An Enterprise Systems Engineering Framework

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INCOSE International Symposium

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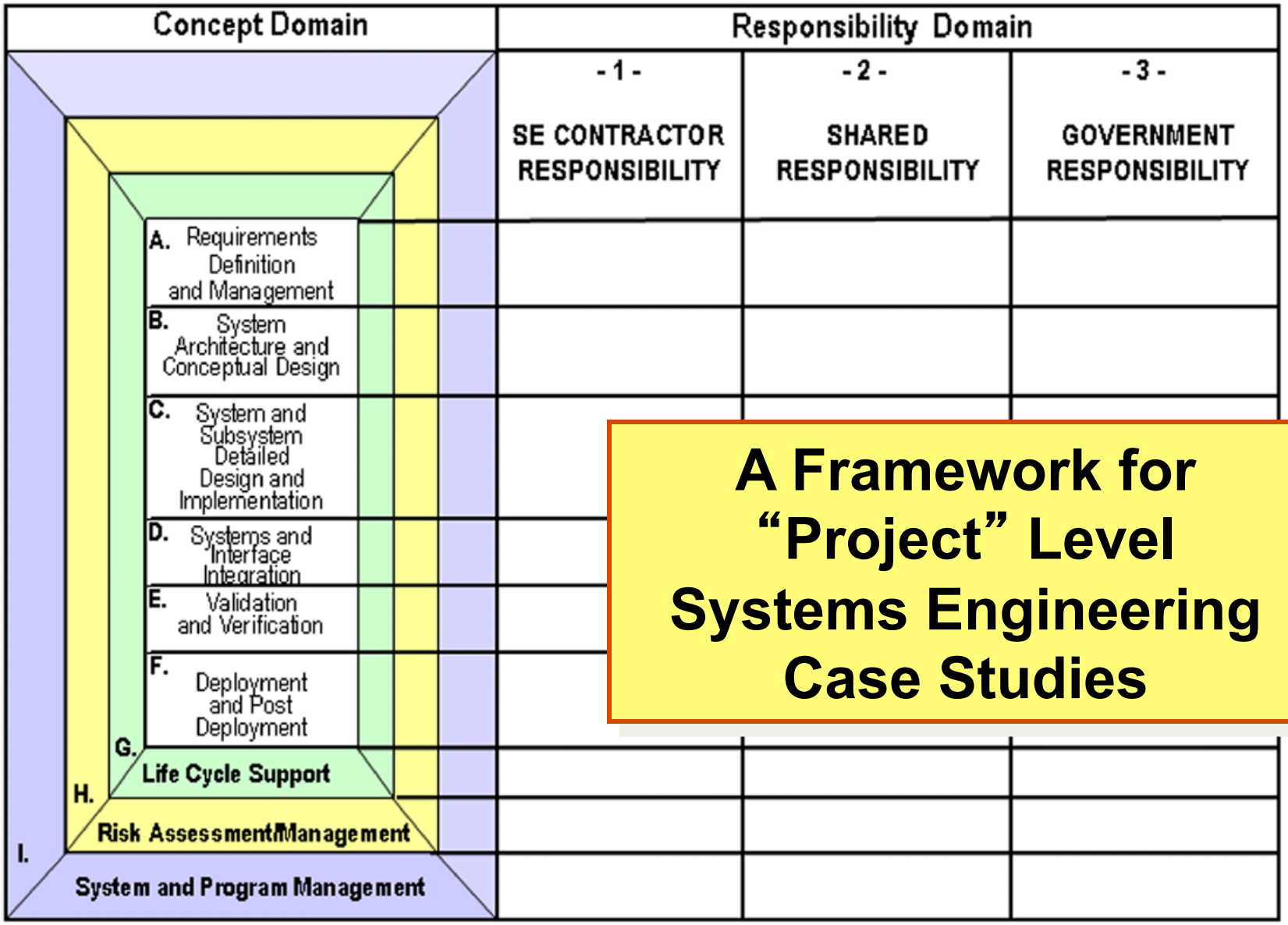
Friedman-Sage Case Study Framework

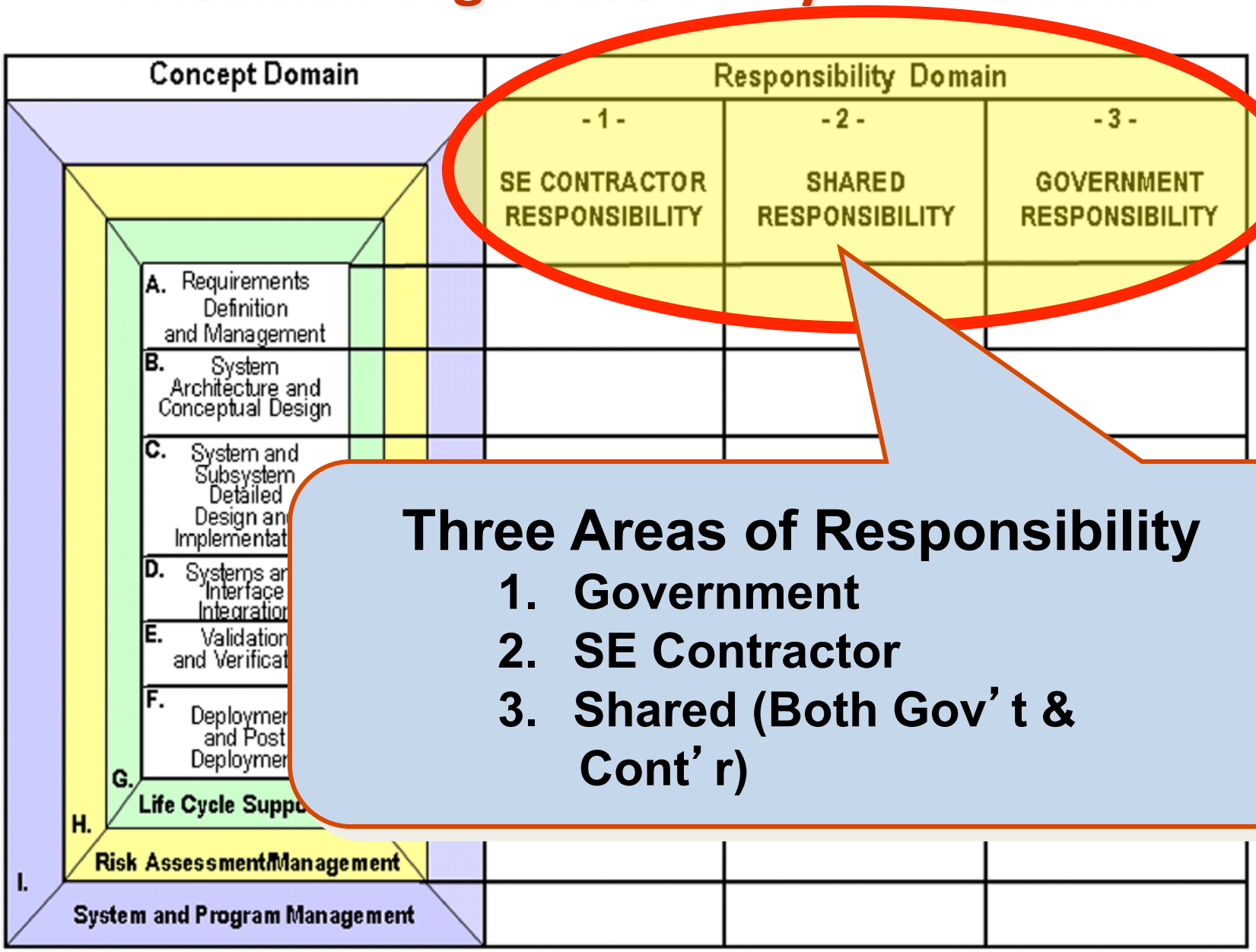


A Framework for "Project" Level Systems Engineering Case Studies

Case Study Frameworks

- Case Studies
  - An evaluation research approach
  - Builds a basis for valid inferences
    - From case study "events"
    - From evidence collected
- Case Study Framework
  - Provides a structure for
    - Collecting evidence
    - Articulating questions
    - Categorizing "events"
  - Facilitates comparison of case study results
    - Providing a common structure
    - Providing common understanding of a domain of interest

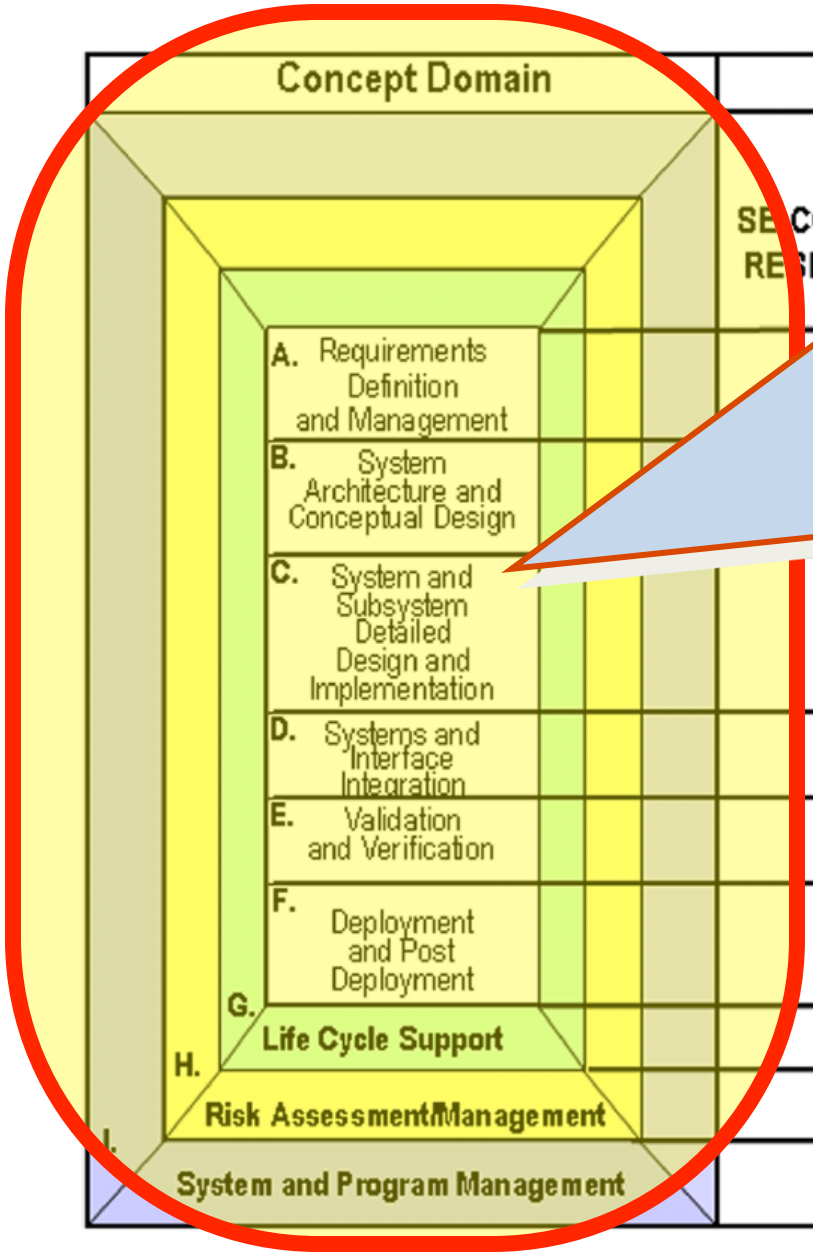
Friedman-Sage Case Study Framework



Three Areas of Responsibility

1. **Government**
2. **SE Contractor**
3. **Shared (Both Gov't & Cont'r)**

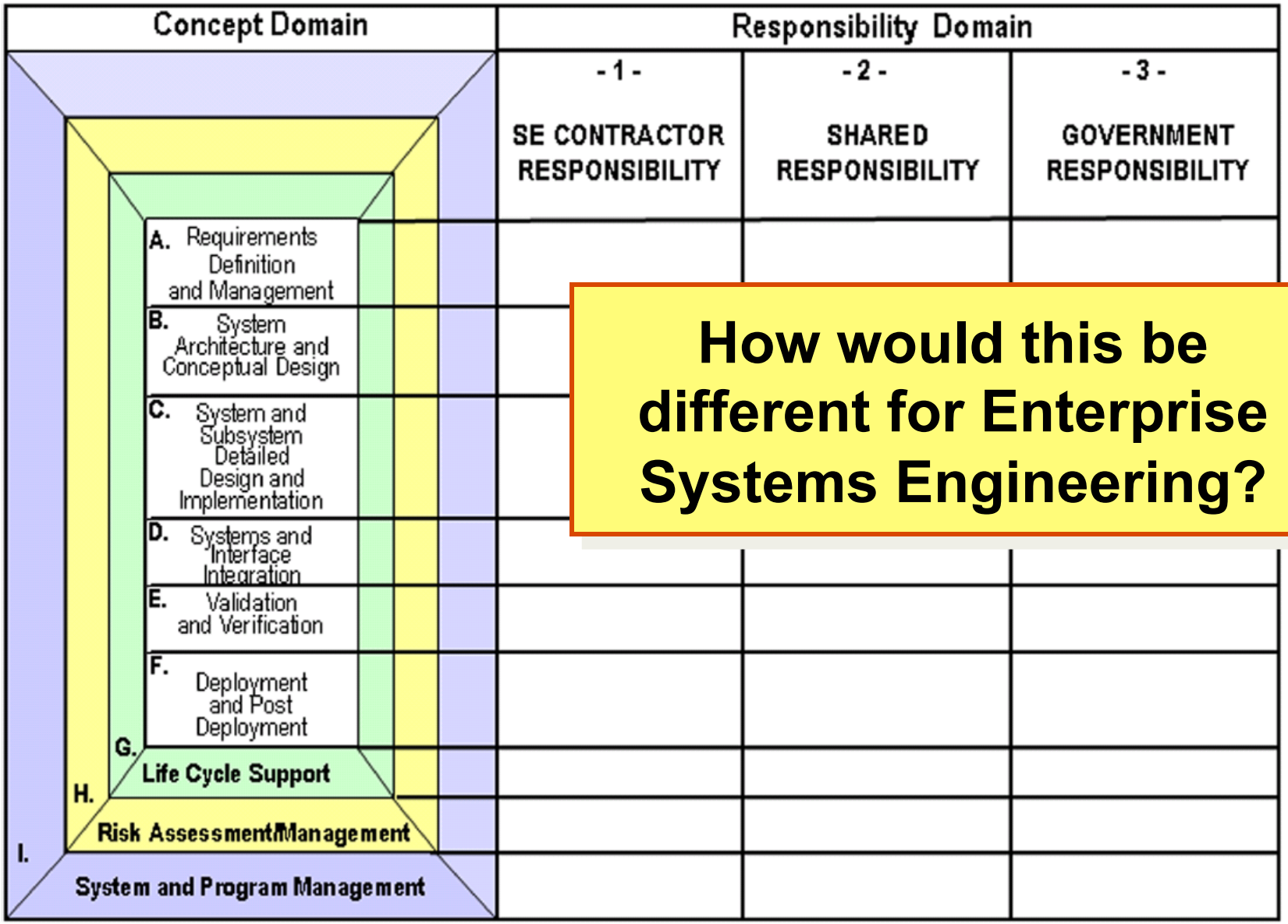
Friedman-Sage Case Study Framework



Nine Concept Domains

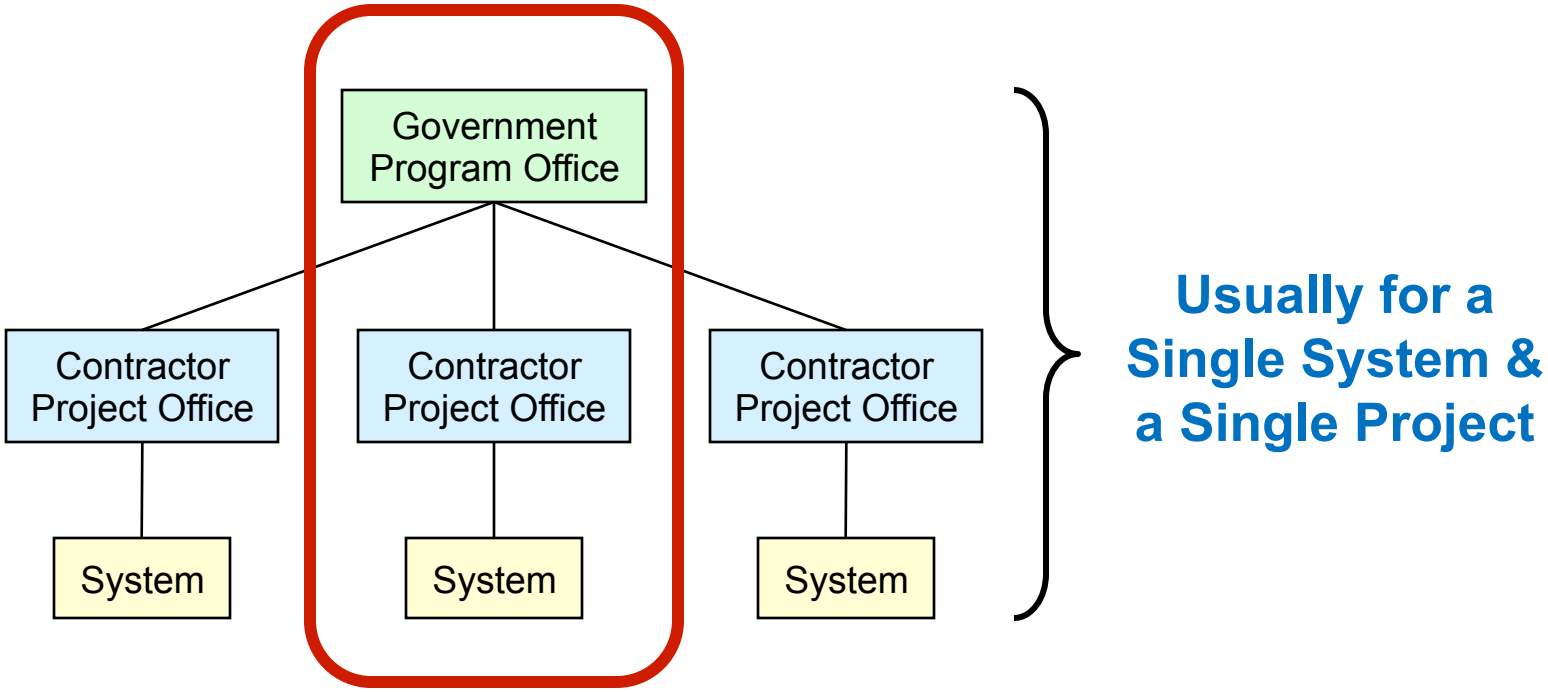
1. Requirements
2. Architecture
3. Detailed Design & Implementation
4. Integration & Interfaces
5. Verification & Validation
6. Deployment
7. Lifecycle Support
8. Risk
9. Management

Friedman-Sage Case Study Framework

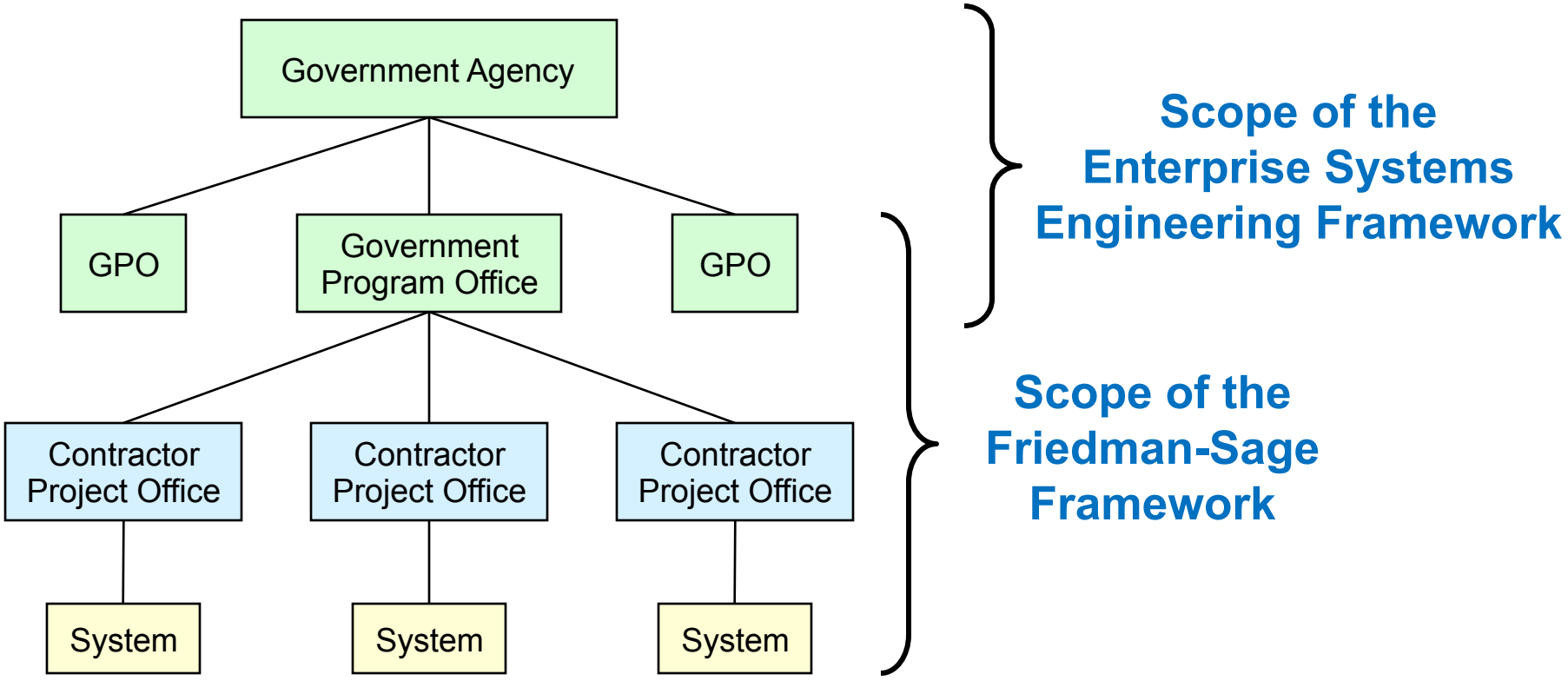


How would this be different for Enterprise Systems Engineering?

Scope of the Friedman-Sage Framework



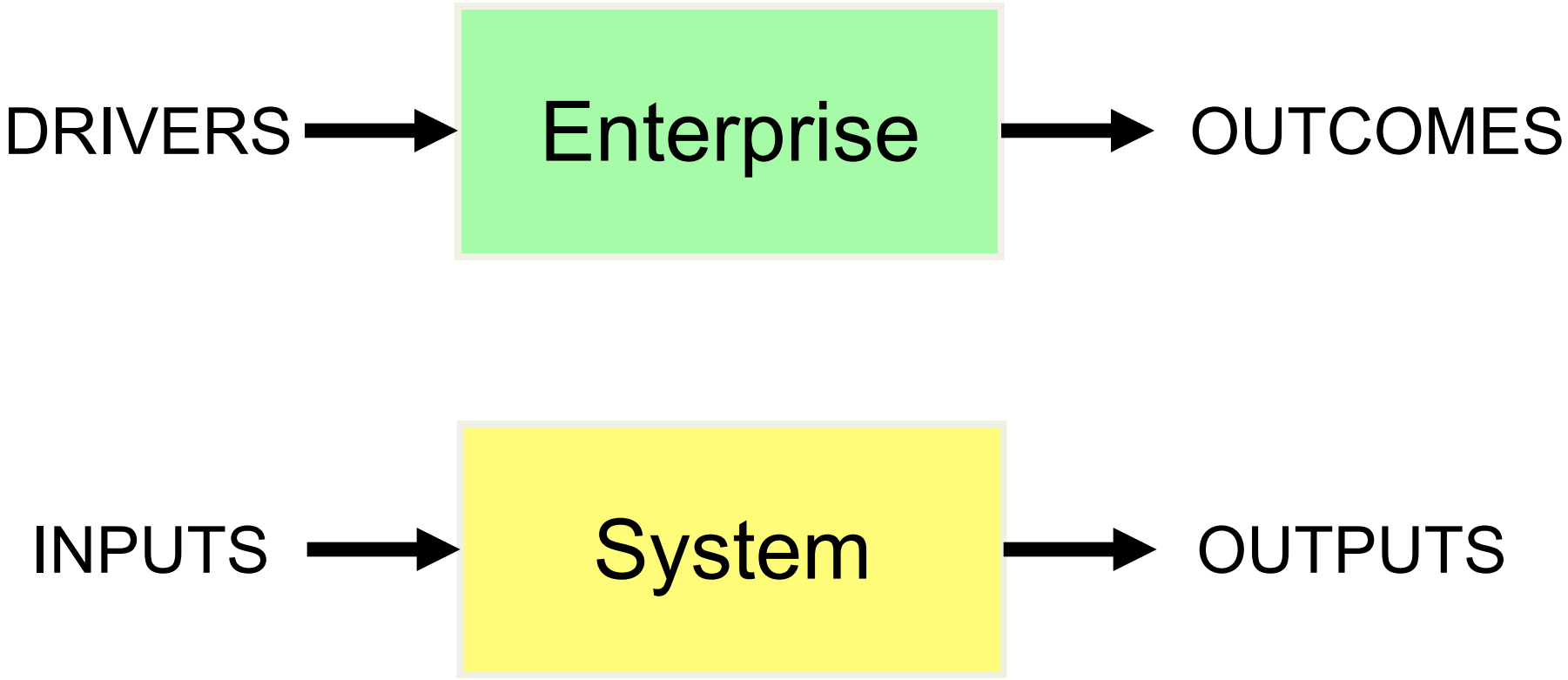
Expanded Scope for ESE



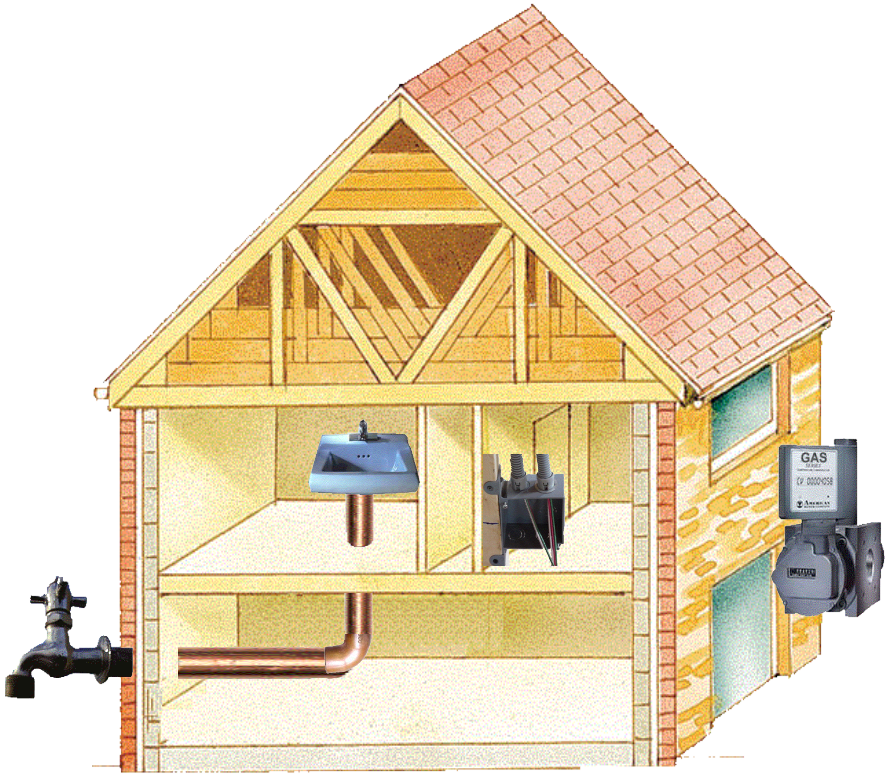
What is an Enterprise?

- **A bold, new business venture**
- **Everything required to accomplish a large, complex undertaking**
- **An Enterprise uses Resources (People, Policies, Practices, Platforms, Money, Energy, Facilities, Infrastructure & Systems) to accomplish its Goals and Objectives**

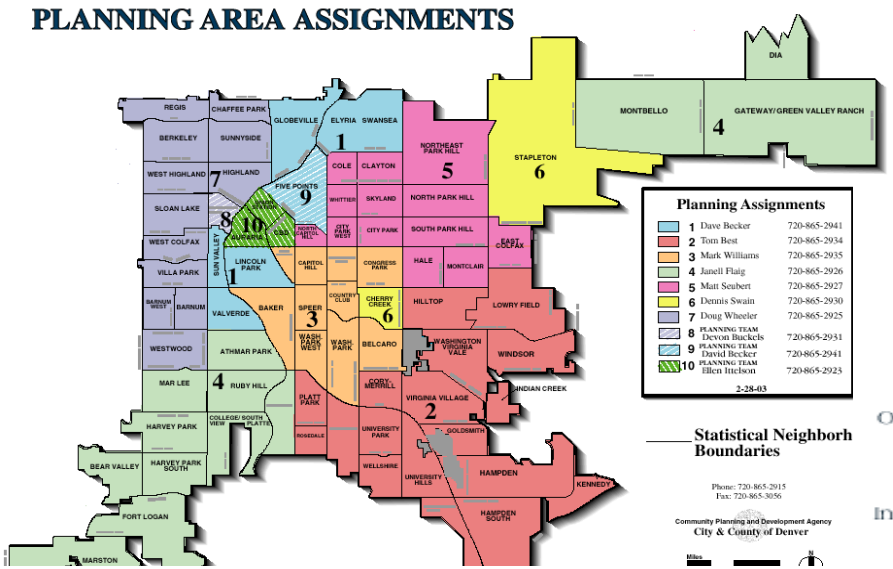
Systems vs. Enterprises

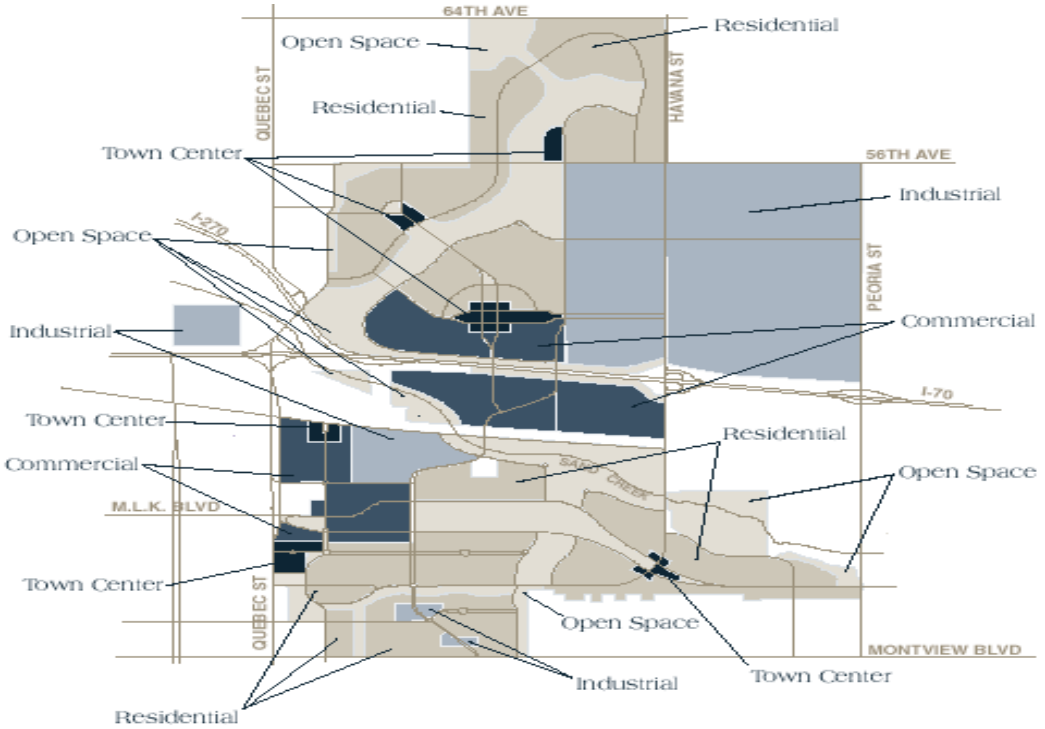


System Architecture is Like Blueprints for a Building



Enterprise Architecture is Like Urban Planning

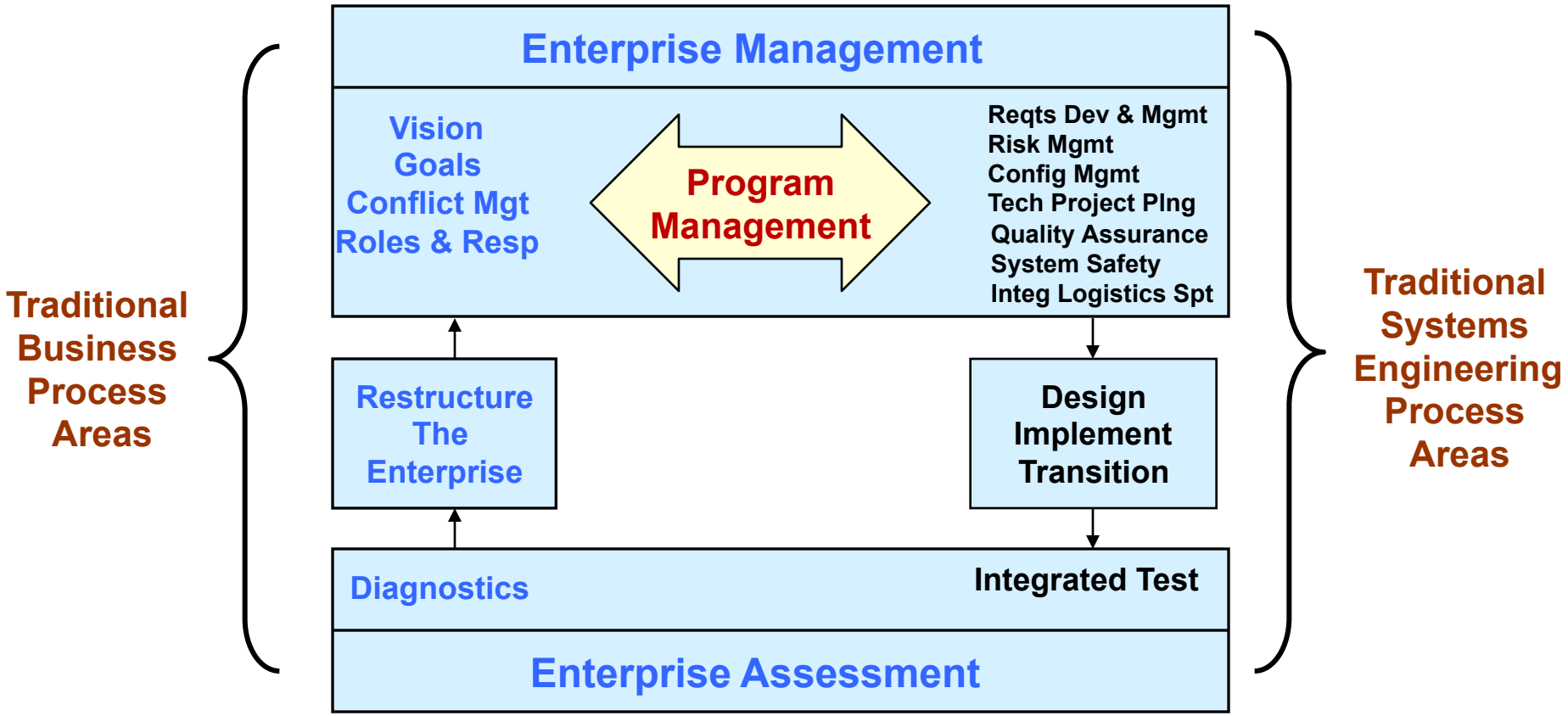




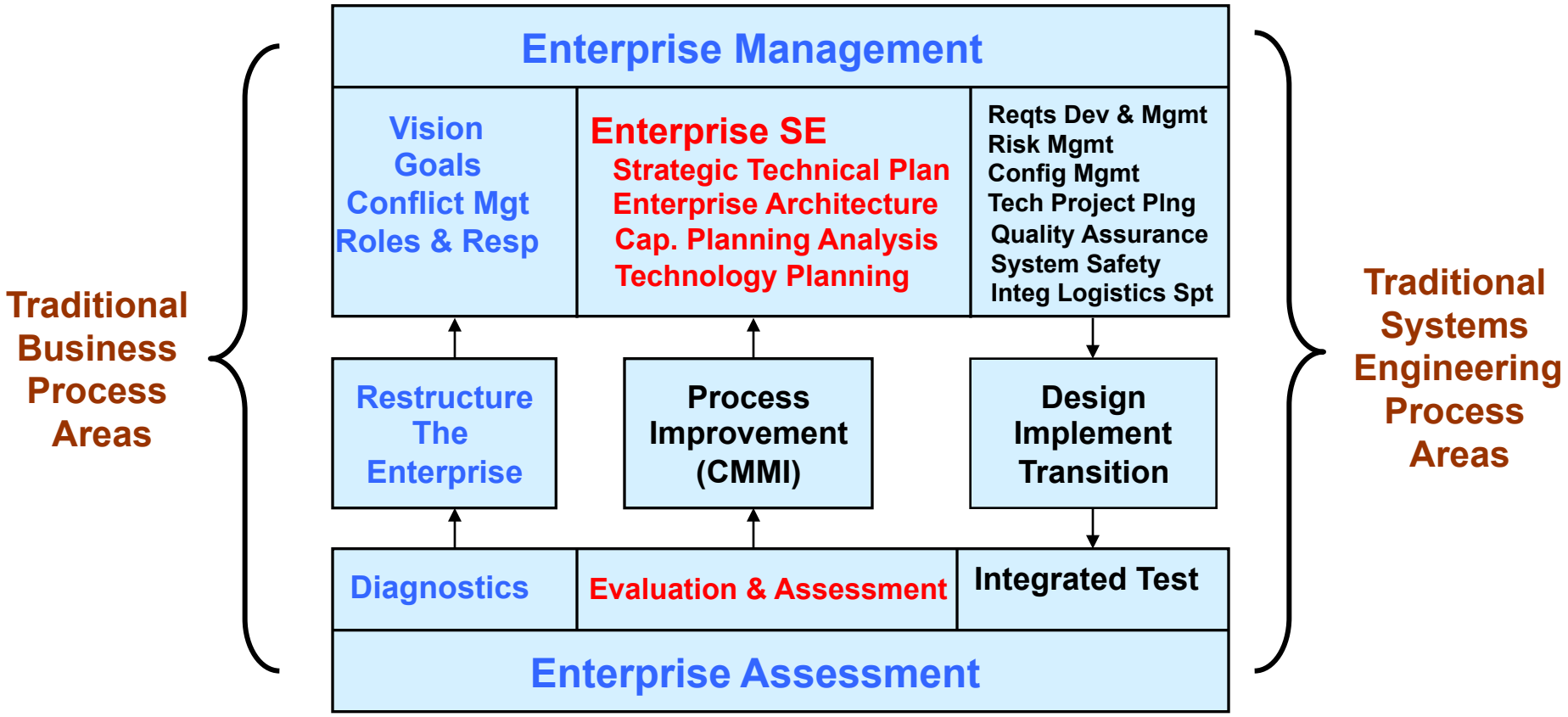
Concept Domain	Responsibility Domain		
	1. Program Responsibility	2. Shared Responsibility	3. Enterprise Responsibility
A. Strategic Technical Planning			
B. Capability-Based Planning Analysis			
C. Technology and Standards Planning			
D. Enterprise Requirements Definition and Management			
E. Enterprise Architecture and Conceptual Design			
F. Program and Project Detailed Design and Implementation			
G. Program Integration and Interfaces			
H. Program Validation and Verification			
I. Deployment and Post Deployment			
J. Program Life Cycle Support			
K. Risk and Opportunity Management			
L. Enterprise Evaluation and Assessment			

New Enterprise-Level SE Case Study Framework

Business & SE Process Areas



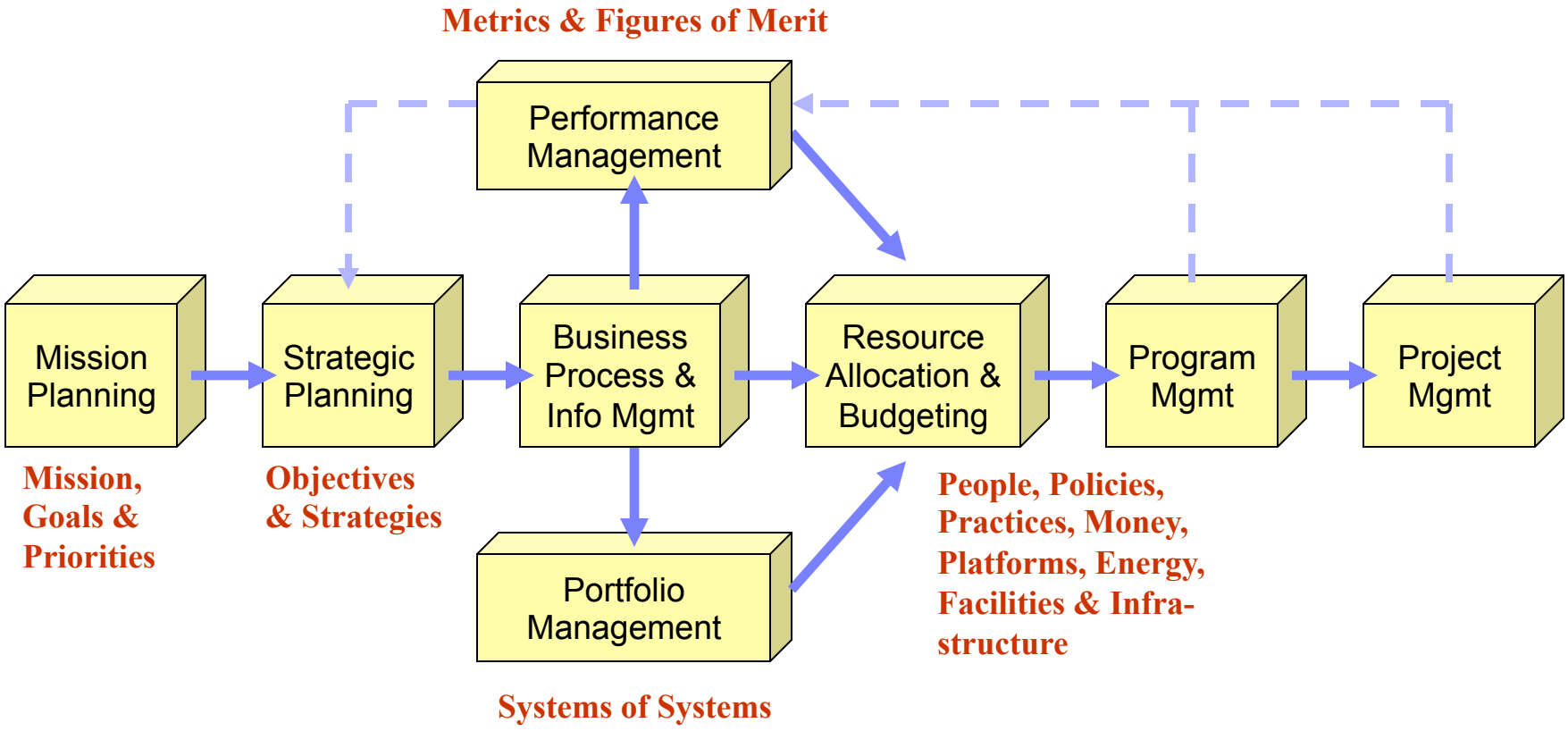
Adding Enterprise SE Process Areas



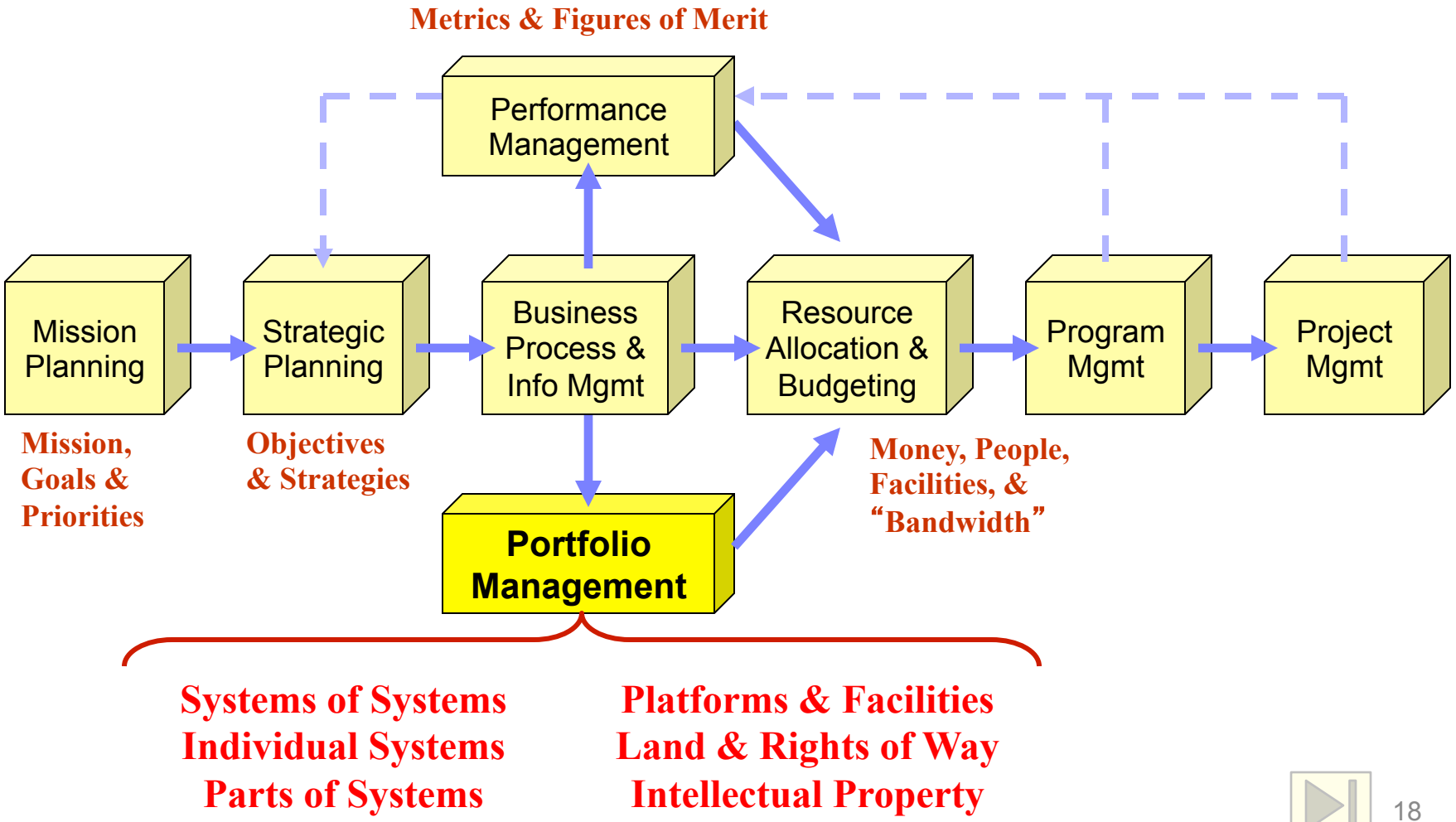
Enterprise-Level SE Processes

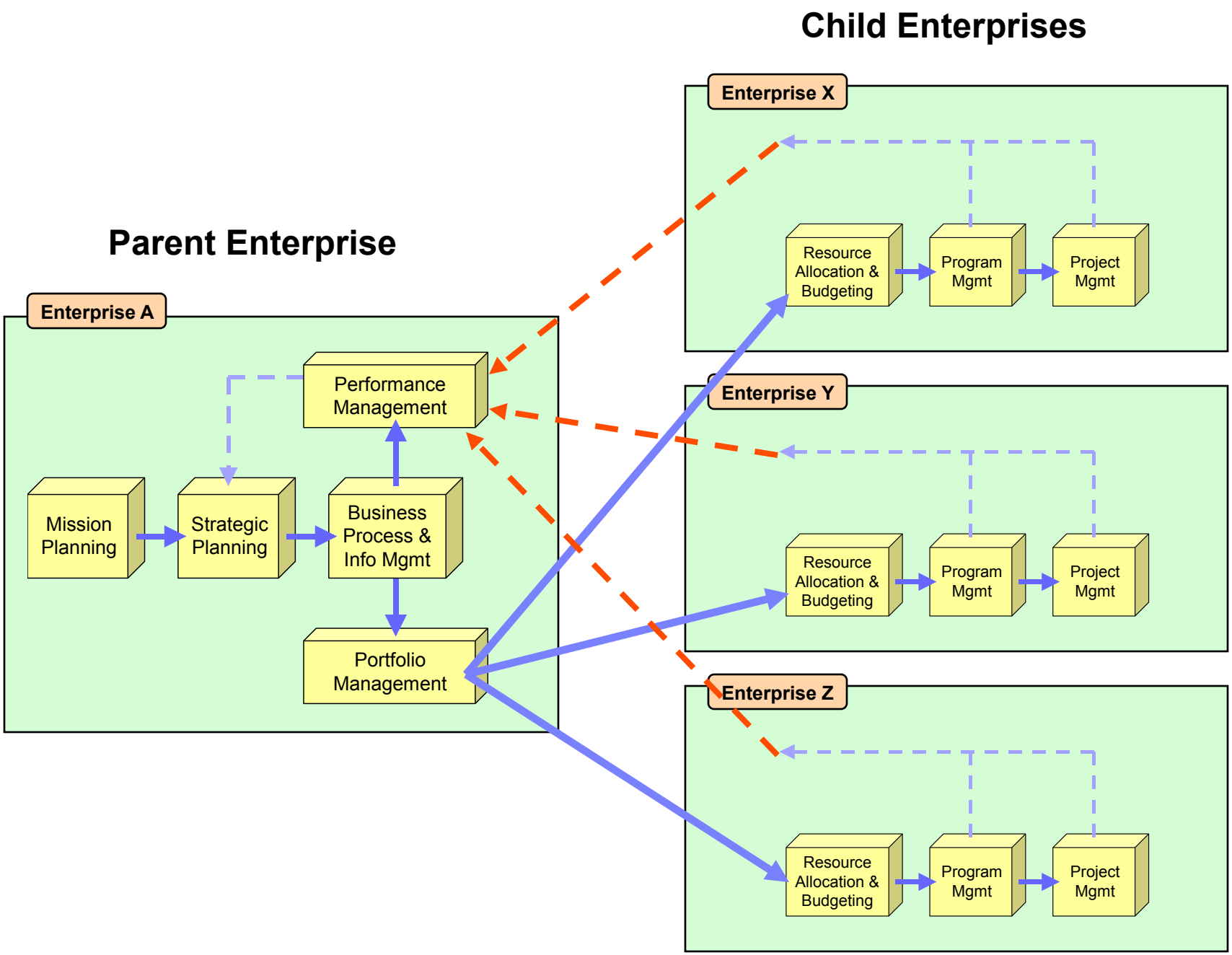
- Strategic Technical Planning
- Enterprise Architecture
- Capabilities-Based Planning Analysis
- Technology Planning
- Enterprise Evaluation and Assessment

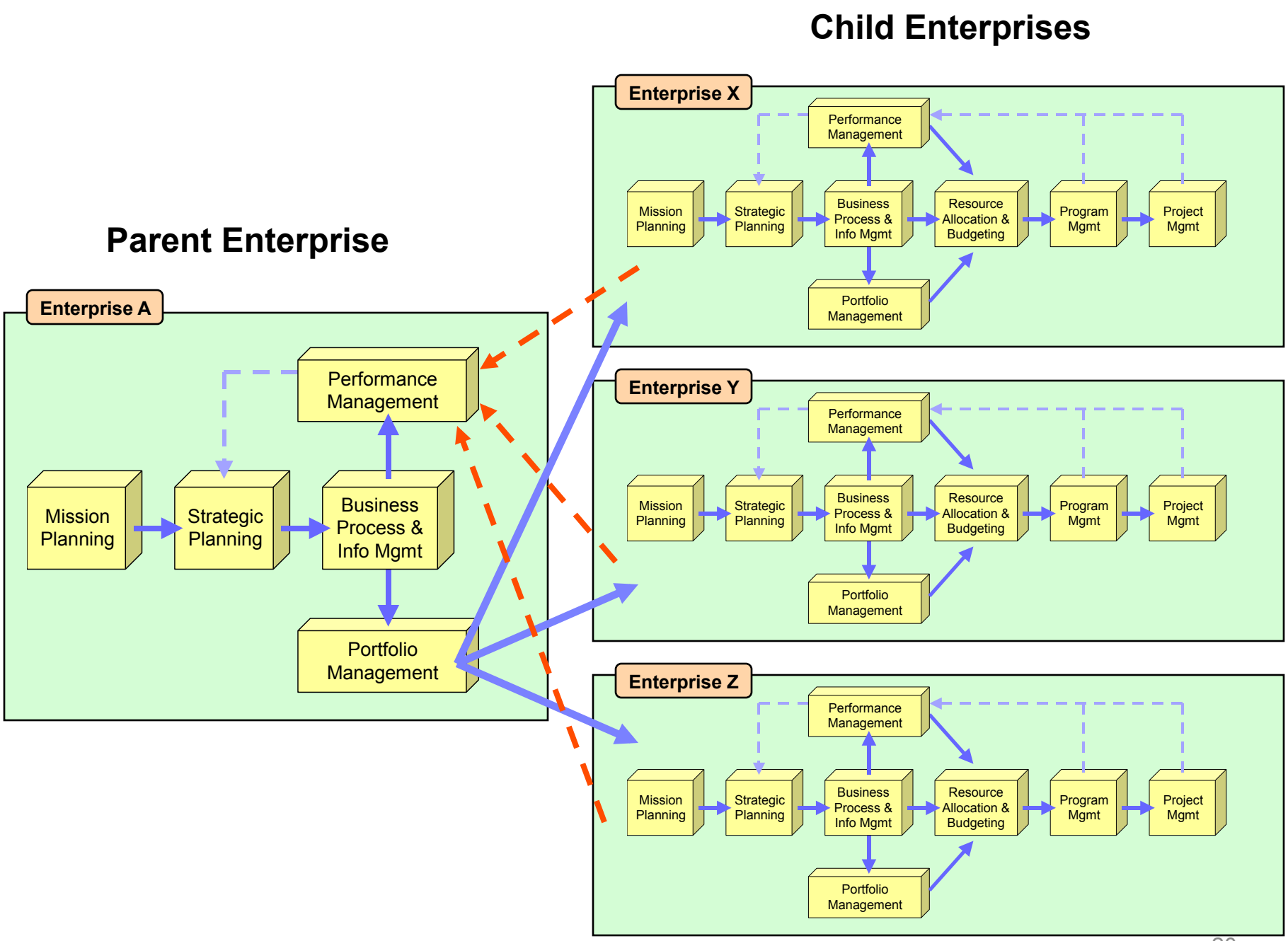
Enterprise Systems Engineering & Management



Enterprise Portfolio Management




Child Enterprises
Parent Enterprise
Enterprise A
Performance Management
Mission Planning
Strategic Planning
Business Process & Info Mgmt
Portfolio Management
Enterprise X
Resource Allocation & Budgeting
Program Mgmt
Project Mgmt
Enterprise Y
Resource Allocation & Budgeting
Program Mgmt
Project Mgmt
Enterprise Z
Resource Allocation & Budgeting
Program Mgmt
Project Mgmt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Performance Management
Resource Allocation & Budgeting
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Project Mgmt
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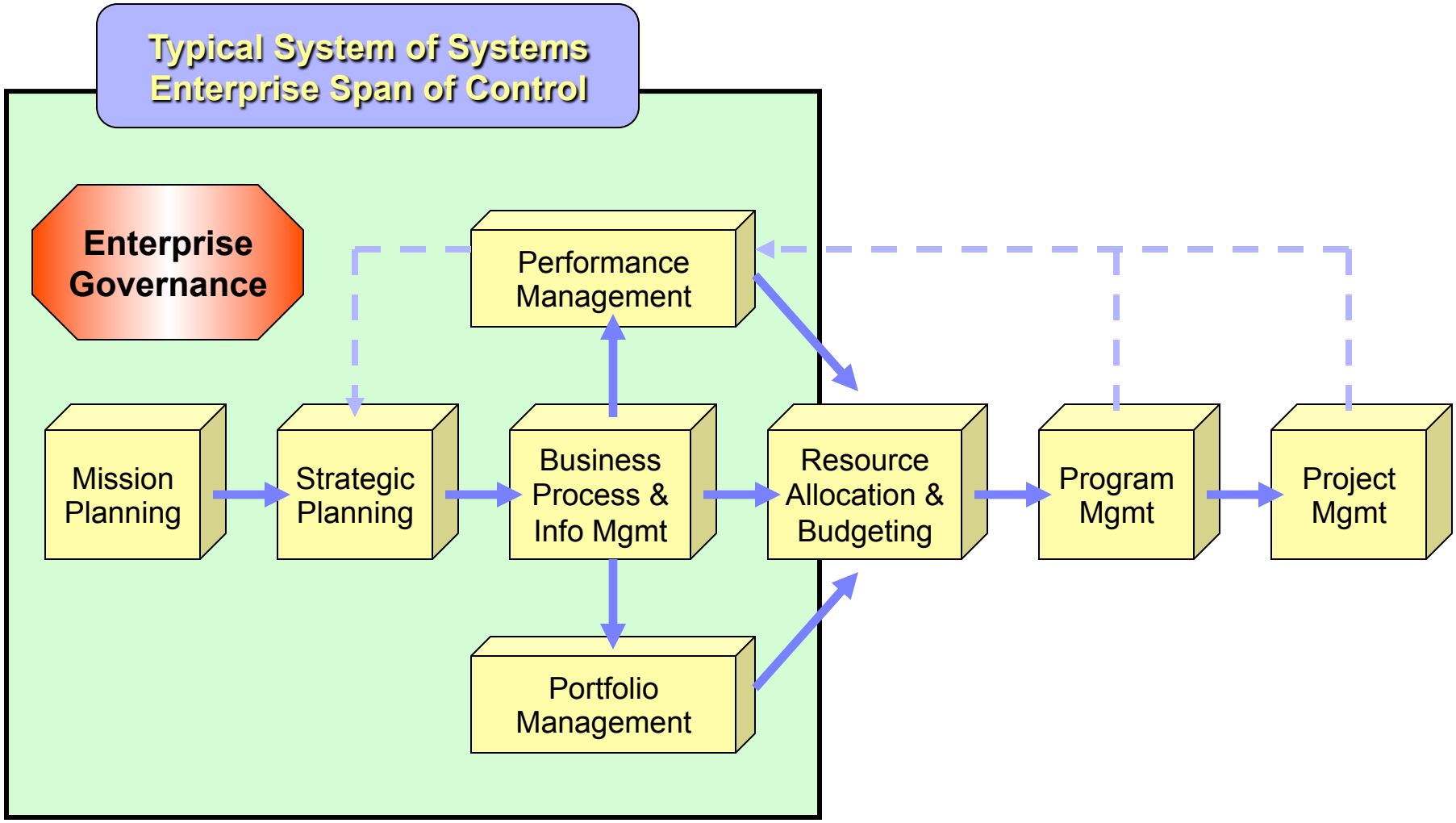
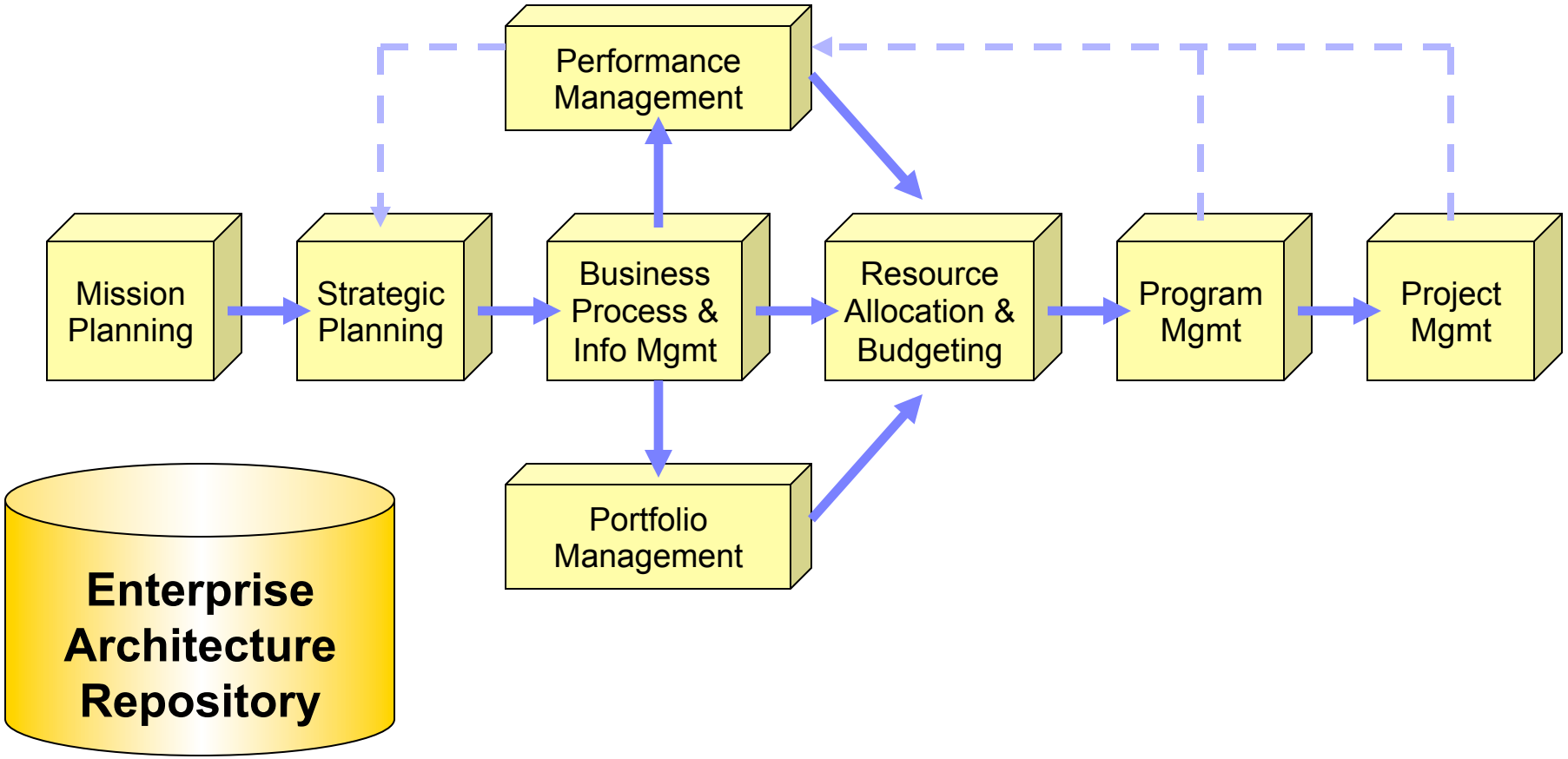
Program Mgmt
Project Mgmt
Portfolio Management

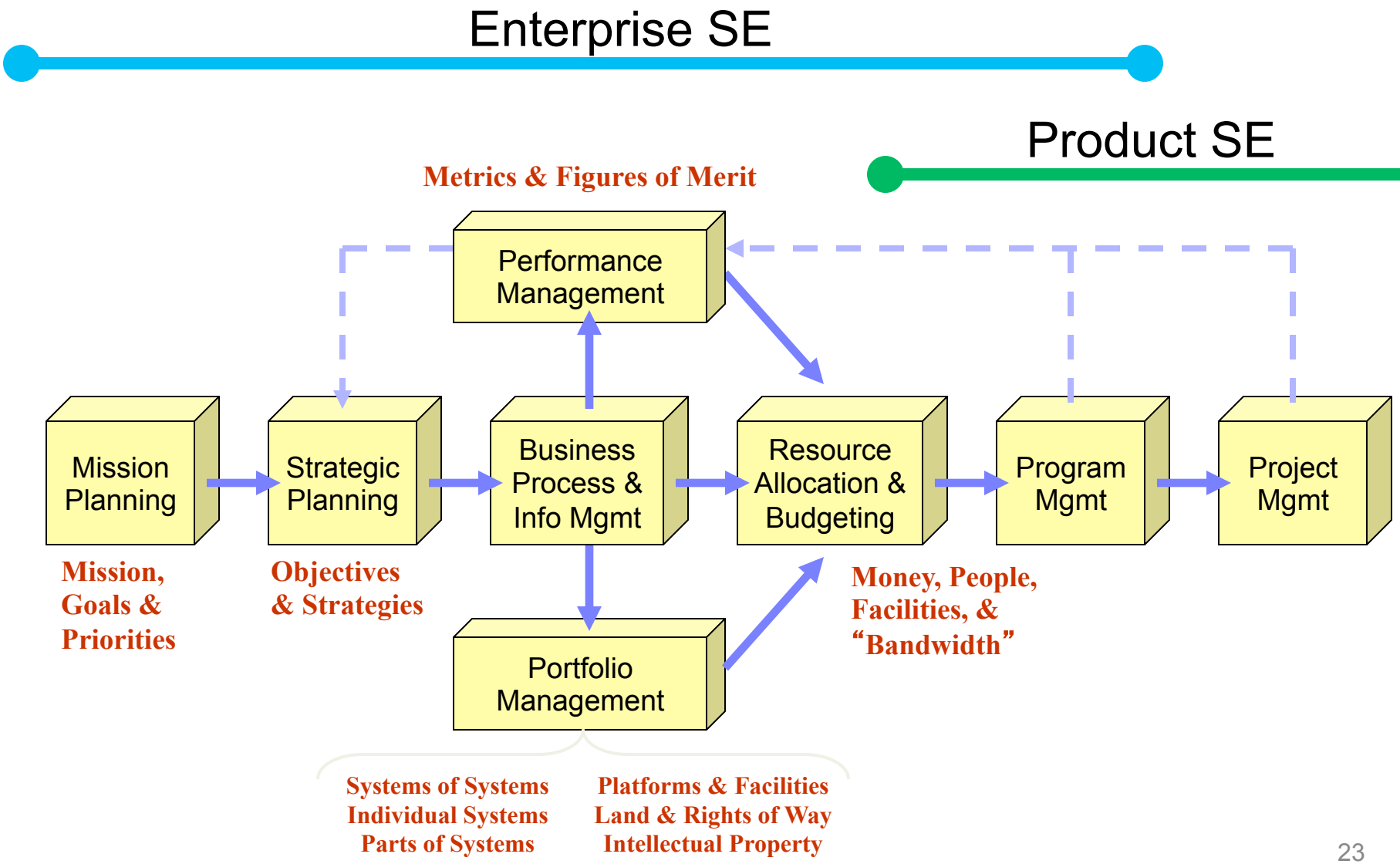
Enterprise Governance is Often Needed to Manage Progress & Control Change



Enterprise Architecture Can Facilitate Understanding of Inter-Relationships & Consequences



Enterprise SE vs Product SE



Achieving Proper Balance

- An Essential Aspect of ESE
  - Balance between Complexity & Order
  - Balance between Effectiveness & Efficiency
  - Balance between Enterprise Objectives & Project Objectives

Enterprise: People, processes and technology interacting with other people, processes and technology, serving some combination of their own objectives, those of their individual organizations and those of the enterprise as a whole.

Friedman-Sage Framework

Concept Domains	Responsibility Domains		
	1. Contractor Responsibility	2. Shared Responsibility	3. Government Responsibility
Requirements Definition & Management			
System Architecture & Conceptual Design			
System & Subsystem Detailed Design and Implementation			
Systems Integration & Interfaces			
Validation and Verification			
Deployment & Post Deployment			
Life Cycle Support			
Risk Assessment & Management			
System & Program Management			

Extension of Traditional SE to Enterprise SE

Acquisition-Oriented Process Areas	Strategic- and Investment-Oriented Process Areas
Requirements Definition & Management	*Enterprise* Requirements Definition & Management
System Architecture & Conceptual Design	*Enterprise* Architecture & Conceptual Design
System & Subsystem Detailed Design and Implementation	*Program* & *Project* Detailed Design & Implementation
Systems Integration & Interfaces	*Program* Integration & Interfaces
Validation & Verification	*Program* Validation & Verification

Extension of Traditional SE to Enterprise SE

Acquisition-Oriented Process Areas	Strategic- and Investment-Oriented Process Areas
Requirements Definition & Management	*Enterprise* Requirements Definition & Management
System Architecture & Conceptual Design	*Enterprise* Architecture & Conceptual Design
System & Subsystem Detailed Design and Implementation	*Program* & *Project* Detailed Design & Implementation
Systems Integration & Interfaces	*Program* Integration & Interfaces
Validation & Verification	*Program* Validation & Verification
Deployment & Post Deployment	Deployment & Post Deployment
Life Cycle Support	*Program* Life Cycle Support
Risk Assessment & Management	Risk *& Opportunity* Management
System & Program Management	*Strategic Technical Planning*
	Capability-Based Planning Analysis
	Technology & Standards Planning
	Enterprise Evaluation & Assessment

The Enterprise SE Framework Elements

Acquisition-Oriented Process Areas	Strategic- and Investment-Oriented Process Areas
Requirements Definition & Management	*Enterprise* Requirements Definition & Management
System Architecture & Conceptual Design	*Enterprise* Architecture & Conceptual Design
System & Subsystem Detailed Design and Implementation	*Program* & *Project* Detailed Design & Implementation
Systems Integration & Interfaces	*Program* Integration & Interfaces
Validation & Verification	*Program* Validation & Verification
Deployment & Post Deployment	Deployment & Post Deployment
Life Cycle Support	*Program* Life Cycle Support
Risk Assessment & Management	Risk *& Opportunity* Management
System & Program Management	*Strategic Technical Planning*
	Capability-Based Planning Analysis
	Technology & Standards Planning
	Enterprise Evaluation & Assessment

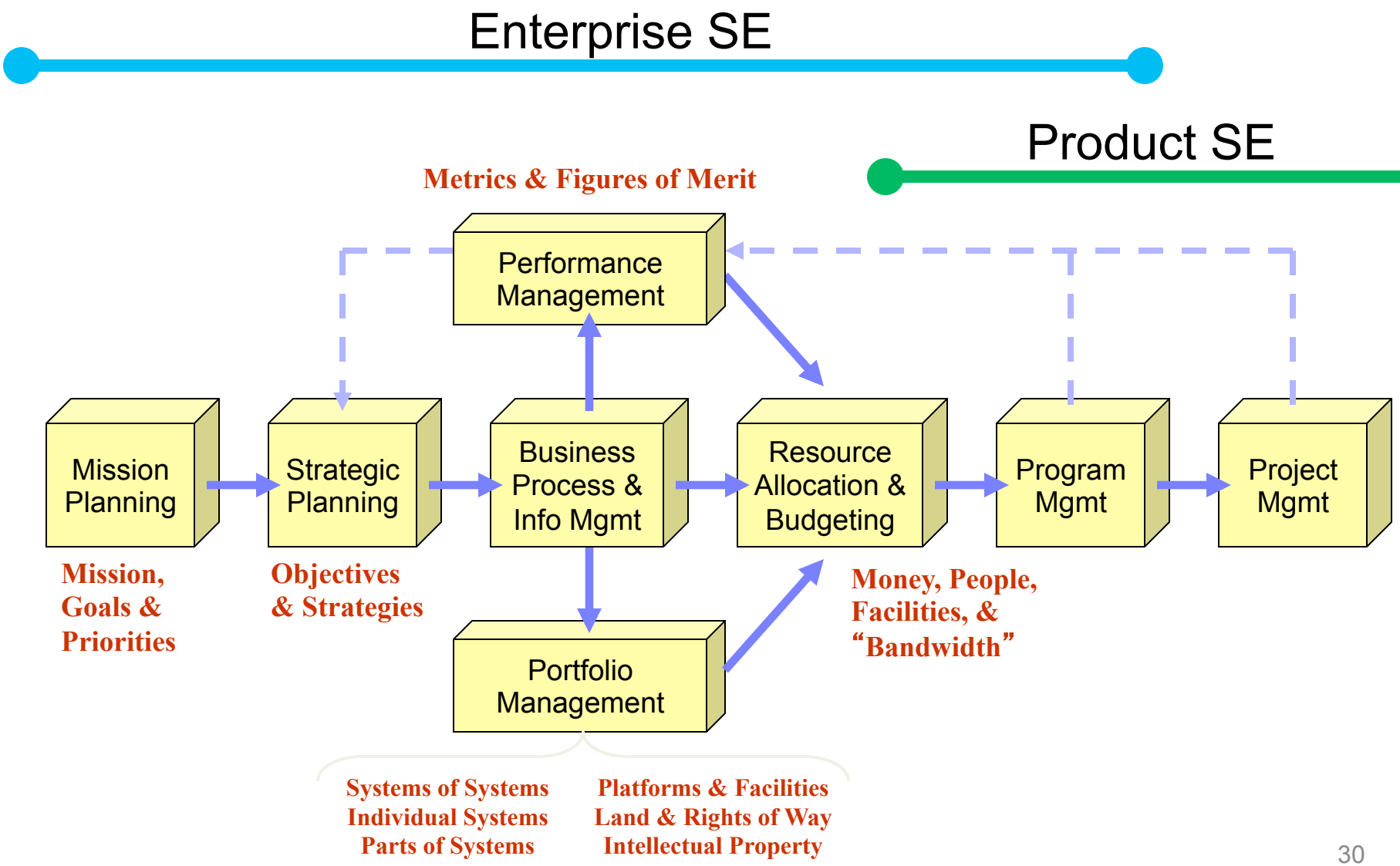
Enterprise Systems Engineering Framework

Concept Domains	Responsibility Domains		
	1. Program Responsi-bility	2. Shared Responsi-bility	3. Enterprise Responsi-bility
Strategic Technical Planning			
Capability-Based Planning Analysis			
Technology & Standards Planning			
Enterprise Requirements Definition & Management			
Enterprise Architecture & Conceptual Design			
Program & Project Detailed Design and Implementation			
Program Integration & Interfaces			
Program Validation & Verification			
Deployment & Post Deployment			
Program Life Cycle Support			
Risk & Opportunity Management			
Enterprise Evaluation & Assessment			

Three Areas of Responsibility

1. Enterprise
2. Program
3. Shared

Enterprise Systems Engineering

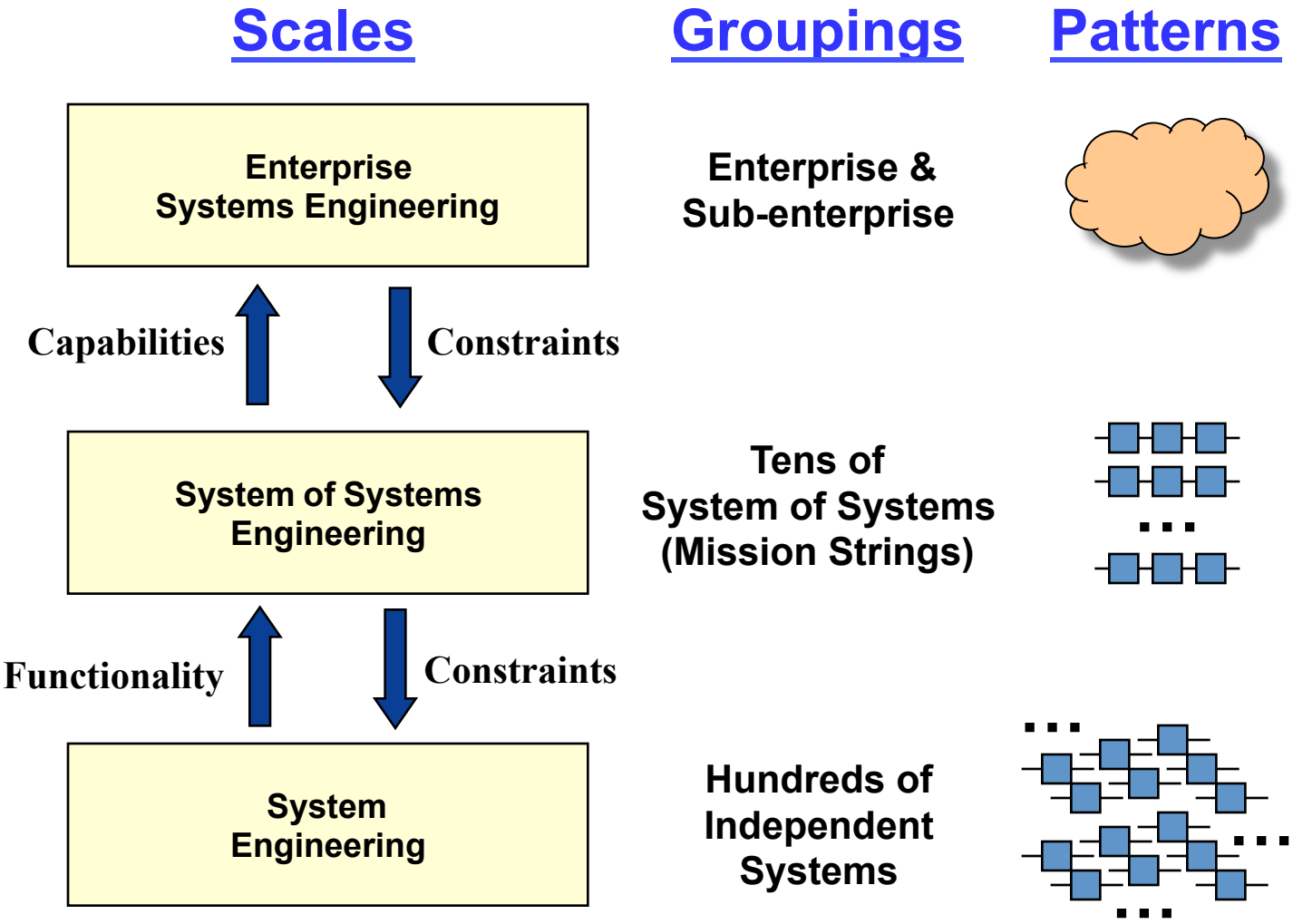


Conclusions

- Enterprise SE is different from Product SE
  - Deals with less tangible "things"
  - Different knowledge & skills
  - Different tools & methods
  - Traditional SE processes are not sufficient for Enterprise-level SE
- Enterprise SE Framework
  - Useful but still immature
  - Needs updating based on more case study research projects & feedback

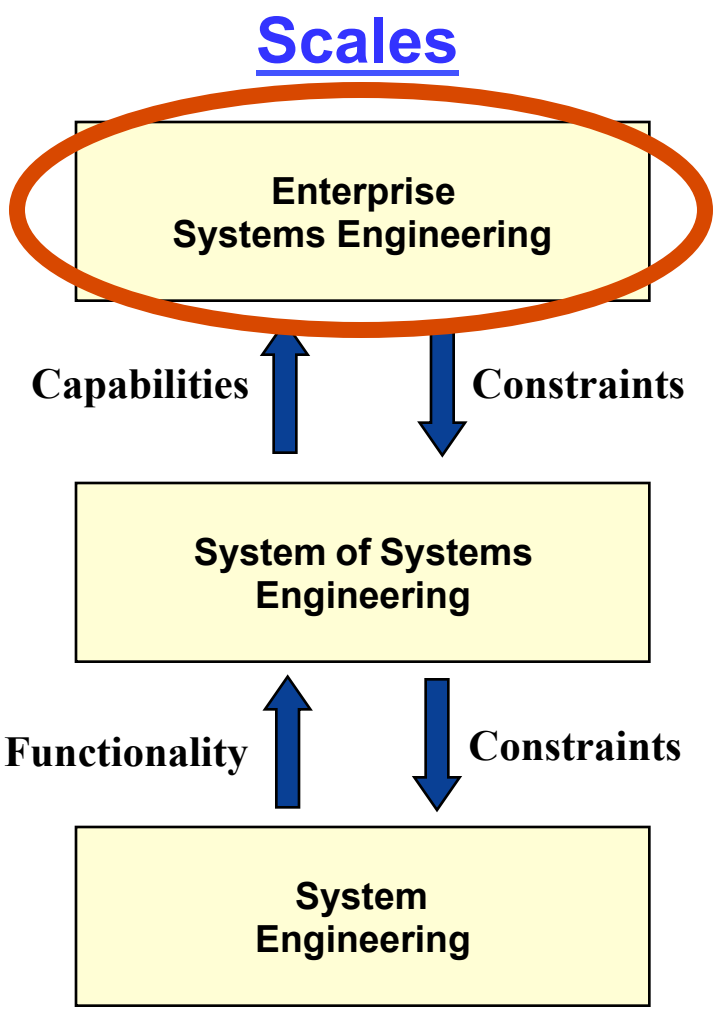
BACKUP

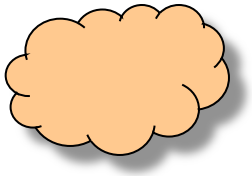
Systems Engineering Applied at 3 Levels (Enterprise, SOS & System)

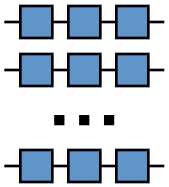


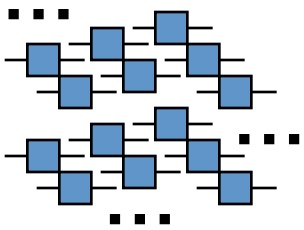
SOURCE: DeRosa, MITRE Corporation

Case Study Focused on the Enterprise Level (ie, Enterprise Architecture)









Patterns

Descriptions

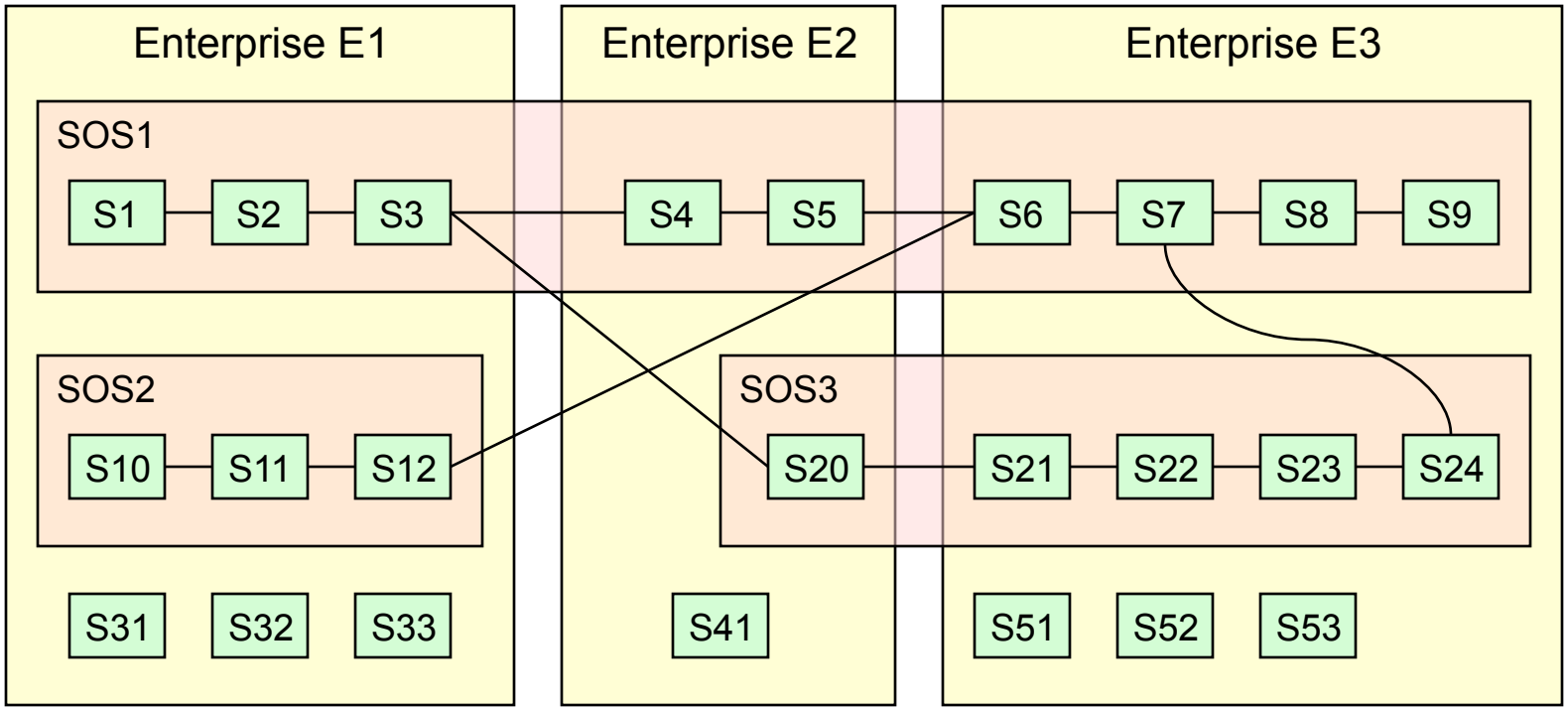
Broad Descriptions
Net-centric
Capabilities-based
Evolutionary Development
Emergent Behavior

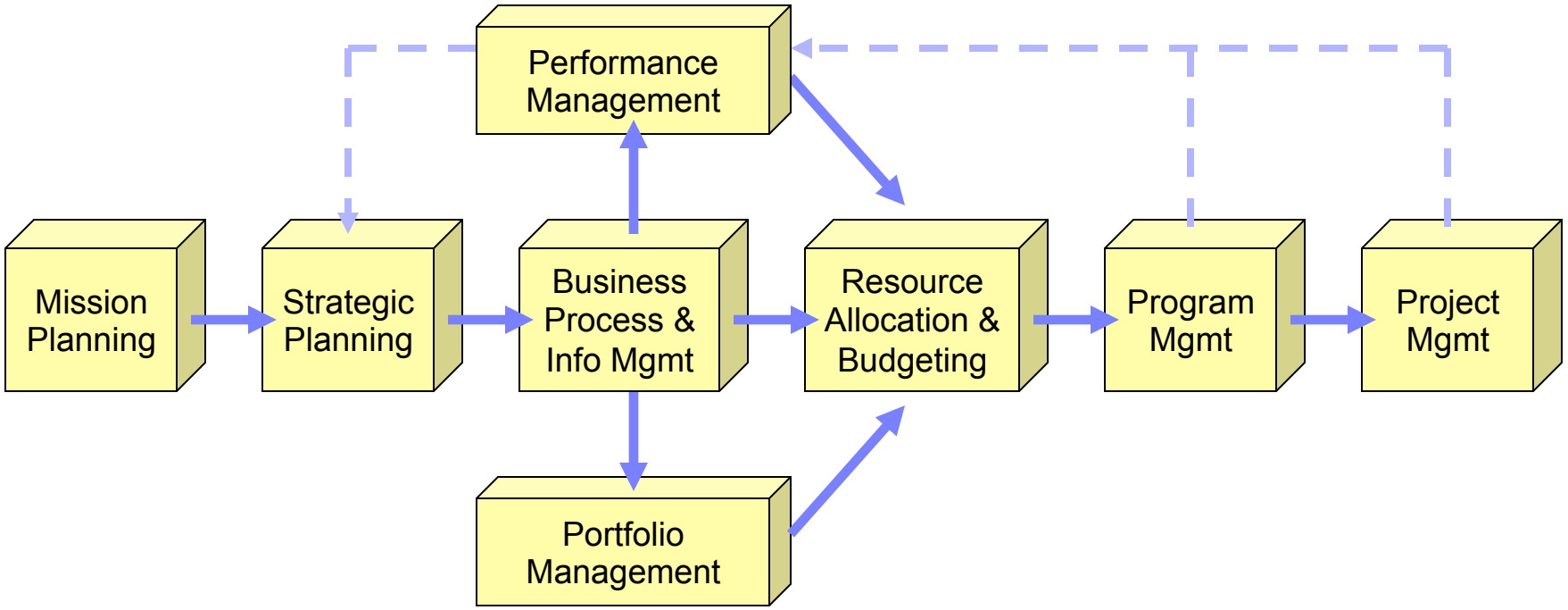
Mission Descriptions
Mission Capabilities-based
Composition of Systems

Functional Descriptions
Detailed Specifications
Detailed Requirements

SOURCE: DeRosa, MITRE Corporation

Enterprise vs. SoS




Performance Management
Mission Planning
Strategic Planning
Business Process & Info Mgmt
Resource Allocation & Budgeting
Program Mgmt
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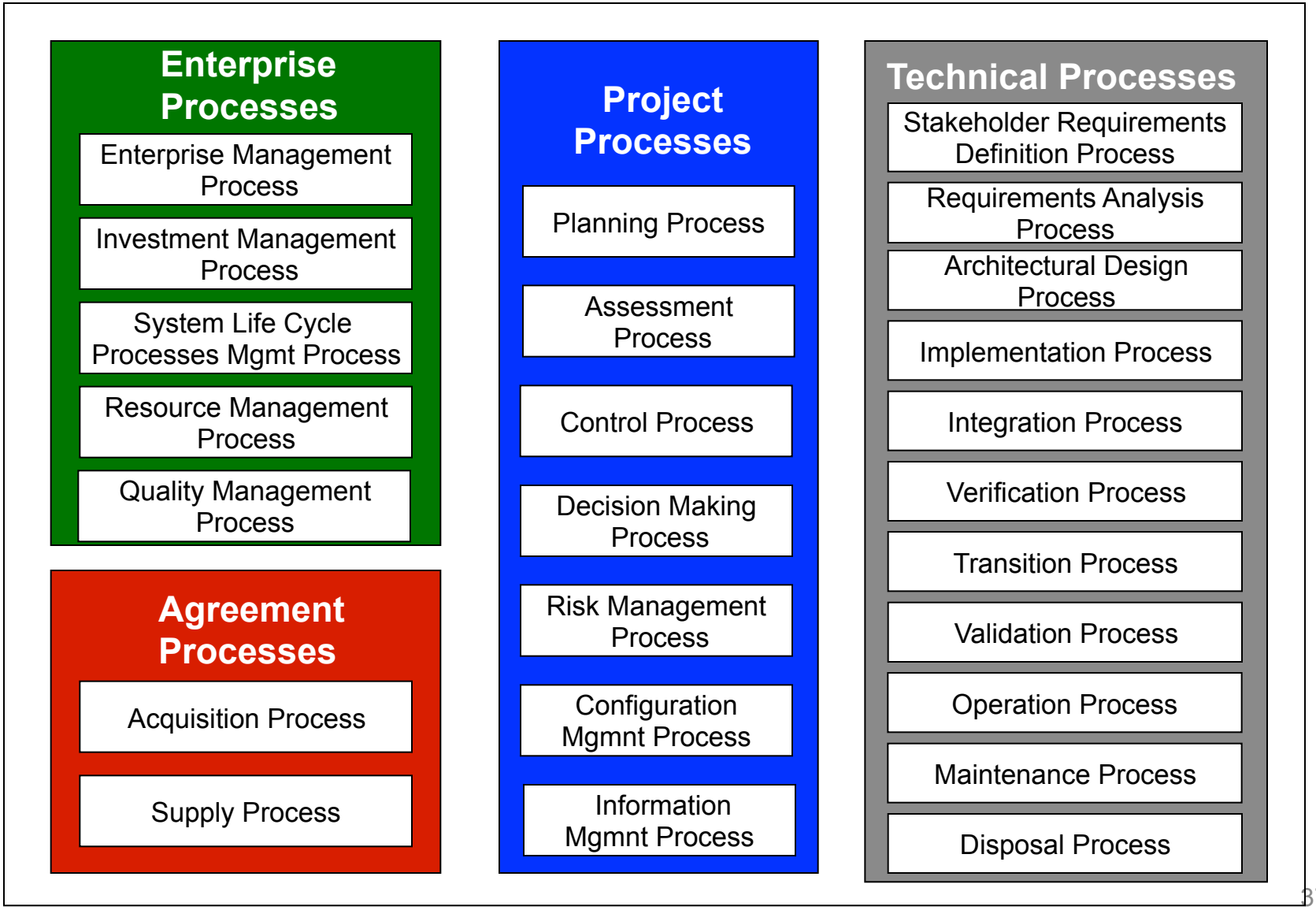
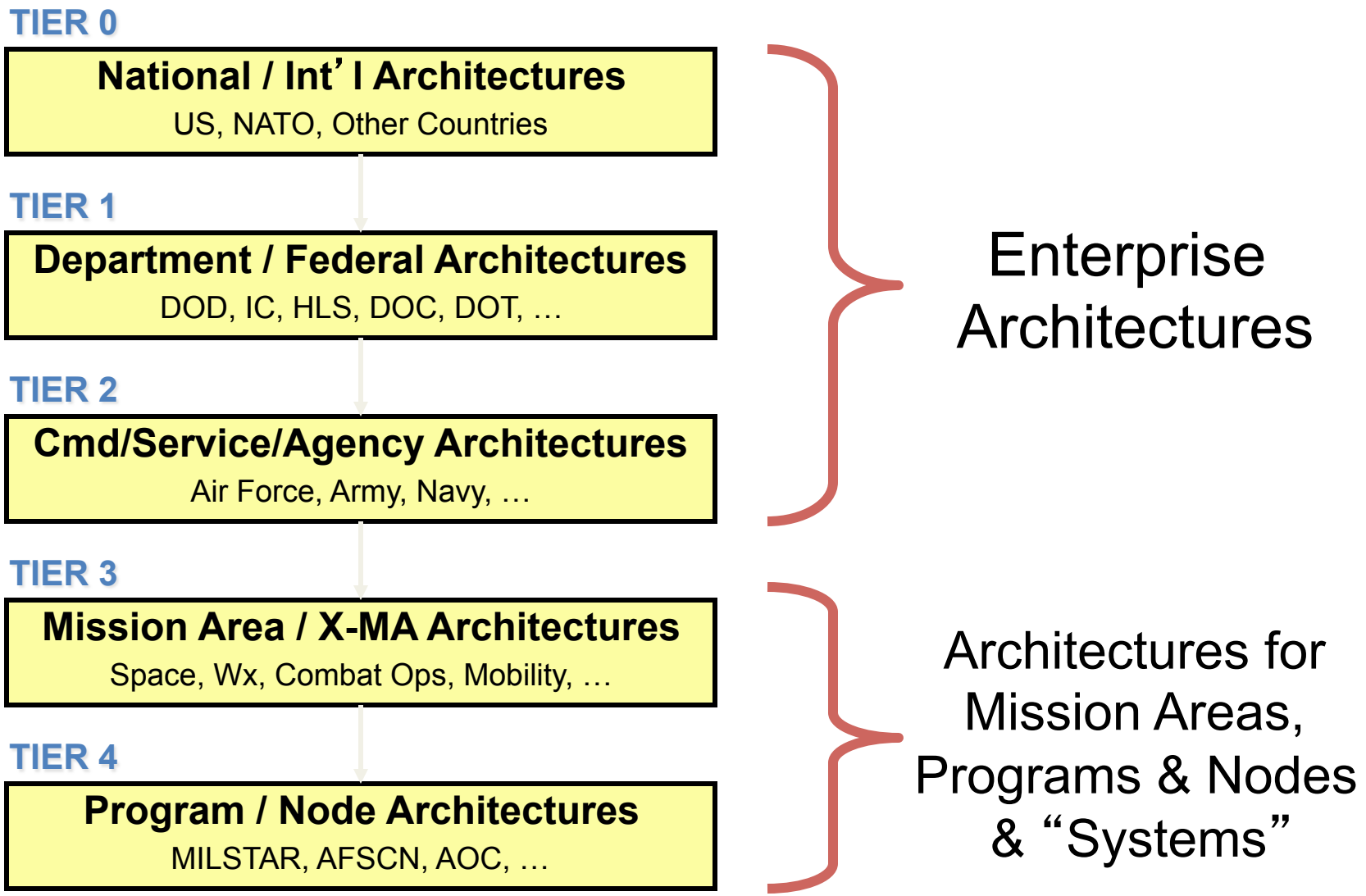
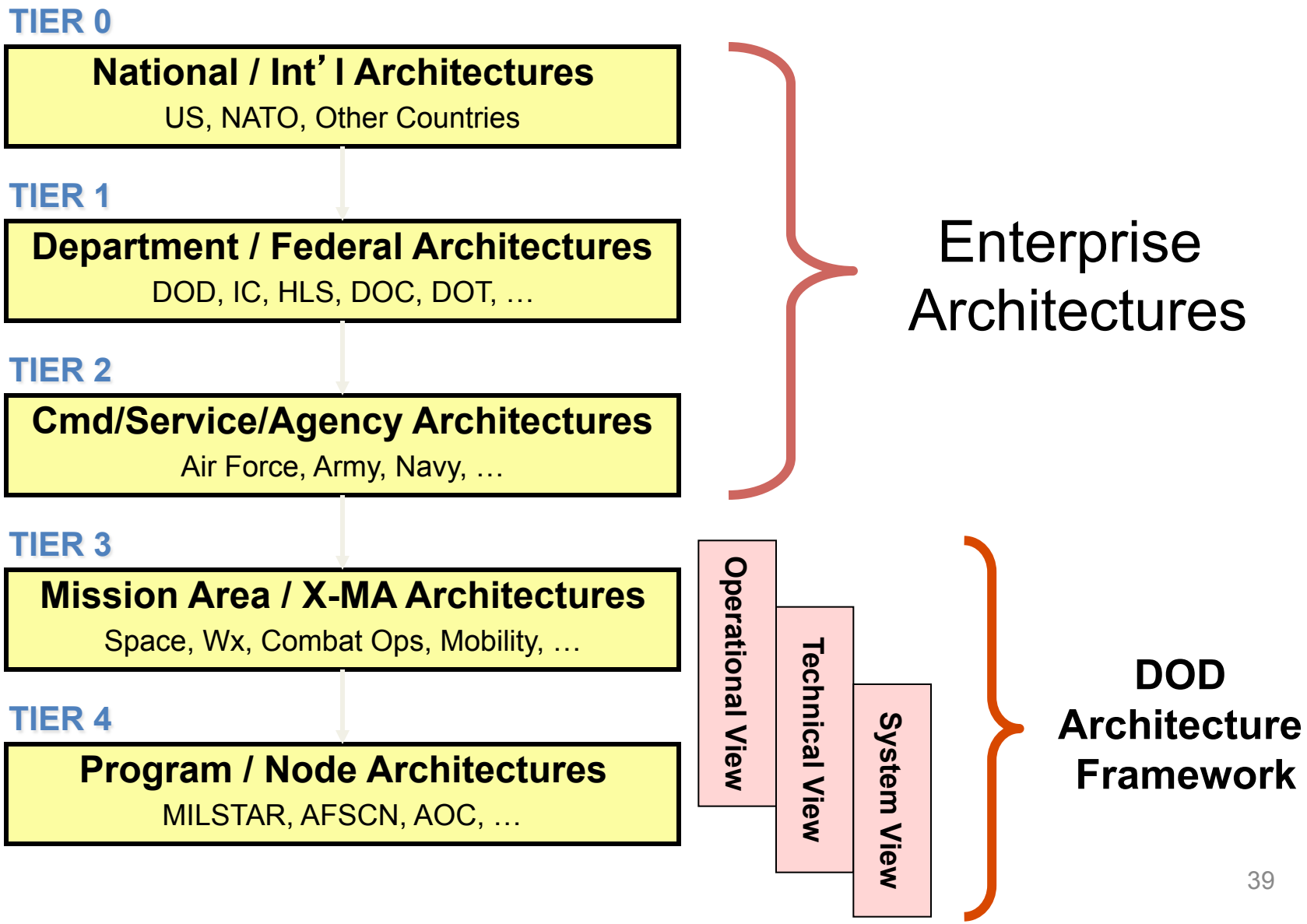
Portfolio Management


Enterprise Processes
Enterprise Management Process
Investment Management Process
System Life Cycle Processes Mgmt Process
Resource Management Process
Quality Management Process
Agreement Processes
Acquisition Process
Supply Process
Project Processes
Planning Process
Assessment Process
Control Process
Decision Making Process
Risk Management Process
Configuration Mgmnt Process
Information Mgmnt Process
Technical Processes
Stakeholder Requirements Definition Process
Requirements Analysis Process
Architectural Design Process
Implementation Process
Integration Process
Verification Process
Transition Process
Validation Process
Operation Process
Maintenance Process
Disposal Process


TIER 0
National / Int'l Architectures
US, NATO, Other Countries
TIER 1
Department / Federal Architectures
DOD, IC, HLS, DOC, DOT, …
TIER 2
Cmd/Service/Agency Architectures
Air Force, Army, Navy, …
TIER 3
Mission Area / X-MA Architectures
Space, Wx, Combat Ops, Mobility, …
TIER 4
Program / Node Architectures
MILSTAR, AFSCN, AOC, …
Enterprise Architectures
Architectures for Mission Areas, Programs & Nodes & "Systems"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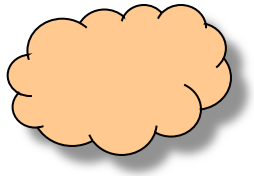
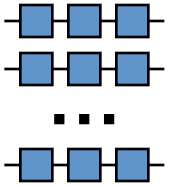
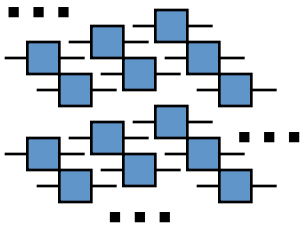
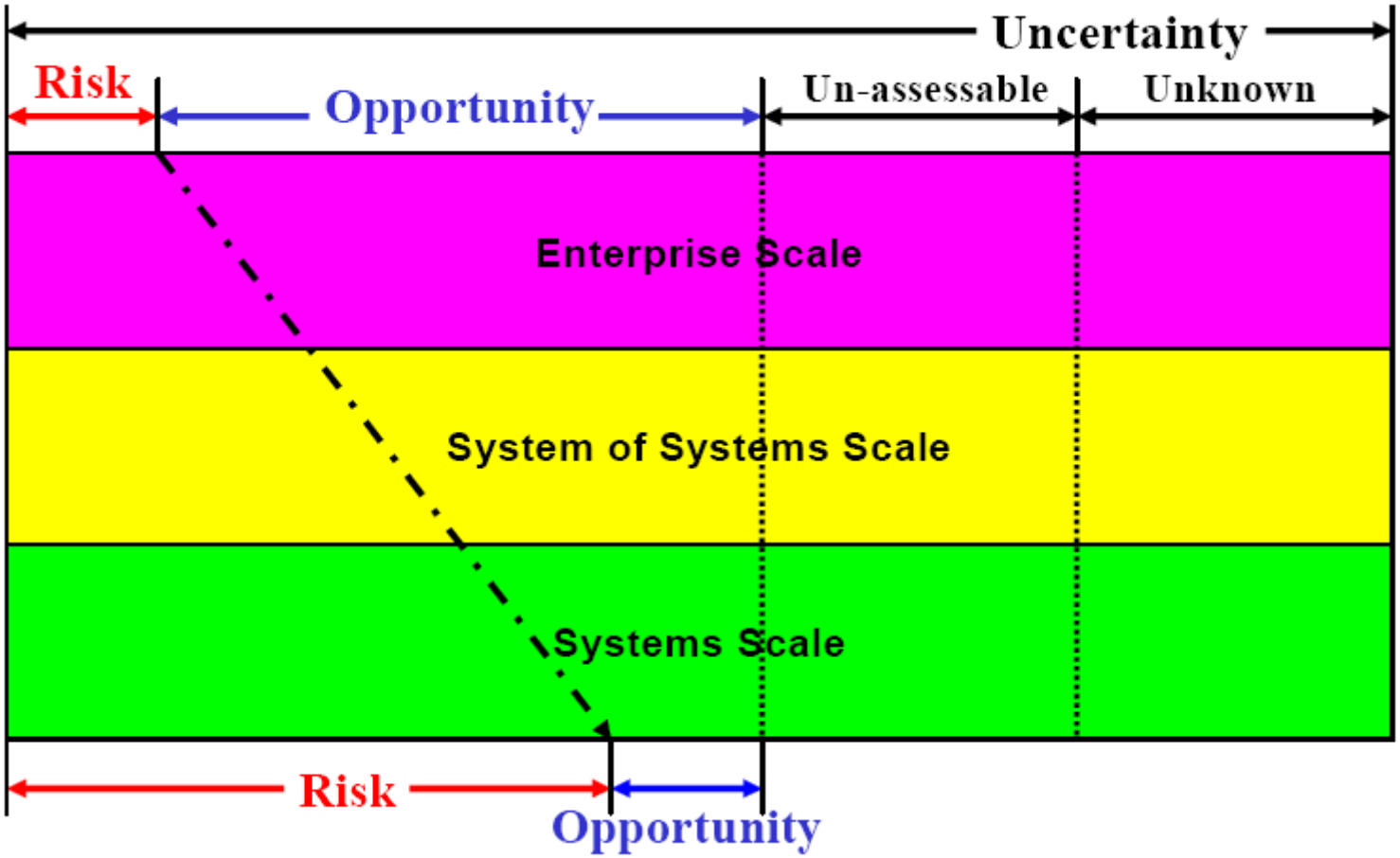
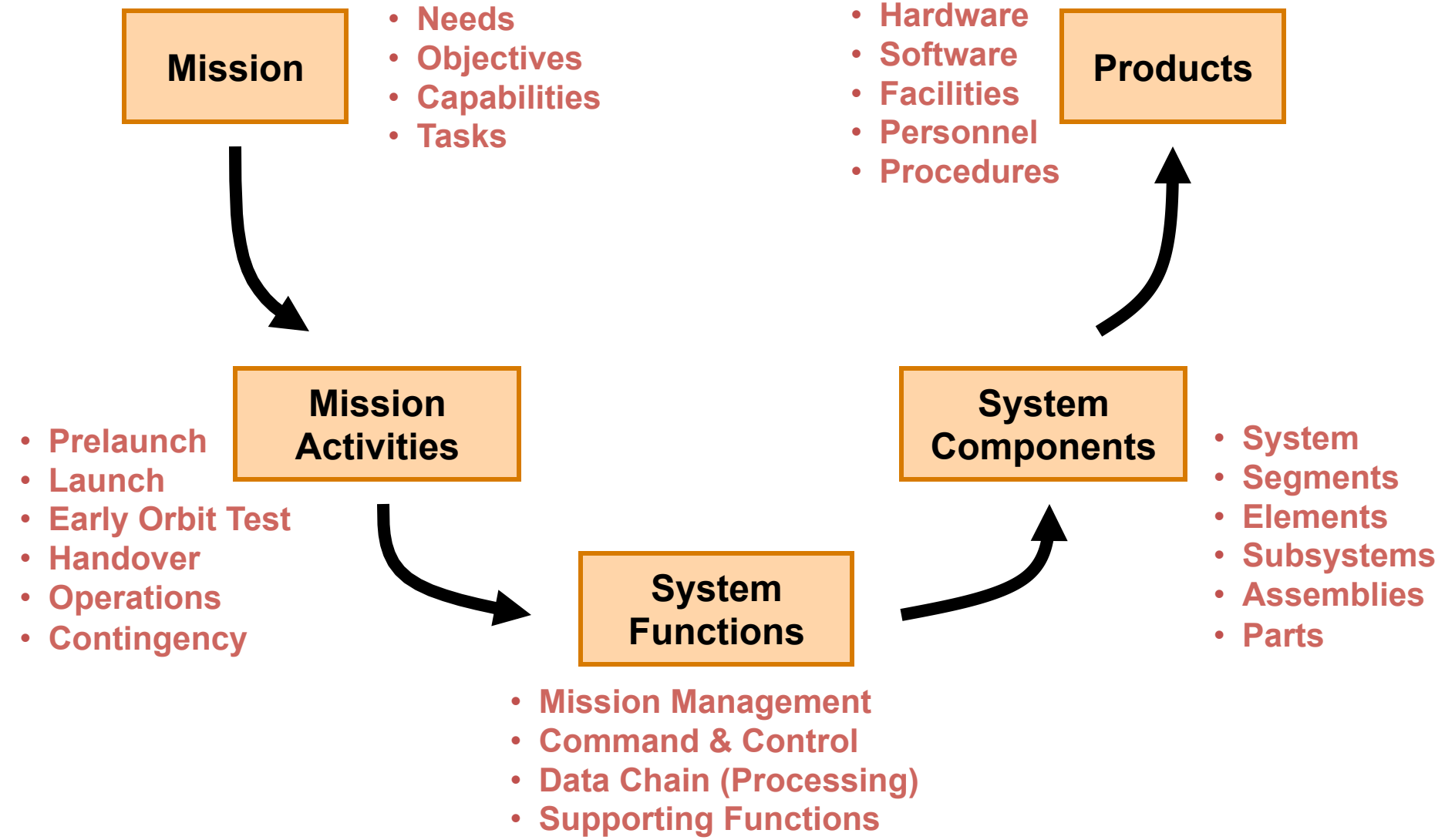
Air Force, Army, Navy, …
TIER 3
Mission Area / X-MA Architectures
Space, Wx, Combat Ops, Mobility, …
TIER 4
Program / Node Architectures
MILSTAR, AFSCN, AOC, …
Enterprise Architectures
Operational View
Technical View
System View
DOD Architecture Framework

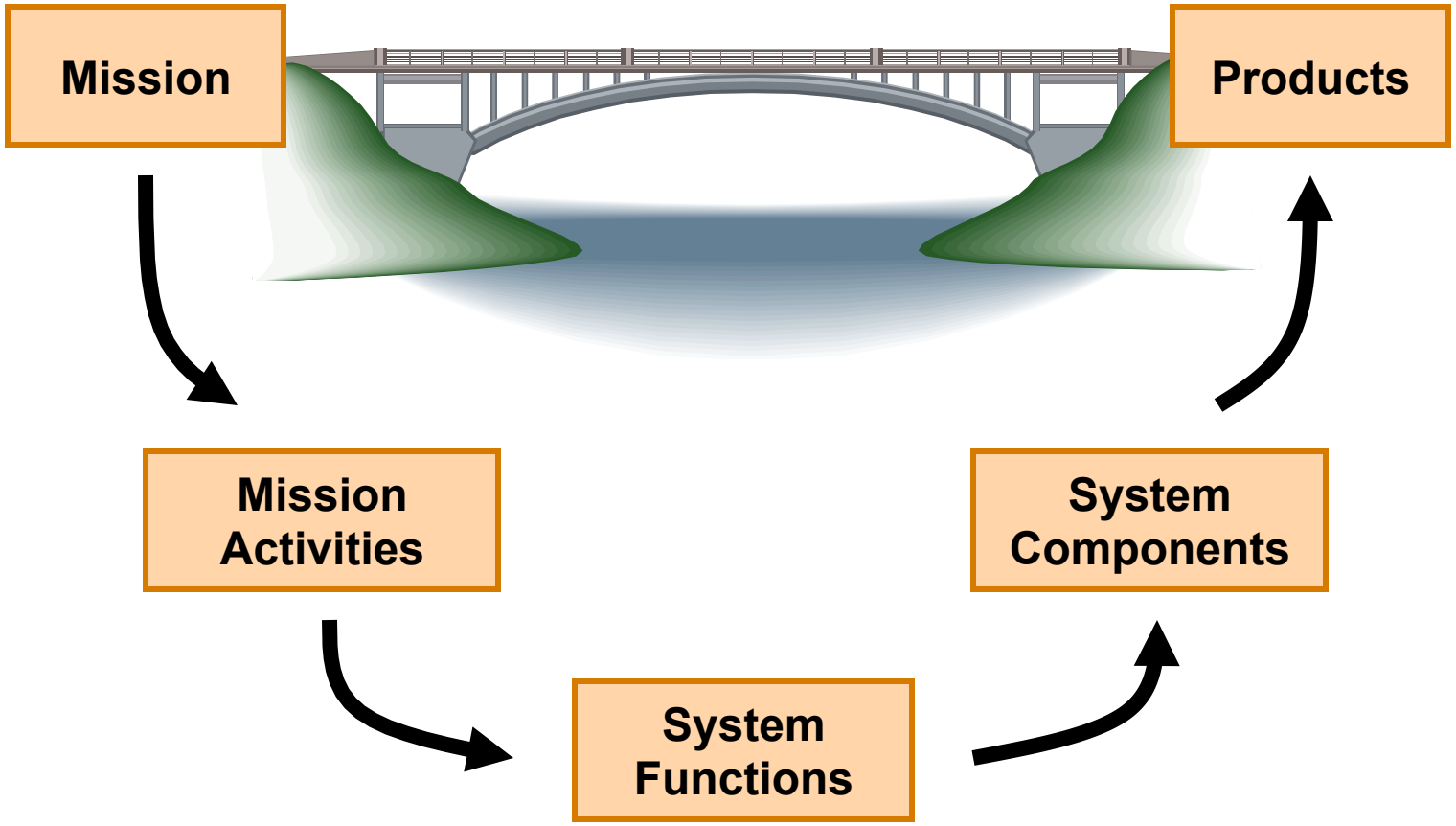
Scales	Groupings	Patterns	Descriptions
Enterprise Systems Engineering	Enterprise & Sub-enterprise		Broad Descriptions Net-centric Capabilities-based Evolutionary Developm Emergent Behavior
Capabilities ↑ ↓ Constraints			
System of Systems Engineering	Tens of System of Systems (Mission Strings)		Mission Descriptions Mission Capabilities-ba Composition of Syst
Functionality ↑ ↓ Constraints			
System Engineering	Hundreds of Independent Systems		Functional Descriptions Detailed Specifications Detailed Requirements


Uncertainty
Risk
Opportunity
Un-assessable
Unknown
Enterprise Scale
System of Systems Scale
Systems Scale
Risk
Opportunity

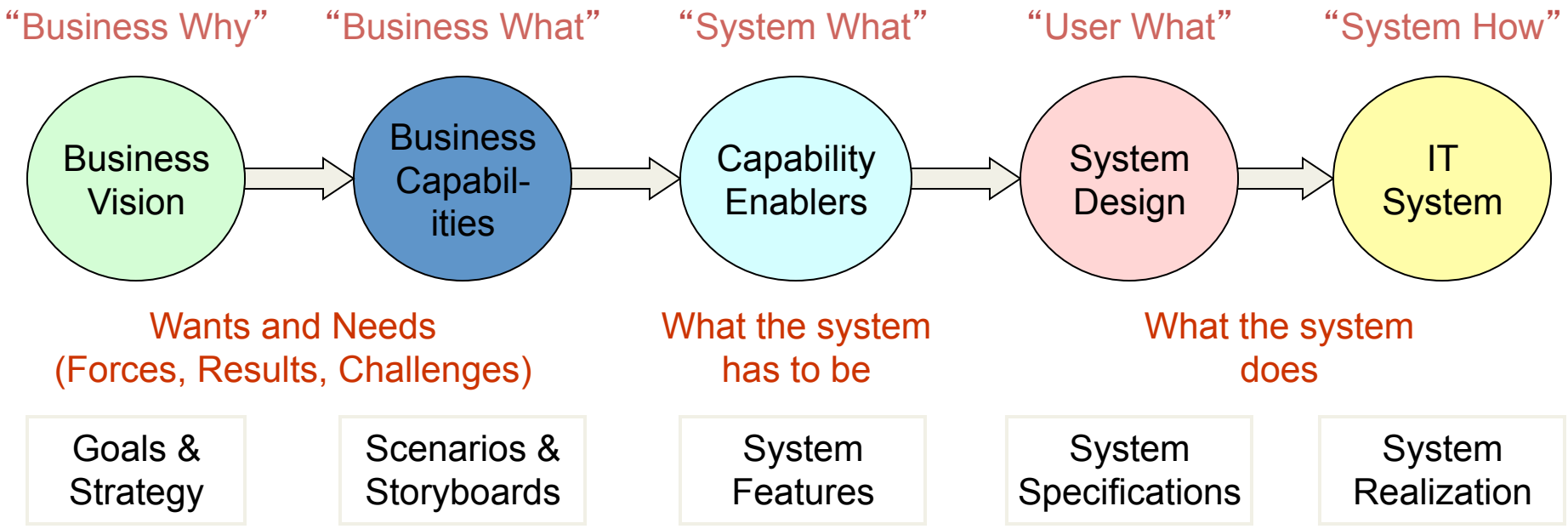
What Does Architecture Do?

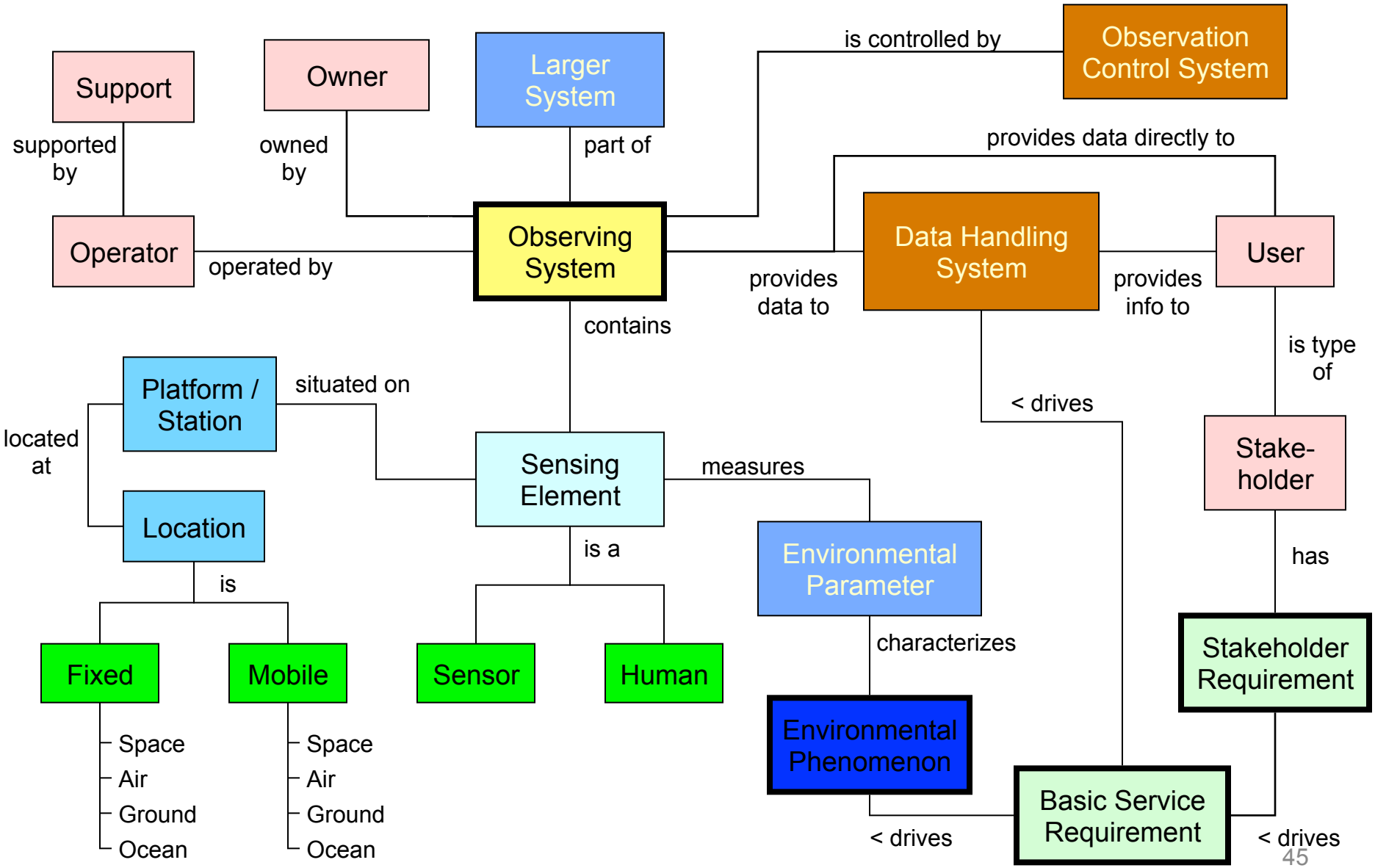


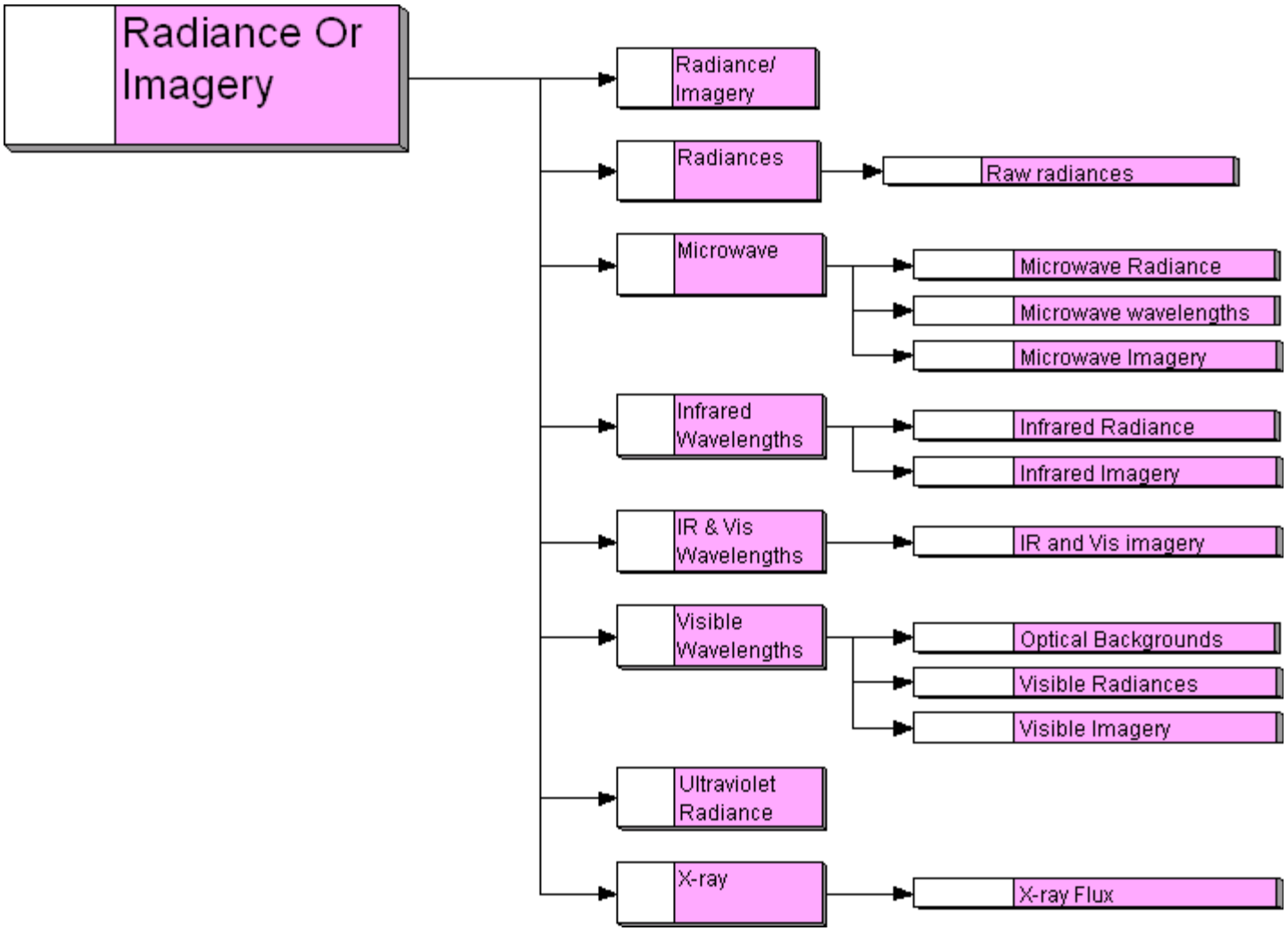
Architecture Provides the "Bridge" Between the Mission & the Products



Architecture is the "Arch" to Success


"Business Why"
"Business What"
"System What"
"User What"
"System How"
Business Vision
Business Capabil-ities
Capability Enablers
System Design
IT System
Wants and Needs (Forces, Results, Challenges)
What the system has to be
What the system does
Goals & Strategy
Scenarios & Storyboards
System Features
System Specifications
System Realization
MEANS
ENDS


Support
supported by
Operator
Owner
owned by
Larger System
part of
Observing System
operated by
is controlled by
Observation Control System
provides data directly to
Data Handling System
provides data to
provides info to
User
is type of
Stake-holder
has
Stakeholder Requirement
contains
Platform / Station
situated on
located at
Location
is
Fixed
Mobile
Space
Air
Ground
Ocean
Space
Air
Ground
Ocean
Sensing Element
is a
Sensor
Human
measures
Environmental Parameter
characterizes
Environmental Phenomenon
< drives
Basic Service Requirement
< drives
< drives


Radiance Or Imagery
Radiance/ Imagery
Radiances
Raw radiances
Microwave
Microwave Radiance
Microwave wavelengths
Microwave Imagery
Infrared Wavelengths
Infrared Radiance
Infrared Imagery
IR & Vis Wavelengths
IR and Vis imagery
Visible Wavelengths
Optical Backgrounds
Visible Radiances
Visible Imagery
Ultraviolet Radiance
X-ray
X-ray Flux

Enterprise Evaluation & Assessment

- Must go beyond traditional system evaluation and assessment practices
  - Must de-emphasize the comparison of detailed metrics against specific individual requirement values
  - must instead look for breakpoints where capabilities are either significantly enhanced or totally disabled

- Key characteristics of this activity are the following:
  - Multi-scale analysis
  - Early and continuous operational involvement
  - Lightweight command and control (C2) capability representations
  - Developmental versions available for assessment
  - Minimal infrastructure
  - Flexible modeling and simulation (M&S), operator-in-the-loop (OITL), and hardware-in-the-loop (HWIL) capabilities
  - In-line, continuous performance monitoring and selective forensics”

Topics

- Friedman-Sage Framework
- Scope
- Enterprise
- Enterprise SE Framework
- Enterprise SE & Mgmt
- Child Enterprises
- Governance
- Enterprise vs. Product SE
- ESE Framework Extension
- Conclusions