5. Product Lifecycle Management

Database Technologies for Integrating Engineering Data

Overview

- Motivation
  - The Product Lifecycle
  - The Product Development Process
  - Islands of Automation
- Overview of Product Lifecycle Management
  - History: From Engineering Databases to PLM Systems
  - Relation to CAD and Enterprise Ressource Planning (ERP)
- Functionality
  - Product Data Management
  - Product Structure Management
  - Document Management
  - Engineering Workflows: Projects, Workflows and State Management
  - Versions, Variants, Configurations
  - User Management
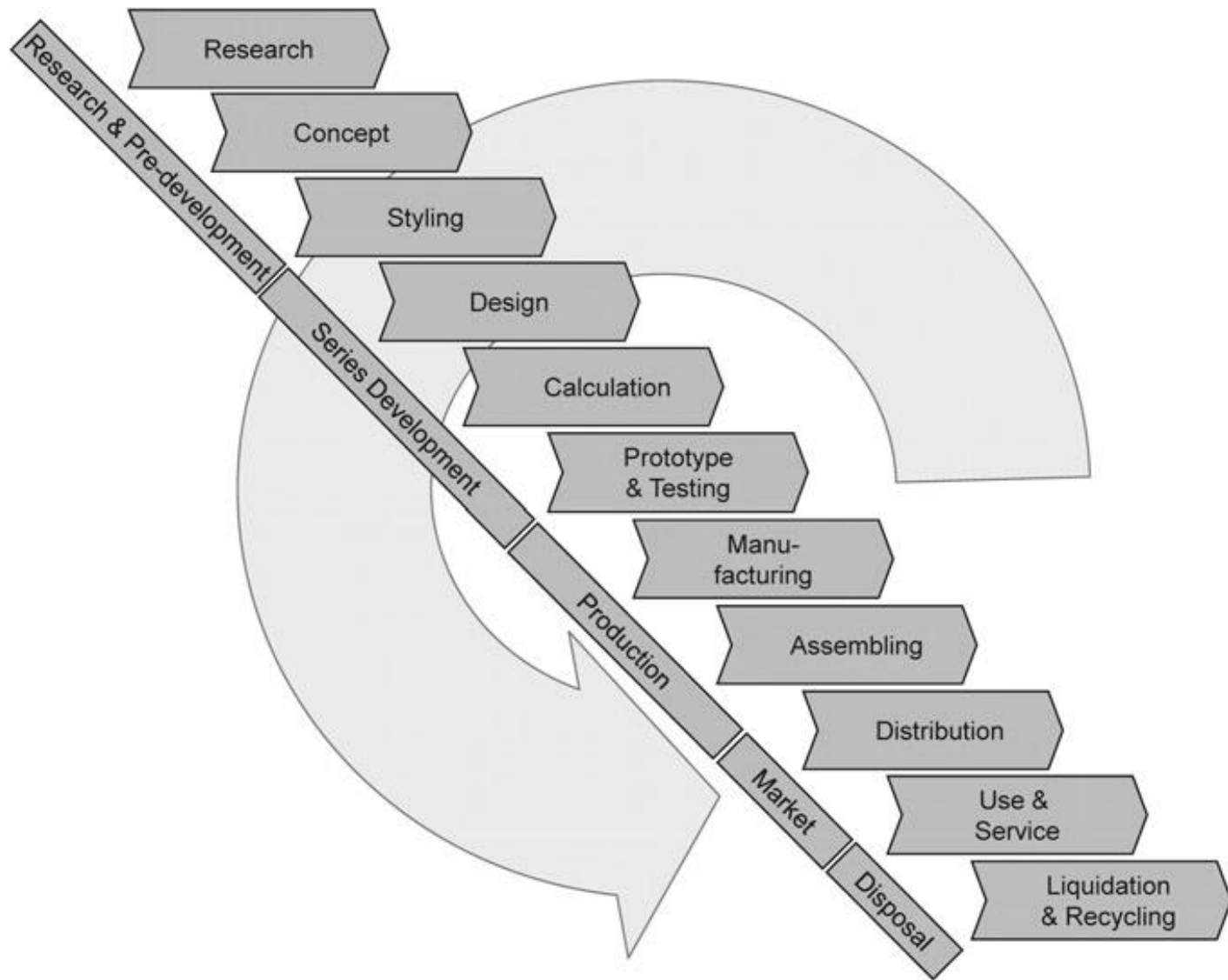- PLM System Products
- PLM and STEP

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Term: Product Lifecycle Management

Product Lifecycle Management (PLM) comprises concepts to manage products and integrate all according product data over their entire lifespan from inception to disposal.

- Strategic management concept
- Includes methods, processes and organizational principles
- Supported by specific software: PLM Systems

A **Product Lifecycle Management System (PLM System)** is a software system that enables and supports Product Lifecycle Management by integrating data and metadata from systems involved in all life phases of a product, and, based on this, provide higher-level functionality.

Product Life Cycle

Research & Pre-development
- Research
- Concept
- Styling

Series Development
- Design
- Calculation
- Prototype & Testing

Production
- Manufacturing
- Assembling

Market
- Distribution
- Use & Service

Disposal
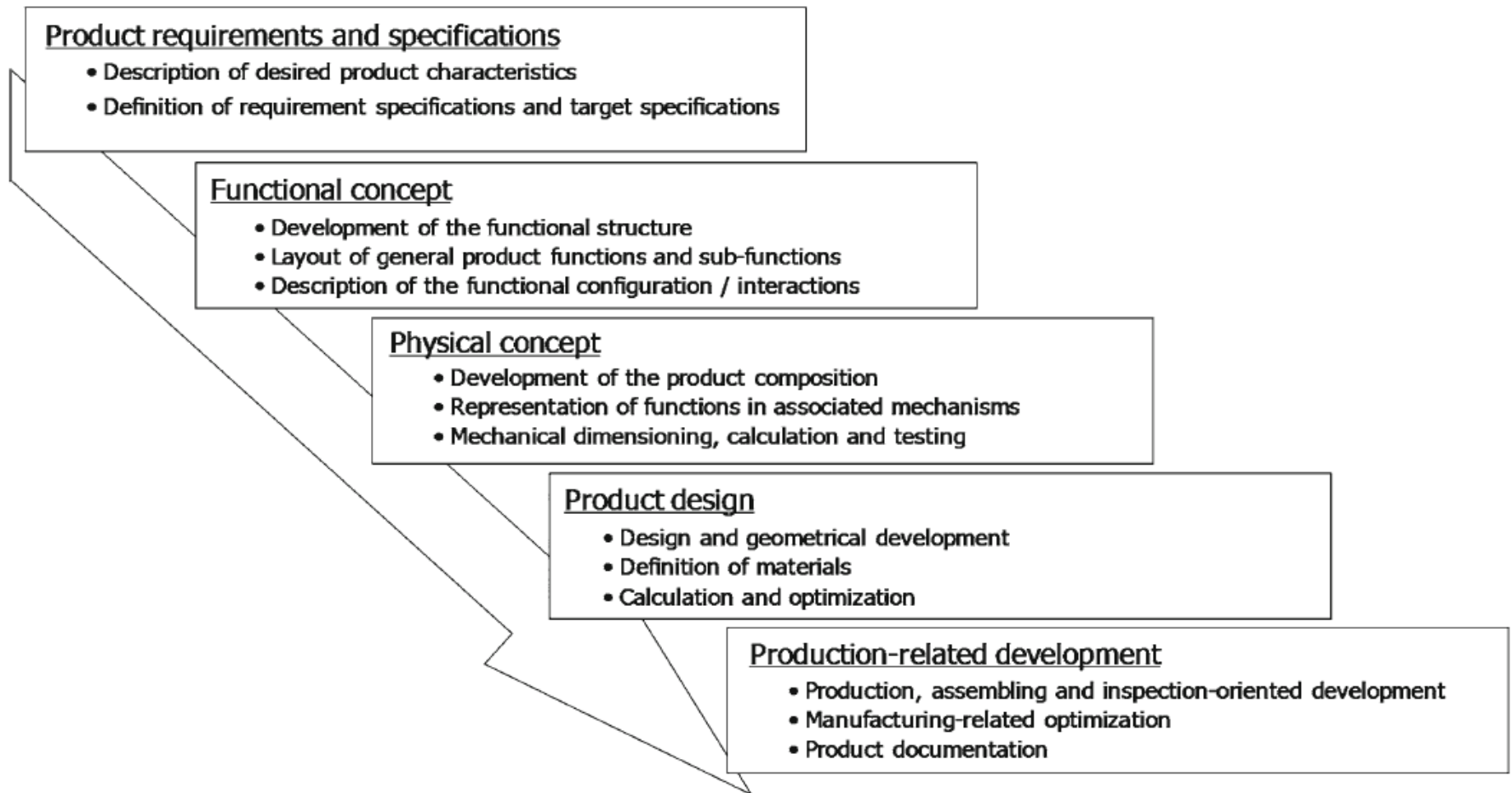- Liquidation & Recycling
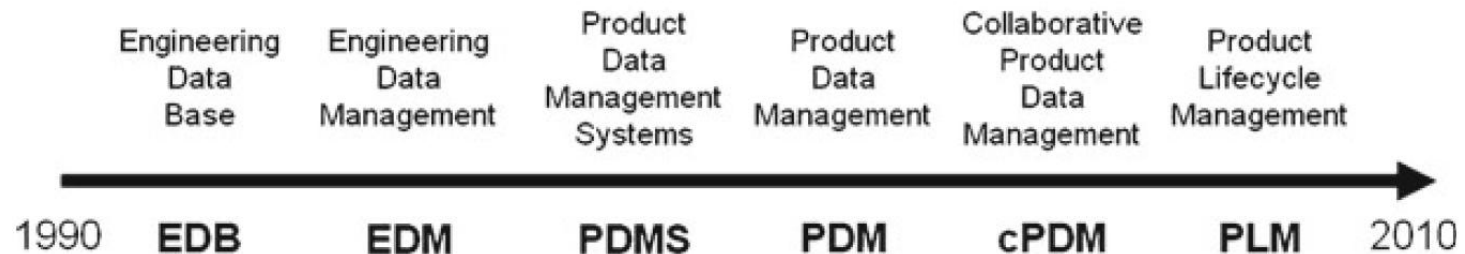
From [2]

Usage in Product Development

- Not limited to usage by engineers
- Historically stemming from "Engineering Databases"
- Still focused on product development process

Product Development Process

Product requirements and specifications
- Description of desired product characteristics
- Definition of requirement specifications and target specifications

Functional concept
- Development of the functional structure
- Layout of general product functions and sub-functions
- Description of the functional configuration / interactions

Physical concept
- Development of the product composition
- Representation of functions in associated mechanisms
- Mechanical dimensioning, calculation and testing

Product design
- Design and geometrical development
- Definition of materials
- Calculation and optimization

Production-related development
- Production, assembling and inspection-oriented development
- Manufacturing-related optimization
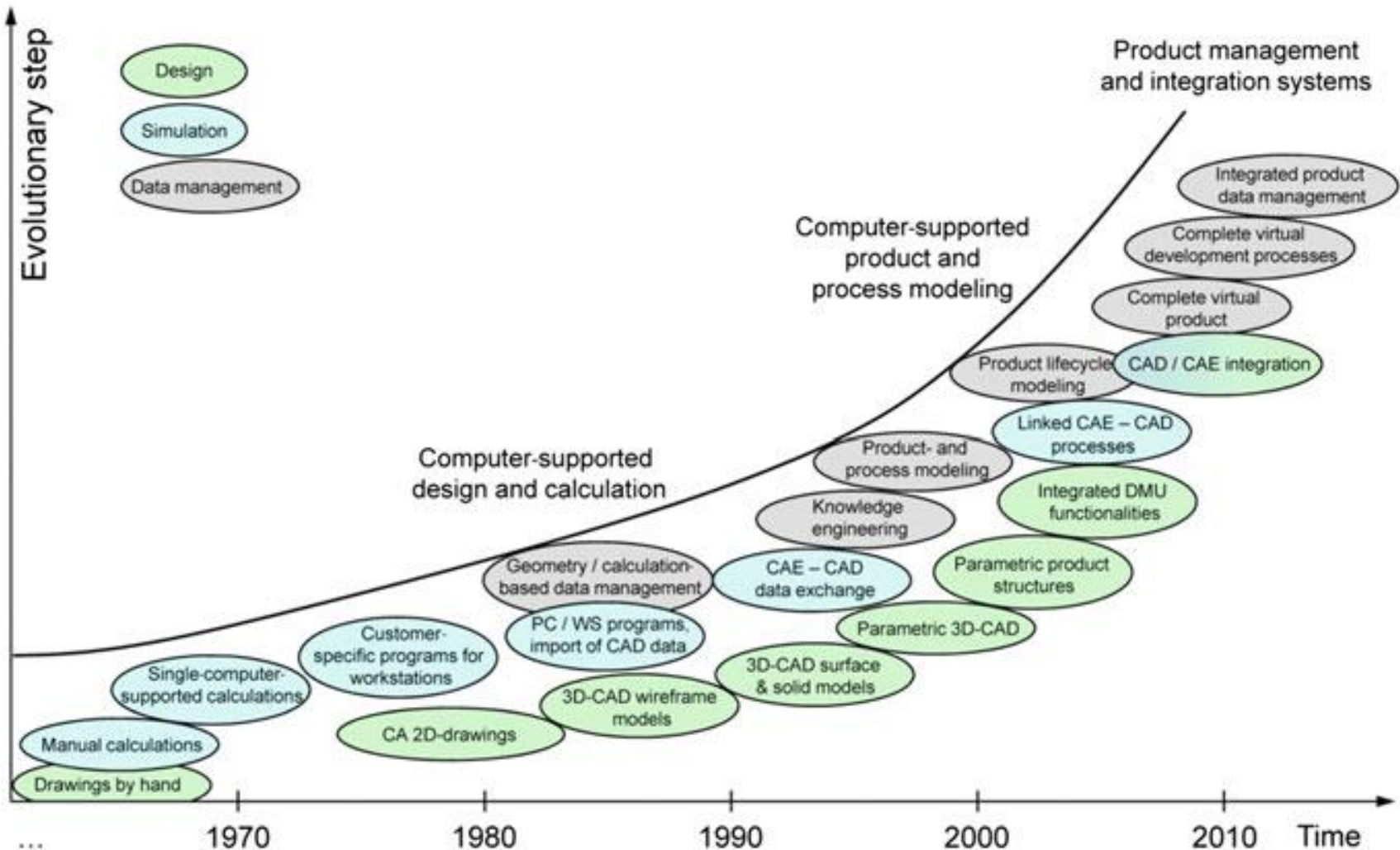- Product documentation

From [2]

History of PLM Systems

- **Engineering Databases (EDB):** software systems to manage and integrate engineering data

- **Engineering Data Management (EDM)**: EDB + concepts to structure engineering processes

- **Product Data Management (PDM)**: EDM + Integration of non-engineering product data (e.g. marketing, sales, etc.)

- **Product Lifecycle Management (PLM)**: PDM + focus on integrated management concepts

Engineering Data Base	Engineering Data Management	Product Data Management Systems	Product Data Management	Collaborative Product Data Management	Product Lifecycle Management
1990 EDB	EDM	PDMS	PDM	cPDM	PLM 2010

From [2]

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Historical Landscape: Engineering Data

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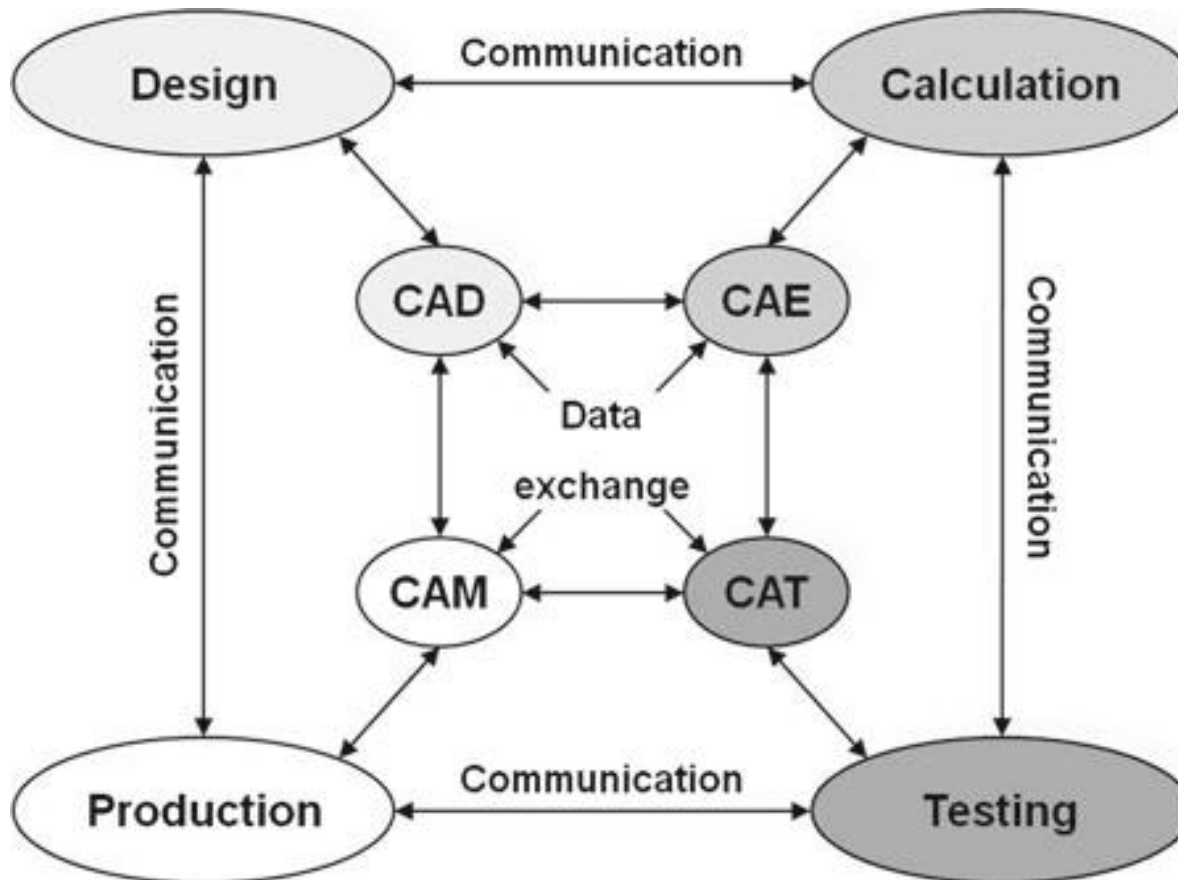
From [2]

Other Related Terms

- Historical or alternative related terms
  - Technical Information System
  - Technical Drawing Management System
  - Engineering Document Management System
  - Product Information Management
  - …

PLM Integration Concepts

- Development from EDB to current PLM systems triggered by so-called **"islands of automation"**
  - Many software specialized systems used in engineering
  - Input for one system may be generated by another system
  - All have their own storage concepts and formats
- PLM systems try to manage integrated Product Model (also Product Information Model, Product Data Model, Product Data Record, etc.)
  - All partial data/models connected through metadata
  - Metadata stored in database system
  - Actual data maybe controlled by PLM system in special vaults (maybe stored in the database as BLOBs)

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Exchange between "Islands of Automation"

From [2]

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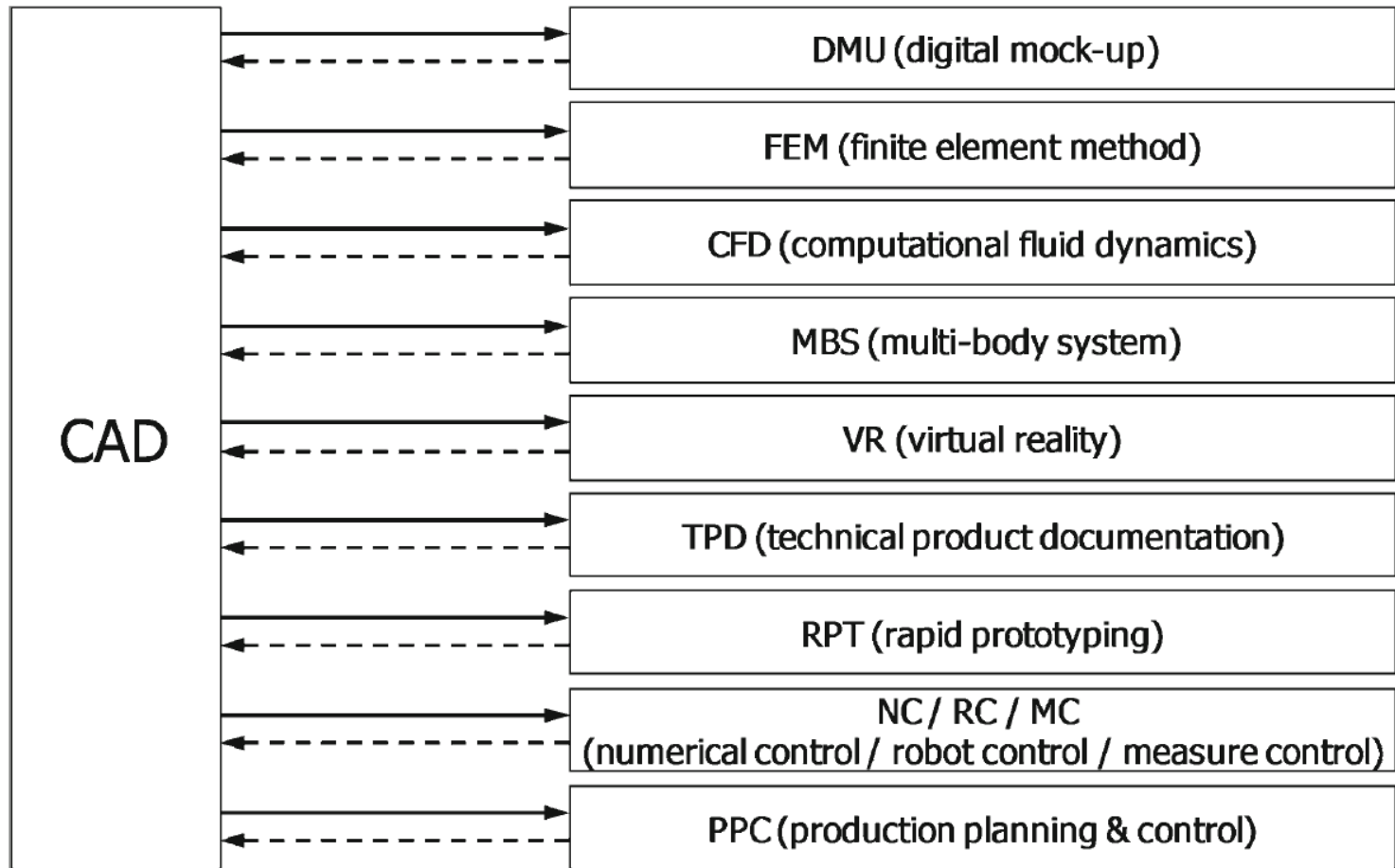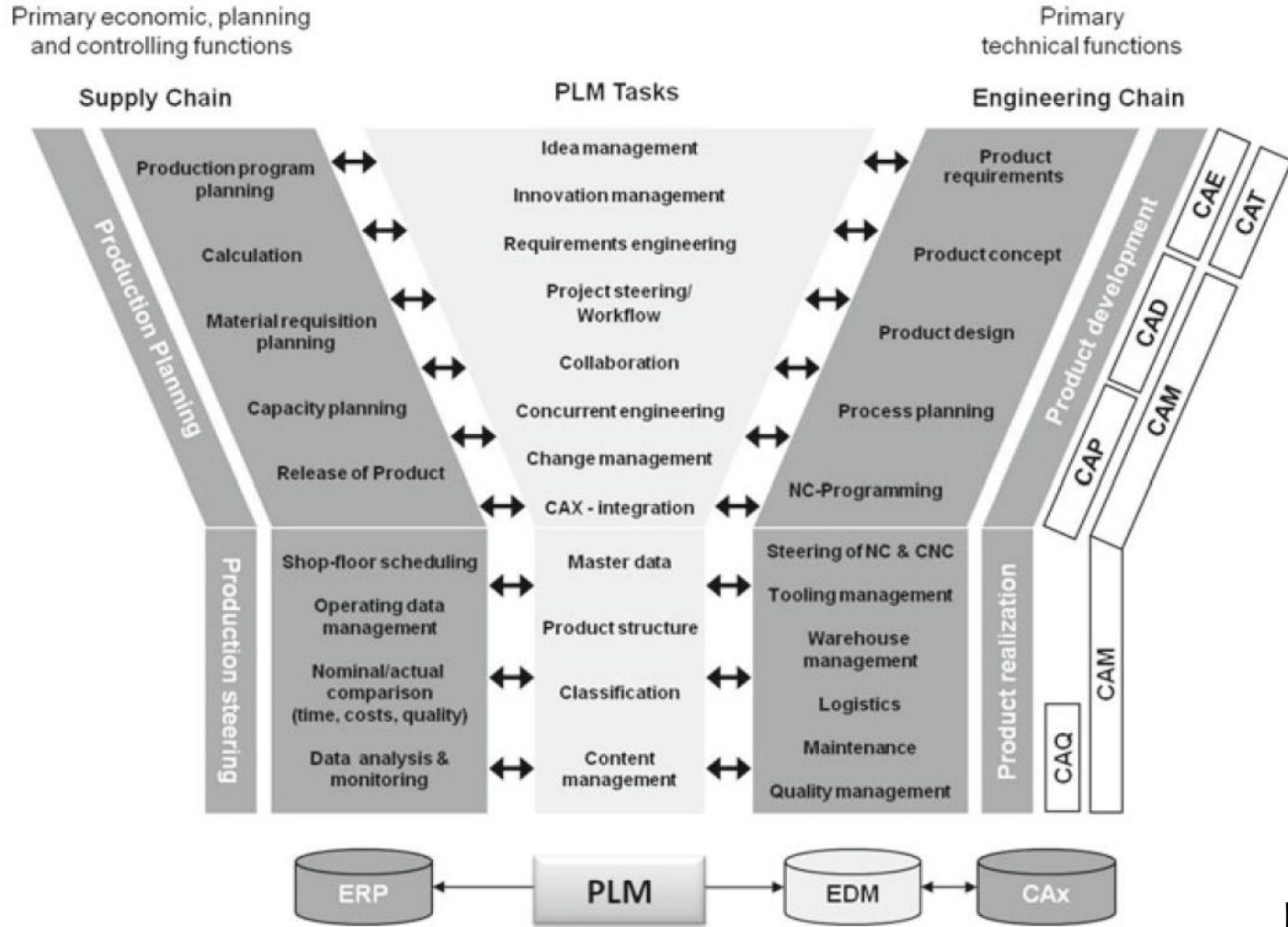
PLM and other Systems

- PLM and CAD Systems
  - CAD Systems have central role in product development
  - Output (geometrical data of solid designs) often input for many further systems
  - Very tightly integrated with PLM systems

- PLM and Enterprise Resource Planning (ERP)
  - ERP systems represent integrative perspective from operative management
  - Overlapping/not clearly separated from PLM, e.g. production planning tightly linked with product data
  - PLM and ERP considered along with Customer Relationship Management and Supply Chain Management as cornerstones of company data management
  - E.g. SAP PLM is part of SAP Business Suite along with SAP ERP

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Central Role of CAD

From [2]

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PLM and ERP

From [2]
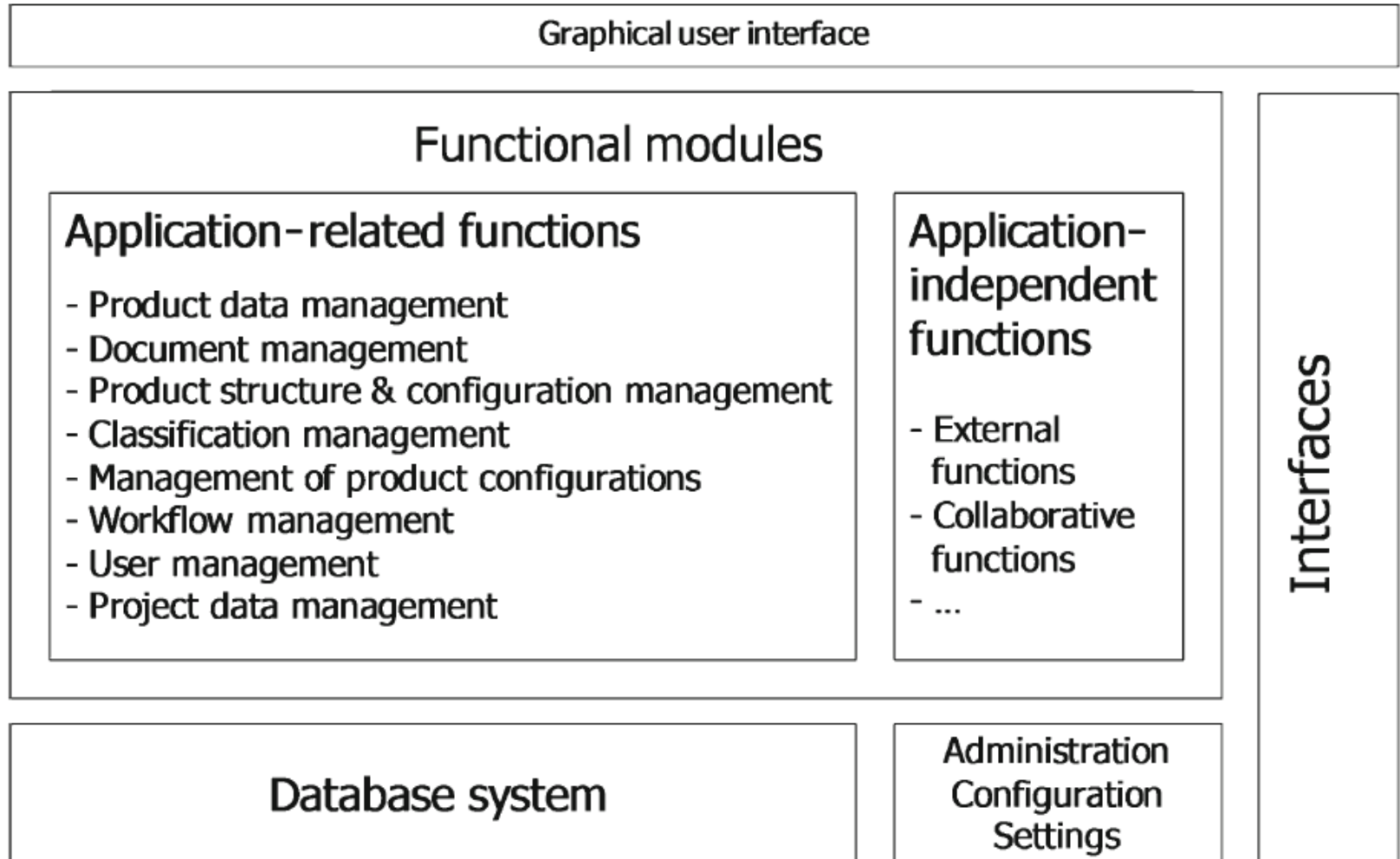
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PLM Systems Architecture

- Typically
  - More or less separated modules providing basic functionality
    - Product data/product structure management
    - Document management
    - Process/workflow management
    - …
  - Database to store
    - Metadata of product data
    - Optional: product data as BLOBs or in Database File System
    - Information about users, projects, processes
  - Interfaces to many systems providing relevant product data
  - Collaboration synchronized by DBMS

PLM System Architecture

Graphical user interface

Functional modules

Application-related functions
- Product data management
- Document management
- Product structure & configuration management
- Classification management
- Management of product configurations
- Workflow management
- User management
- Project data management

Application-independent functions
- External functions
- Collaborative functions
- ...

Interfaces

Database system

Administration Configuration Settings

From [2]

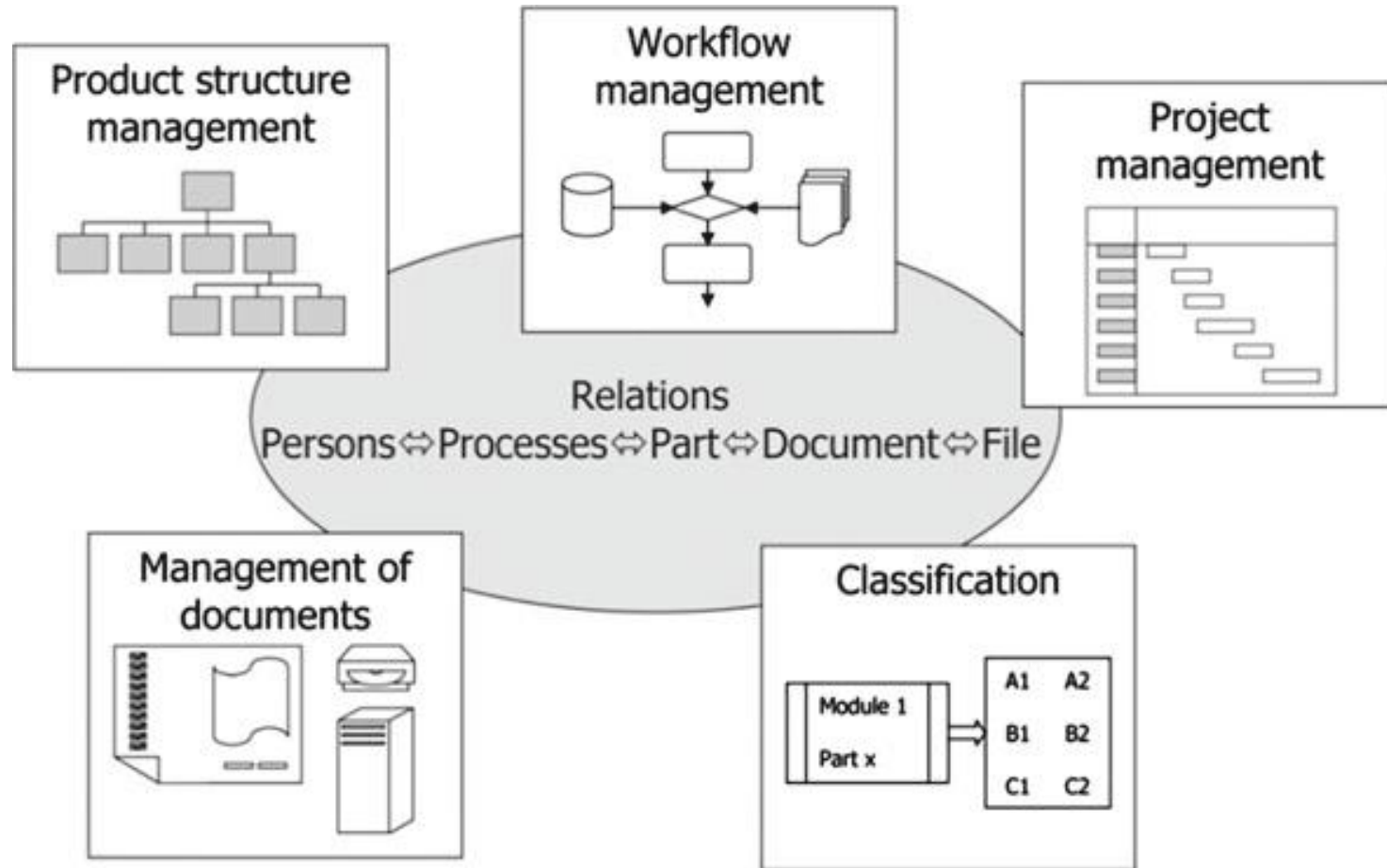Schallehn: Data Management for Engineering Applications

PLM Main Functionality

- **Product Structure Management:** construction of products from parts or assemblies - input for production planning and Bill of Material (BOM)

- **Document Management:** control of storage for engineering data

- **Product Data Management:** references and relationships between partial product information from various engineering systems

- **Process Management:** representation and support for execution of engineering workflows

- **Configuration and Version Management:** management of changes and states of product data

- User Management: management of engineers, their roles, and collaboration in processes

From [2]

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PLM Main Functionality

Product structure management

Workflow management

Project management

Relations
Persons ⇔ Processes ⇔ Part ⇔ Document ⇔ File

Management of documents

Classification

Module 1

Part x

A1	A2
B1	B2
C1	C2

From [2]

Schallehn: Data Management for Engineering Applications
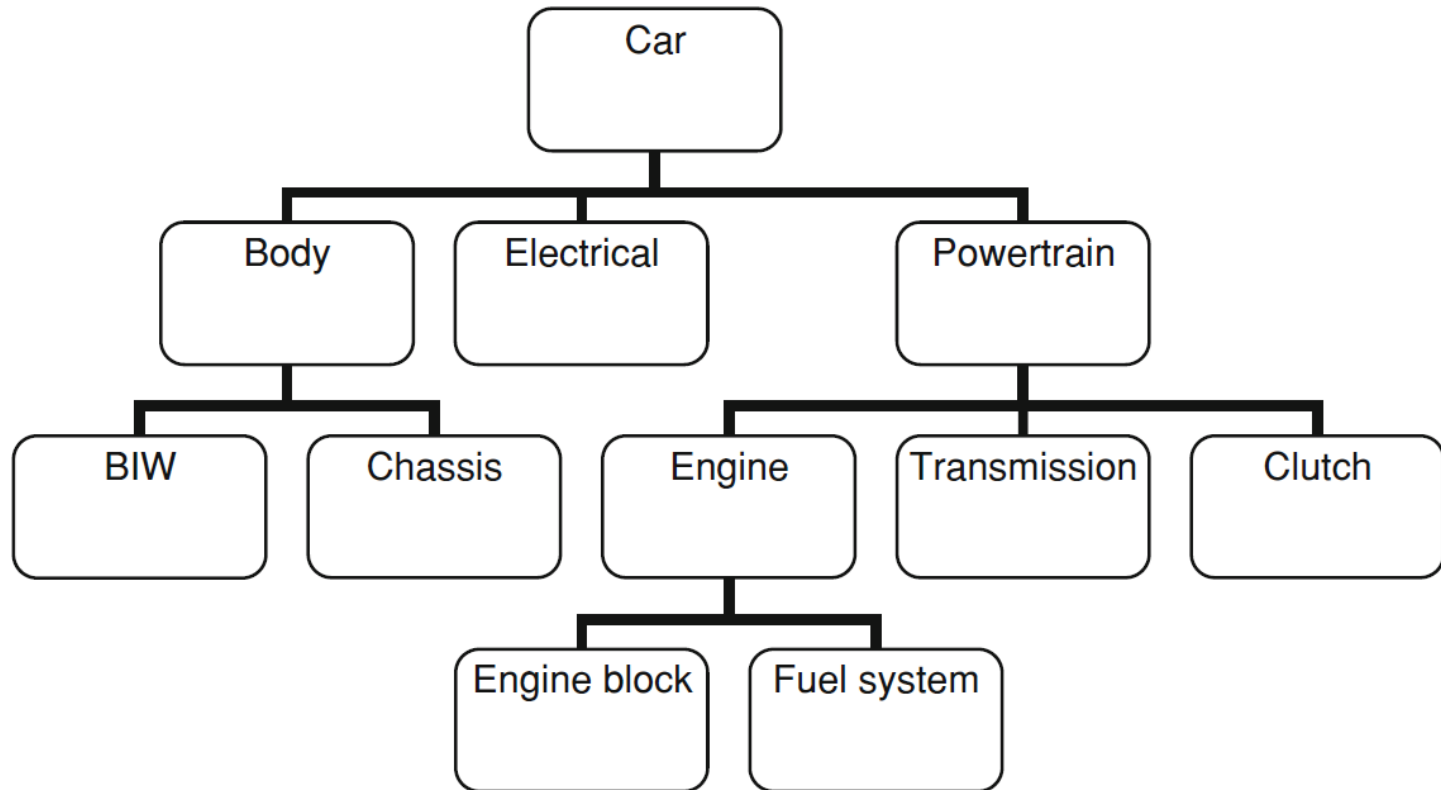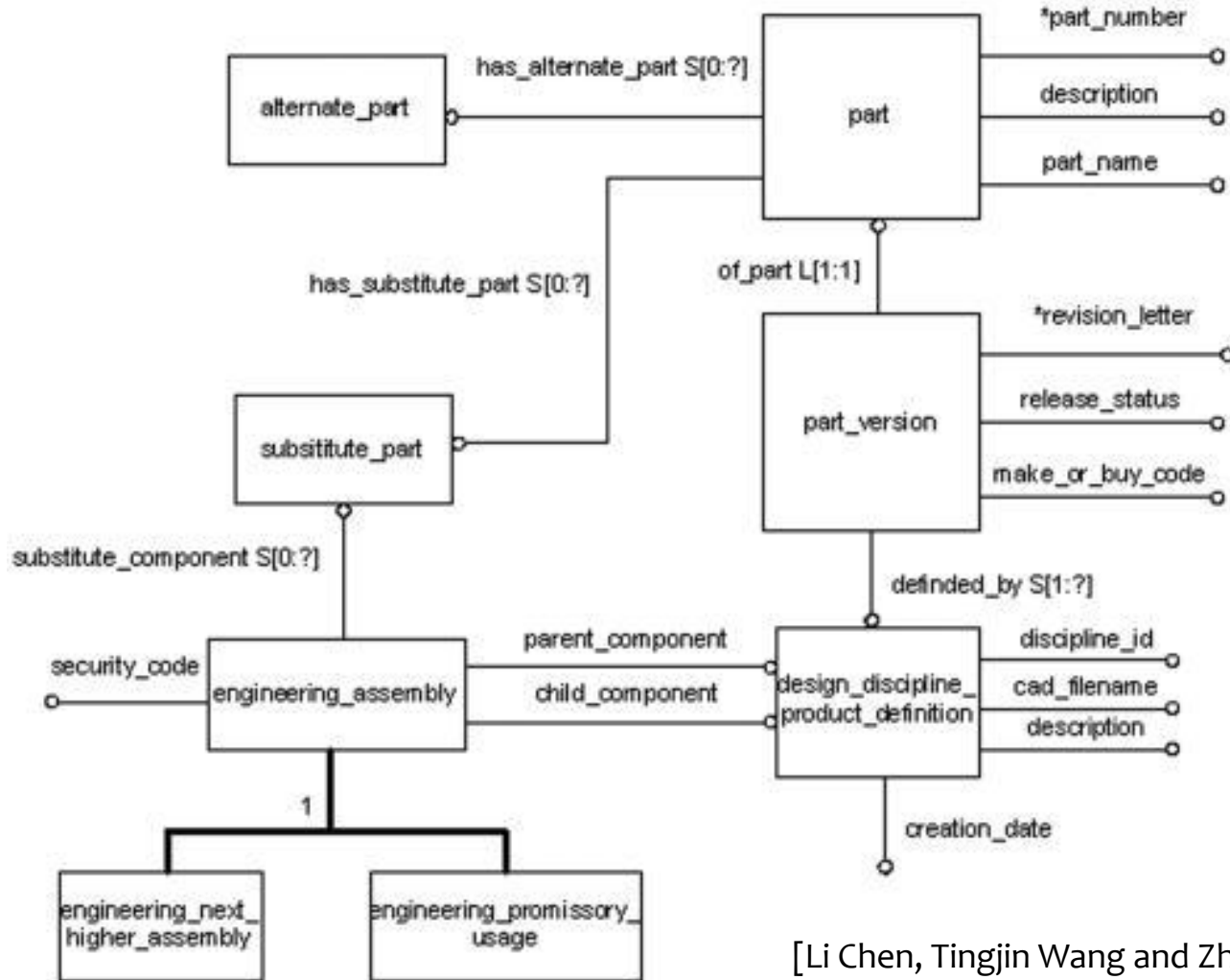
Product Structure Management

- Hierarchical/tree-like structure
  - Product as root of tree
  - Assemblies as inner nodes consisting of other assemblies or parts
  - Parts (produced within company or bought from supplier) as leaf nodes
- Central role in data management
  - Product data and documents are linked to parts in tree
  - Alternatives represented in tree are subject to configuration management
- Bill of Materials (BOM) can be created from product structure

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Example: Product Structure

From [1]

Example: Product Structure Schema

[Li Chen, Tingjin Wang and Zhijie Song : A Web-based Product Structure Manager to Support Collaborative Assembly Modeling]

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Bill of Materials (BOM)

- Special form of representation of the product structure data

- May contain varying information depending on usage in
  - Engineering
  - Manufacturing
  - Sales

- Configurable BOMs can be applied for configuration management

BOM Example
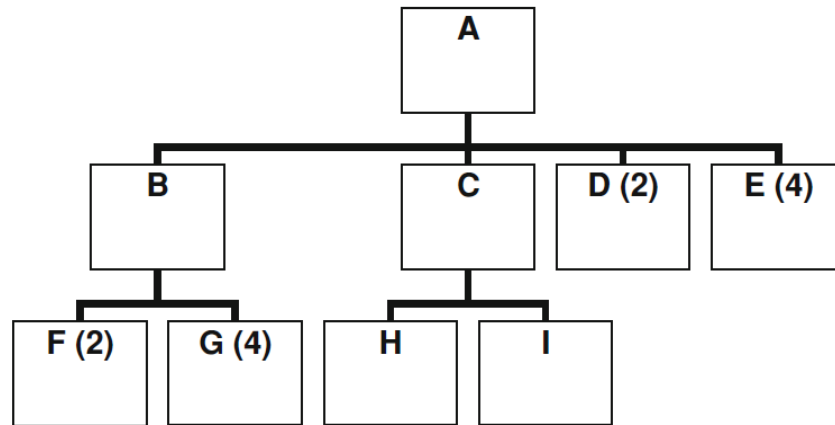
Level	Item	Quantity
0	A	1
.1	B	1
..2	F	2
..2	G	4
.1	C	1
..2	H	1
..2	I	1
.1	D	2
.1	E	4

From [1]

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Document Management

- Strong requirements and regulations regarding the management of engineering documents
  - Legal regulations to store product data for certain time-span
  - ISO 15226:1999 Technical product documentation -- Life cycle model and allocation of documents
- N:M Relation to product data and product structure
  - There may be many documents on one part (e.g. design, specification, simulation, electronic components, etc.)
  - There may be documents related to many parts/products (e.g. specification of product line or parameterizable design)

From [3]

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Document Management /2

From [3]
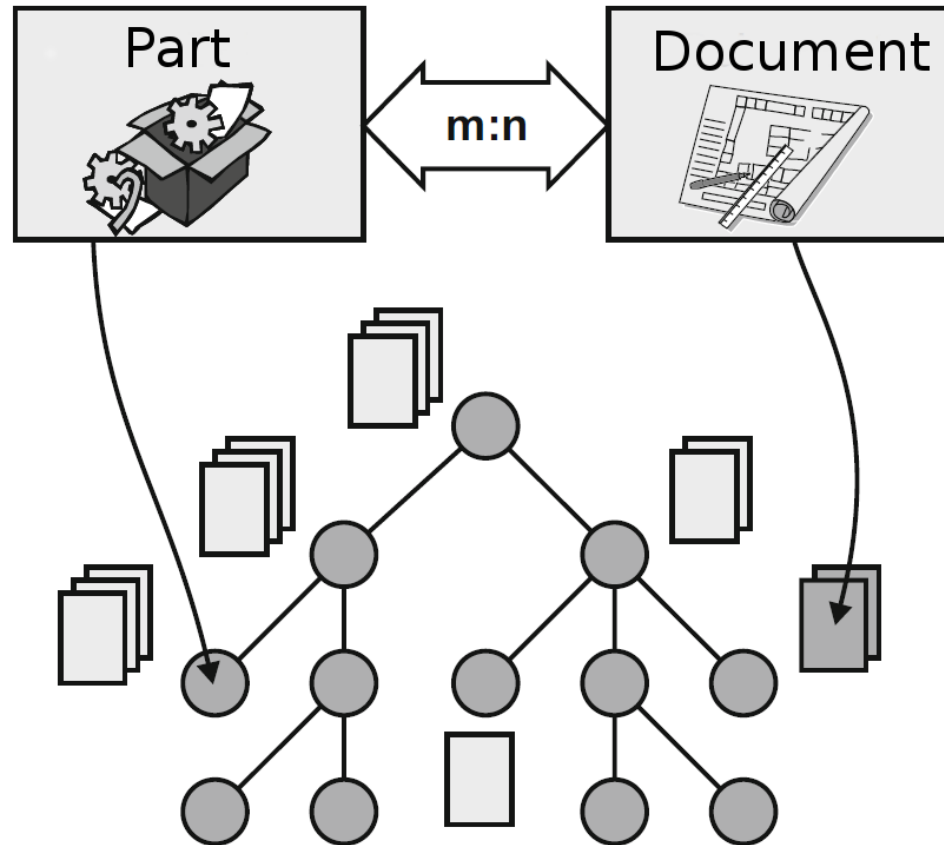
Document Management /3

- Document Structure: similar to product structure
  - Document may contain other documents
- N:M-relation to files
  - Document may consist of several files
  - Same file may be contained in many documents
- Vault: Controlled storage location
  - Special area in file system (special control mechanisms access right, distribution, etc.)
  - BLOB in relational database

Document Management /4

Originalname	interner Name
Modell.wrl	Z1147.d44
Part2.sldprt	G8639.a98
Dokument.docx	R8819.r48
	…

From [3]
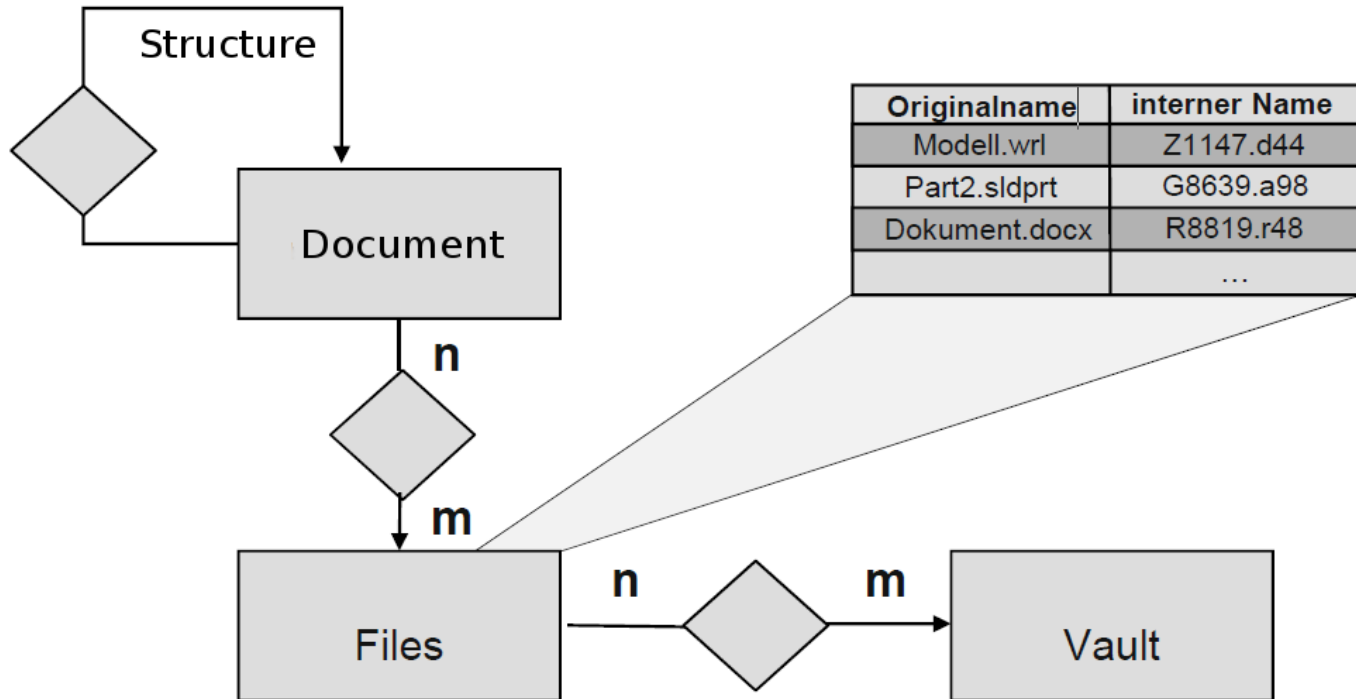
Variants, Version, Configurations

- Management of versions and variants key functionality of PLM systems
  - Sequence of version
  - Branches of Alternatives
- Combined with hierarchical product structure become configuration management (CM)
- Configuration = state of a complex product
- Tightly integrated with process/worflow model

PLM Systems

- Enovia (Dassault Systems)

- TeamCenter (Siemens)

- Windchill (Parametric Technology Corporation)

- Oracle Agile Engineering (Oracle)

- SAP PLM (SAP)

PLM Systems: ENOVIA

Aerospace · Construction · Energy · Industrial Equipment
Automotive · Consumer Goods · Shipbuilding · Life Science
Business Services · High Tech · Consumer Packaged Goods

3D PLM User Experience
IP Search & Navigate

3dvia DS

Collaborative Business Processes — ENOVIA

CBP Industry Accelerators

- Mechanical CAD
- Electrical CAD
- Artwork
- Semiconductor EDA
- Embedded Software

- CATIA
- DELMIA
- SIMULIA

Virtual Product Management

Design Data Management

- X-BOM Management
- Program and Portfolio Management
- Requirements Management
- Enterprise Sourcing
- Materials Compliancy

PLM Meta-model

VPM Foundation
- 3D Indexing
- 3D Search
- Lifecycle

CBP Foundation
- Workflow
- Business Metrics
- Team Workspaces
- Doc Management

ENOVIA Foundation
- IP Indexing
- IP Search
- IP Classification
- Lifecycle
- Rules
- Administration
- Security

V6 PLM Enterprise Foundation

Req · F/L · P · PDM · PDM · PDM · CRM · SRM · ERP

[U. Bracht et al., *Digitale Fabrik*, *Springer 2011*]

PLM Systems: Siemens

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[U. Bracht et al., *Digitale Fabrik, Springer 2011*]

PLM Systems: Siemens TeamCenter

From [3]

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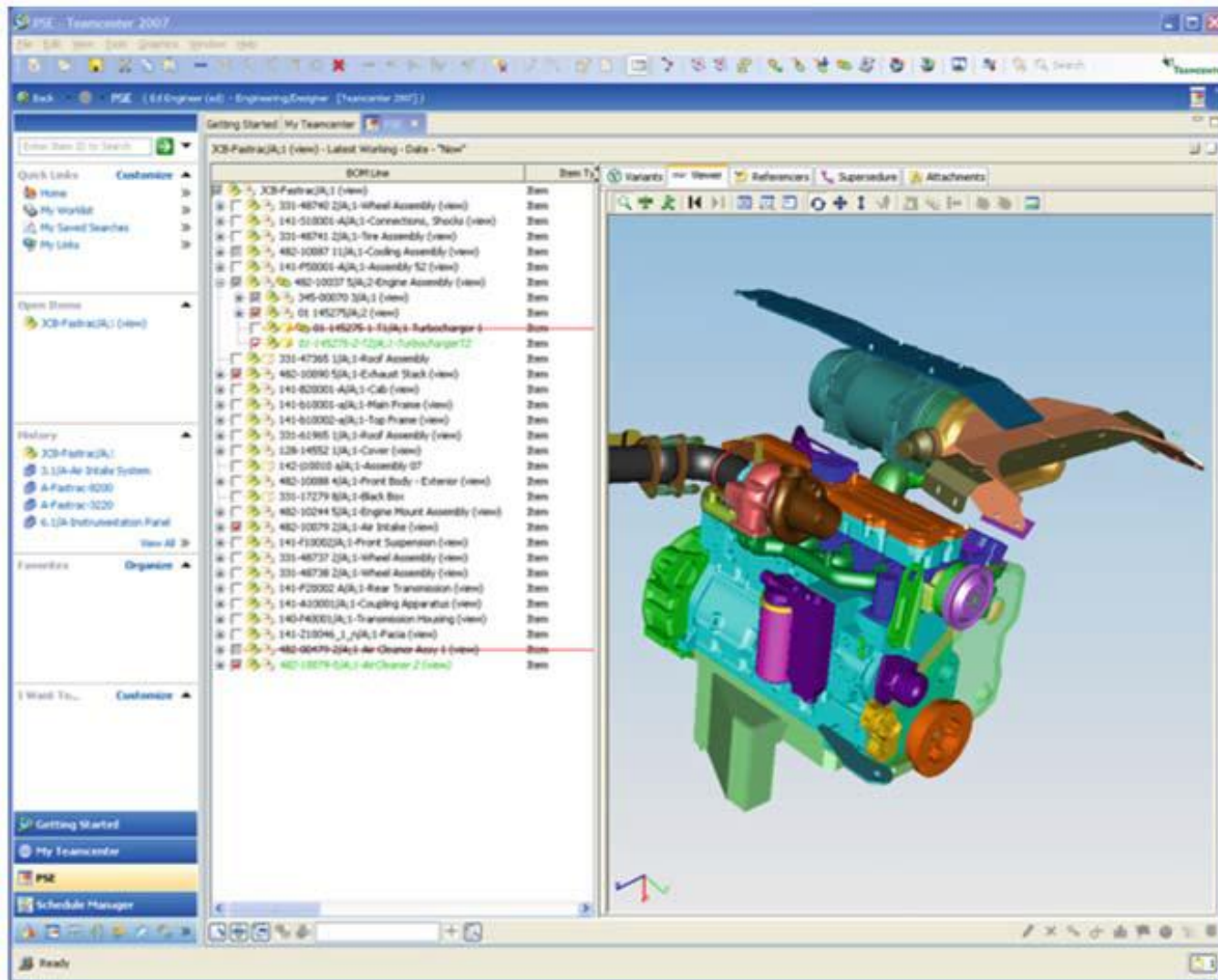
PLM Systems: Oracle Agile PLM

BOM Browser

From [3]

Schallehn: Data Management for Engineering Applications
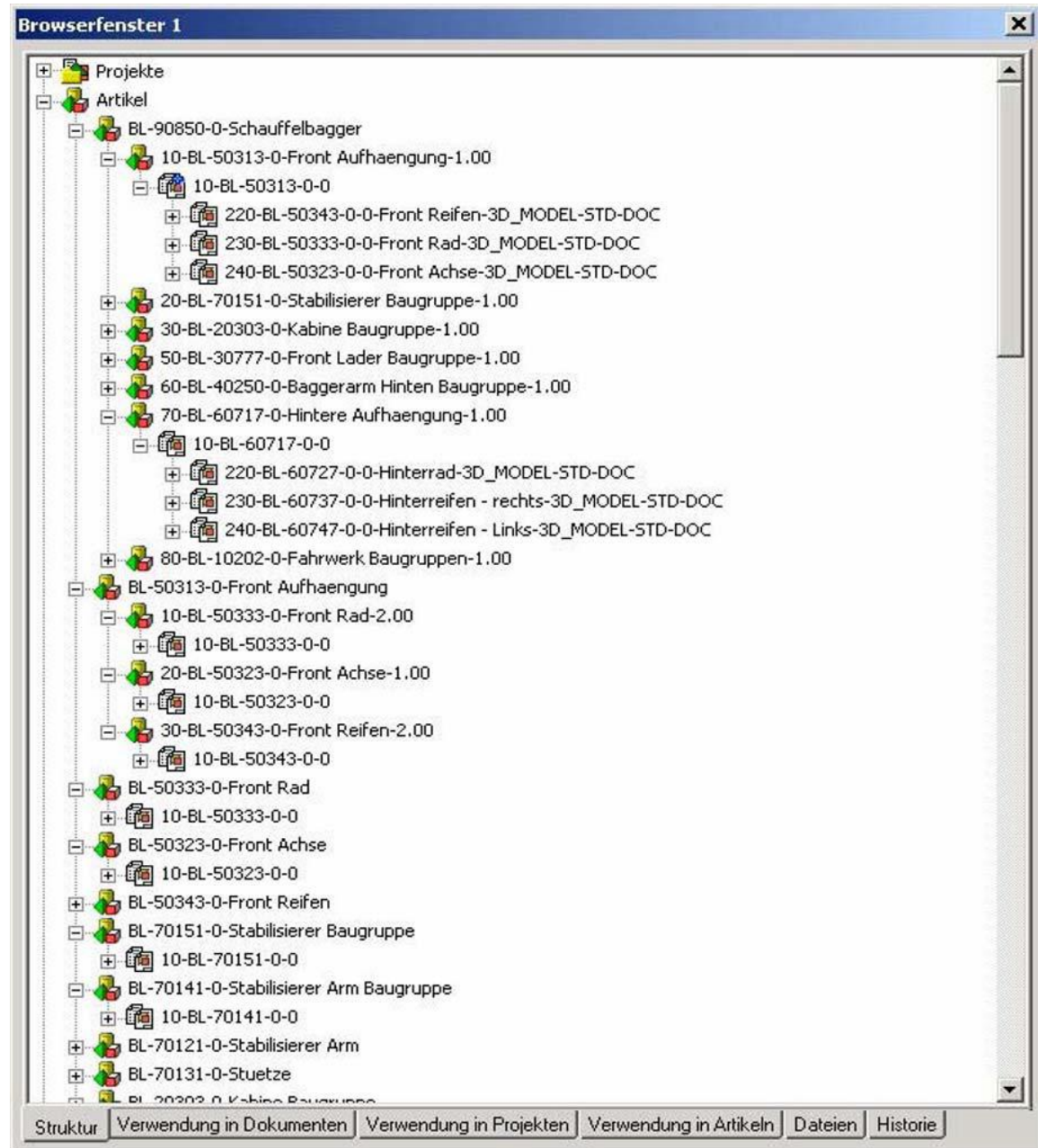
PLM and STEP

- STEP does not define a single dedicated work package to support PLM systems

- Relevant protocols

  - **AP 203:** Configuration controlled 3D design (mainly for CAD)

  - **AP 214:** Core data for automotive mechanical design processes (mainly for CAD)

  - **AP 212:** Electrotechnical design and installation (ECAD, EDA)

  - **AP 232:** Technical Data Packaging Core Information and Exchange (exchange and archiving)
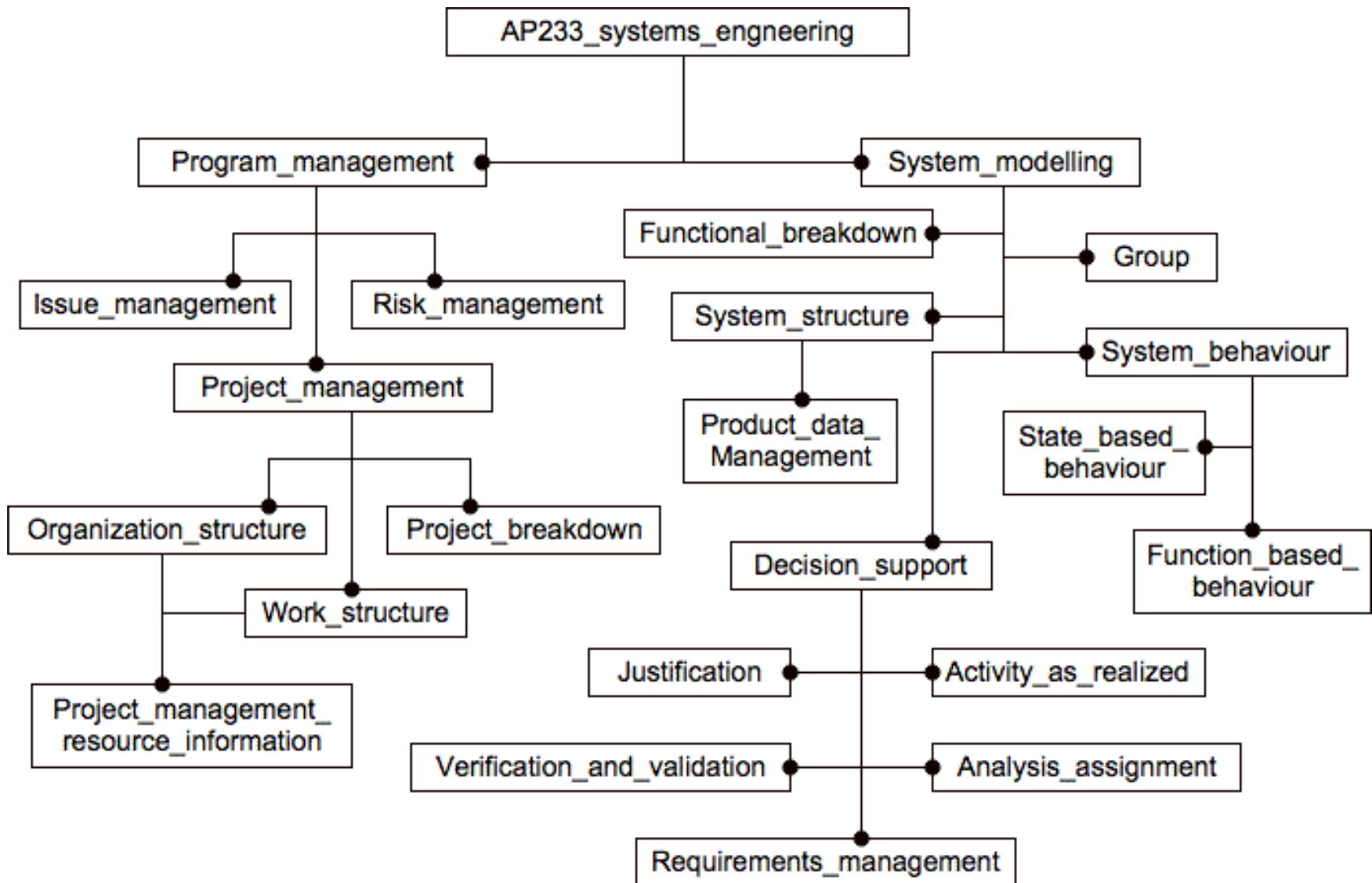
PDM Schema Initiave (by ProStep)
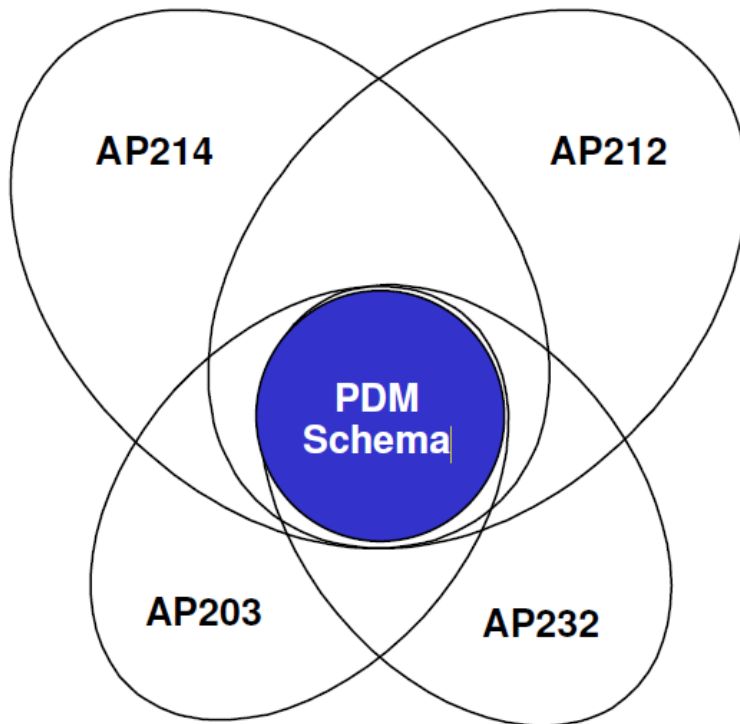
☞ **Common PDM data Schema generated and maintained by PDES, Inc. and ProSTEP**

☞ **Real Subset of PDM relevant STEP APs (AP203, 212, 214, 232)**

☞ **Fulfills nearly all requirements for PDM data exchange**

Main functionality for parts and documents:
- identification
- versioning
- structures incl. transformations
- approvals and authorization
- project, work order, work request
- effectivities
- classification and properties

[ProSTEP: Usage Guide for the STEP PDM Schema V1.2 Release 4.3, 2002]

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PLM and STEP /2

- Some recently developed APs address more holistic view of engineering activities

    - **AP 233:** Systems Engineering data representation (added PLM relevant concepts in 2012)

    - **AP 239:** Product Lifecycle support (focused on phases after product development)

    - **AP 242:** Managed model based 3D engineering (merges 203 and 214 + some PDM functionality)

STEP AP 233 (Systems Engineering)

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[Top-level schema from STEP AP233]

STEP AP 239

[Overview of Usage, from STEP AP239]
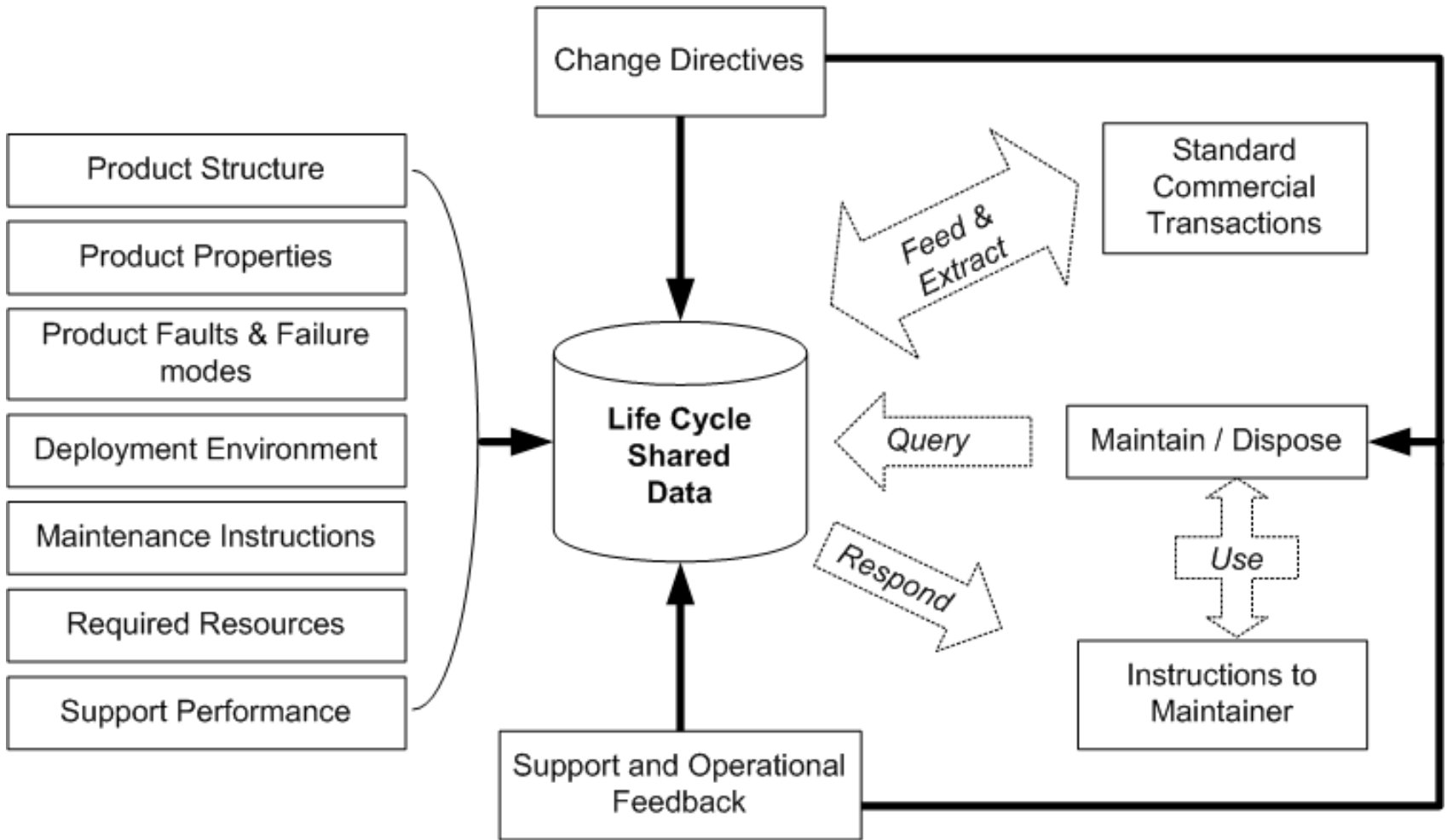
STEP AP 242

[Package overview from STEP AP 242]

PDM
Part identification
Characterictics,
Document Management
General management information
Physical part
Activity and work management
Effectivity
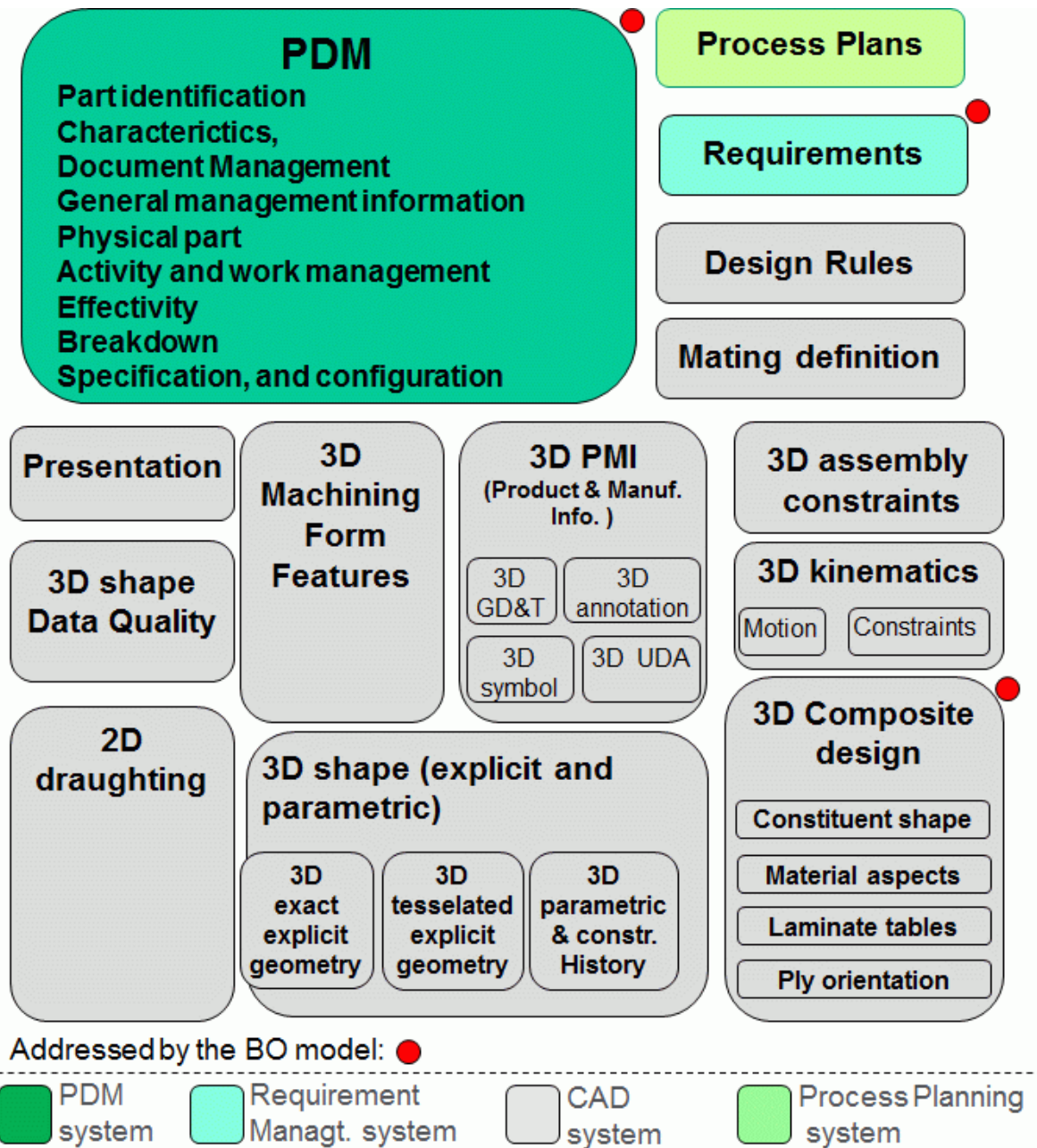Breakdown
Specification, and configuration

Process Plans

Requirements

Design Rules

Mating definition

Presentation

3D shape Data Quality

3D Machining Form Features

3D PMI (Product & Manuf. Info.)
3D GD&T | 3D annotation
3D symbol | 3D UDA

3D assembly constraints

3D kinematics
Motion | Constraints

2D draughting

3D shape (explicit and parametric)
3D exact explicit geometry | 3D tesselated explicit geometry | 3D parametric & constr. History

3D Composite design
Constituent shape
Material aspects
Laminate tables
Ply orientation

Addressed by the BO model: ●

PDM system | Requirement Managt. system | CAD system | Process Planning system

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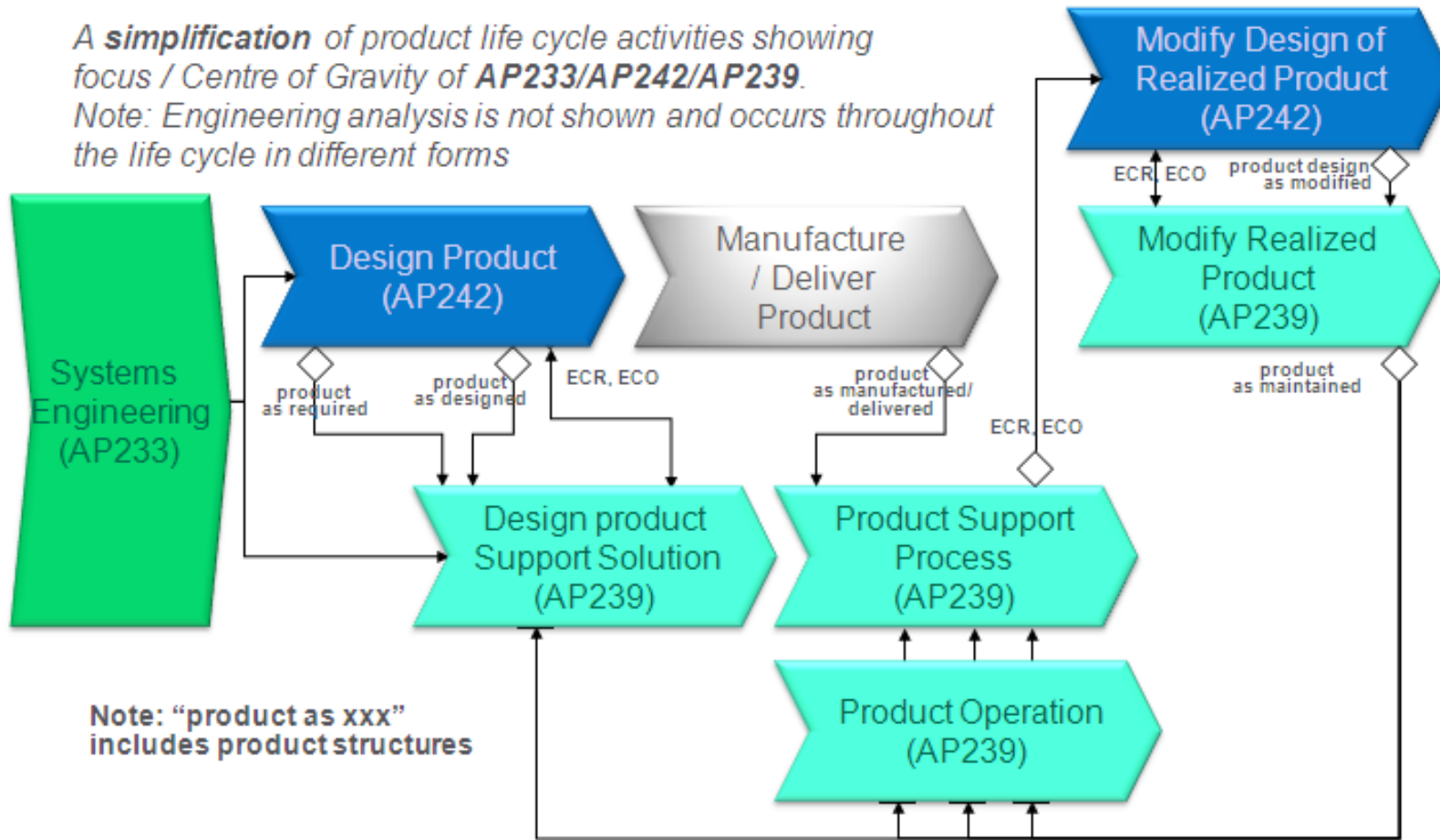
Combined Usage of relevant APs

A **simplification** of product life cycle activities showing focus / Centre of Gravity of **AP233/AP242/AP239**.
Note: Engineering analysis is not shown and occurs throughout the life cycle in different forms

Systems Engineering (AP233)

Design Product (AP242)

Manufacture / Deliver Product

Modify Design of Realized Product (AP242)

Modify Realized Product (AP239)

product as required

product as designed

ECR, ECO

Design product Support Solution (AP239)

product as manufactured/ delivered

Product Support Process (AP239)

ECR, ECO

ECR, ECO   product design as modified

product as maintained

Product Operation (AP239)

Note: "product as xxx" includes product structures

[from http://www.ap242.org/]

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STEP Modular Architecture

- Numerous overlapping and redundant definitions across APs are problematic

- Recently addressed by decomposed and combinable APs of AP4xx and AP1xxx series, e.g.
  - AP439 is reworked version of AP239
  - Consists of several atomic building blocks
    - Part 1287 – AP239 activity recording
    - Part 1297 – AP239 document management
    - Part 1289 – AP239 management resource information
    - Part 1293 – AP239 part definition information
    - Part 1304 – AP239 product status recording
    - …

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Literature / Further Readings

[1]   John Stark: Product Lifecycle Management - 21st Century Paradigm
       for Product Realisation.
       ISBN: 978-0-85729-545-3 , Springer 2013

[2]   Hirz Mario, Wilhelm Dietrich, Anton Gfrerrer, Johann Lang:
       Integrated Computer-Aided Design in Automotive Development.
       ISBN: 978-3-642-11939-2, Springer 2013

[3]   Martin Eigner, Ralph Stelzer: Product Lifecycle Management - Ein
       Leitfaden für Product Development und Life Cycle Management.
       ISBN: 978-3-540-44373-5, Springer 2009