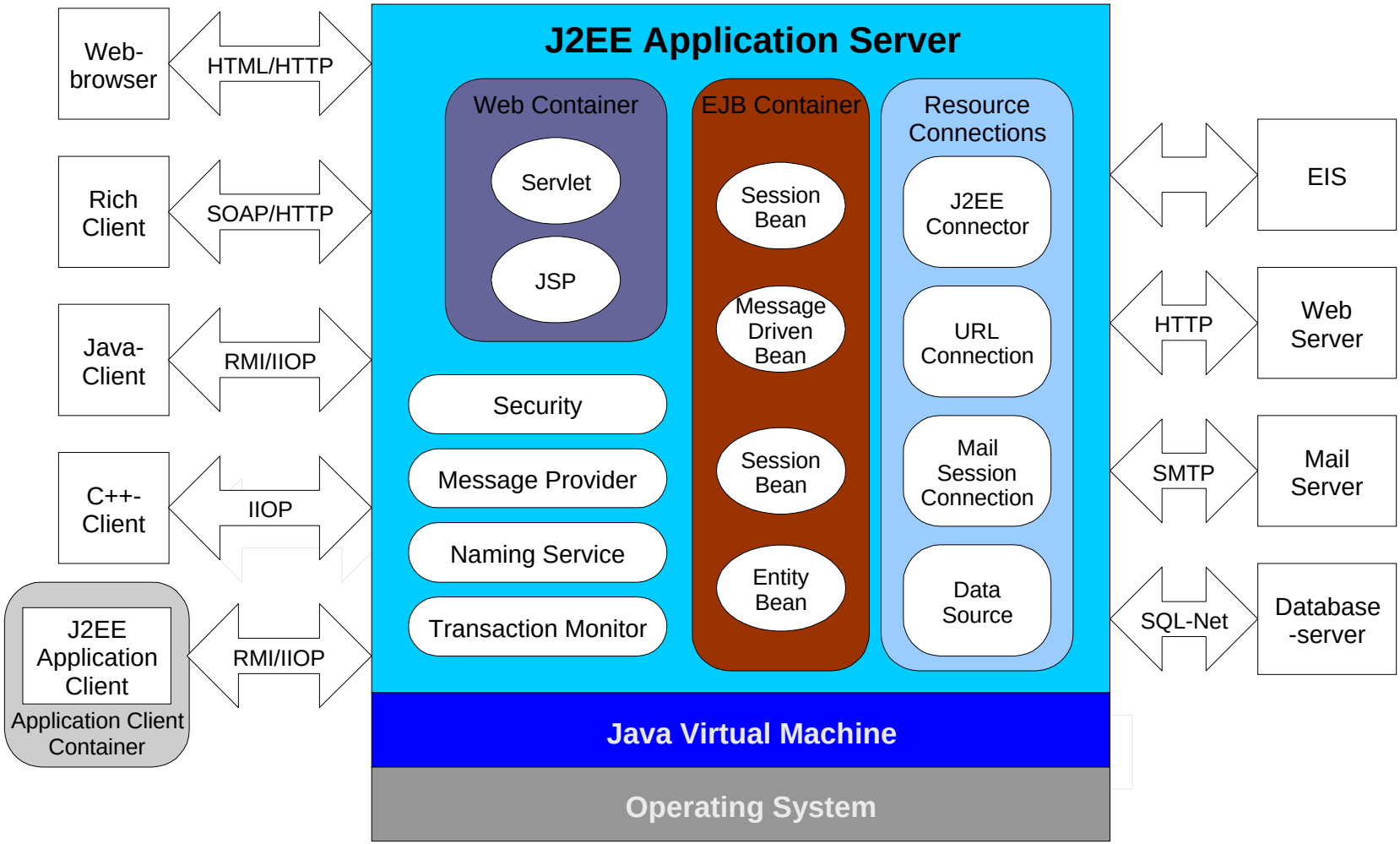
STEP TAS (currently formalized under ISO)

Related Standards



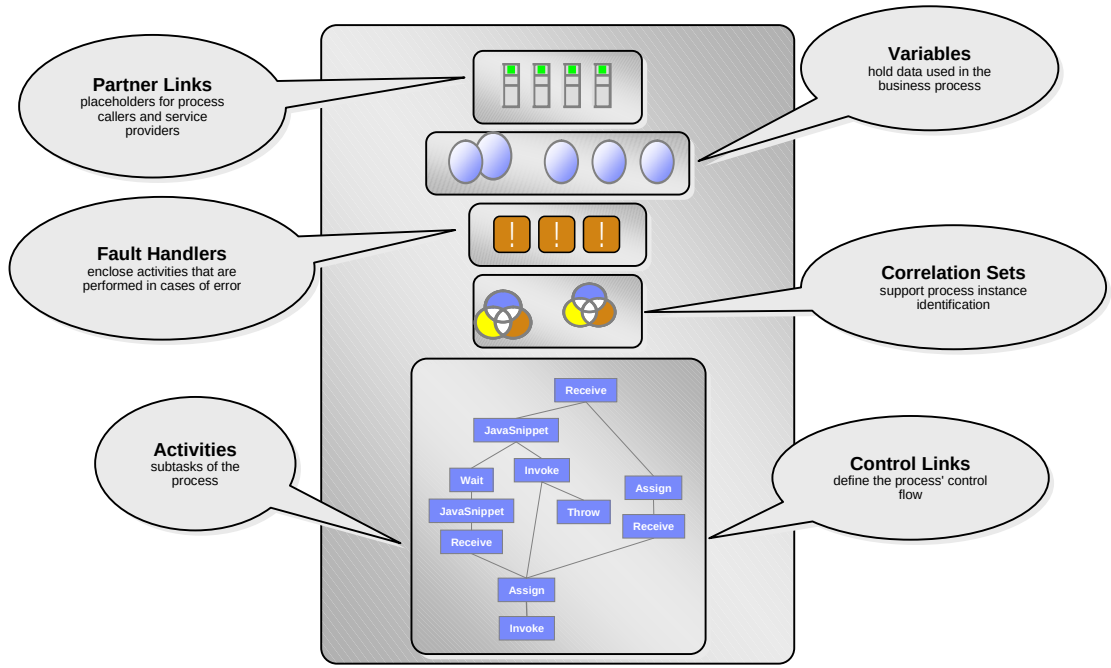
ISO 13584 (Parts Library Exchange)

Technological Basis Application Server (J2EE)



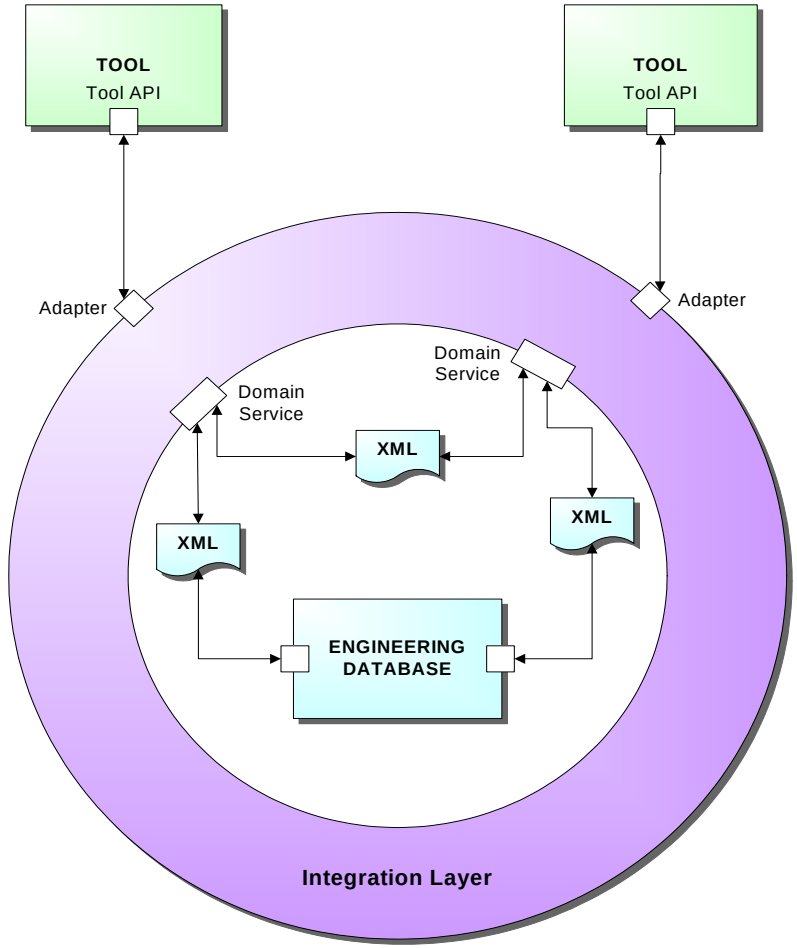
Technological Basis Workflow (BPEL)

- Programming language for business processes combined with graphically representation
- Extensible for new language elements
- Properties of a BPEL process
  - Process is a service and itself can be used from other services
  - Process can be synchronous or asynchronous
- OASIS standard



Implementation Architecture
Logical Architecture

- Tools connected via Adapters to the Integration Layer
- Adapter
  - uses the tool API
  - performs data transformation
- Integration Layer maps Adapters to Services
- Services
  - hide the details from the user
  - can be used in workflows
- Domain Service
  - provides methods to access or manipulate data for a domain
  - data format is XML
- Engineering Database
  - a special "tool"
  - contains the SSRM as data model



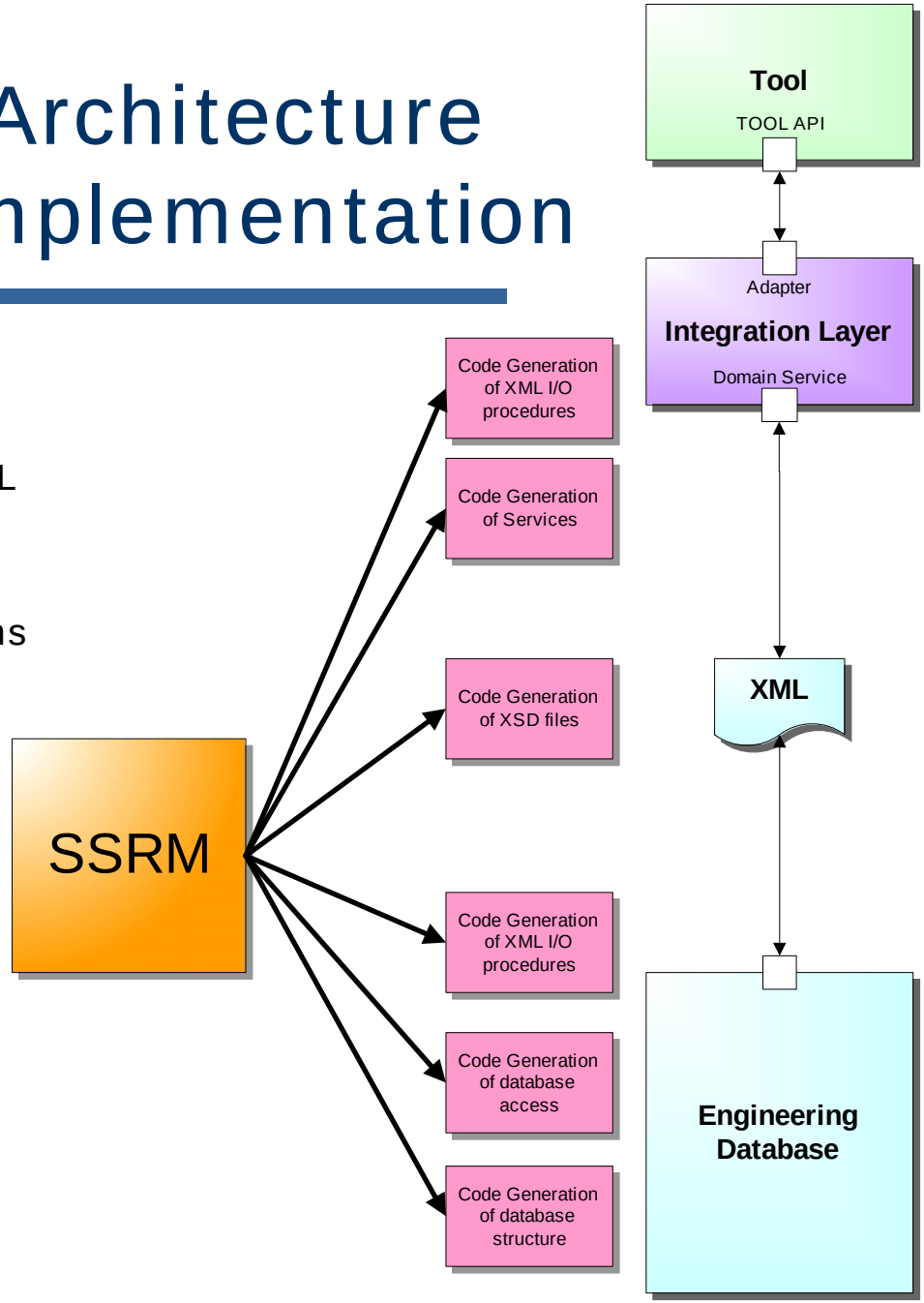
Implementation Architecture
From Model to Implementation

From Informational Model

- XSD files
  - define the structure of the XML streams
- XML I/O functionality
  - routines to format XML streams
- Database structure
  - tables to accommodate data
- Database access code
  - object relational mapping

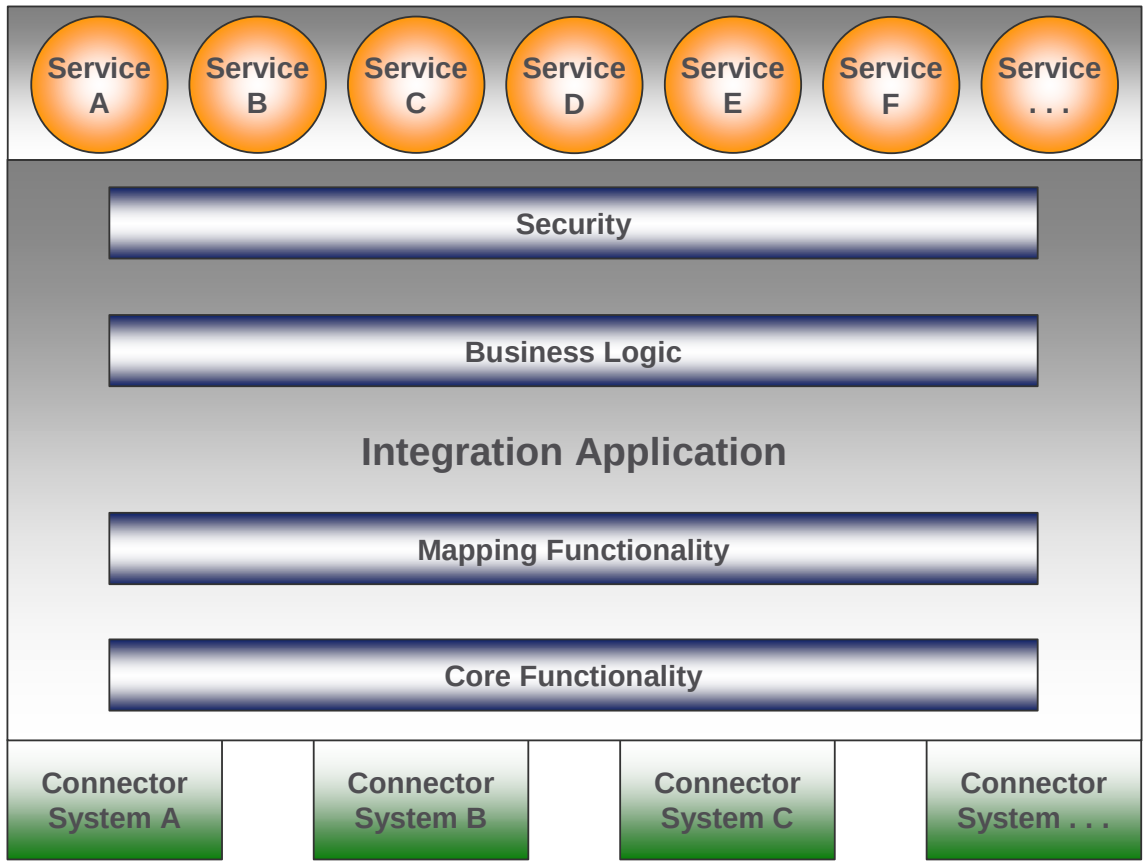
From Computational Model

- Services
  - each domain represented by services (1..n)



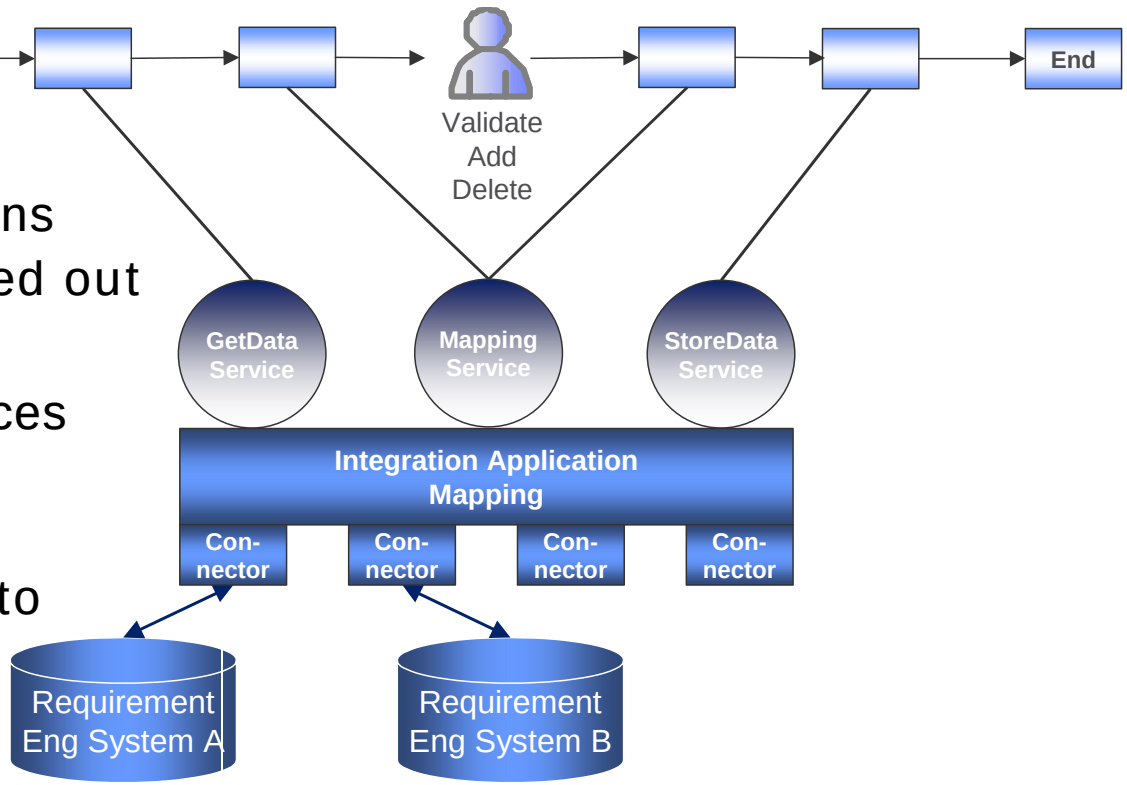
Demonstration Environment Components

- Integration Application
- Service Layer
- Connector Layer



Demonstration Environment Scenarios

- Realization of Scenarios
  - Combining (orchestrating) services to workflows (business logic)
- Business Logic
  - Complex functions
  - repeatedly carried out
- Workflow
  - Consumes services
  - re-uses existing components
  - combines them to tailor-made functions



… and finally

- Outlook
  - Plan to report on results at PDE 2008
- Many thanks to the all co-workers in the project:
  - Robert Birn (EADS Astrium)
  - Emmanuel Cheguillaume (EADS ST)
  - Carsten Zerbst (PROSTEP)
  - Mirko Theiss (PROSTEP)
- Thank you!