Enterprise Architecture

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Overview

- Understand what an enterprise architecture is and why companies are developing them

- Understand how reference architectures are used to derive enterprise architectures

- Provide examples of several popular reference architectures

- Illustrate an enterprise architecture for actual companies

Enterprise Architecture

- To deal with the complexity of designing an enterprise many now use enterprise architecture

- *Architecture* represents the structure of the system embodied by its components, their relationships to each other, their relationships with the environment, and the principles guiding the system's design and evolution

- With regard to an enterprise the architecture represents conceptual components, conceptual relationships, and enterprise-wide principles

Architecture

Architecture – a representation of the structure or form of a system embodied by its components, their relationships to each other, their relationships with the environment, and the principles guiding the system's design and evolution over time.
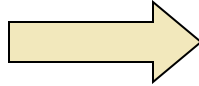
Architecture gives *physical form* to the *functions* needed by the system.
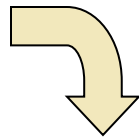
Form
- The collection of elements in the system
- The configuration of those elements
- The arrangement of the elements and how they are related to each other

Why Enterprise Architecture?

You cannot build this

in the same way you build this

*Sagrada Familia in Barcelona, Spain*

Winchester House

- Sarah Winchester heiress to the Rifle mfr. had a mansion under constant construction from 1884 until 1922
- No blueprints exist for the house, she would sketch ideas for rooms and so forth on paper or even tablecloths

- The mansion is remarkable for oddities such as stairs leading nowhere, interior windows, etc.

Think an enterprise avoids these problems?

- Enterprises regularly develop stovepipes, and systems that don't work together

Thousands of files without referential integrity, foreign key constraints, etc.
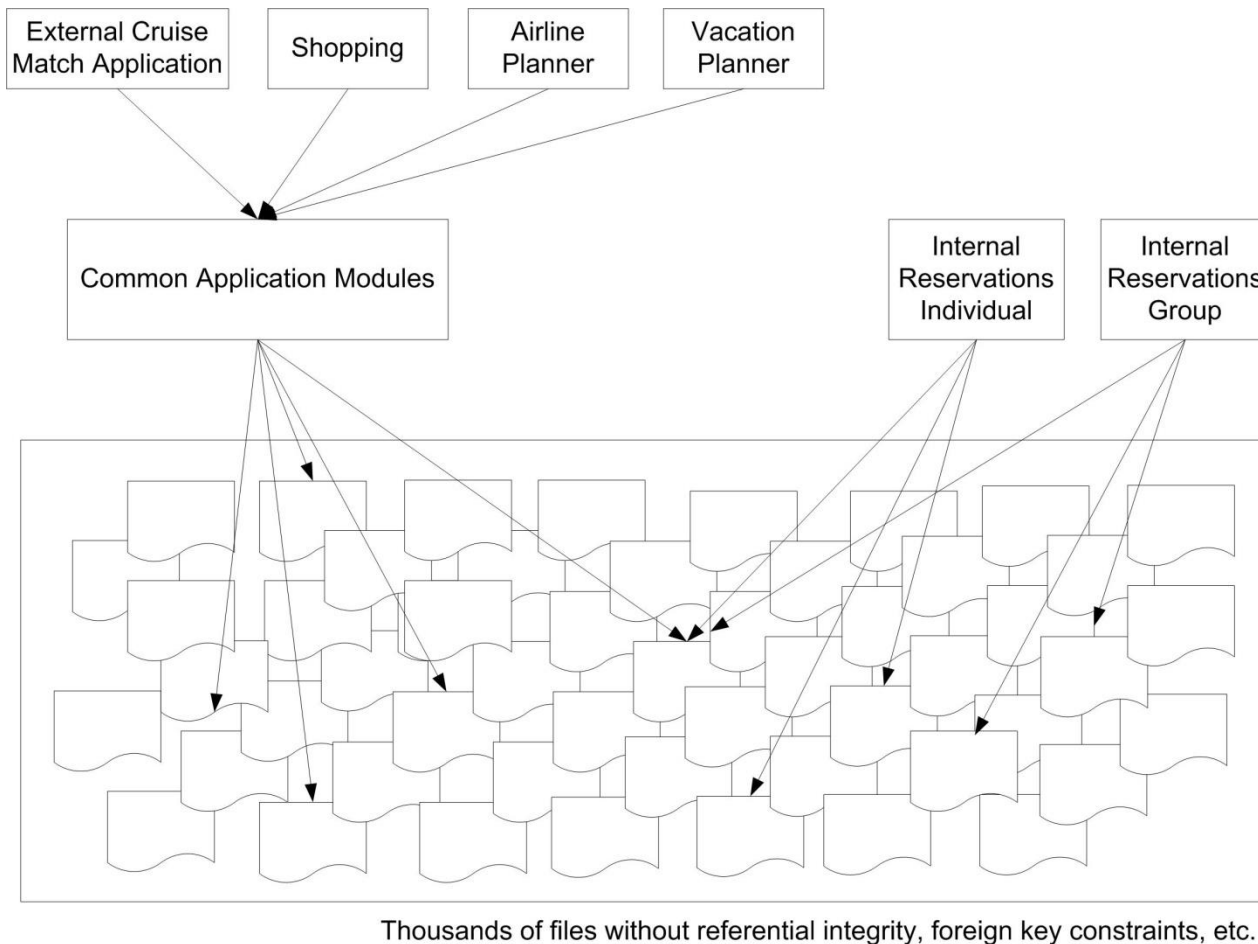
Think an enterprise avoids these problems?

- Departments purchase systems that don't work with other systems!

Engineering
Applicon Bravo

incompatible

Manufacturing
Anvil5000

Print
drawing

Redraw in
Mfg CAD
system

Manufacturing
Engineer
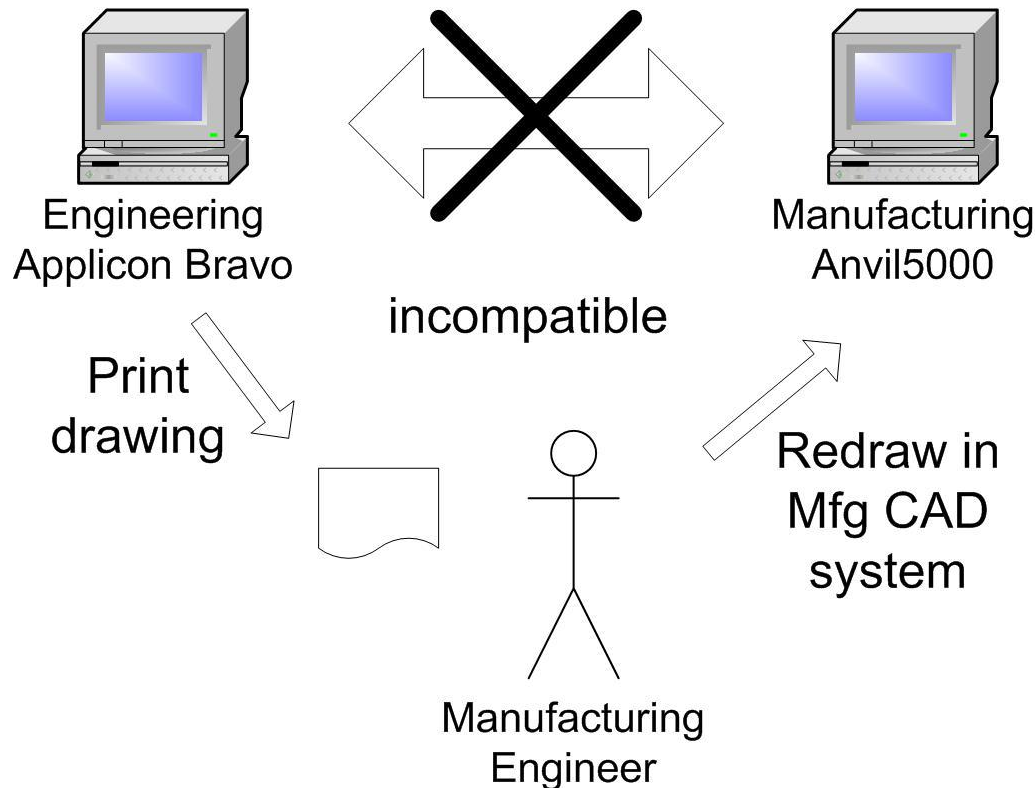
Why enterprise architecture?

- Actually, even simple houses are built to architectures

- Architectures:
  - Ensure compliance to standards
  - Ensure the parts fit together
  - Achieve overall design goals at the lowest cost
  - Breaks up a complex design problem into simpler design problems
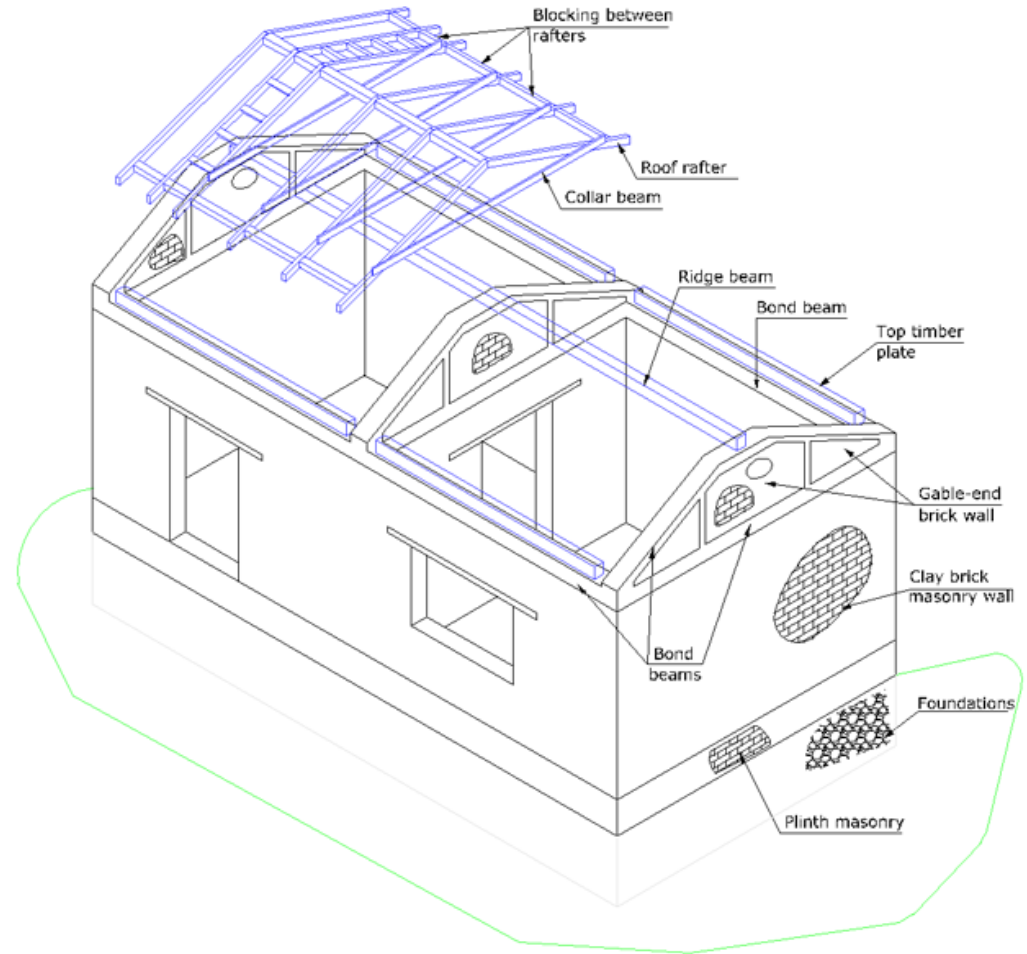
Why enterprise architecture?

- The value of having an architecture is:
  - The primary reason to have an enterprise architecture is to provide an overall, high-level design of the enterprise
   - Since enterprises are not designed in one step, the enterprise architecture provides the structure for all enterprise projects to conform to
    - It expresses architectural principles of a long-term vision
    - It communicates the system design vision and enterprise strategy to all stakeholders
    - It helps management to plan, manage, and effectively utilize the enterprise's resources
    - It can help ensure legal and regulatory compliance

Work with Complexity
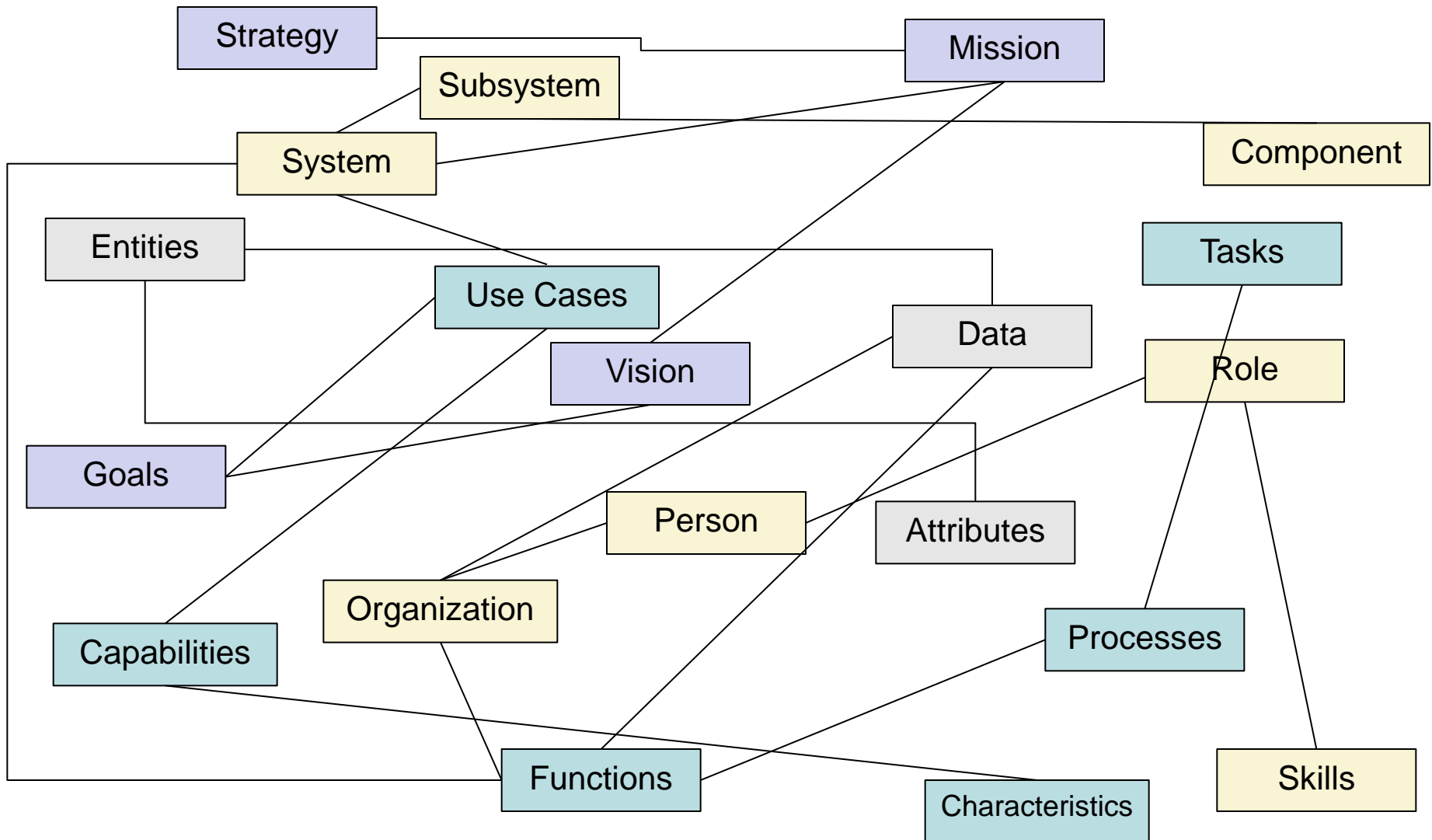
Architecture Organizes Complexity
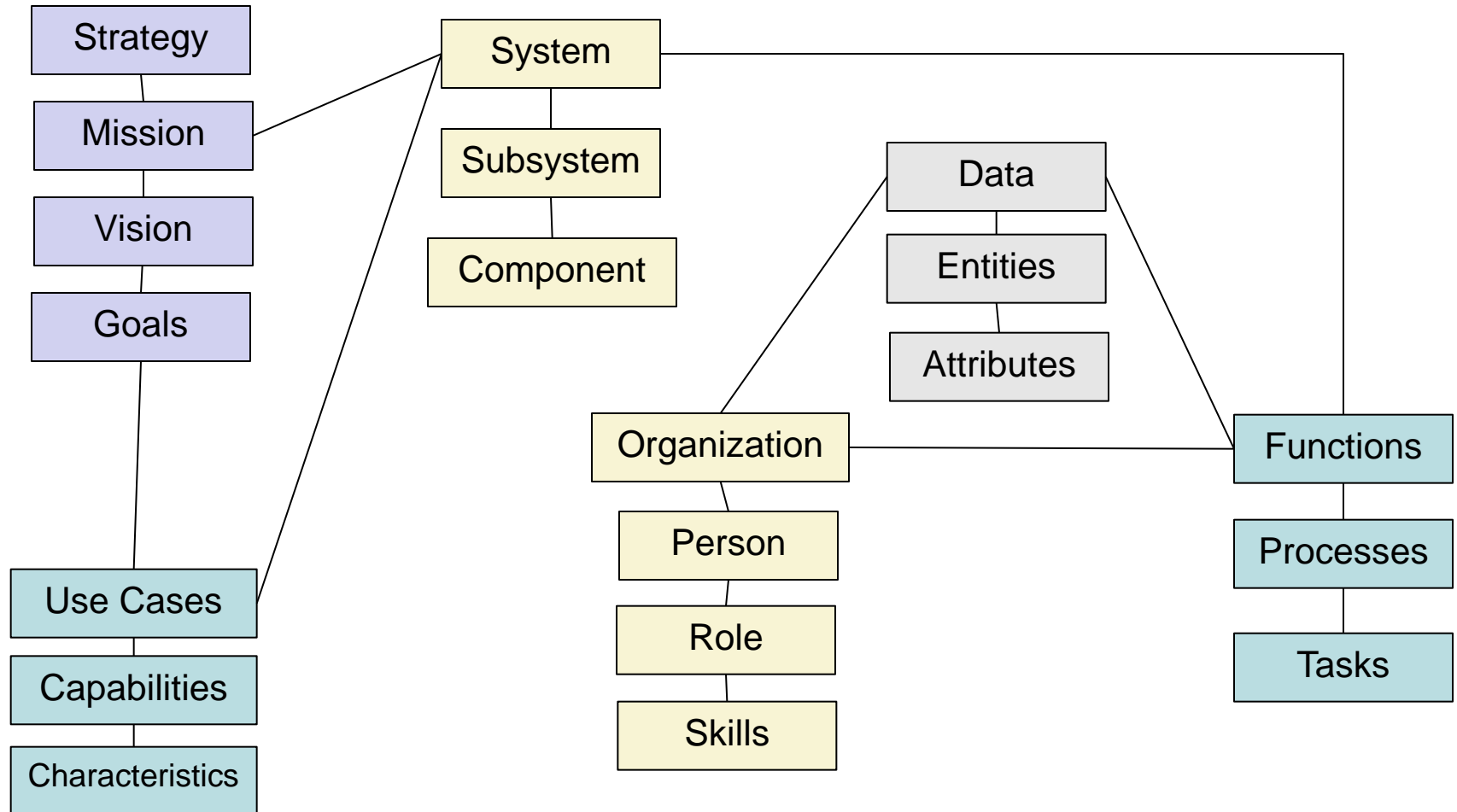
The value of architecture is

- The primary reason to have an enterprise architecture is to provide an overall, ***high-level design*** that
    - Addresses stakeholder needs
    - Shows how those needs will be satisfied
    - Explains the trade-offs required to meet those needs
- Architecture expresses the principles of a long-term vision for the system – it is done to support growth and change because many systems have long expected life-times
- Architecture communicates the system design vision to all stakeholders

Developing an Enterprise Architecture

- Use a ***Reference Architecture*** as a starting point

- It describes a structured set of models that collectively represent the building blocks of the system in a specific domain

- Knowledge Reuse – Reference Architectures embody the knowledge gathered, on a large scale, from a multitude of enterprise engineering projects

Reference Enterprise Architecture

Enterprise Architecture for *Mega Ltd*

Enterprise Architecture for *Acme Mfg*

Enterprise Architecture for *Diamond Corporation*
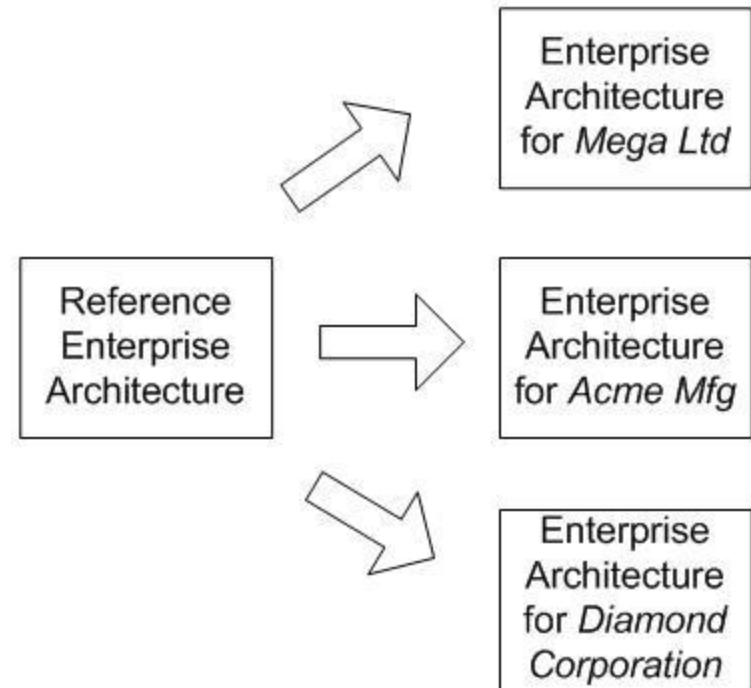
Reference Architectures

- **Zachman's Framework**
  - Original developed at IBM as an IT framework to help clients understand information system projects
  - Expanded to entire enterprise, used as basis for government enterprise architectures
- **Federal Enterprise Architecture**
  - The CIO Council, formed by the CIO's of major government agencies, developed the Federal the Federal Enterprise Architecture Framework [FEAF1999] for the US federal government
- **TOGAF**
  - TOGAF Version 8.1 Enterprise Edition is an industry standard architecture framework that can be freely used by any enterprise developing enterprise architecture for use within [TOGAF2003]
- **CIMOSA**
  - Created by European research consortium for manufacturing systems
- **ARIS**
  - Created in Germany, principles adopted by SAP. Widely used

Zachman's Framework

- The Framework is a logical structure for classifying and organizing the descriptive representations of an Enterprise that are significant to the management of the Enterprise as well as to the development of the Enterprise's systems

- It borrows the ideas from the older disciplines of Architecture/Construction and Engineering/Manufacturing that classify and organize the design artifacts created over the process of designing and producing complex physical products (e.g. buildings or airplanes)

- First developed while Zachman was at IBM, now a separate company

Zachman's Framework

Views

	What	How	Where	Who	When	Why
Scope (Planner's)						
Enterprise Model (Owner's)						
System Model (Designer's)						
Technology Model (Builder's)						
Detailed Representation (Subcontractor's)						
Functioning Enterprise	Data	Function	Network	People	Time	Motivation

Perspectives

- Provides a good classification of the stakeholder views and the enterprise views

- Has 36 cells that need to be filled with artifacts (models)

- Shows how these cells are related horizontally (between views) and vertically (from concept to technical implementation)

- No methodology or guidance on how to fill cells

TOGAF

- The Open Group Architecture Framework (TOGAF) that is developed by The Open Group.
  - **Business architecture** — Describes the processes the business uses to meet its goals. It links strategy formulation to strategy implementation.
  - **Application architecture** — Describes how specific applications are designed and how they interact with each other
  - **Data architecture** — Describes the enterprise's logical and physical data resources and how the data is managed.
  - **Technical architecture** — Describes the hardware and software infrastructure that supports the business processes, applications, and their interactions.
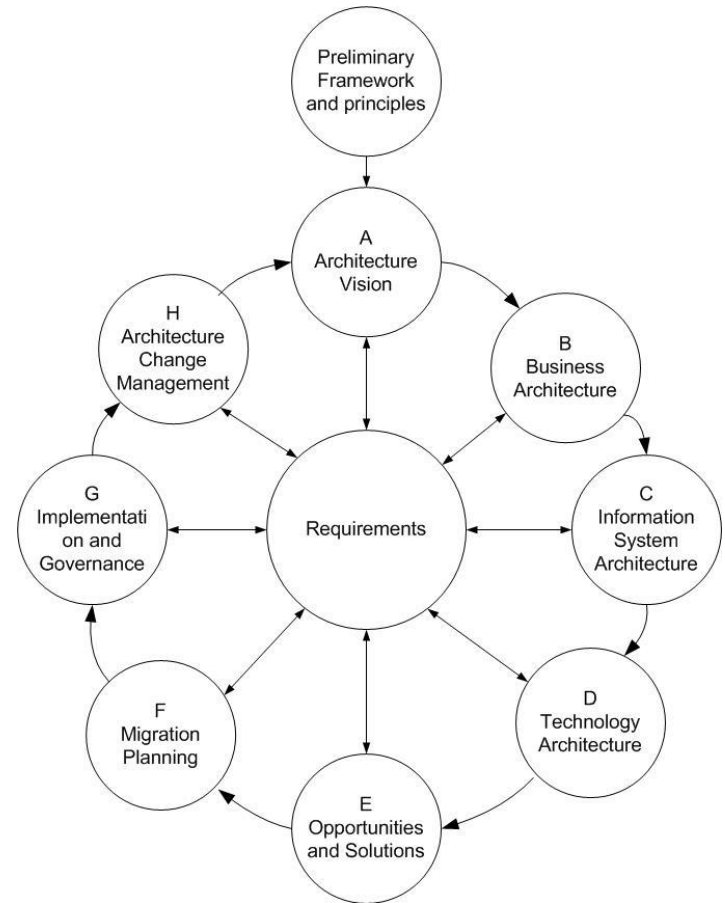
CIMOSA

- Computer Integrated Manufacturing Open System Architecture (CIMOSA)

  - Developed in 1990's by European research consortium (academia, industry, and government)
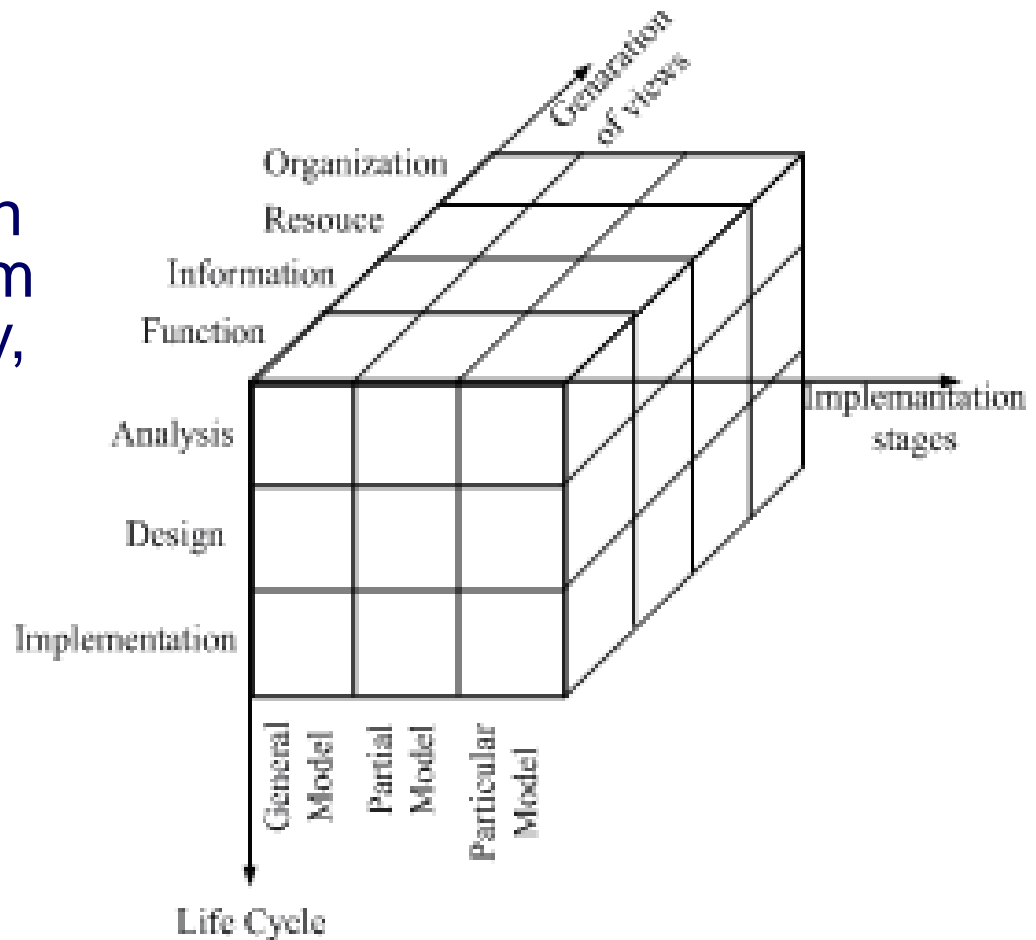
Process Definition

- ## CIMOSA is process-centric

An *enterprise domain* represents a functional area of an enterprise.

A *domain process* is a complete chain of activities flowing through an enterprise, communicating with each other via events and results.

A *business process* is a partially ordered set of process steps defined by a business user to fulfill goals of the enterprise mission.

An *enterprise activity* describes an elementary task of an enterprise to be done using a resource.

The connection of enterprise activities is described by a set of behavioral rules.

Functional operations represent the lowest level of activity decomposition
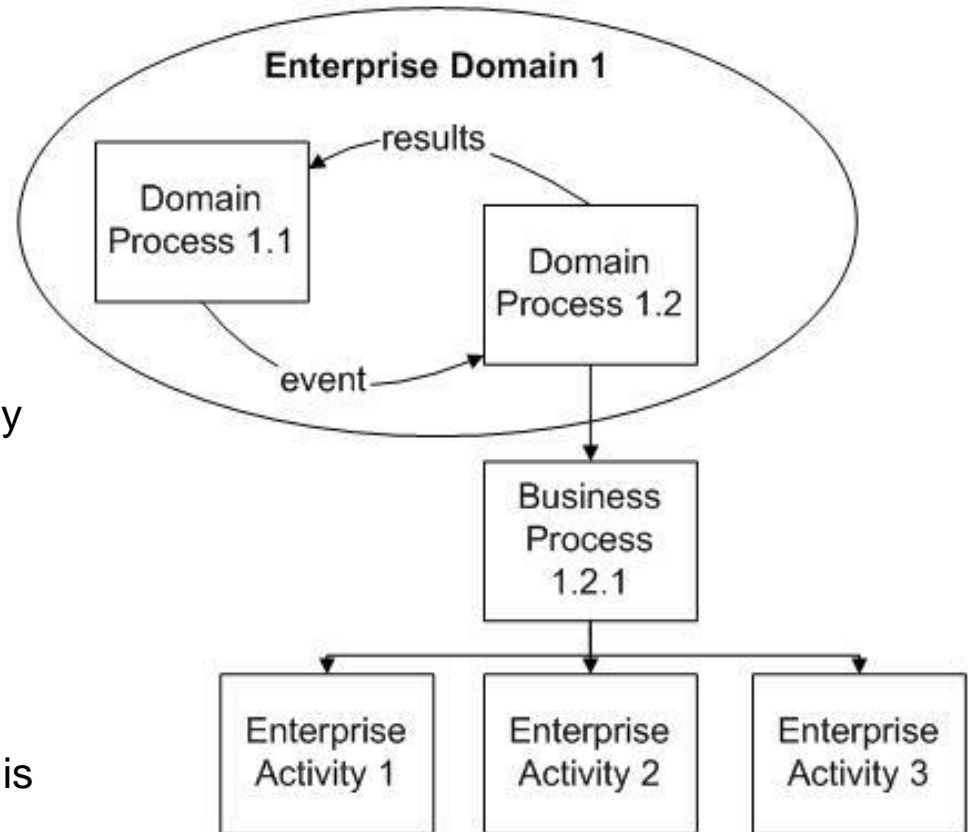
ARIS

- The Architecture of Integrated Information Systems (ARIS) was developed in Germany and has been adopted by SAP, a leading vendor of ERP systems
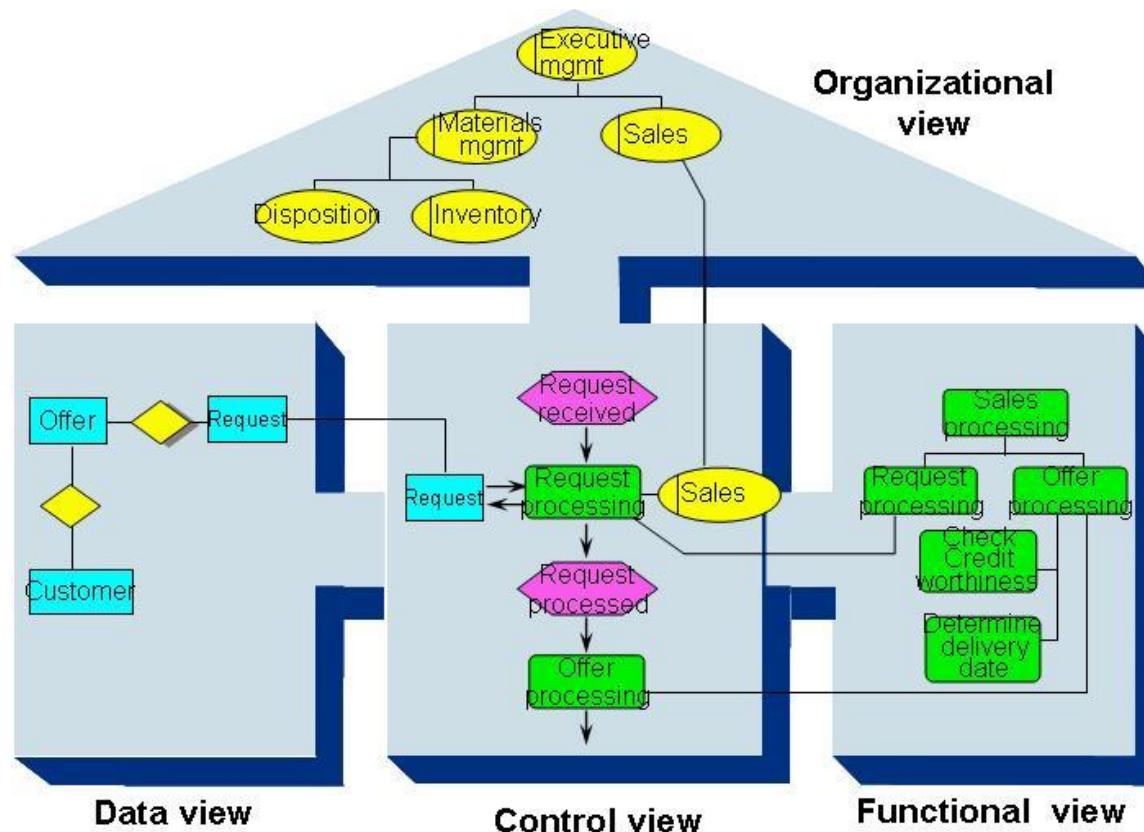
DoD Reference Architecture

- Defines viewpoints
- Defines what to include
- Defines net-centric architecture
- Defines DoD-wide requirements
- Prescribes guidelines for good enterprise architecture
- Describes a methodology to develop an architecture
- Describes how to use the enterprise architecture
- Describes governance of enterprise architecture

U.S. DoD Architecture Framework

Common Architecture Environment

Operational

Operational tasks, elements and information flows required to accomplish military operation

- Op Concept
- Command Relationships
- OpNode Connectivity
- Activity Model
- Op Event/Trace
- Op Info Exchange
- Logical Data Model
- Op State Transition
- Op Rules

System

Systems and interconnections providing for or supporting military operation

- Sys Interface Desc
- System Tech Forecast
- Physical Data Model
- System Performance
- System Rules
- System Event Trace Desc
- System Info Exchange
- Comms Desc
- Systems Functionality
- Op Activity -to- System Func
- Systems Matrix
- State Transition

Technical

Minimal set of rules governing the arrangement, interaction and interdependencies of system parts or elements

- Technology Architecture Profile
- Standards Technology Forecast

What's in an Enterprise Architecture?

- An enterprise architecture contains:

  - Decisions that are enterprise-wide

  - High-level structure defining viewpoints and abstract levels Common views are:
    - Information
    - Process
    - Organization
    - The integration of the views

  - Definition of terminology and architectural principles
    - E.g. ClientID will be the unique identifier across all systems for our clients. A client receives an ID once the client completes an application

  - High-level, strategic decisions
    - E.g., All technology development will be Microsoft tools such as ASP, .Net, VisualBasic

Enterprise Architecture Decisions

	Low impact	High impact
System-wide	Not an architectural decision	Architectural decisions
Local	Not an architectural decision	Not an architectural decision (but architecture might set guidelines and policies)

What's in an Enterprise Architecture?

- EA deals with enterprise-wide, high-level design decisions

EA at this level

Process 1

Subprocess 1.1

Subprocess 1.2

Subprocess 1.3

Activity 1.3.1

Activity 1.3.2

Activity 1.3.3

NOT at this level

Task 1.3.1.1

Task 1.3.1.2

Step 1.3.1.2.1

Step 1.3.1.2.2
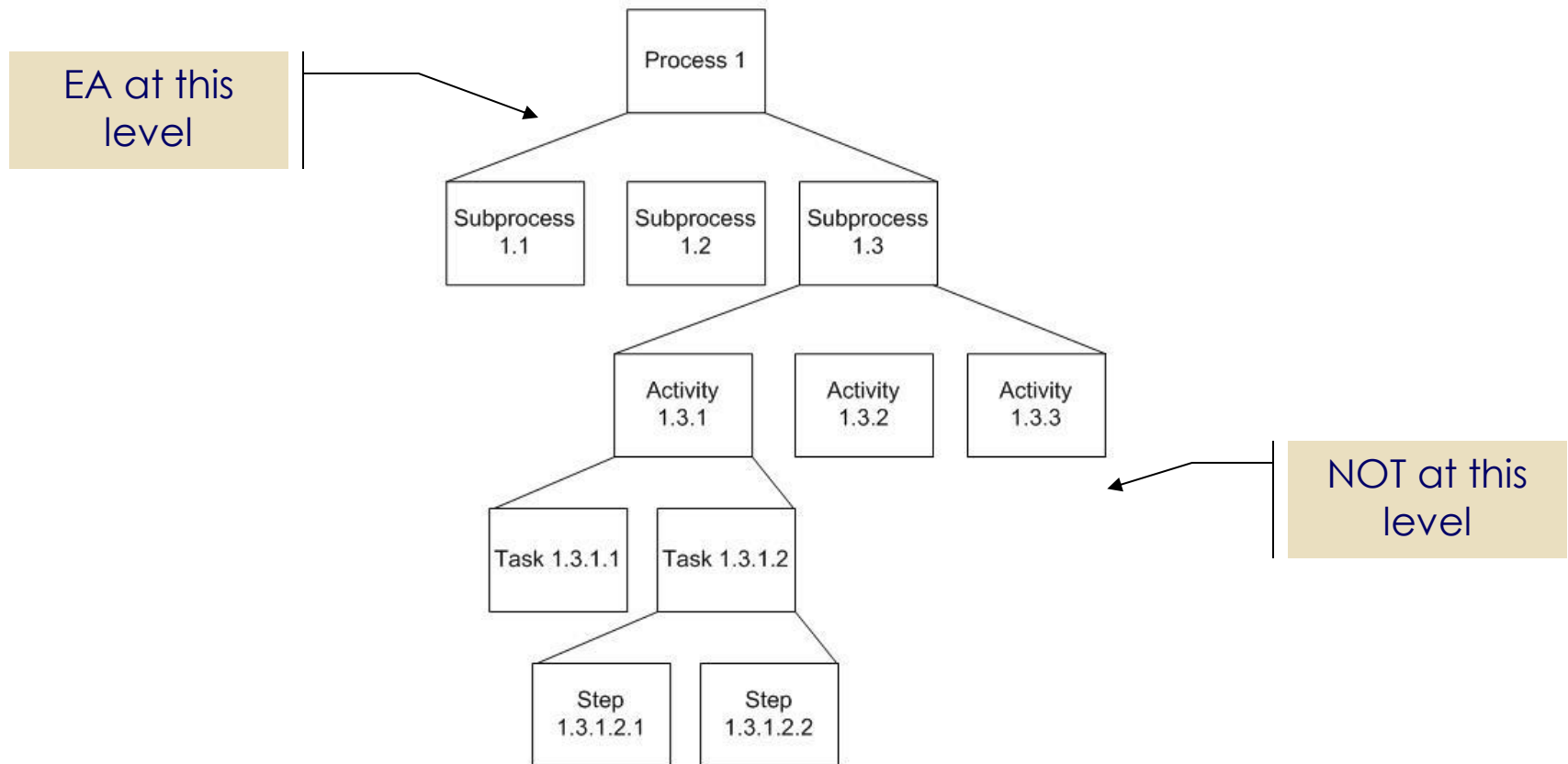
Enterprise Architecture Principles (TOGAF example)

- **Principle 1: Primacy of Principles** – These principles of information management apply to all organizations within the enterprise.

    - Rationale: The only way we can provide a consistent and measurable level of quality information to decision-makers is if all organizations abide by the principles. Implications:

    - Without this principle, exclusions, favoritism, and inconsistency would rapidly undermine the management of information.

    - Information management initiatives will not begin until they are examined for compliance with the principles.

    - A conflict with a principle will be resolved by changing the framework of the initiative.

Enterprise Architecture Principles (TOGAF example)

1. Primary of principles
2. Maximize benefit to the enterprise
3. Information management is everybody's business
4. Business continuity
5. Common use application
6. Service orientation
7. Compliance with the law
8. IT Responsibility
9. Protection of intellectual property
10. Data is an asset
11. Data is shared
12. Data is accessible
13. Data trustee
14. Common vocabulary and data definitions
15. Data security
16. Technology independence
17. Ease of use
18. Requirements-based change
19. Responsive change management
20. Control Technical diversity
21. Interoperability

Characteristics of a Good Architecture

- Resilient
- Simple
- Open in that it is scalable and extendable
- Clear separation of concerns
- Balanced distribution of responsibilities
- Balances economic and technology constraints

System architecture at cruise line

LAPS
Crew Scheduling System

Scheduler

schedule   Penalties
Set assignments

Demand Planning Module

Crew Scheduling Optimization Module

Schedule parameters

Scheduler Interface Module

Overbook levels

Good Design Practice:
Separate application from data

No-Show and Early Departure Data

LAPS Working Data

Crew schedule

rules

Rules Data

Management

Data Extraction

Schedule Generation

Middleware Concept –
Isolate LAPS from external changes:
If enterprise data changes, then only need to update extraction, does not change LAPS System

Crew availability
PAR requirements
Vessel itinerary

Formatted Crew schedule

No-show
Early departure codes

Enterprise Data

Good Design Practice:
Minimum interface with other systems

Functional Architecture of Ship

Source: Jack Abbot, AOC Inc.
in presentation to NPS on April 27, 2006

Magellan Spacecraft Subsystem Block Diagram Shows Some of its Communications Interfaces

Electrical Power Subsystem
- Solar Array
- Shunt Regulator
- Pyro Switching Unit
- Power Control Unit
- Battery
- Power Distribution Unit
- Inverter
- AC / DC To Other Subsystems

Structure Subsystem
- Spacecraft Separation
- Solar Array Deployment
- Solid Rocket Motor Separation
- Spacecraft Structures
- Mechanical Devices Subsystem componenets also shown.

Temperature Control Subsystem
- Heaters
- Louvers
- Black Paint
- White Paint
- Optical Solar Reflectors
- Multi-Layer Insulation

Command, Data & Data Storage Subsystem
- CDS Computer
- Science Data From Radar Subsystem
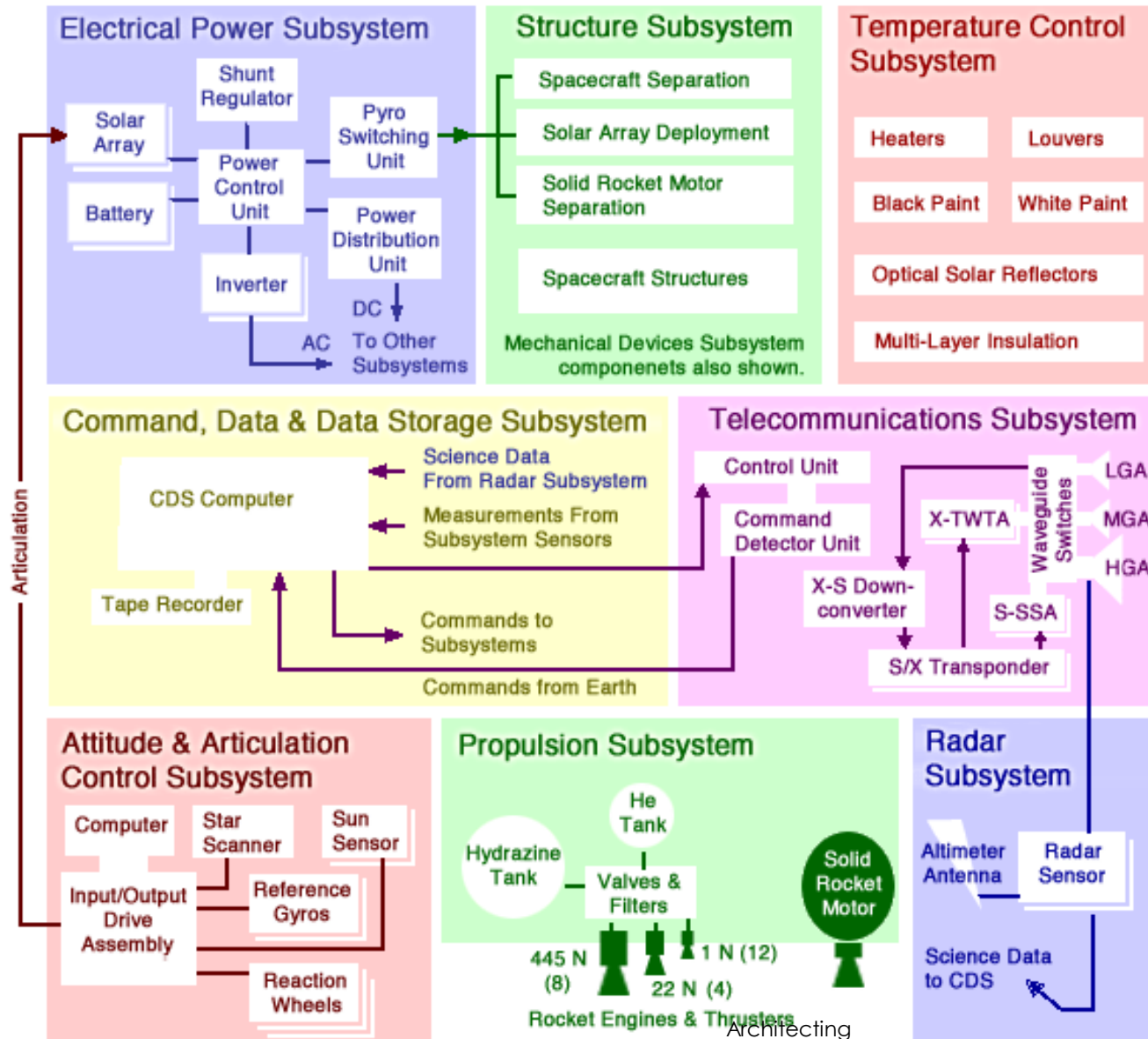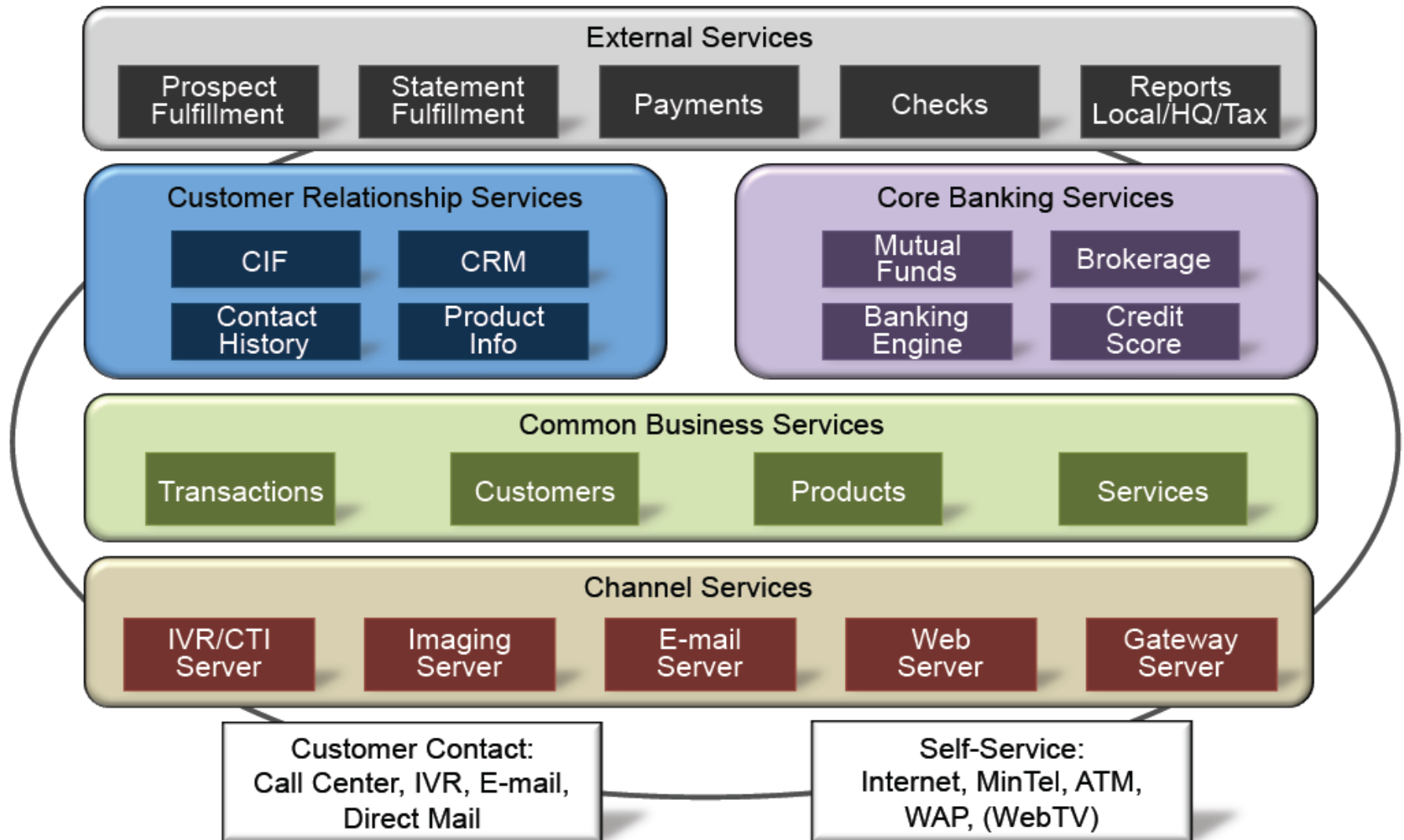- Measurements From Subsystem Sensors
- Tape Recorder
- Commands to Subsystems
- Commands from Earth

Telecommunications Subsystem
- Control Unit
- Command Detector Unit
- X-TWTA
- Waveguide Switches
- LGA
- MGA
- HGA
- X-S Down-converter
- S-SSA
- S/X Transponder

Attitude & Articulation Control Subsystem
- Computer
- Star Scanner
- Sun Sensor
- Input/Output Drive Assembly
- Reference Gyros
- Reaction Wheels
- Articulation

Propulsion Subsystem
- He Tank
- Hydrazine Tank
- Valves & Filters
- Solid Rocket Motor
- 445 N (8)
- 22 N (4)
- 1 N (12)
- Rocket Engines & Thrusters

Radar Subsystem
- Altimeter Antenna
- Radar Sensor
- Science Data to CDS

Architecting

From NASA's Space Systems Engineering training

ING DIRECT's Replication Operating Model

External Services
- Prospect Fulfillment
- Statement Fulfillment
- Payments
- Checks
- Reports Local/HQ/Tax

Customer Relationship Services
- CIF
- CRM
- Contact History
- Product Info

Core Banking Services
- Mutual Funds
- Brokerage
- Banking Engine
- Credit Score

Common Business Services
- Transactions
- Customers
- Products
- Services

Channel Services
- IVR/CTI Server
- Imaging Server
- E-mail Server
- Web Server
- Gateway Server

Customer Contact: Call Center, IVR, E-mail, Direct Mail

Self-Service: Internet, MinTel, ATM, WAP, (WebTV)

Architecture & Engineering

Architecture defines the
parameters and overall constraints

- Holistic
- Satisficing
- Heuristic
- Ambiguous
  'fuzzy' needs
- High
  uncertainty

Engineering optimizes
the parameters subject to
the constraints

- Reductionist
- Optimizing
- Algorithms
- Requirements
- Less uncertainty

Commercial Example

- **SAP Solution Maps** are designed to be used as a tool to help visualize, plan, and implement a coherent, integrated, and comprehensive information technology solution within a company

- Two Levels

  - **Level I**: a broad picture of the major processes within each industry. These are arranged in process categories and represent the critical business processes for an industry.

  - **Level II**: a more detailed view of the specific functionality required for each process.

Insurance - Edition 2001

Enterprise Management	Strategic Enterprise Management		Business Intelligence	Managerial Accounting	Financial Accounting
Customer Relationship Management	Customer & Prospect Management	Agency & Broker Management	Direct Business Management	Relationship Marketing Management	Sales Management
Marketing & Product	Market Research & Analysis	Risk Analysis	Premium Calculation & Rate Setting		Product Development
Sales	Commissions	Sales Support	New Business & Renewals	Business Development	Sales Controlling
Operational Management	Policy Management	Commission Management	Claims Management / Reinsurance	Pension Funds Administration	Collections & Disbursements
Investment Management	Asset Allocation	Portfolio Management	Portfolio Accounting	Controlling & Performance	
Business Support	Human Resource Core Functions & Strategy	Human Resource Analytics & Enabling Solutions / Procurement		Treasury/ Corporate Finance Management	Fixed Asset Management

Automotive OEM - Edition 2001

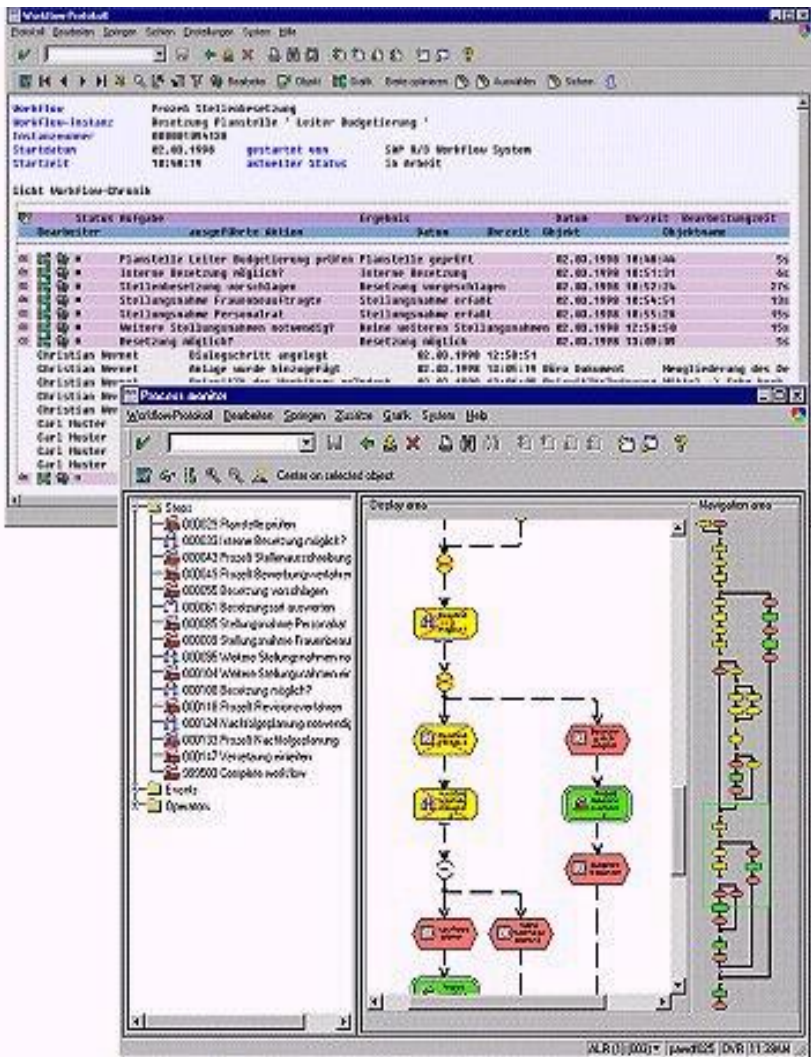| Enterprise Management	Strategic Enterprise Management		Business Intelligence		Managerial Accounting		Financial Accounting
Customer Relationship Management	Market Research & Analysis	Product/Brand Marketing	Marketing Program Management	Sales Management	Sales Cycle Management	Sales Channels	Installation Management
Engineering OEM	Engineering Projects	Product Engineering	Process Engineering		Target Costing	Product Data Management	
Supply Chain Planning & Monitoring OEM	Variant Demand Management	Resource Planning	Order Scheduling & Sequencing	Distribution Planning	Supply Chain Monitoring	Supplier Workplace	
Procurement OEM	Strategic Purchasing	Operative Procurement	Inbound Logistics	Inventory Management	Billing	Vendor Performance	
Manufacturing OEM	Supply to Line	Manufacturing Execution	Quality Management	Manufacturing Confirmation & Monitoring			
Sales OEM	Sales Planning	Direct Sales	Sales Execution	Vehicle Distribution	Billing	After-Sales Tracking	
Completely Knocked-Down Kits (CKD)	Planning	Packing & Shipping	Kit Management	Assembly	Manufacturing Confirmation & Monitoring		
Business Support	Human Resource Core Functions & Strategy	Human Resource Analytics & Enabling Solutions	Procurement	Treasury/Corporate Finance Management	Fixed Asset Management		

Automotive OEM - Edition 2001

Engineering OEM

Engineering Projects	Product Engineering	Process Engineering	Target Costing	Product Data Management
● New Platform Development (*S2*)	● Definition of Options (*S2*)	● Line Layout Definition (*S2*, *S20*, *S110*)	● Calculation for configured products (*S1*)	● Product Variant Structure (PVS) (*S20*, *S110*)
● Supplier Development (Localization) (*S2*)	● Engineering Constraints (*S2*)	● Takt Time Calculation (*S2*)	◉ Calculation for Assembly Groups (*S1*)	● Bill of Material/Configured BOM (*S2*)
℗ Supplier/Parts Catalogue (*S2*, *P42*)	● Marketing Constraints (*S2*)	● Line Balancing (*S2*, *S110*)	● Simulation (*S1*)	℗ CAD Integration (*S2*, *S110*, *P103*)
● Project Cost Tracking (*S1*)	● Product Structure (*S2*, *S110*)	● Master Data for Material Flow (*S20*, *S110*)	◉ Costing of Options (*S1*)	● Engineering Change Management (*S110*)
● Project Schedule Tracking (*S2*)	● Views on the Product Structure (*S110*)	◉ Simulation of Material Flow (*S2*)		● Configuration Management (*S2*)
● Work Breakdown Structure (*S2*)	● Completeness Check (*S110*)	● Tooling/PRT (*S2*)		● Revision Level (*S2*)
	● Consistency Check (*S110*)	● Operational Methods Sheets/Process Sheets (*S2*)		● Digital Mock-Up (DMU) (*S2*, *S110*)
	● Simulation (*S2*)	● Activities (*S110*)		℗ Document Management (*S2*, *P102*)
	● Link to Sales & Configuration Engine (*S32*)			● Classification (*S2*)
	◉ Customization Engineering (*S2*)			● Concurrent Engineering/Distribution & Exchange of Product Data (*S2*)

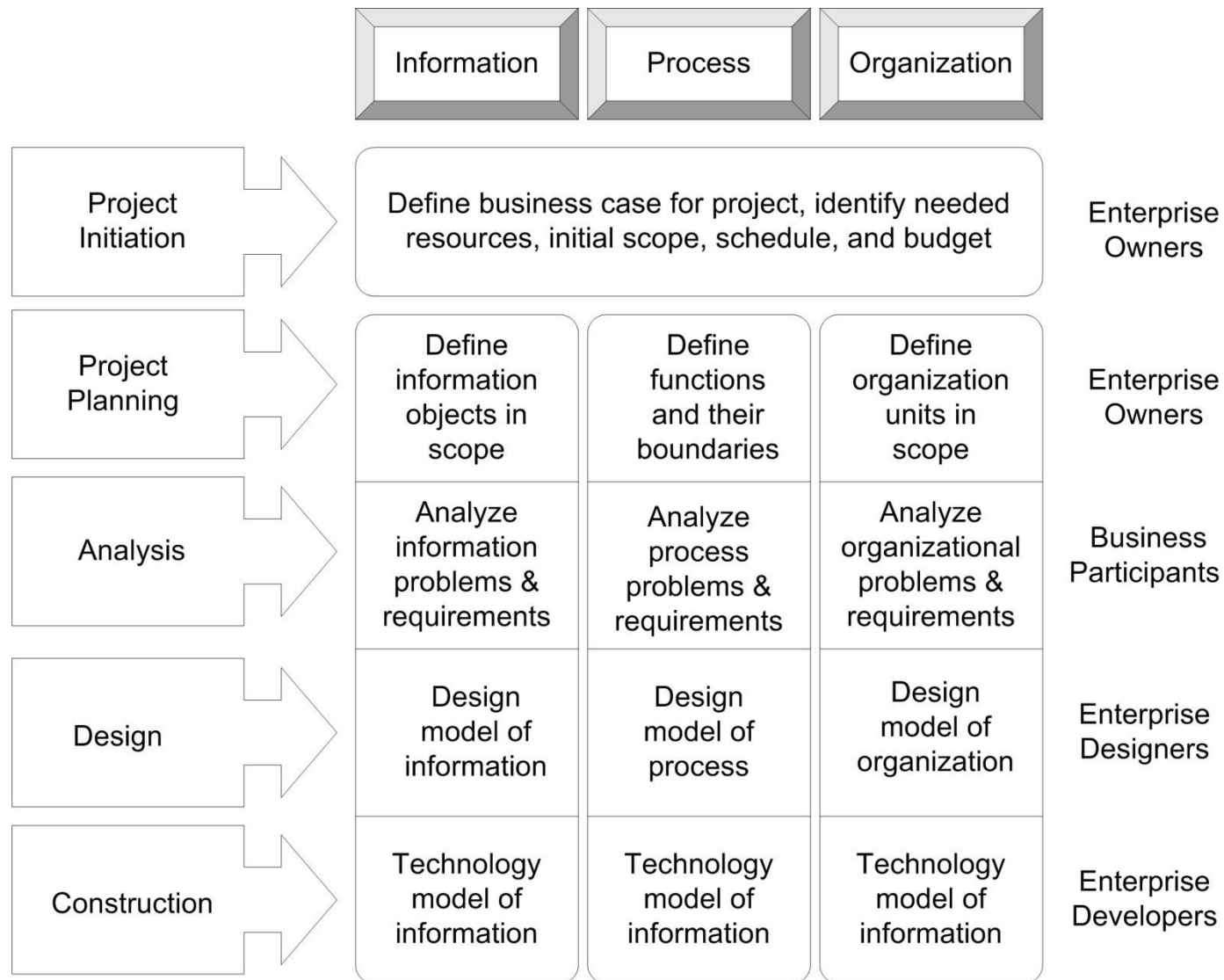|				
●	SAP Component Available	℗	Partner Product Available	
▶	SAP Component Available with Future Releases	▷	Partner Product Available with Future Releases	
◉	Future Focus	Sxx	SAP Component	
◉	Link to Collaborative Business Map	Pxx	Partner Product	

Please note that the Solution Map, containing proprietary information of SAP AG, reflects SAP's current development intentions, which are subject to change. Future focus coverage may be provided by SAP or SAP partners. Check for local availability of all SAP and SAP partner solutions. ® SAP AG 2001

General Information

Engineering Projects

SAP Business Workflow

An Enterprise Reference Architecture

	Information	Process	Organization	
Project Initiation	Define business case for project, identify needed resources, initial scope, schedule, and budget			Enterprise Owners
Project Planning	Define information objects in scope	Define functions and their boundaries	Define organization units in scope	Enterprise Owners
Analysis	Analyze information problems & requirements	Analyze process problems & requirements	Analyze organizational problems & requirements	Business Participants
Design	Design model of information	Design model of process	Design model of organization	Enterprise Designers
Construction	Technology model of information	Technology model of information	Technology model of information	Enterprise Developers

Summary

- You should be able to:
    - Define enterprise architecture
    - Explain business and technical reasons why an enterprise would want to develop an architecture
    - Describe what an enterprise architecture contains and provided a few partial examples
    - Describe and compare the different reference architectures and how they are used to derive enterprise architectures
    - Describe what an enterprise architecture should contain