International Council on Systems Engineering
A better world through a systems approach

Enabling Enterprise Transformation:

Using Systems Principles and Concepts

INCOSE International Symposium 2025 |
Ottawa, Canada

Enabling Enterprise Transformation Using Systems Principles & Concepts

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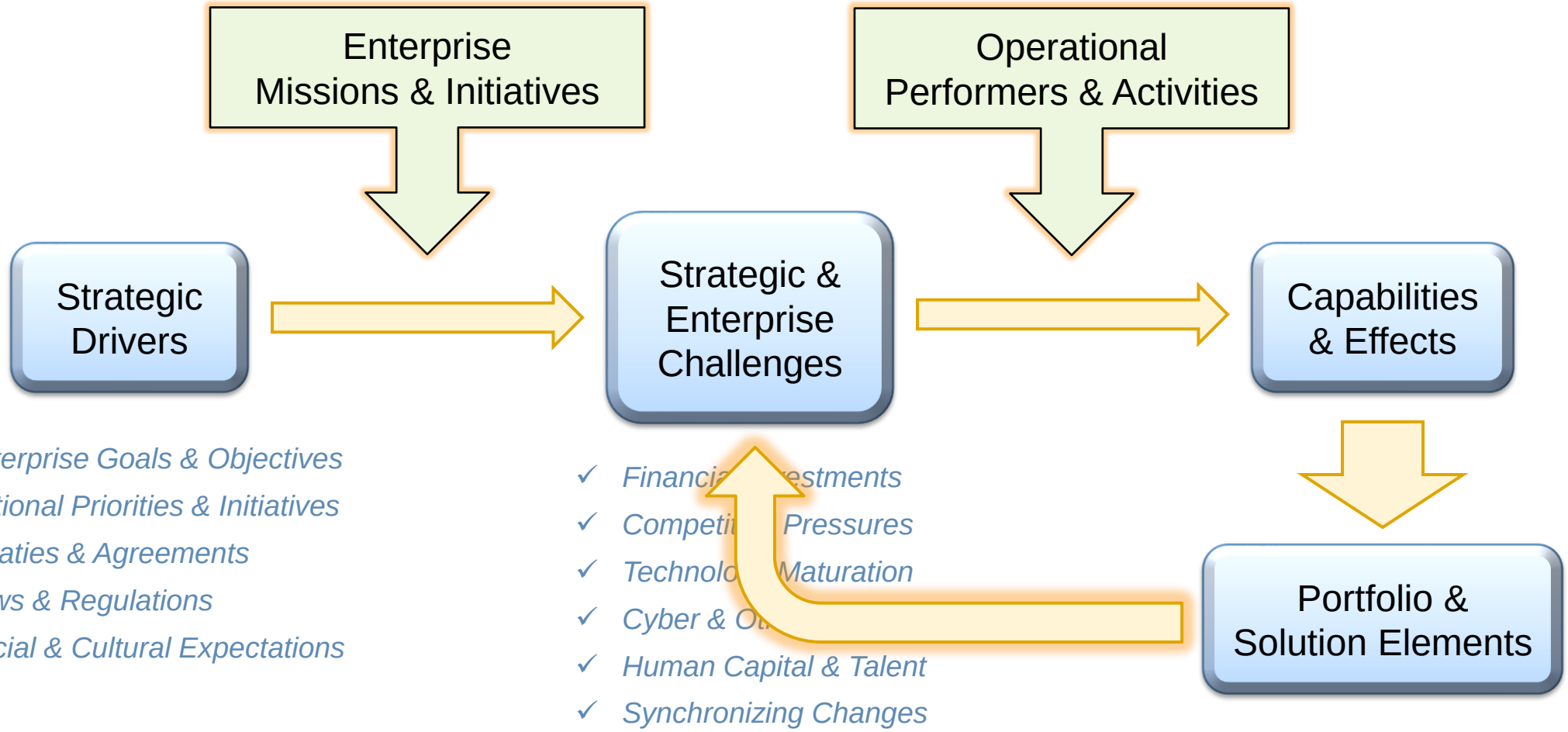
Enterprise Transformation Considerations

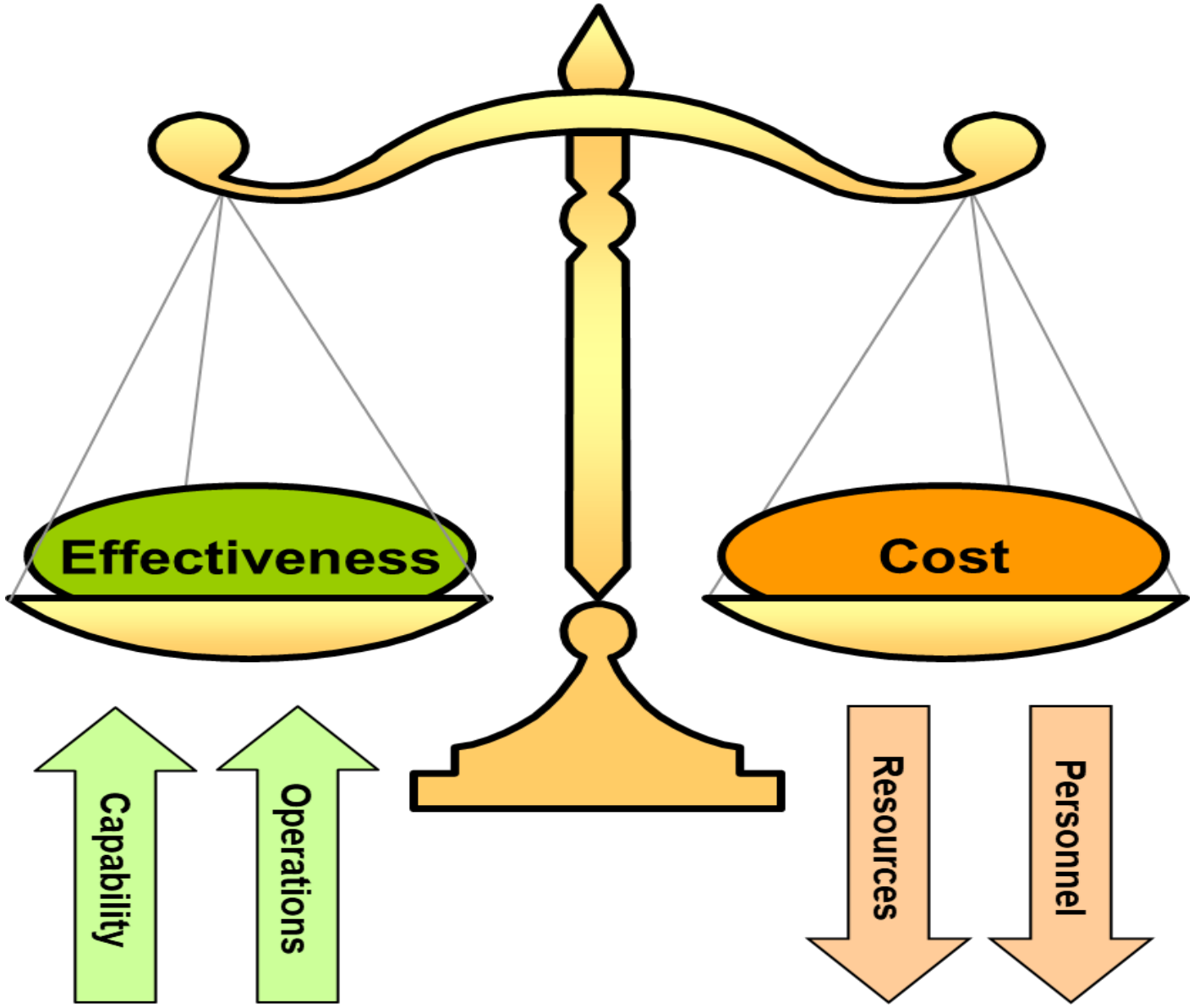
Managing the Enterprise Portfolio to Maximize Mission Impact



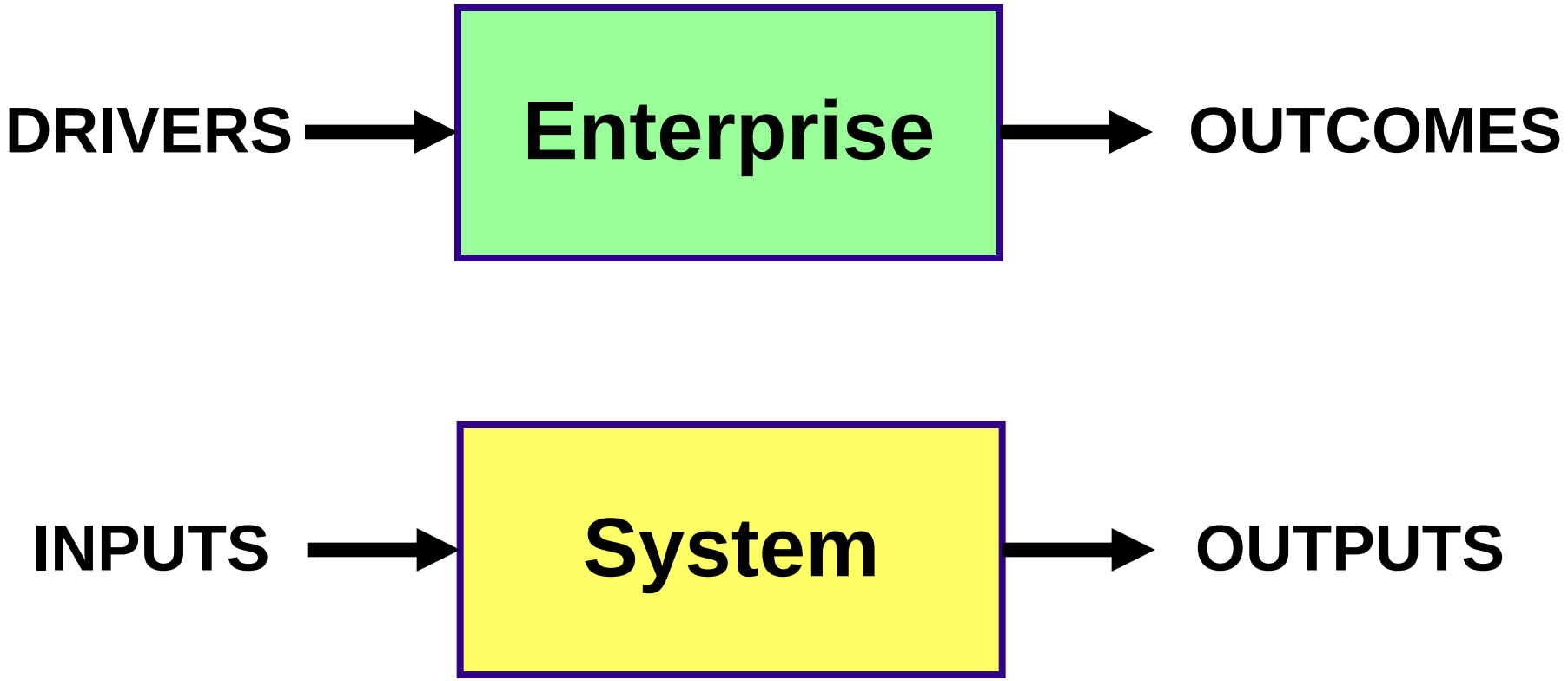
If you don't proactively manage your Portfolio, then your Portfolio will manage you!

Portfolio Management Examines Cost versus Effectiveness

What changes to Capabilities and Operations can lead to improved Outcomes?

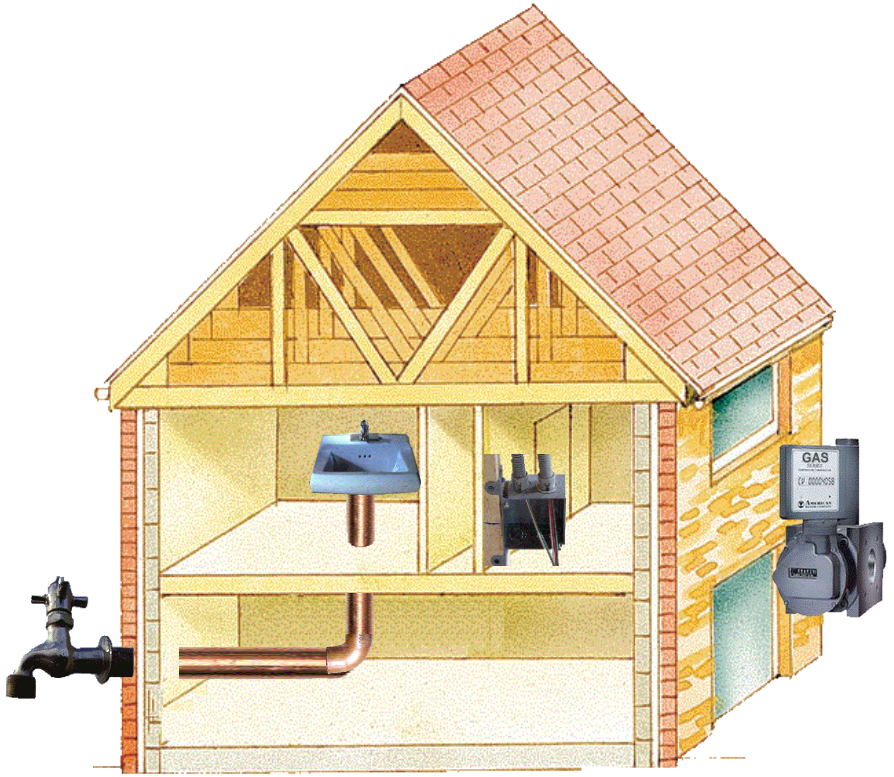


Systems vs. Enterprises



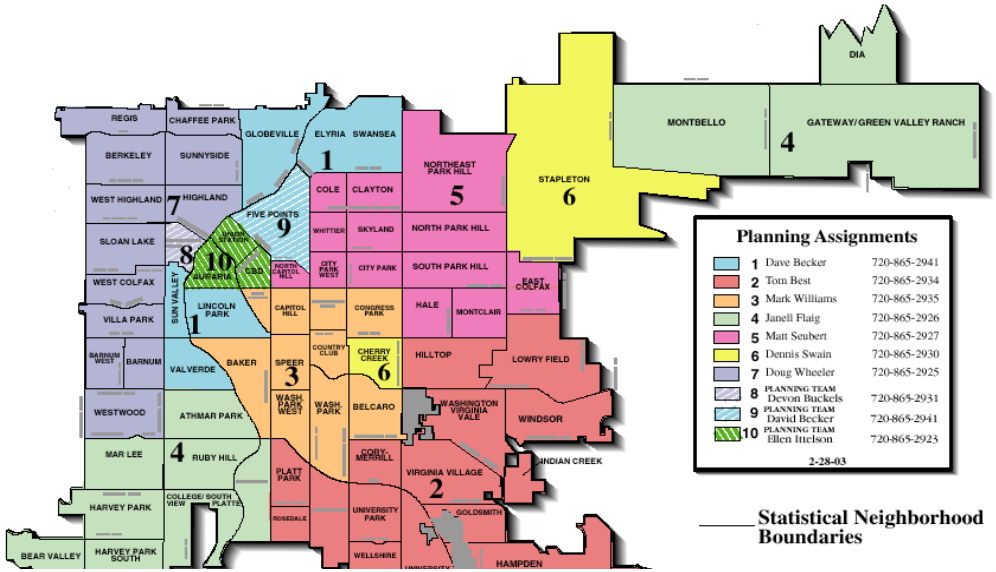
Primary aim of the Enterprise is to maximize Positive Outcomes and minimize Negative Outcomes…

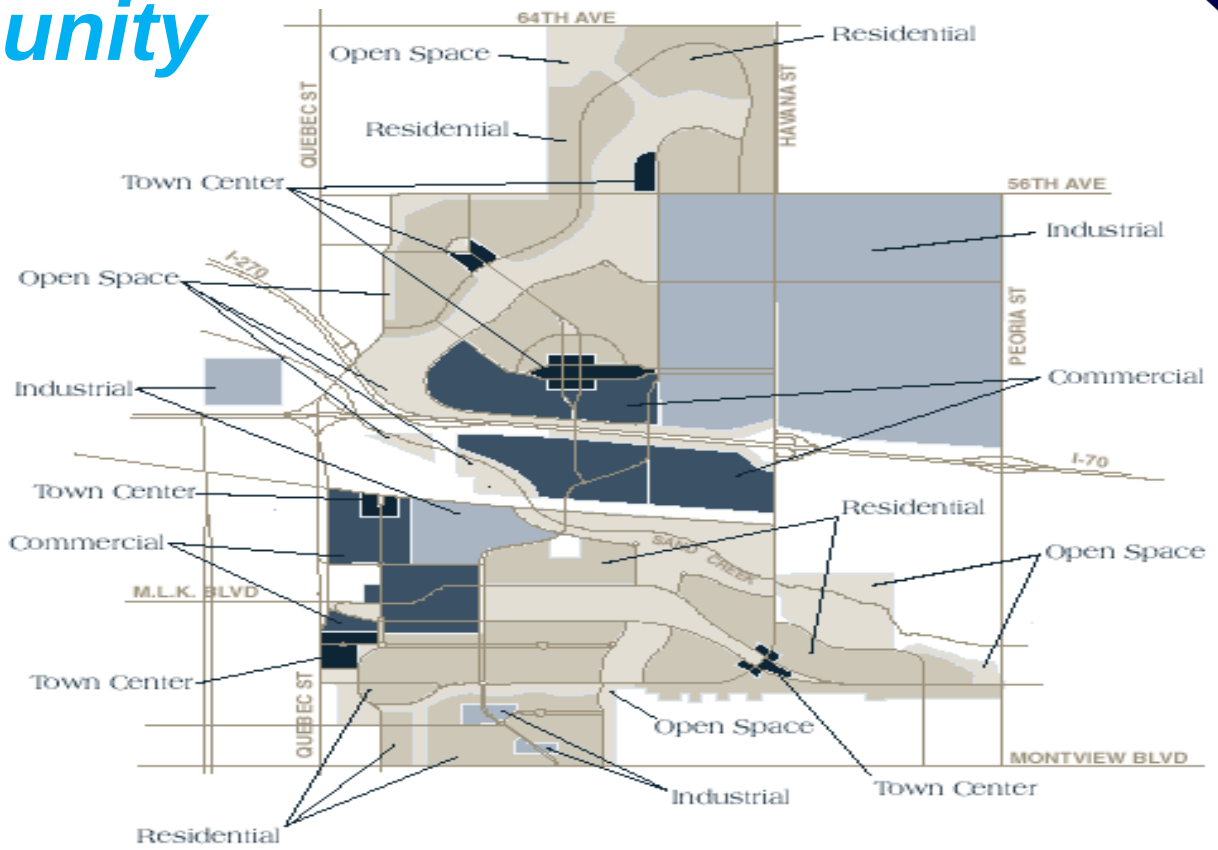
System Architecture is Like Blueprints for a Building



Outputs for a "System" tend to be the same over its lifetime. The requirements are established early on and tend not to change very much. Results for a system are more readily predictable.

Enterprise Architecture is More Like Urban Planning for a Community





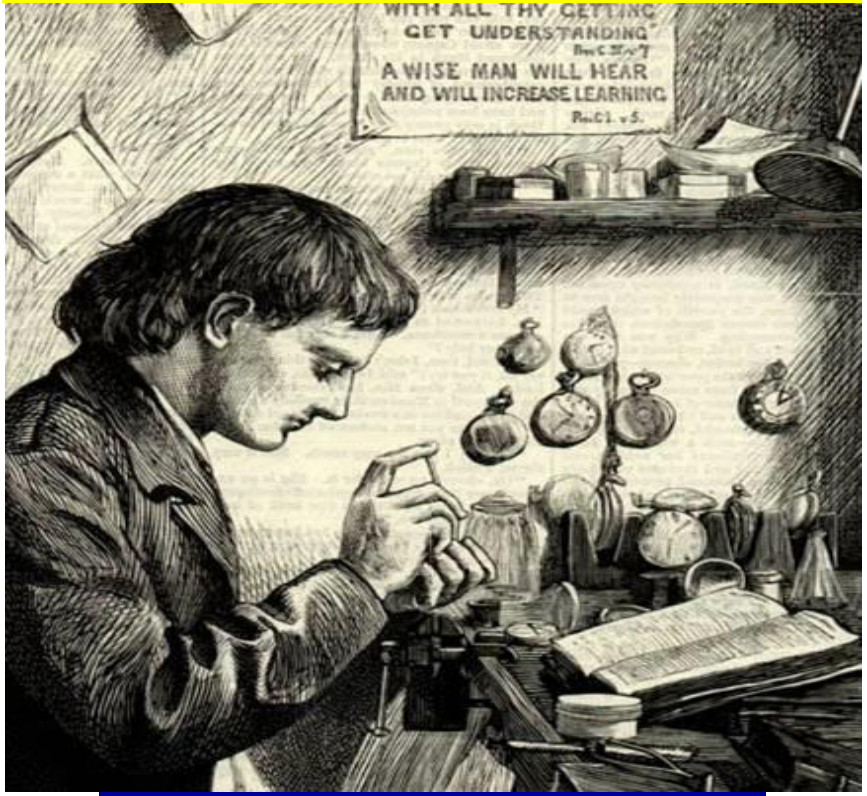
Outcomes for an Enterprise are very complex and are shifting over time…

- *Usually a "sequence" of outcomes is laid out in a Capability Roadmap*
- *The Enterprise can even change its own Objectives and Priorities!*

Change the Focus from Control to Intervention…

Traditional Systems Engineering

The Watchmaker:
Everything has its place…



Static: As Is – To Be Views
Passive: One Design Choice
Uniform: All Parts Are Equal

Enterprise Systems Engineering

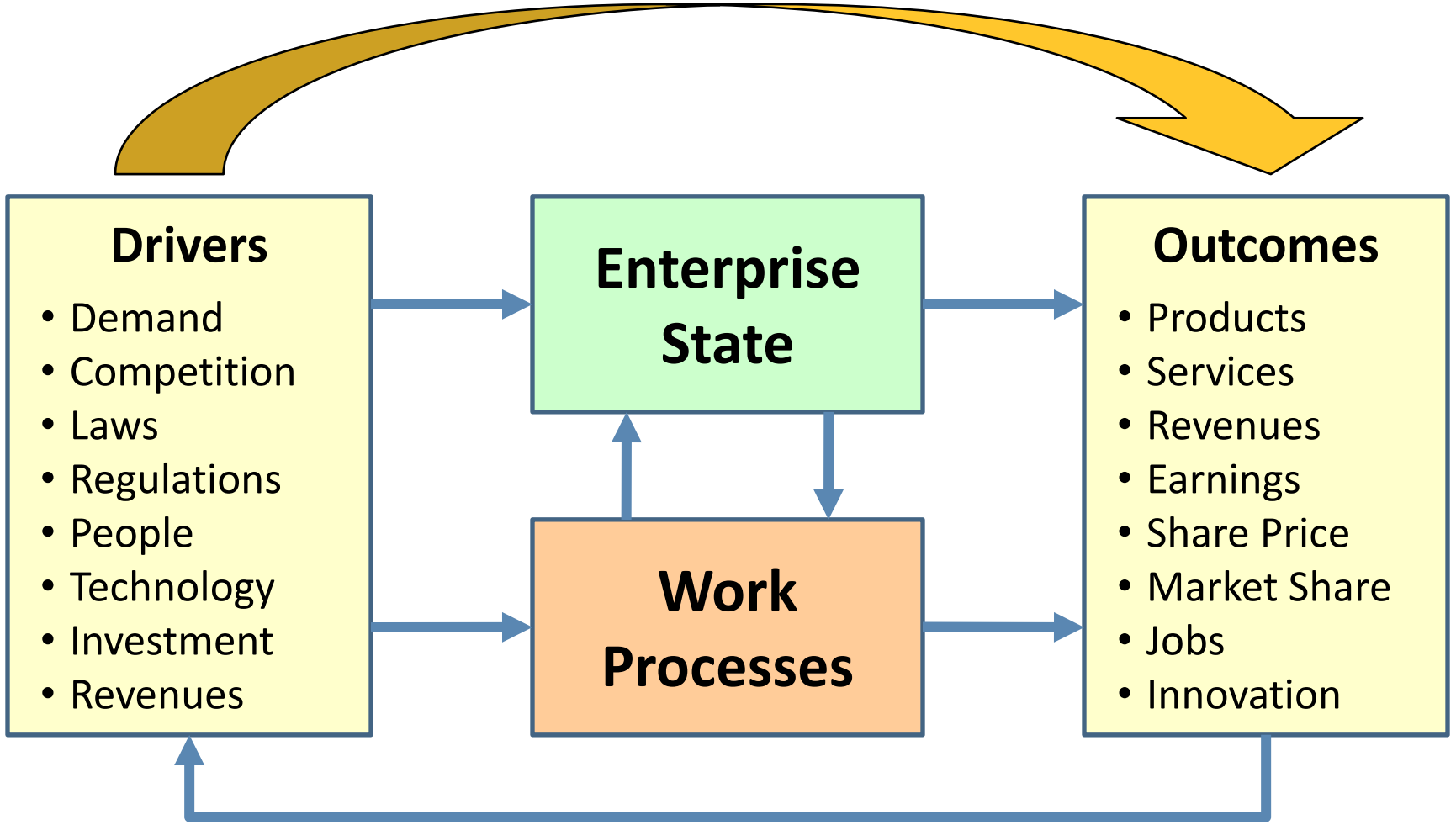
The Gardener:
Plant, Fertilize, Weed → Repeat

Dynamic: Constant Change
Competitive: Crops compete
Scale Free: 80-20 Rule

Source: Evolution Toward Engineering Complex Systems, Joseph DeRosa, MITRE, Complex Conference, Brisbane, Australia, 2007 (Used with permission)

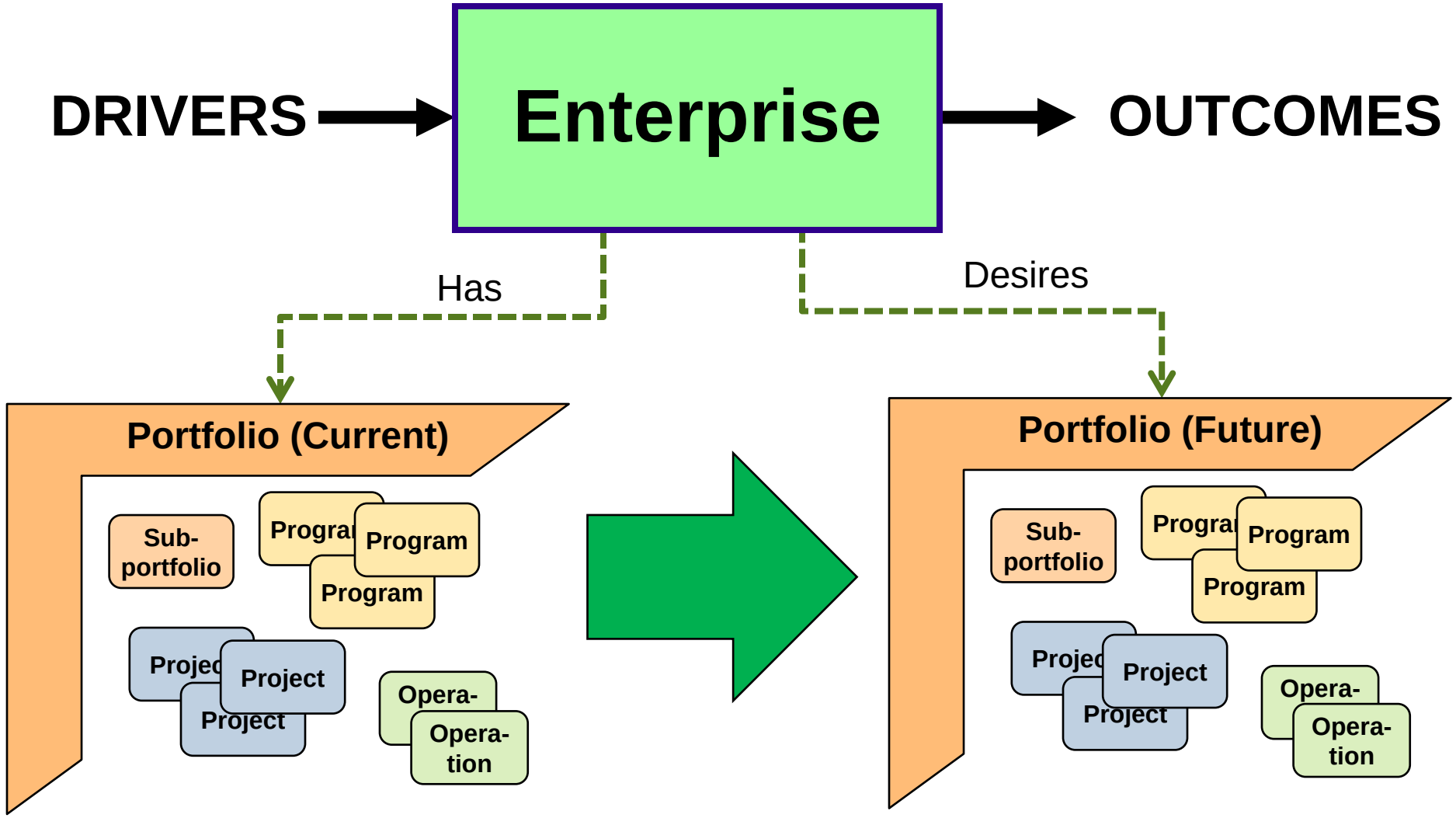
Transforming the Enterprise to Achieve Desired Outcomes

Finding the Optimal States and the Right Processes

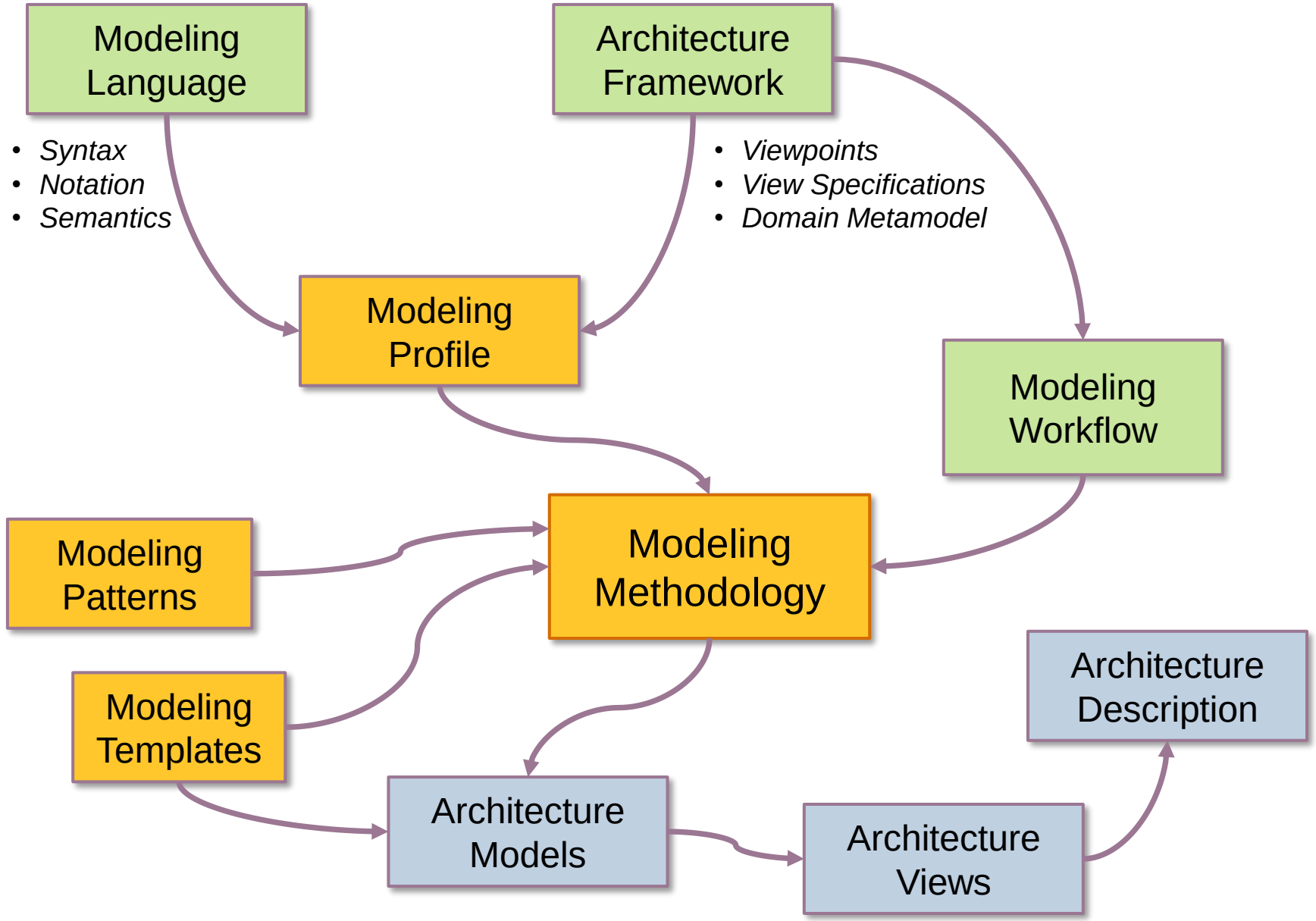


Architecture Models can help understand the landscape and how to change things for the better

Portfolio Management



The Modeling Landscape



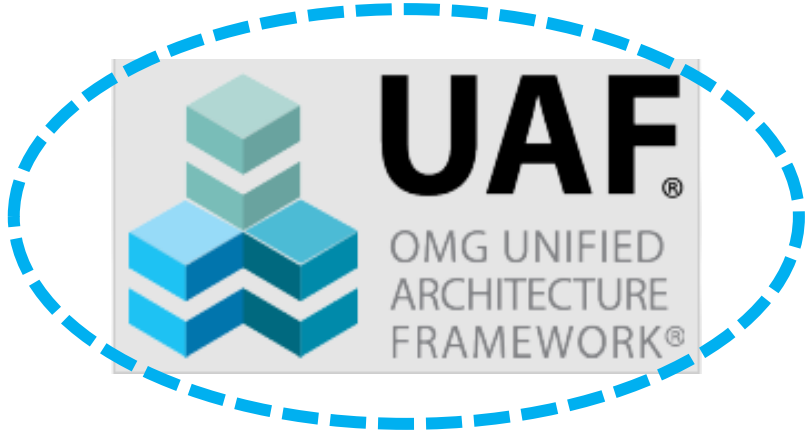
OMG Modeling Standards

Modeling Languages

For modeling complex **Software Architectures** and applications

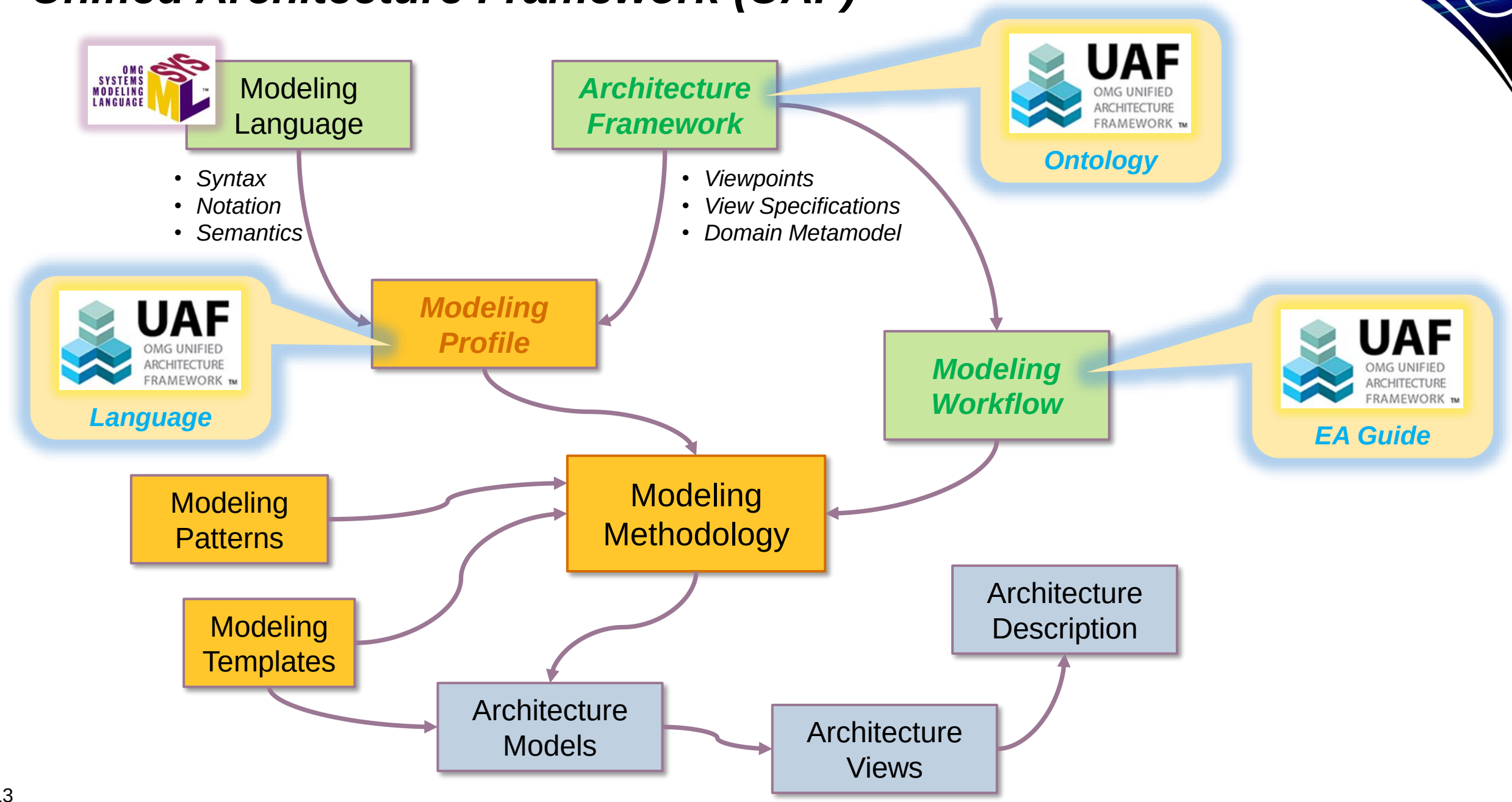
For modeling complex **System Architectures** that may include hardware, software, personnel, processes and facilities

For modeling complex **Business Processes**

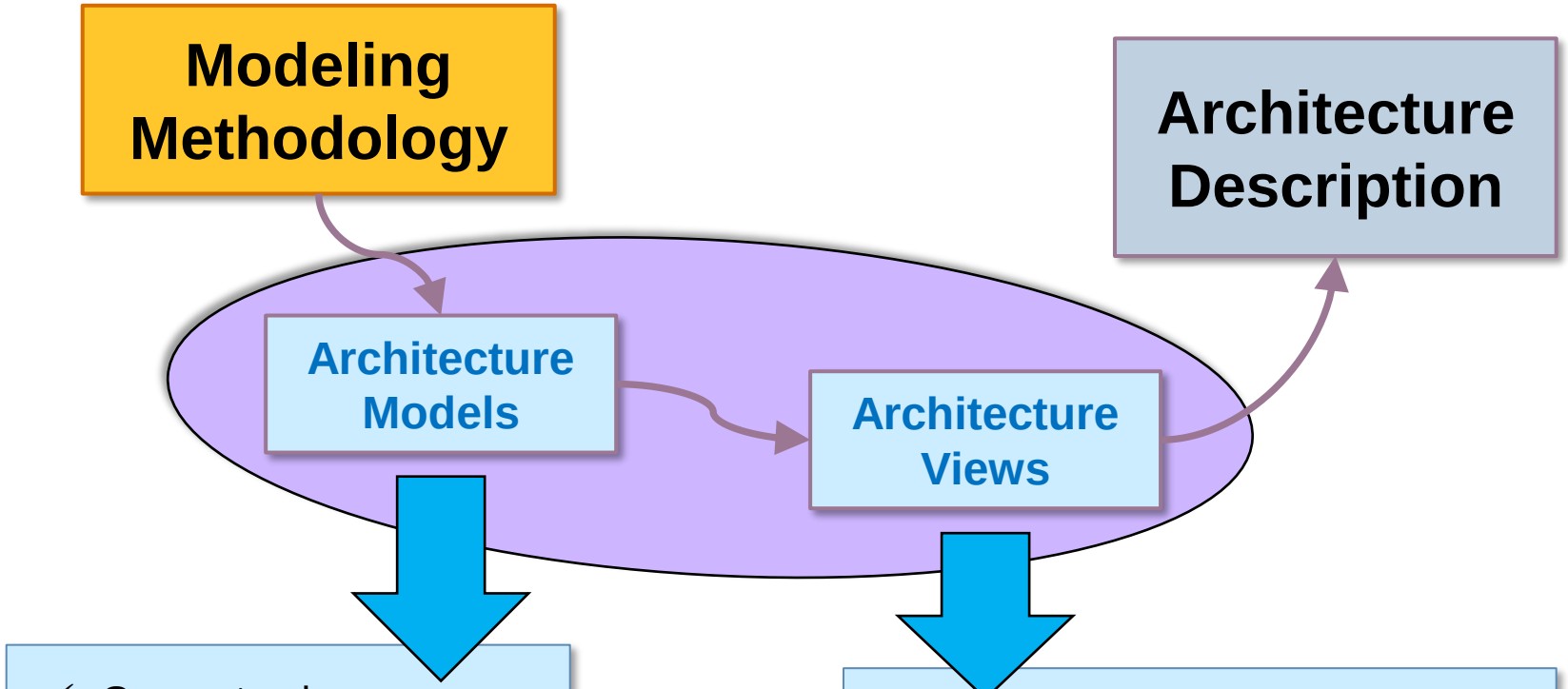


For modeling complex **Enterprise Architectures** that includes strategy, capabilities, operations, programs/projects, services, resources, security, personnel, organizations and standards

Unified Architecture Framework (UAF)



Primary Use Cases for Architecture Models & Views



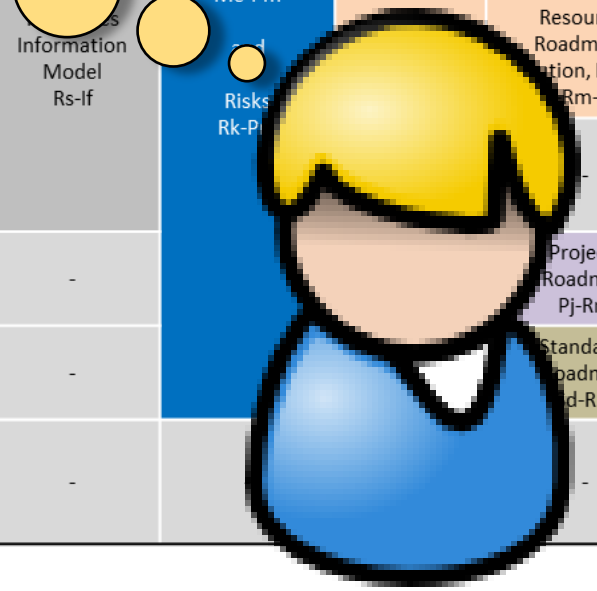
- ✓ Generate views
- ✓ Basis for analysis
- ✓ Link Architecture to Design Engineering
- ✓ Check that architecture is complete & correct
- ✓ Capture ASOT data for a system or enterprise

- ✓ Inform Decision Makers*
- ✓ Validate with Stakeholders*
- ✓ Justify budget request & plans*
- ✓ Basis for requirements definition & management
- ✓ Basis for V&V planning and execution (eg, test cases)

** Use cases most relevant to Portfolio Management*

UAF	Motivation Mv	Taxonomy Tx	Structure Sr	Connectivity Cn	Processes Pr	States St	Sequences Sq	Information If	Parameters Pm	Constraints Ct	Roadmap Rm	Traceability Tr
Architecture Management	Architecture	Architecture							Architecture Parameters Am-Pm	Architecture Constraints Am-Ct	Architecture Roadmap Am-Rm	Architecture Traceability Am-Tr
Ps						Ps-St	Ps-Sq		Environment En-Pm and Measurements Me-Pm	Competence, Drivers, Performance Ps-Ct-C, -D, -P	Availability, Evolution, Forecast PS-Rm-A,-E,-F	Personnel Traceability Ps-Tr
Resources Rs		Resources Taxonomy Rs-Tx	Resources Structure Rs-Sr	Resources Connectivity Rs-Cn	Resources Processes Rs-Pr	Resources States Rs-St	Resources Sequences Rs-Sq	Information Model Rs-If			Resources Roadmaps: ...tion, Forecast ...Rm-E, -F	Resources Traceability Rs-Tr
Security Sc	Security Controls Sc-Mv	Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr	-	-				-	Security Traceability Sc-Tr
Projects Pj	-	Projects Taxonomy Pj-Tx	Projects Structure Pj-Sr	Projects Connectivity Pj-Cn	Projects Processes Pj-Pr	-	-	-			Projects Roadmap Pj-Rm	Projects Traceability Pj-Tr
Standards Sd	-	Standards Taxonomy Sd-Tx	Standards Structure Sd-Sr	-	-	-	-	-			...tandards ...oadmap ...d-Rm	Standards Traceability Sd-Tr
Actual Resources Ar	-	-	Actual Resources Structure, Ar-Sr	Actual Resources Connectivity, Ar-Cn	Simulation			-			-	-

What Elements are in my Portfolio?
How much Value do they deliver?
How are these Elements related?
How much Cost is involved?



UAF®
OMG UNIFIED ARCHITECTURE FRAMEWORK®

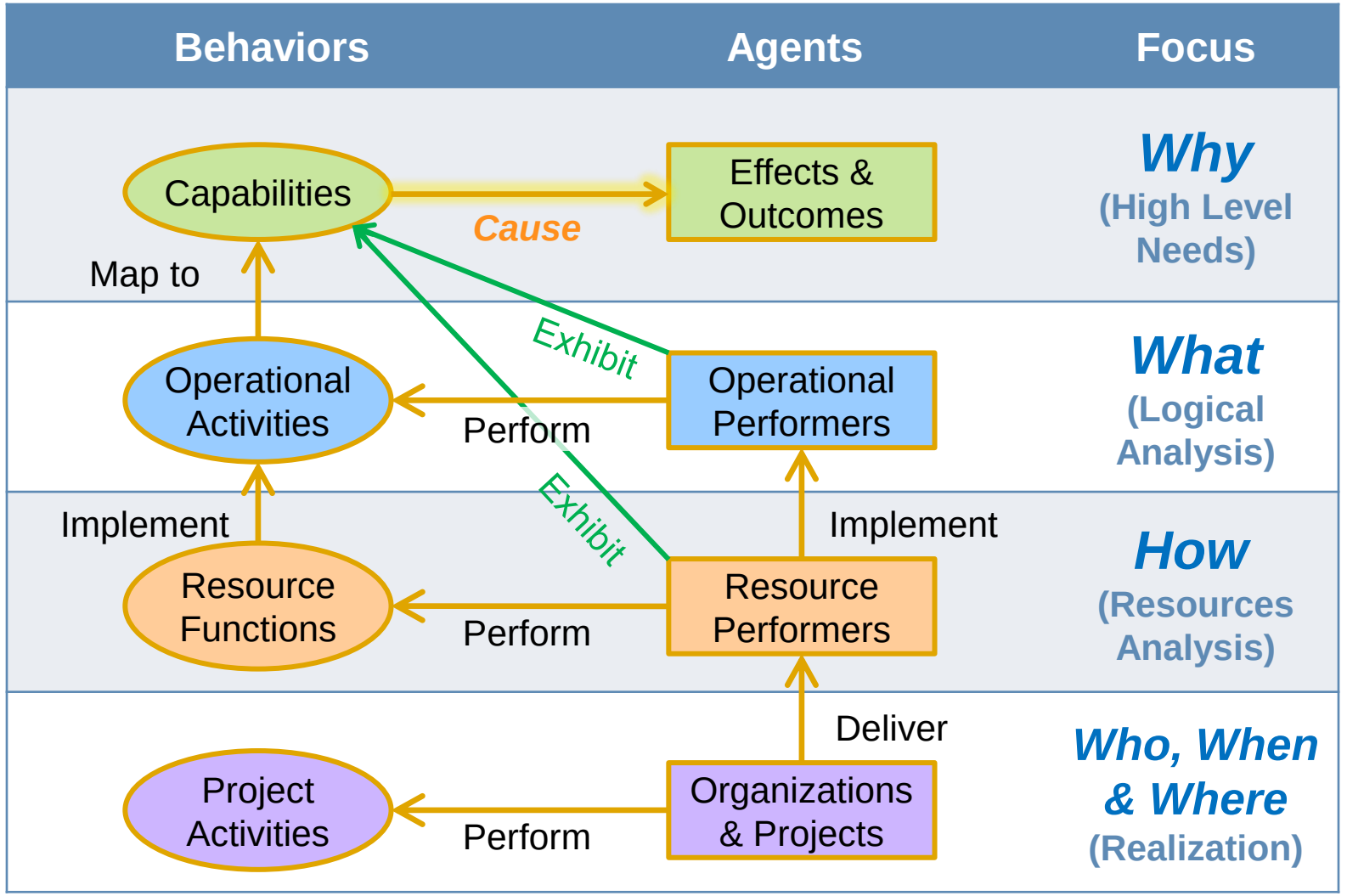
The Four Layers of Enterprise Modeling

Behaviors & Agents (ie, Doing and Being) at Different "Levels of Abstraction"

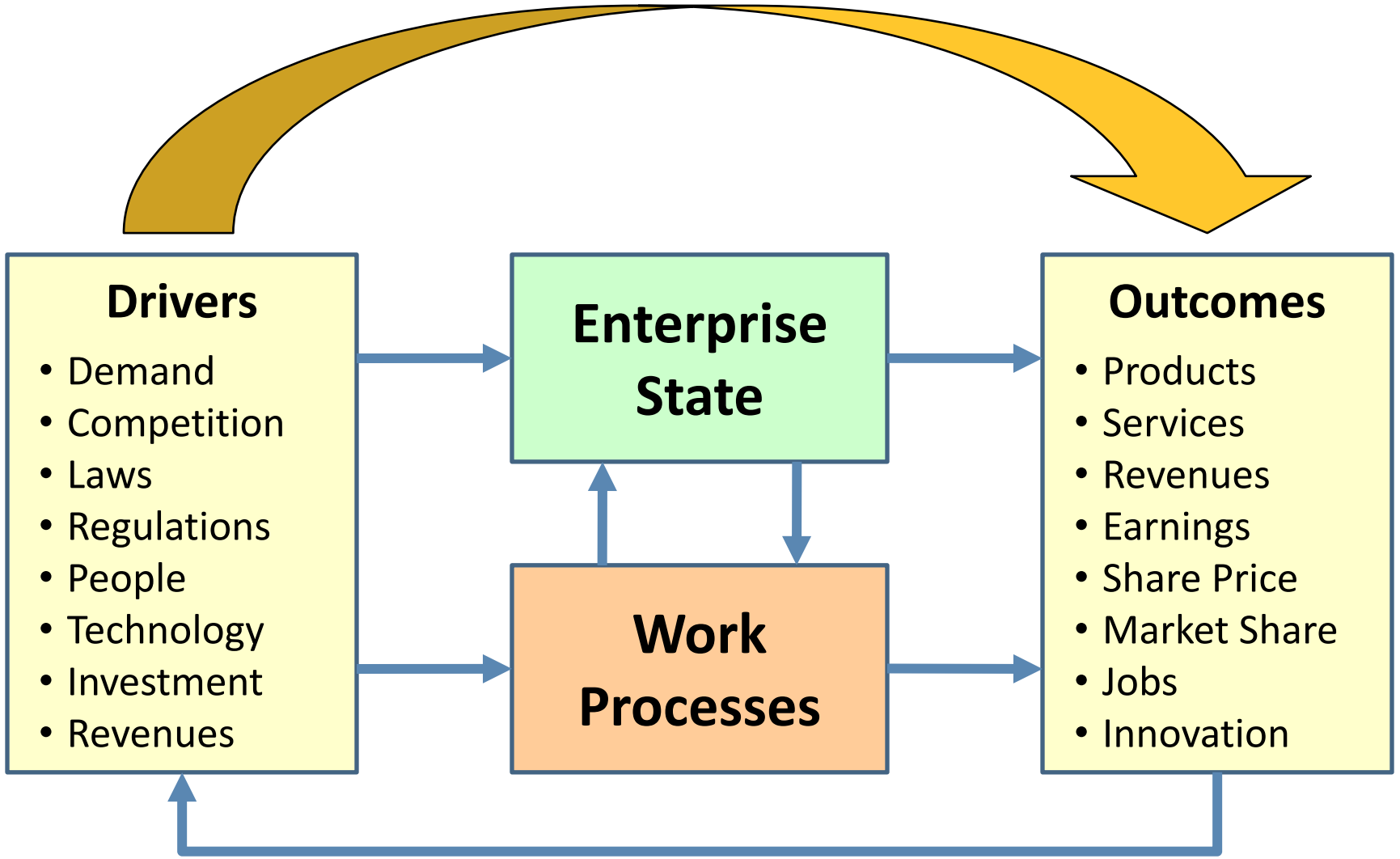
Behaviors	Agents	Focus
Capabilities	Effects & Outcomes	***Why*** **(High Level Needs)**
Operational Activities	Operational Performers	***What*** **(Logical Analysis)**
Resource Functions	Resource Performers	***How*** **(Resources Analysis)**
Project Activities	Organizations & Projects	***Who, When & Where*** **(Realization)**

The Four Layers of Enterprise Modeling

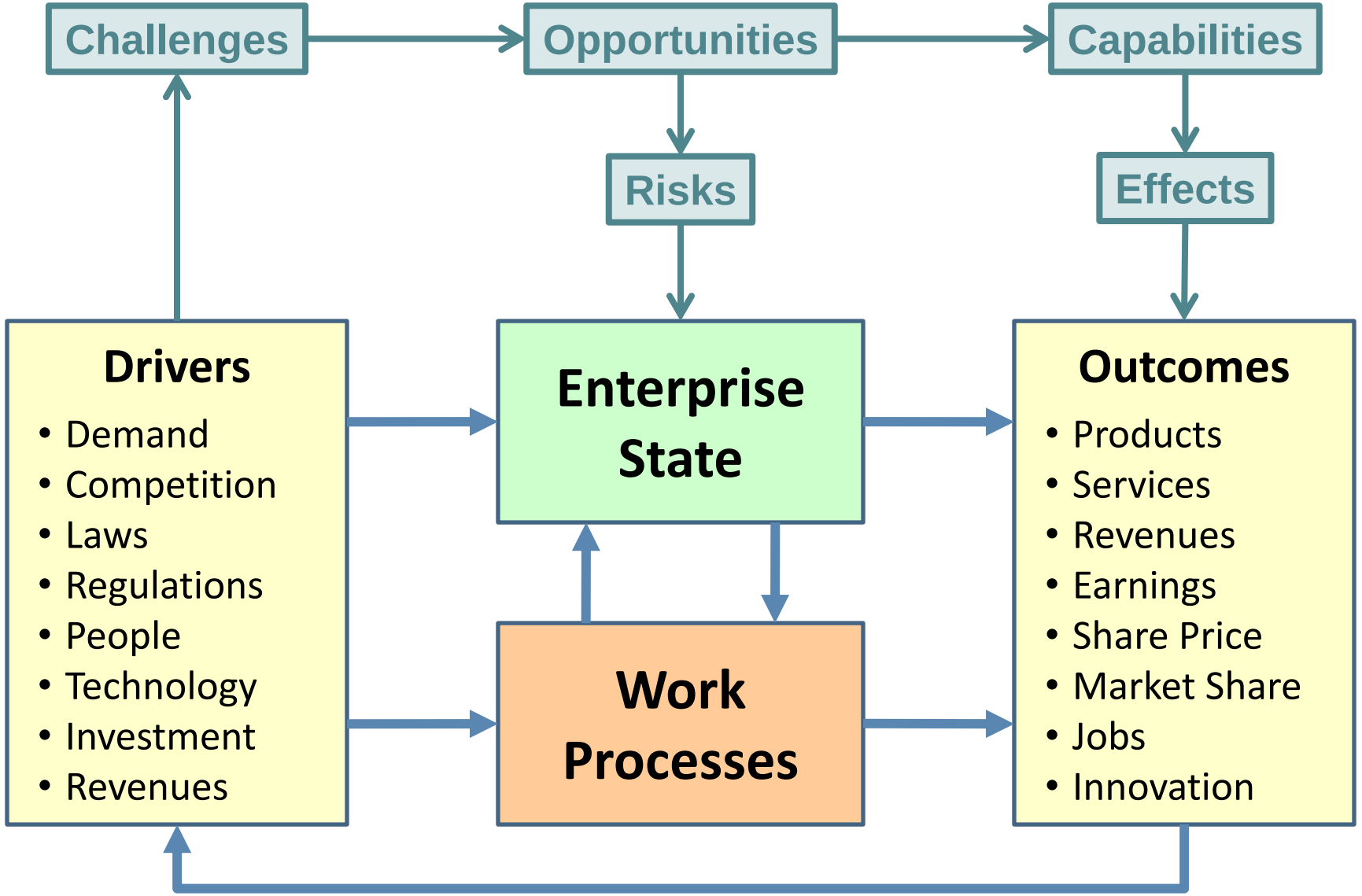
Key Relationships Between Behaviors & Agents



Drivers → Challenges → Opportunities → Capabilities → Effects → Outcomes

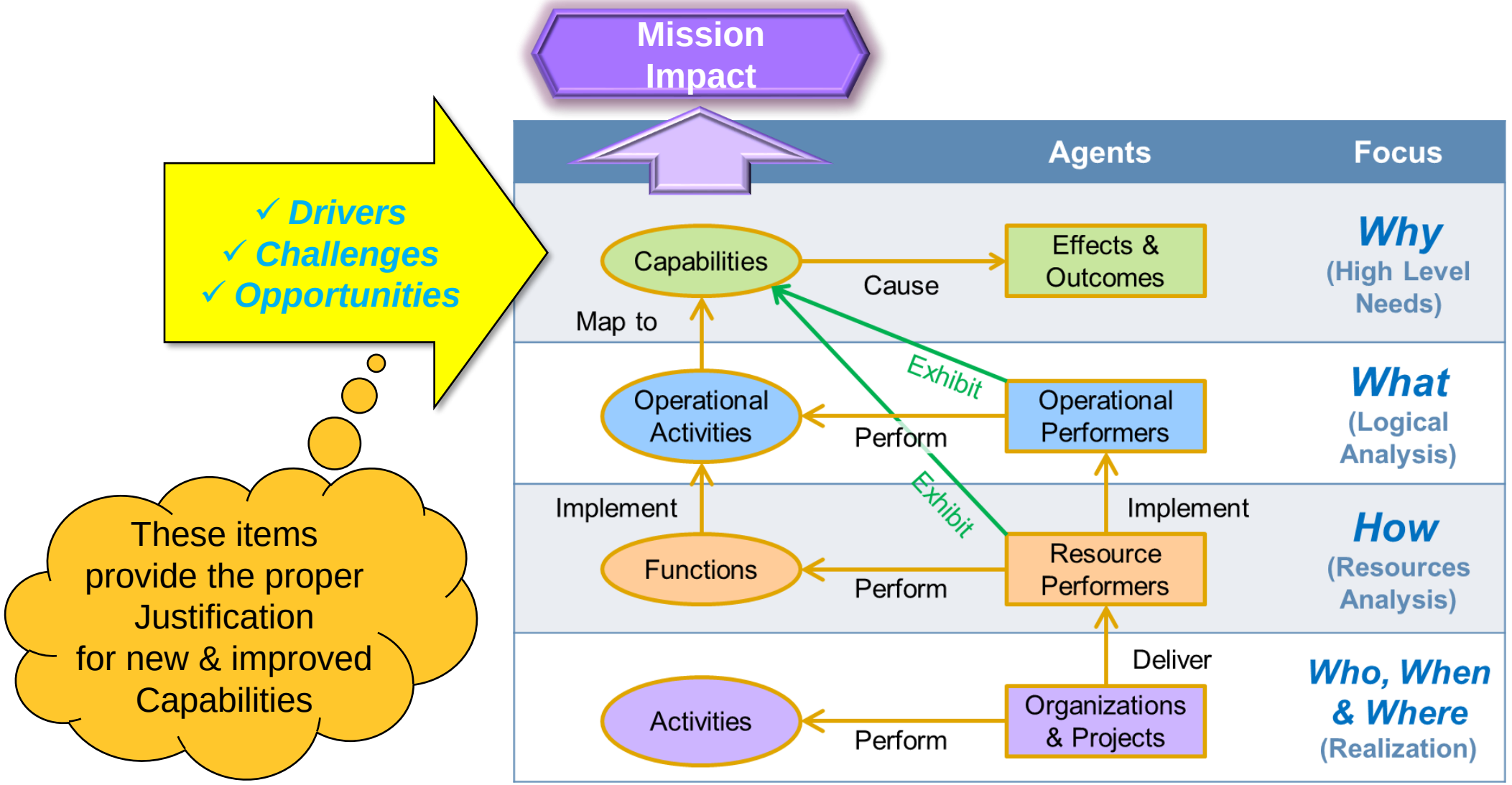


Challenges & Opportunities to be Identified for Achieving Enterprise Transformation



Identification of Capability Gaps and Shortfalls

Focus on Enterprise Capabilities & Desired Effects for Portfolio Management



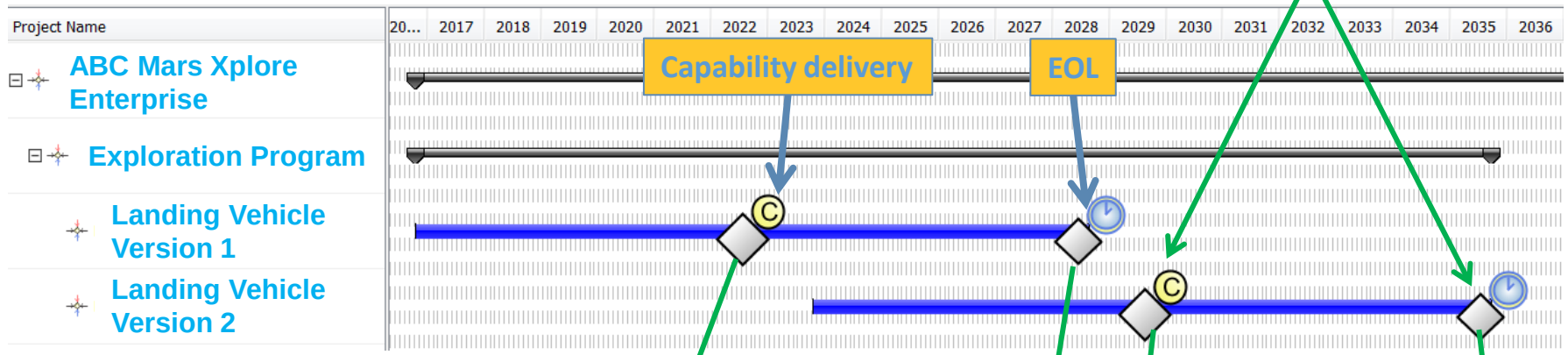
Need to examine various factors that will help identify which Capabilities in the Enterprise have gaps and shortfalls with respect to causing desired Effects (and minimizing undesirable Effects)

System End of Life Before Next Delivery Causes a Capability Gap

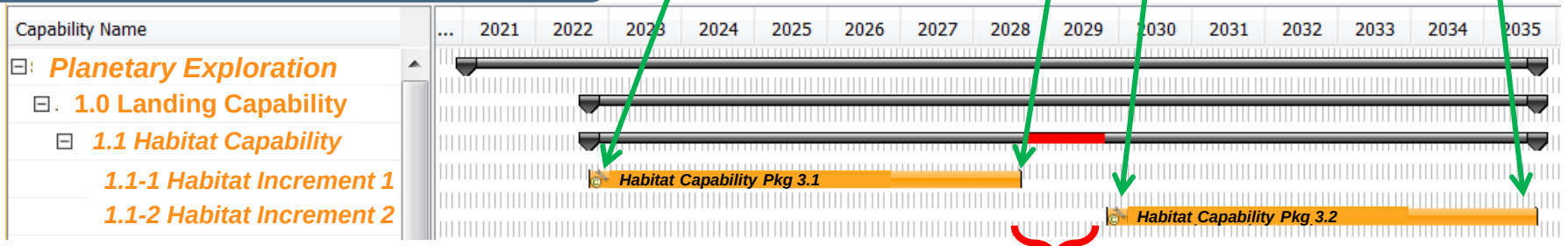
Roadmap views provide key insights into Portfolio change impacts

Adjusting milestones in the PV-2 Project View will affect the CV-3 Capability Roadmap

PV-2 Project Timelines (Pj-Rm)



CV-3 Capability Phasing (St-Rm)



Capability Gap

Mars Exploration Enterprise Projects & Capabilities

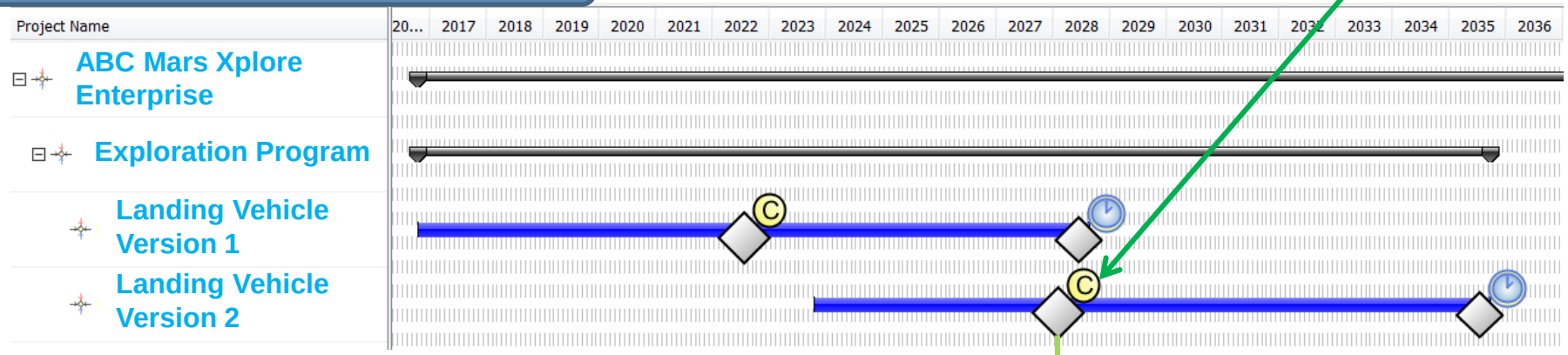
Enterprise Models of the Portfolio can highlight issues and potential problems

Schedule Adjustment Closes Gap

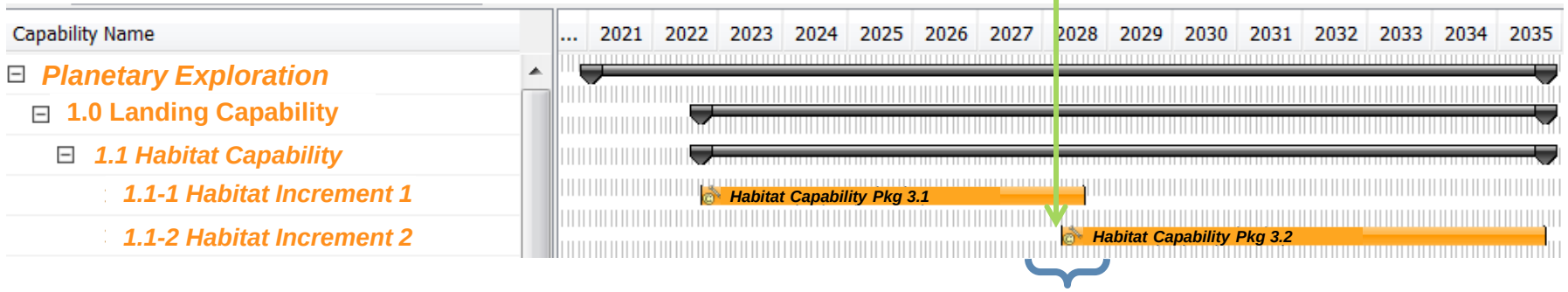
Changing the Portfolio further to achieve proper balance

Adjusting this milestone to the left closes the gap

PV-2 Project Timelines (Pj-Rm)



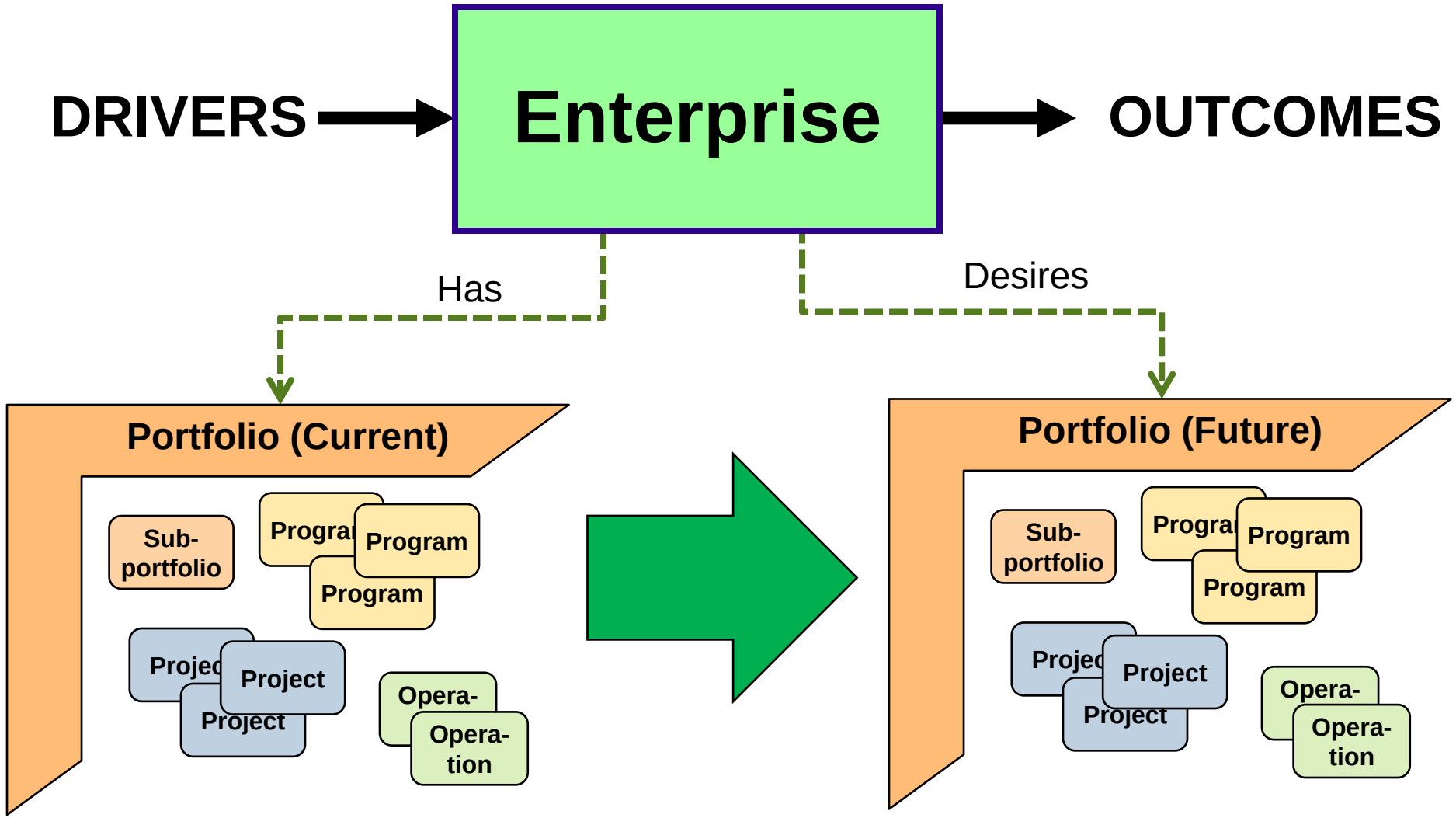
CV-3 Capability Phasing (St-Rm)



Gap Closed

Without a good model of the Enterprise, it can be very difficult to discern impacts due to changes in a Portfolio

Portfolio Management



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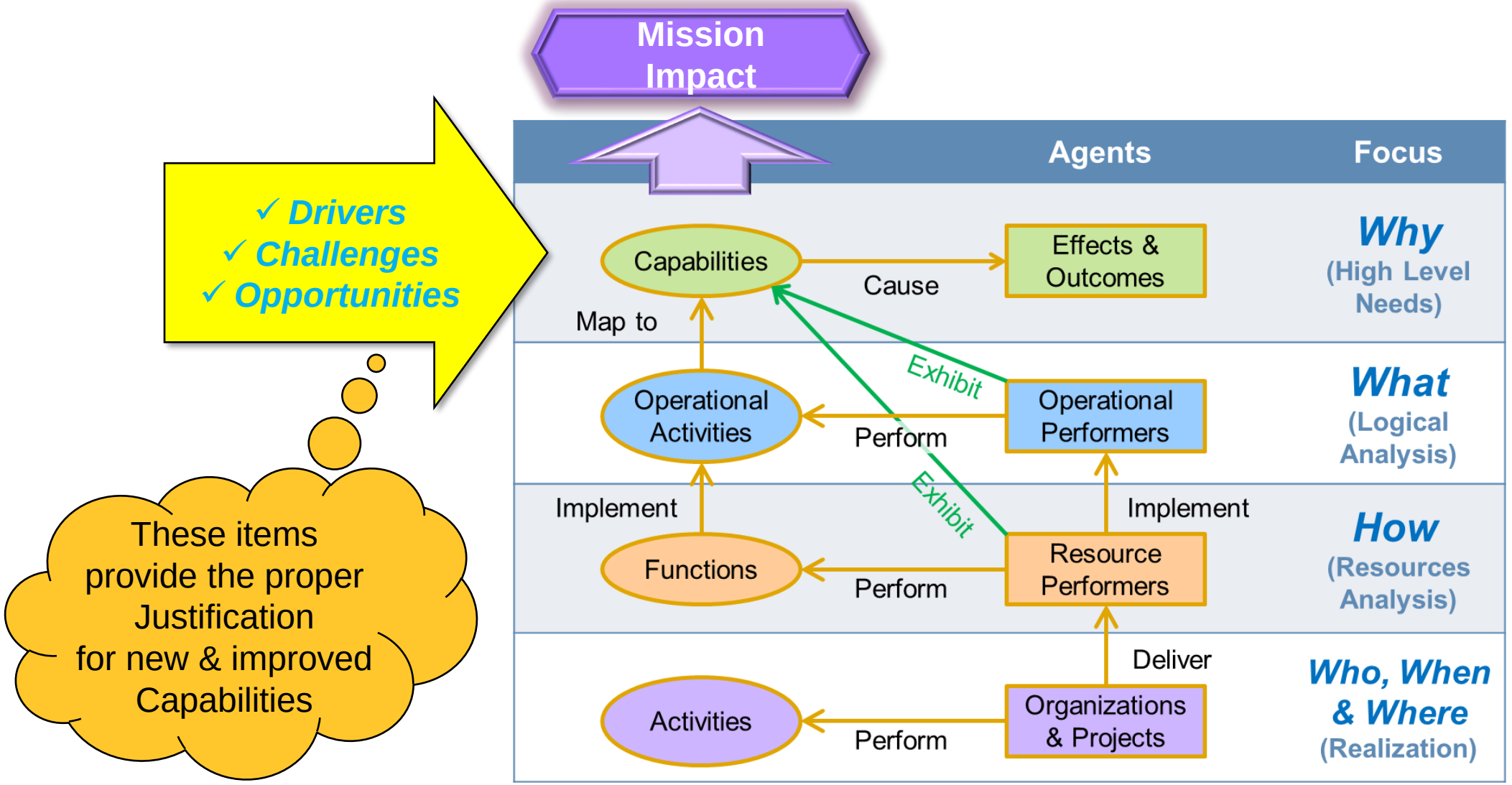

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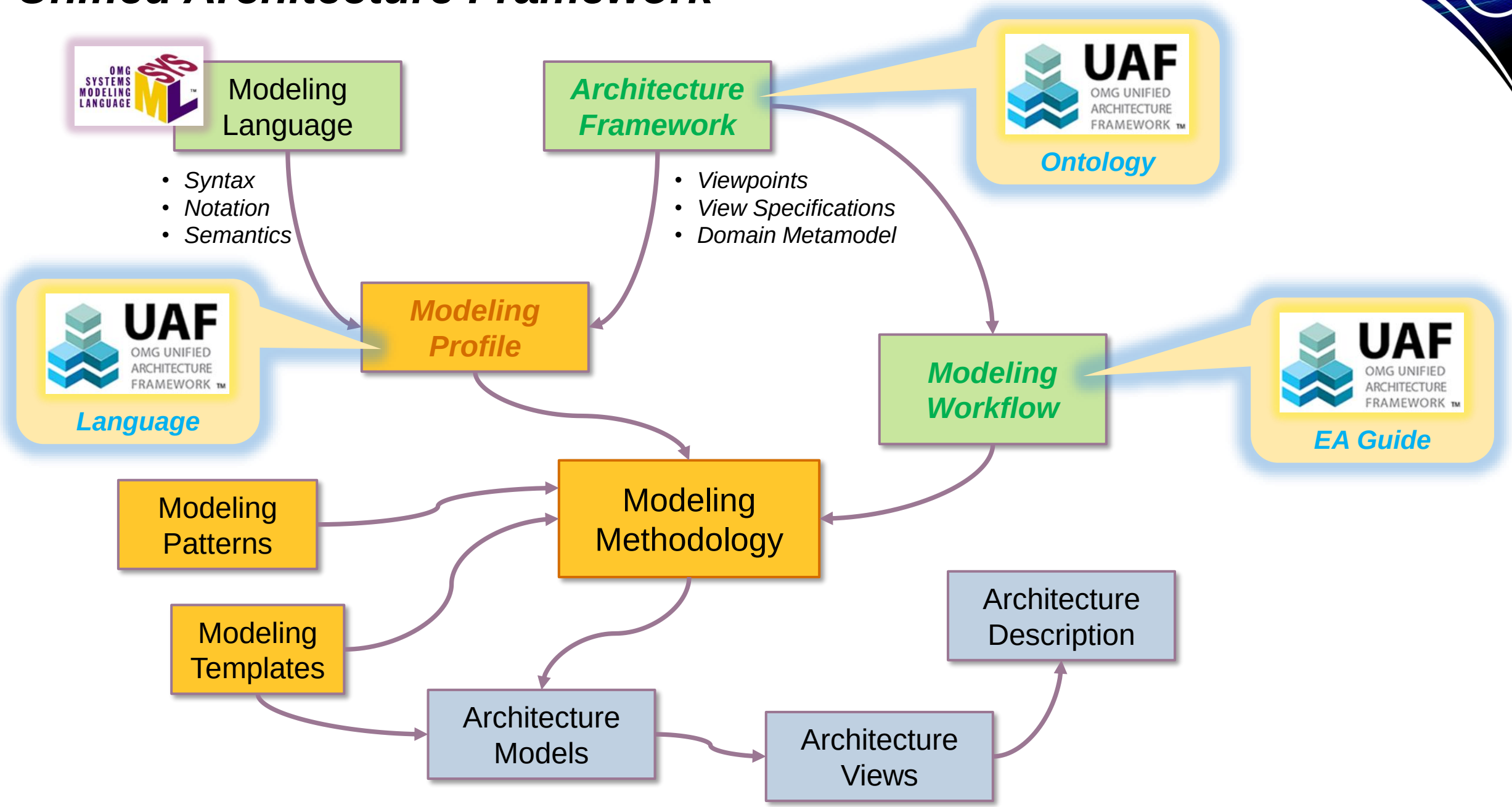
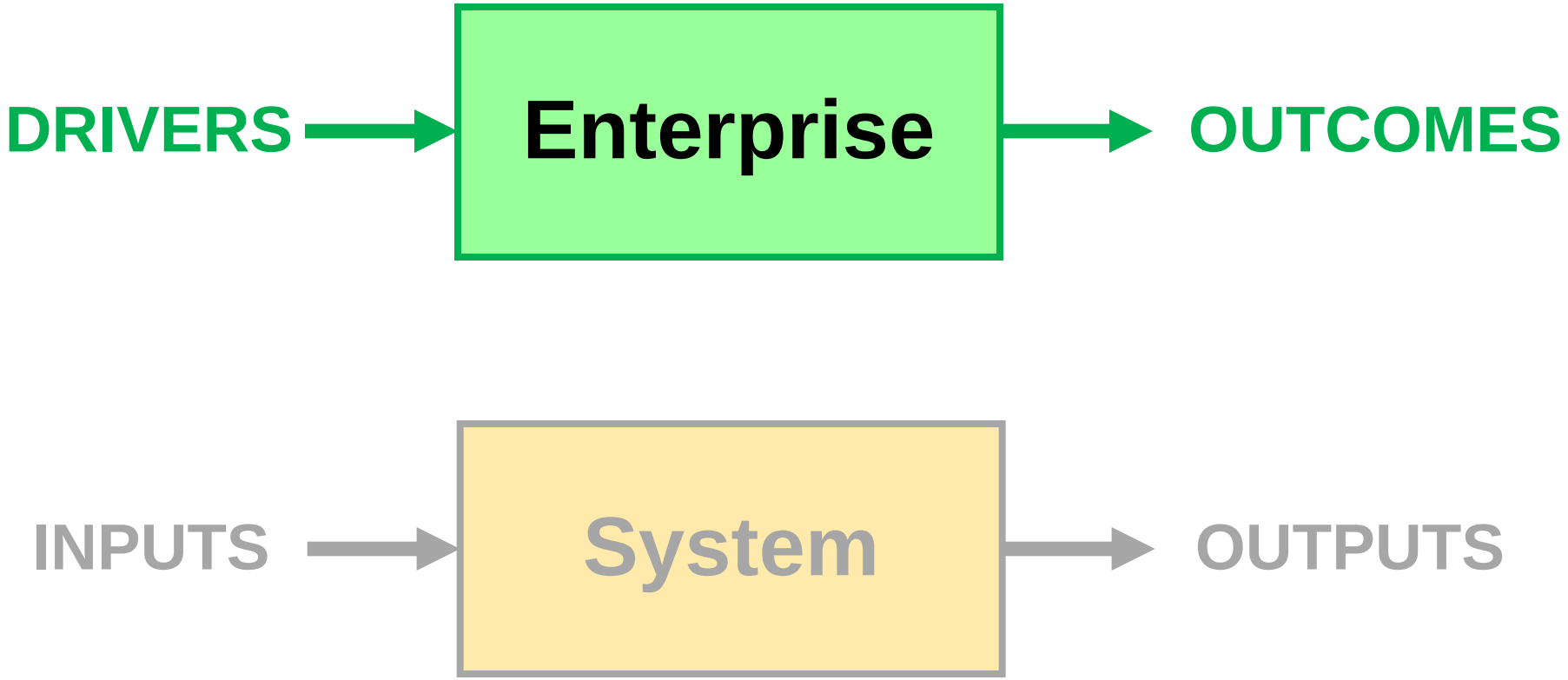
Unified Architecture Framework

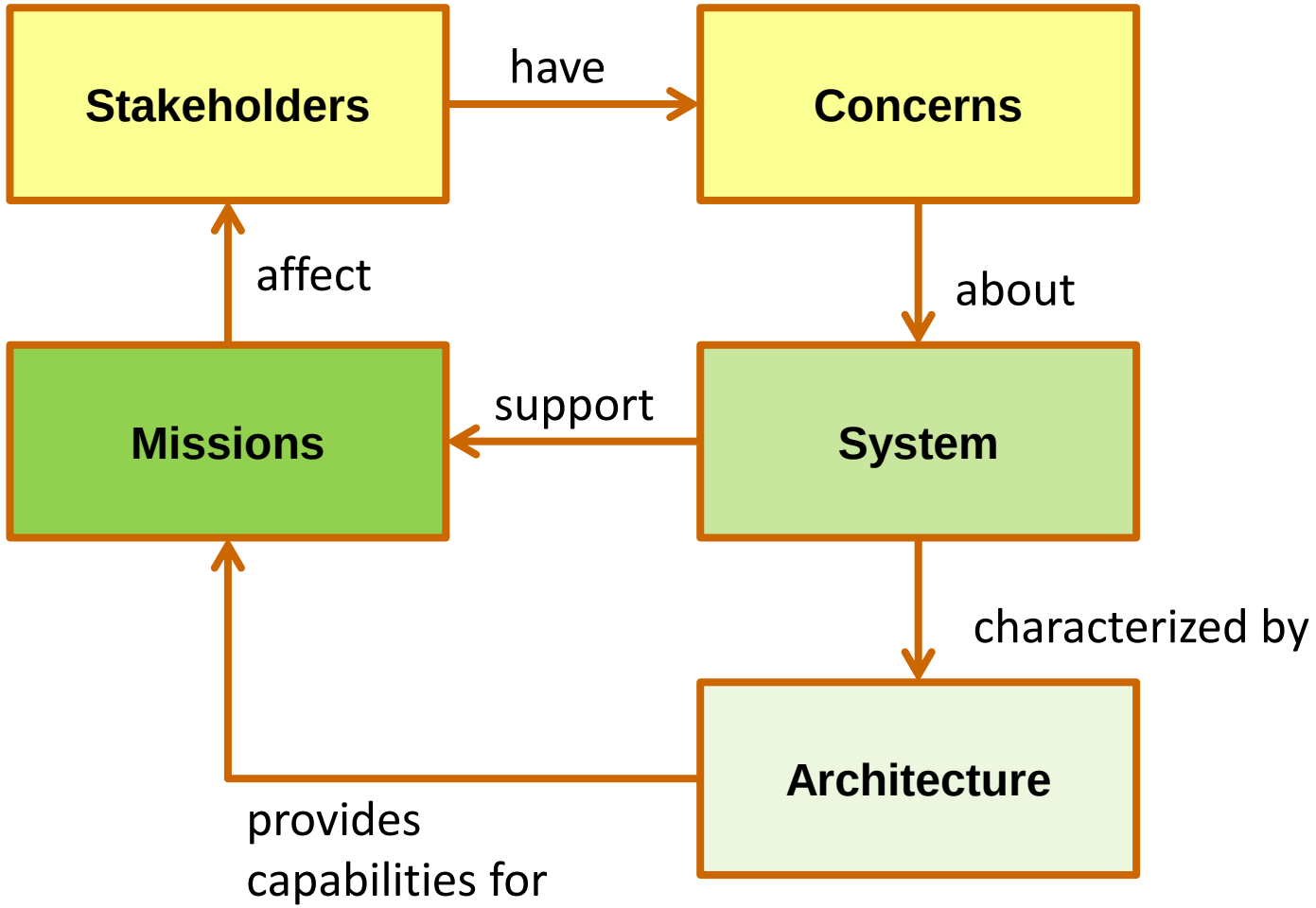


The Enterprise Mindset…

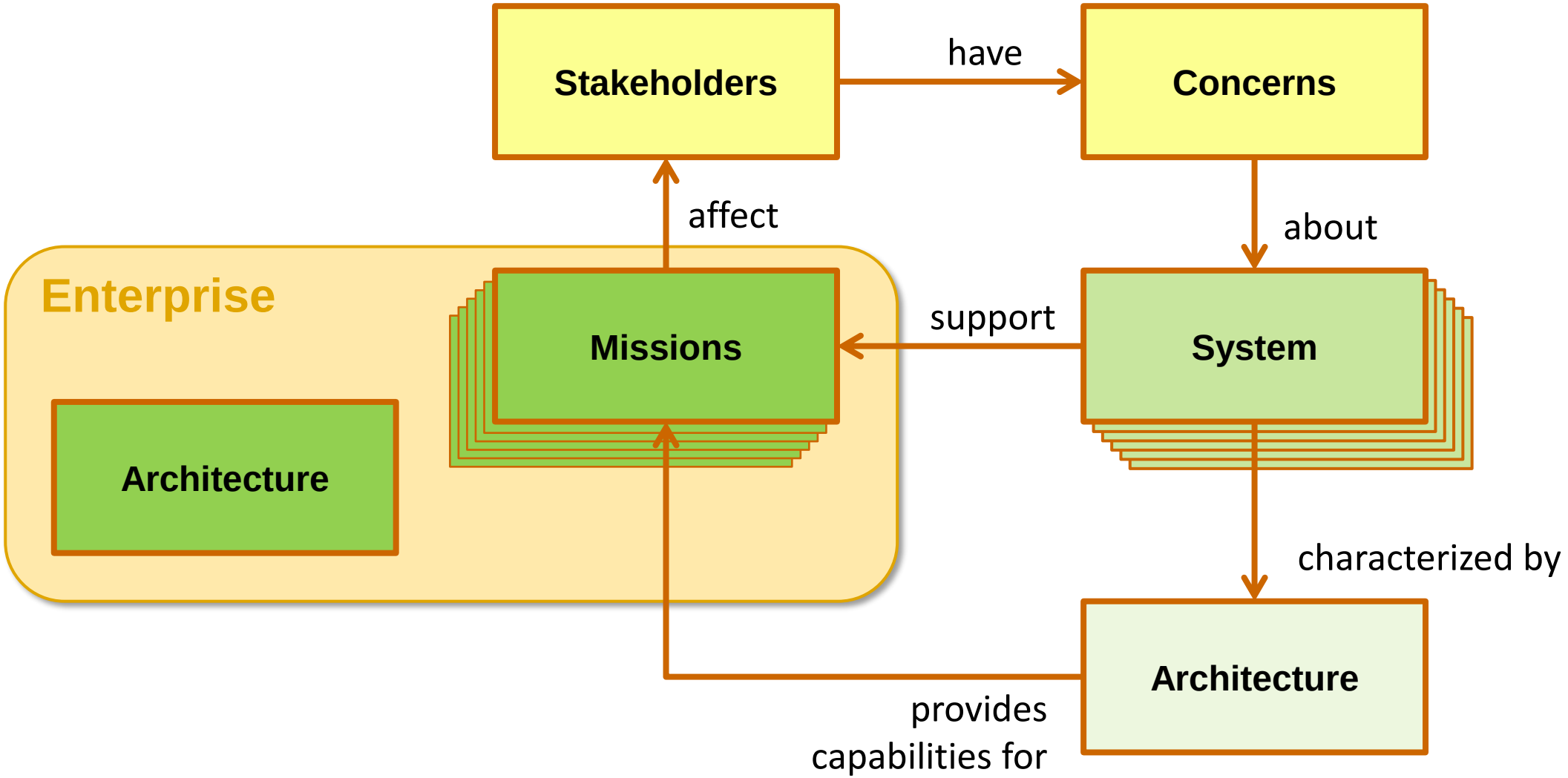


Outcomes for an Enterprise are very complex and are shifting over time. However, you must be eternally mindful of the various Drivers in the environment, which are changing constantly…

Systems Engineering defines an **Architecture** of the **System** that addresses **Stakeholder Concerns** regarding the relevant **Missions**



The *Enterprise Architecture* defines the various **Missions** along with associated **Mission Objectives** and **Strategic Capabilities**



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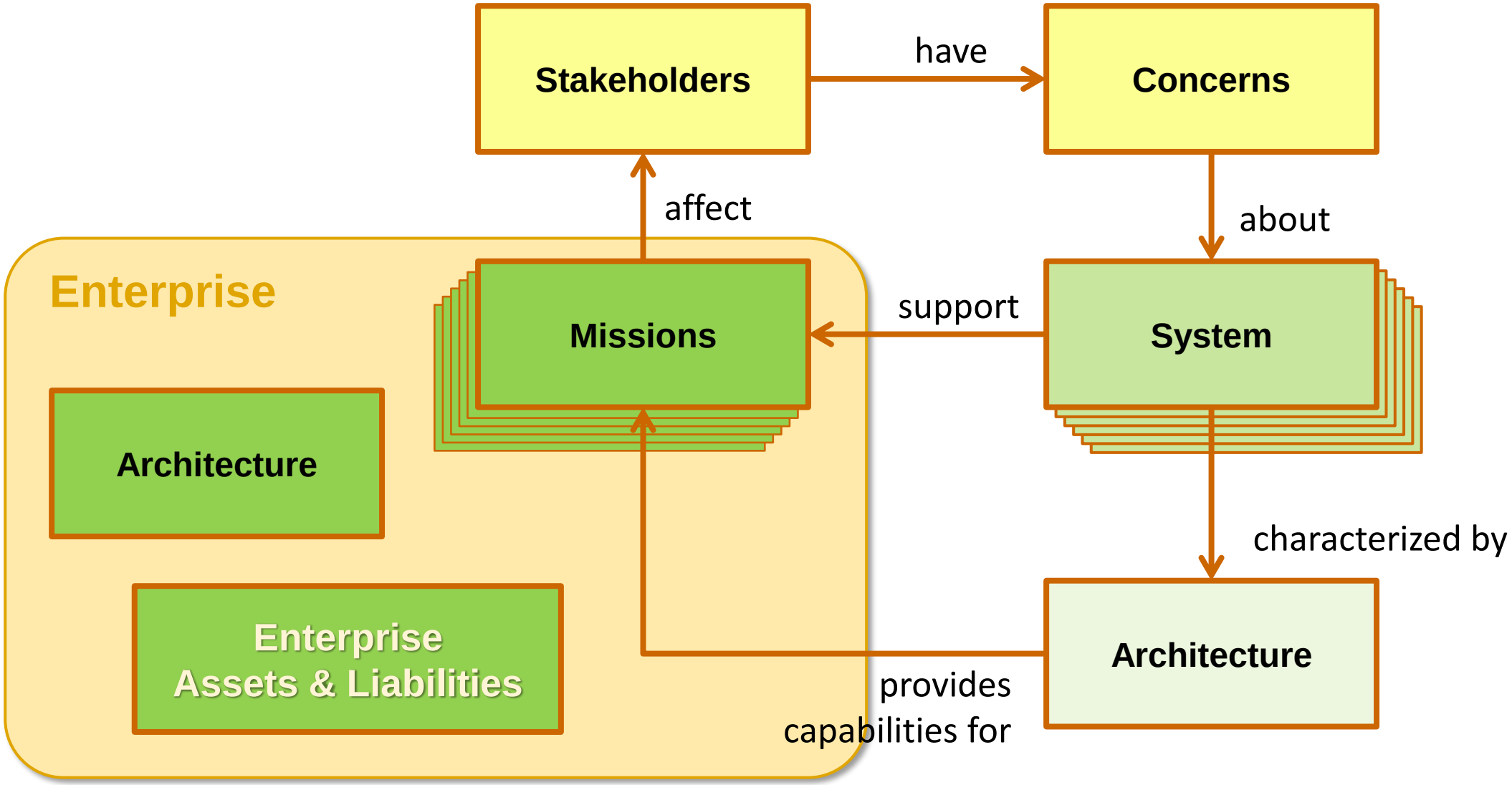
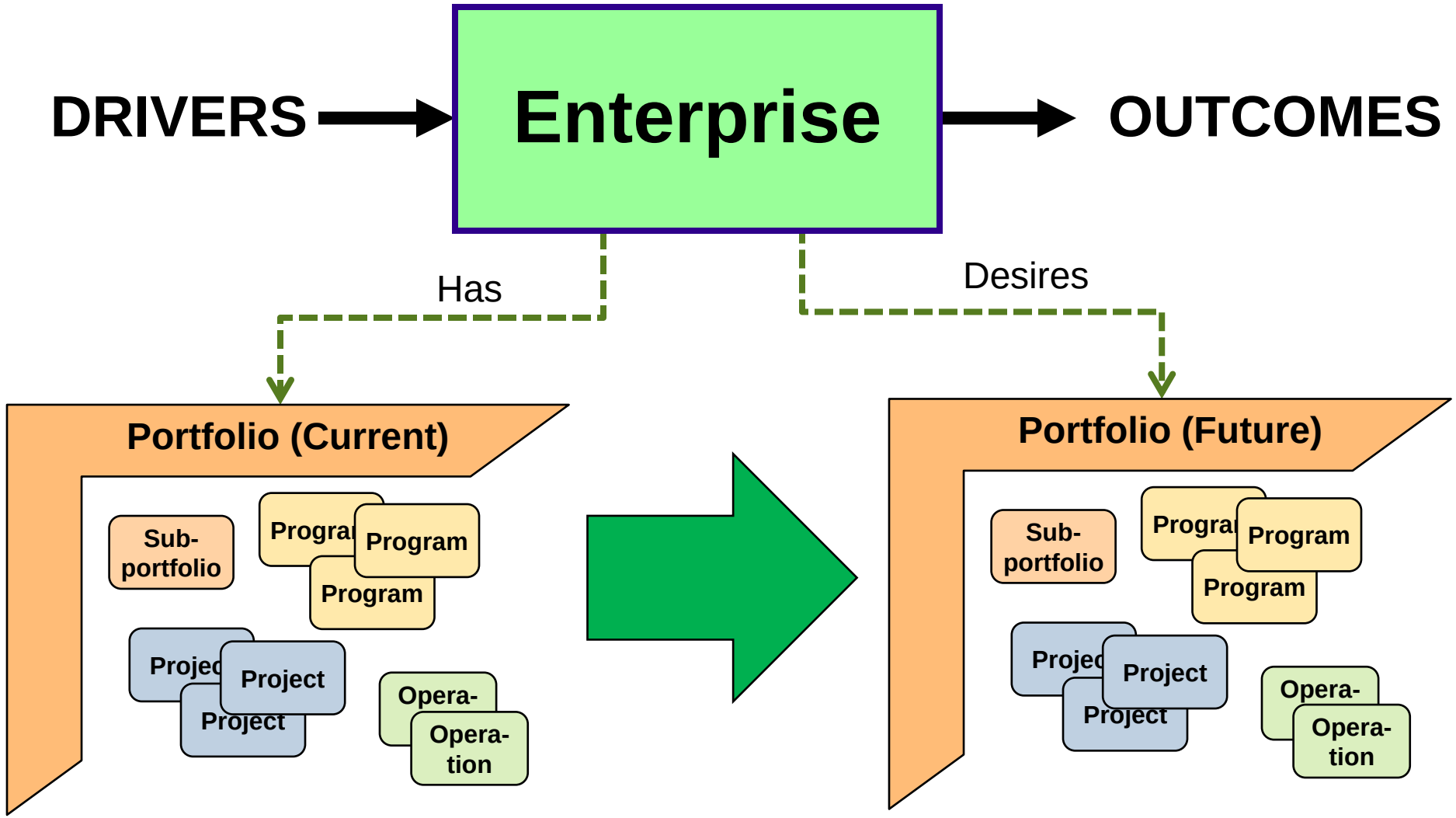
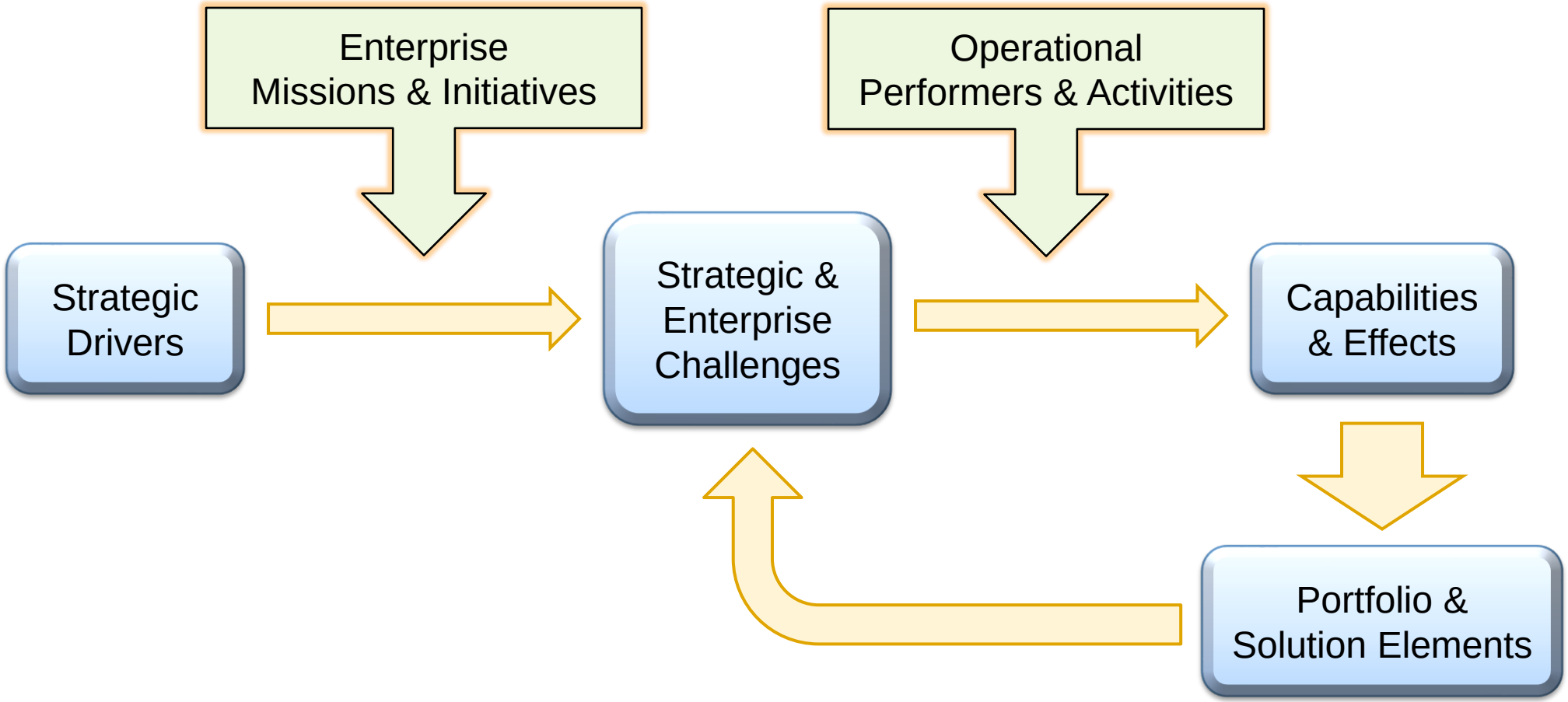


Portfolio Management



Enterprise Transformation Considerations

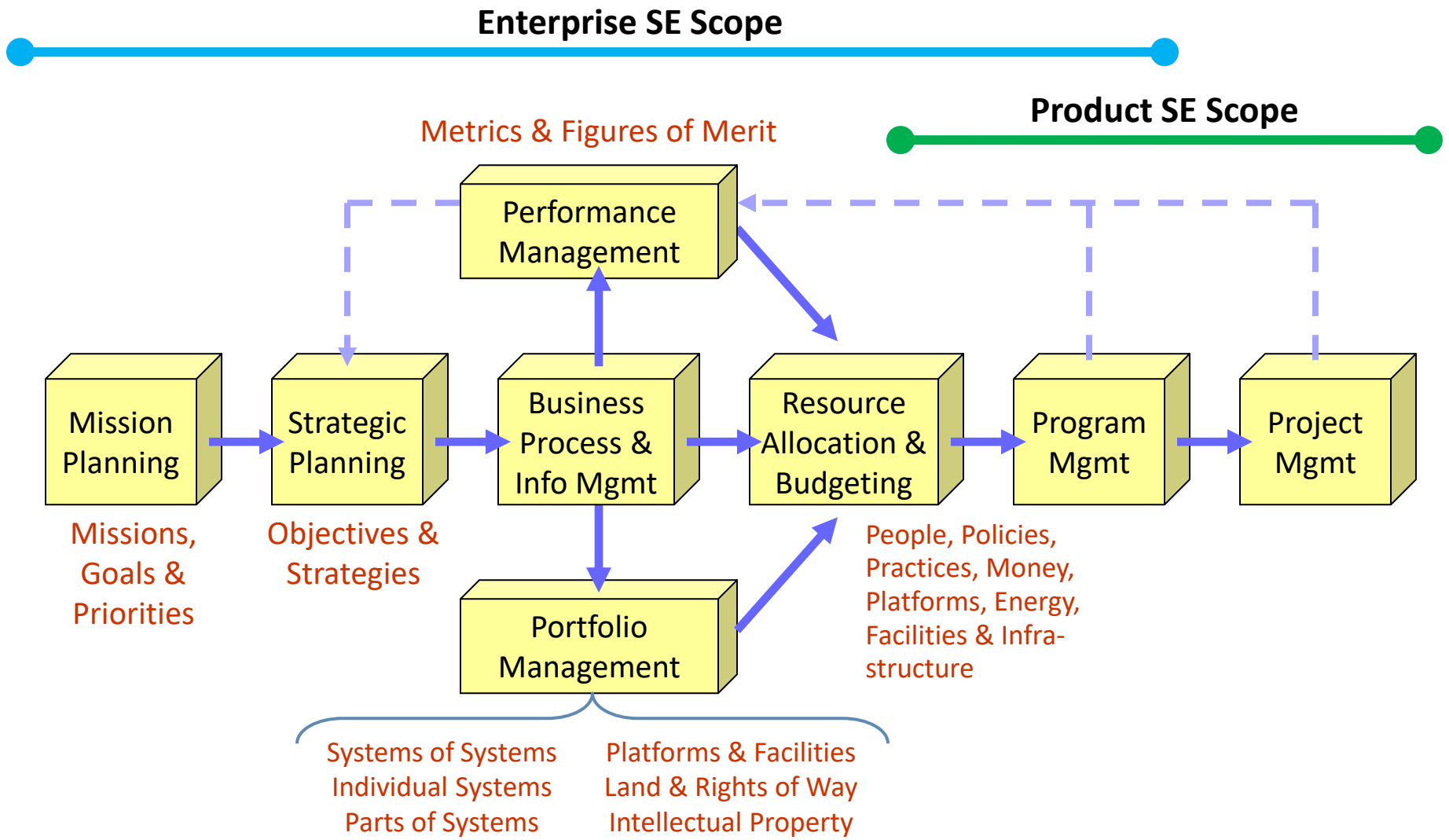
Managing the Enterprise Portfolio to Maximize Mission Impact



Keeping our focus on the most important dimensions of the Enterprise Total Solution

BACKUP

Higher Level for the Scope of Enterprise SE



Source: Martin, James N. 2010. "An Enterprise Systems Engineering Framework," INCOSE Symposium Proceedings. Copyright owned by Aerospace Corporation.

Major Role of Enterprise SE

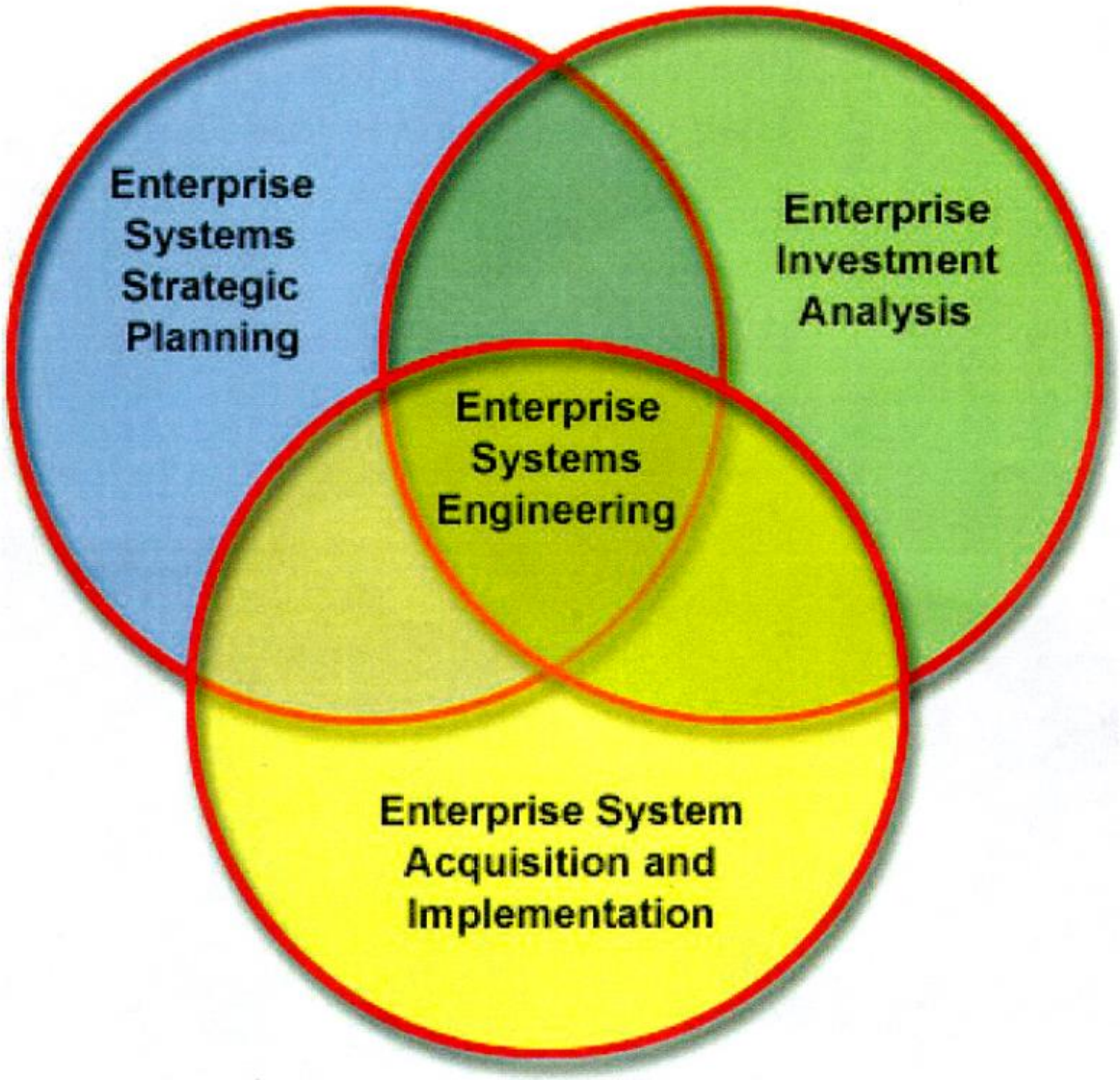
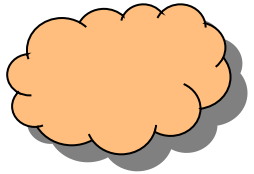
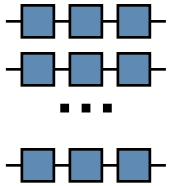
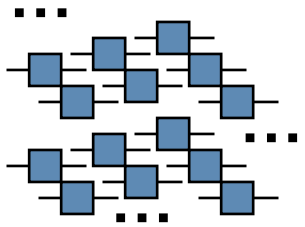


Fig 1, System of Systems (SoS) Enterprise Systems Engineering for Information-Intensive Organizations, Paul Carlock and Robert Fenton, Systems Engineering Journal, Vol 4, No 4, 2001

Different Groupings and Patterns Revealed at Different Scales

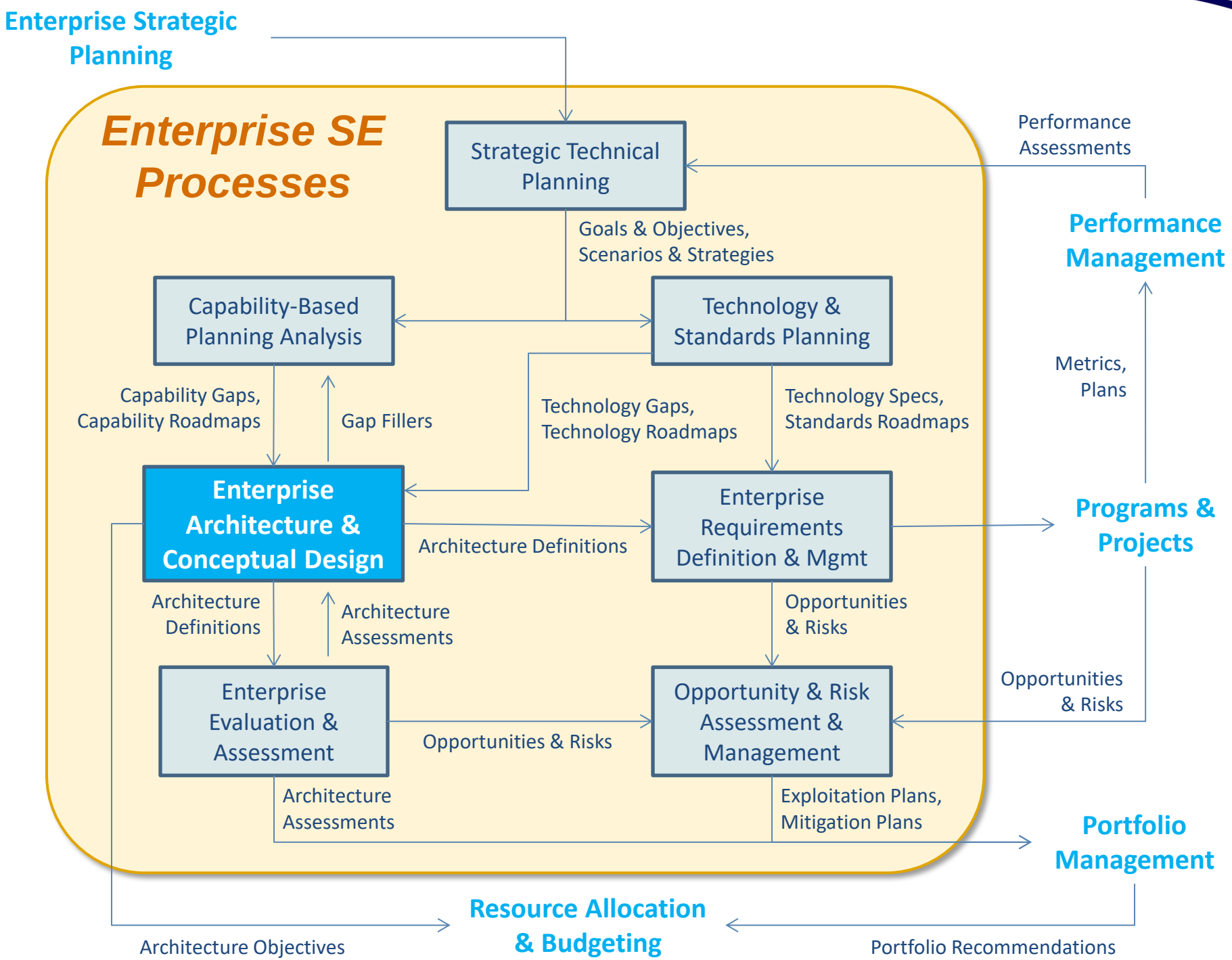
Scales	Groupings	Patterns	Descriptions
Enterprise Systems Engineering	Enterprise & Sub-enterprise		Broad Descriptions Net-centric Capabilities-based Effects Evolutionary Development Emergent Behavior
Capabilities ↑ / Constraints ↓			
System of Systems Engineering	Tens of System of Systems (Mission Strings)		Mission Descriptions Mission-based Execution Composition and Structure of Systems and SOS's
Functionality ↑ / Constraints ↓			
Systems Engineering	Hundreds of Independent Systems		Functional Descriptions Detailed Specifications Detailed Requirements

Source: DeRosa, Joseph K. 2005., "Enterprise Systems Engineering," Air Force Association, Industry Day, Day 1, Danvers, MA, 4 August 2005, https://www.paulrevereafa.org/IndustryDay/05/presentations/index.asp

How Can SE Enable Enterprise Transformation?

Executive Concerns	SE Enablers
Identifying ends, means, and scope and candidate changes	System complexity analysis to compare "as is" and "to be" enterprises
Evaluating changes in terms of process behaviors and performance	Organizational simulation of process flows and relationships
Assessing economics in terms of investments, operating costs, and returns	Economic modeling in terms of cash flows, volatility, and options
Defining the new enterprise in terms of processes and their integration	Enterprise architecting in terms of workflow, processes, and levels of maturity
Designing a strategy to change the culture for selected changes	Organizational and cultural change via leadership, vision, strategy, and incentives
Developing transformation action plans in terms of what, when, and who	Implementation planning in terms of tasks, schedule, people, and information

Source: Rouse, W.B., 2009. "Engineering the enterprise as a system." (Chapter 10) In Sage, Andrew P. and William B. Rouse (Eds.), Handbook of Systems Engineering and Management, (Chapter 10), 2nd edition. John Wiley & Sons, 2009. FIGURE 10.3.


Enterprise Strategic Planning
Enterprise SE Processes
Strategic Technical Planning
Goals & Objectives, Scenarios & Strategies
Capability-Based Planning Analysis
Technology & Standards Planning
Capability Gaps, Capability Roadmaps
Gap Fillers
Technology Gaps, Technology Roadmaps
Technology Specs, Standards Roadmaps
Enterprise Architecture & Conceptual Design
Architecture Definitions
Enterprise Requirements Definition & Mgmt
Architecture Definitions
Architecture Assessments
Opportunities & Risks
Enterprise Evaluation & Assessment
Opportunities & Risks
Opportunity & Risk Assessment & Management
Architecture Assessments
Exploitation Plans, Mitigation Plans
Performance Assessments
Performance Management
Metrics, Plans
Programs & Projects
Opportunities & Risks
Portfolio Management
Resource Allocation & Budgeting
Architecture Objectives
Portfolio Recommendations

Components of the UAF Specification (v1.2)

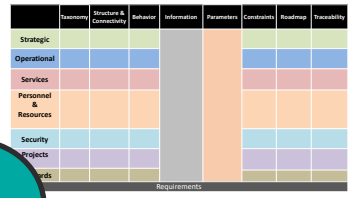
UAF
OMG UNIFIED ARCHITECTURE FRAMEWORK ™

Specification

EA Guide

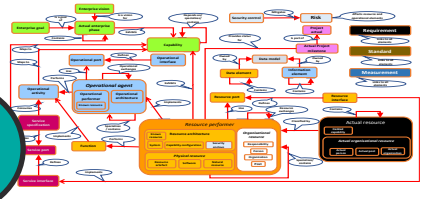
4

View Specifications organized in Viewpoints and Aspects (Grid)



1

UAF Domain MetaModel (DMM)



2

UAF Modeling Language* (UAFML) based on SysML

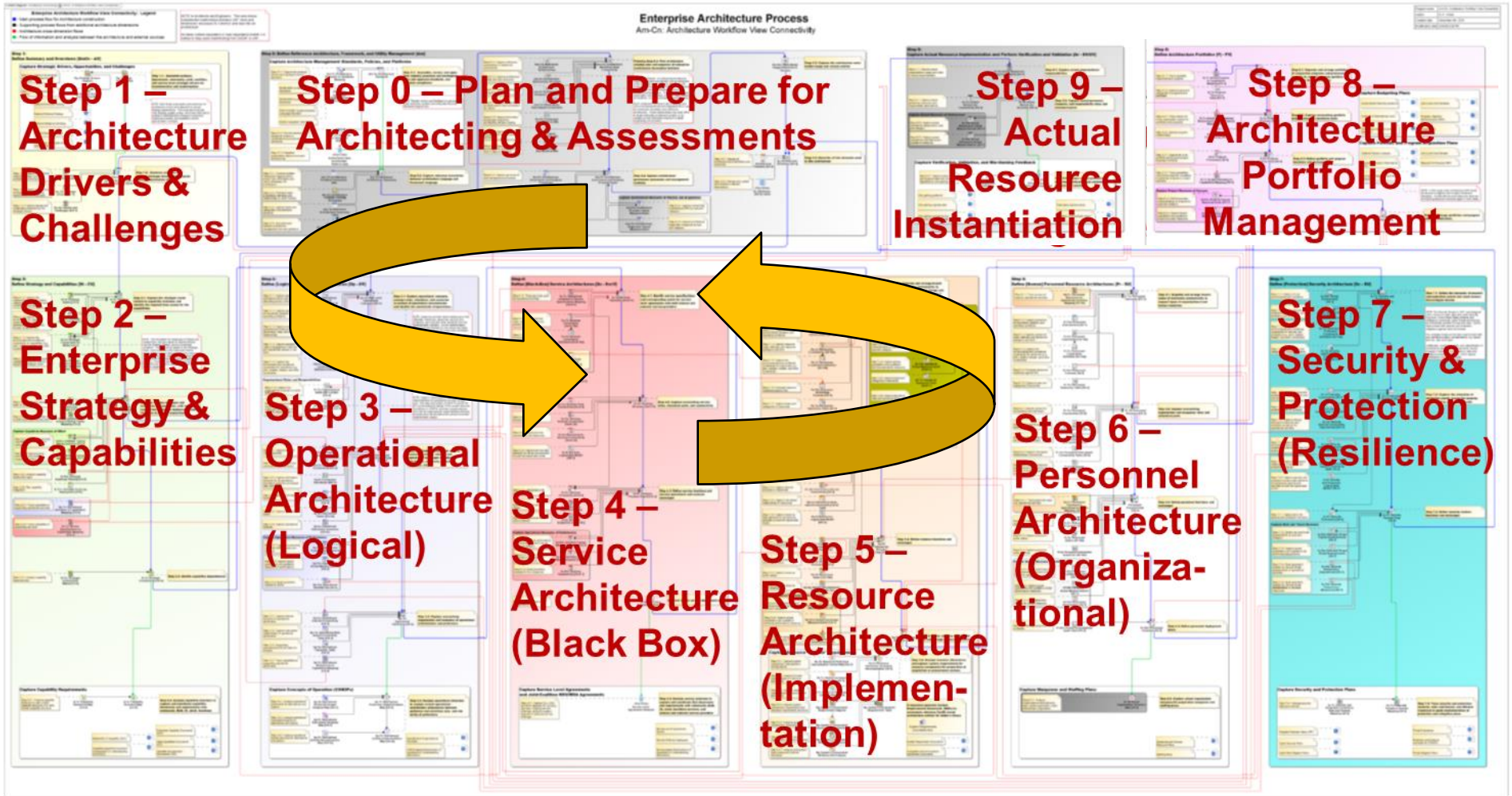
3

** Formerly called the "UAF Profile (UAFP)" in version 1.1 of the UAF specification*

https://www.omg.org/spec/UAF/

Standardized Enterprise Architecture Workflow in UAF

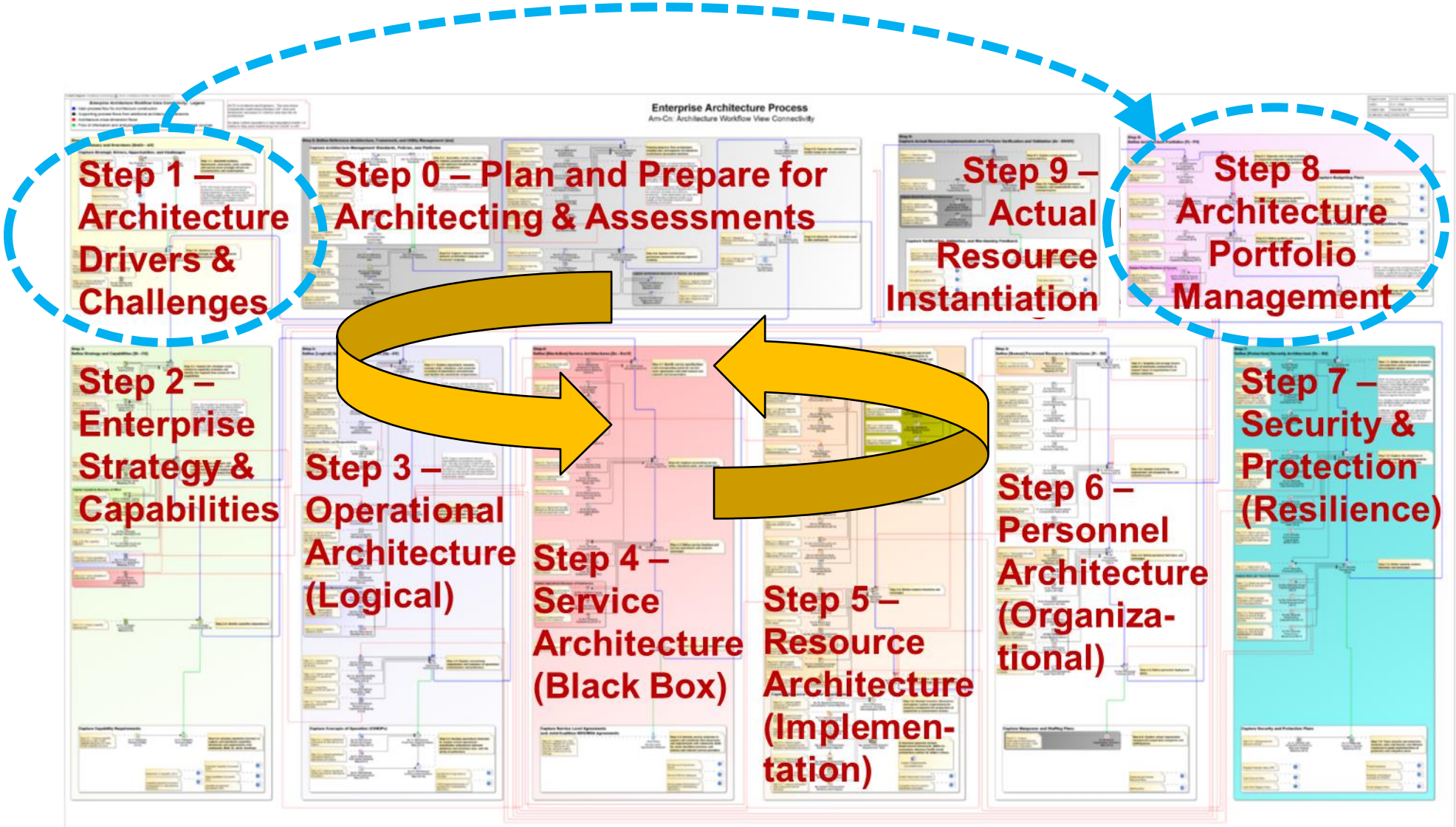
Establishes a Business Rhythm for Enterprise Transformation activities



Improves coordination and synchronization among the many players involved in Portfolio Management effort

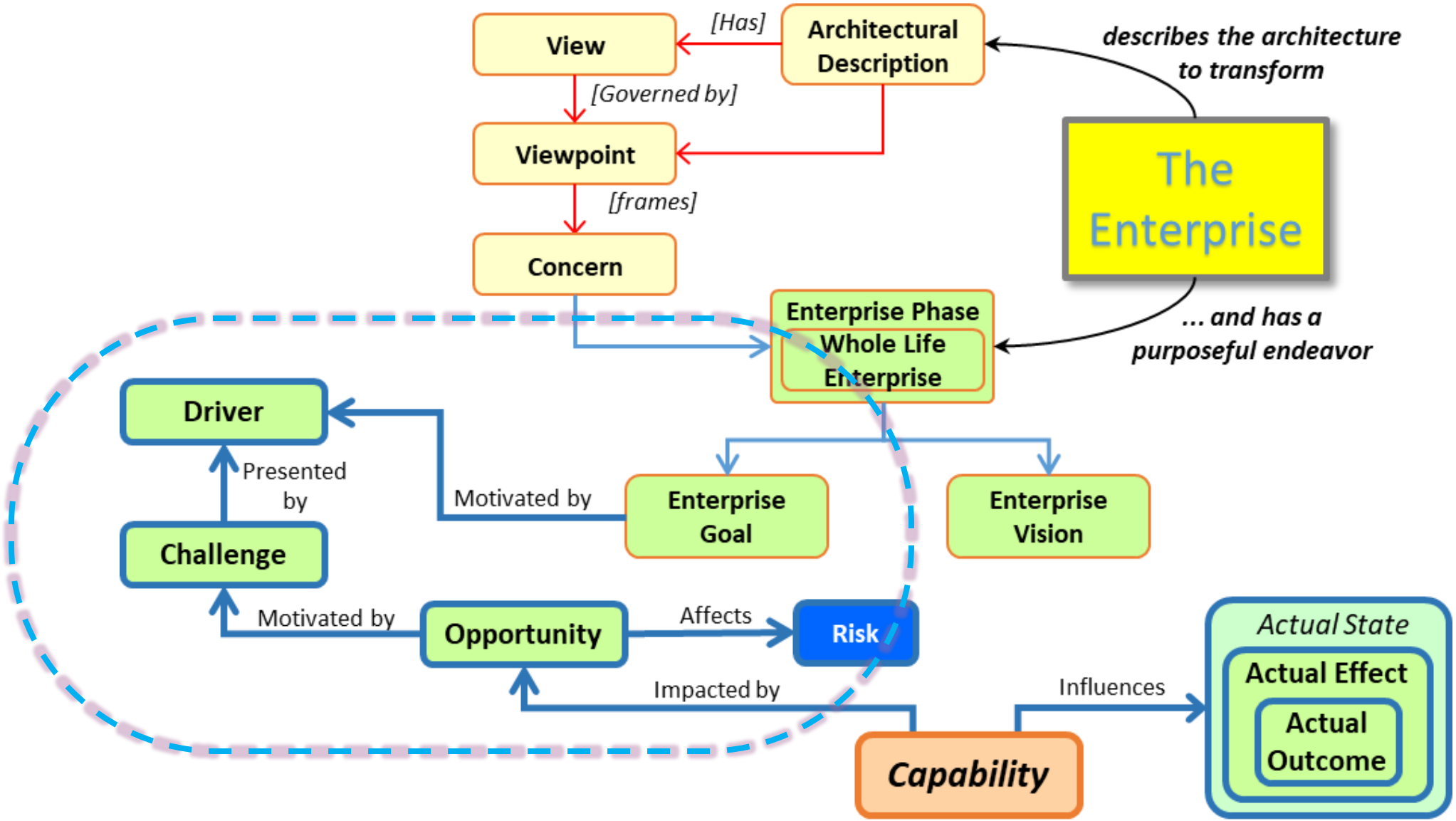
Changing the Portfolio in Response to New Drivers & Challenges

The Enterprise Architecture serves as the foundation for understanding impact of changes



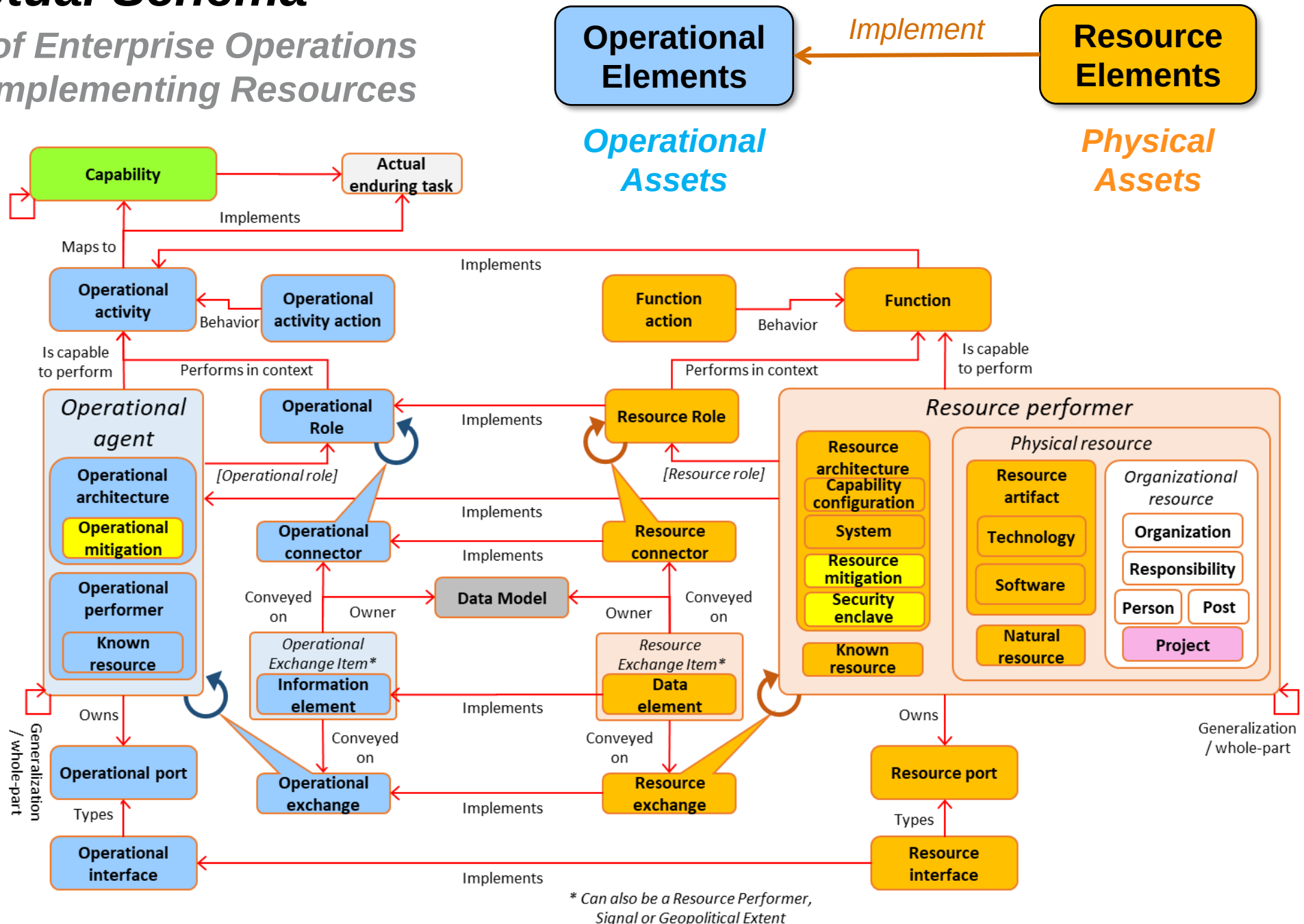
What should motivate the Enterprise to change?

Drivers & Challenges as the basis for identification of Opportunities to pursue…

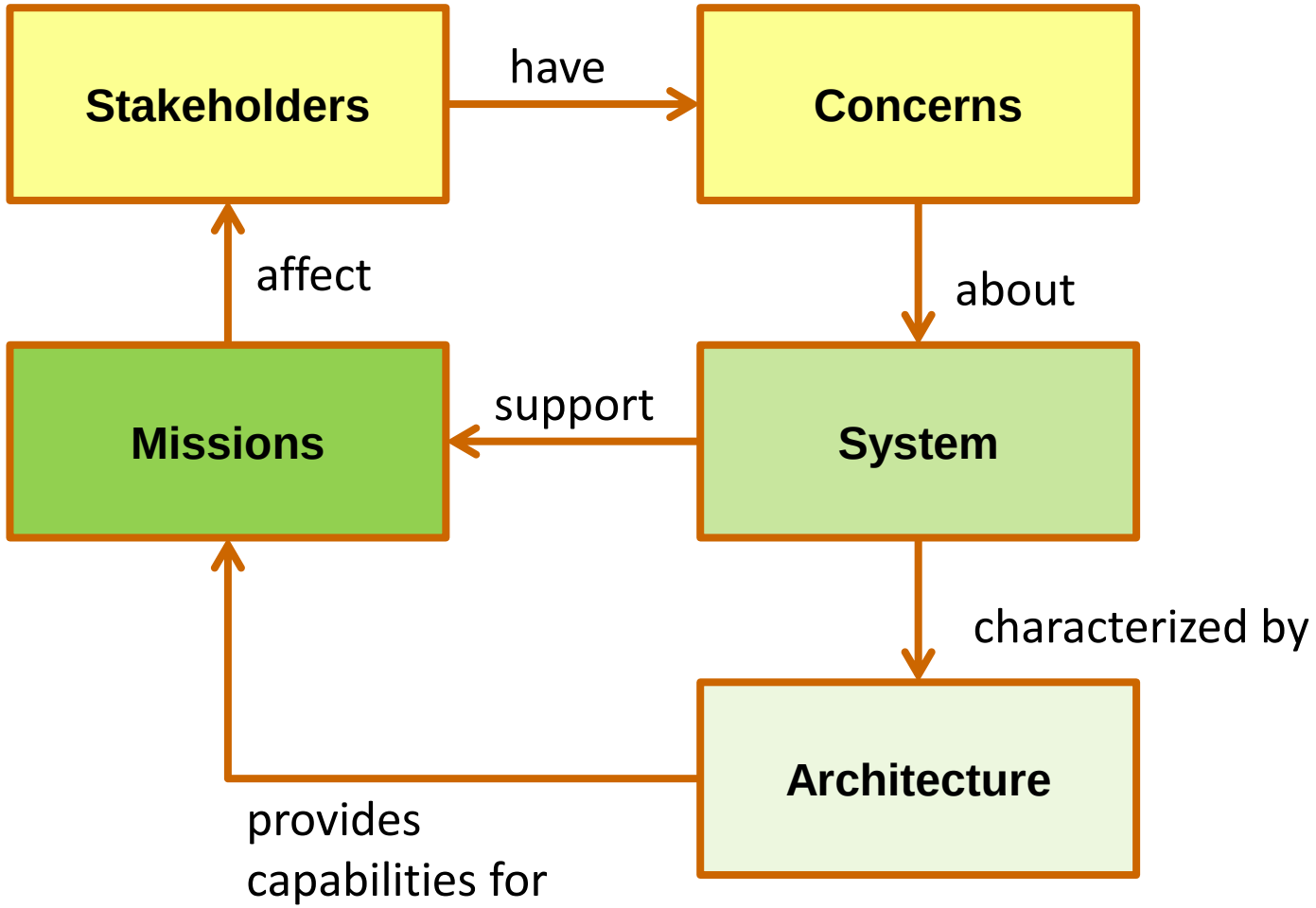


Conceptual Schema

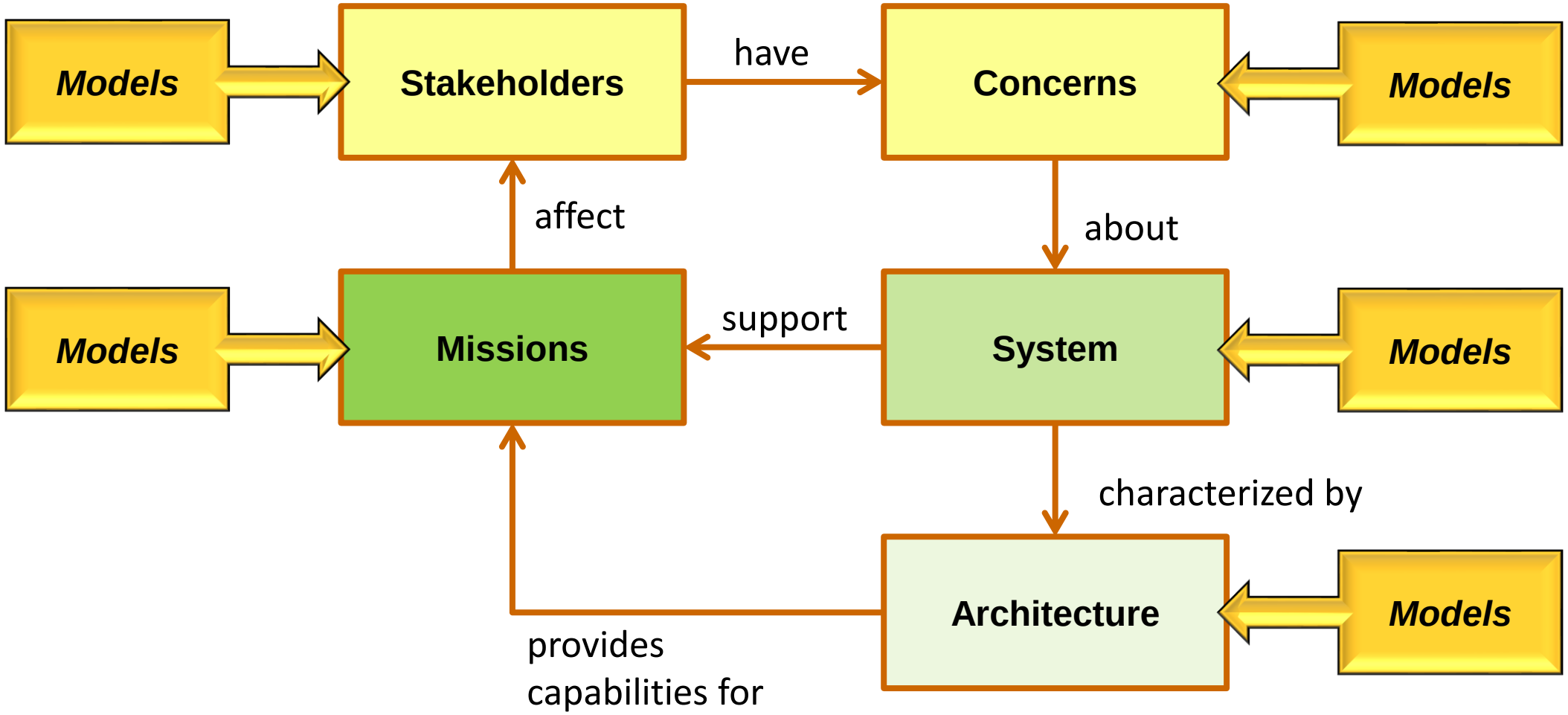
Modeling of Enterprise Operations and their Implementing Resources



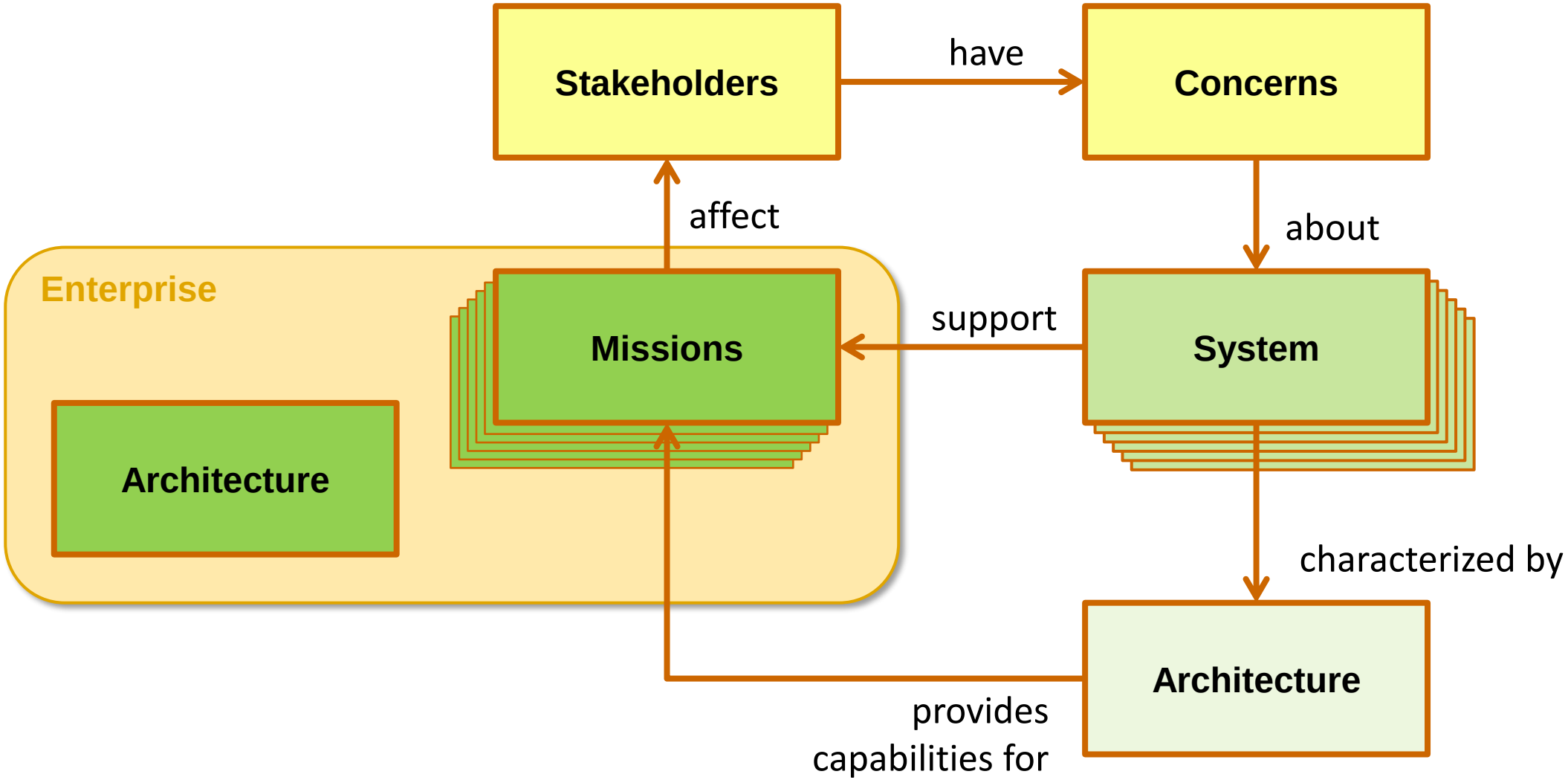
Systems Engineering defines an **Architecture** of the **System** that addresses **Stakeholder Concerns** regarding the relevant **Missions**



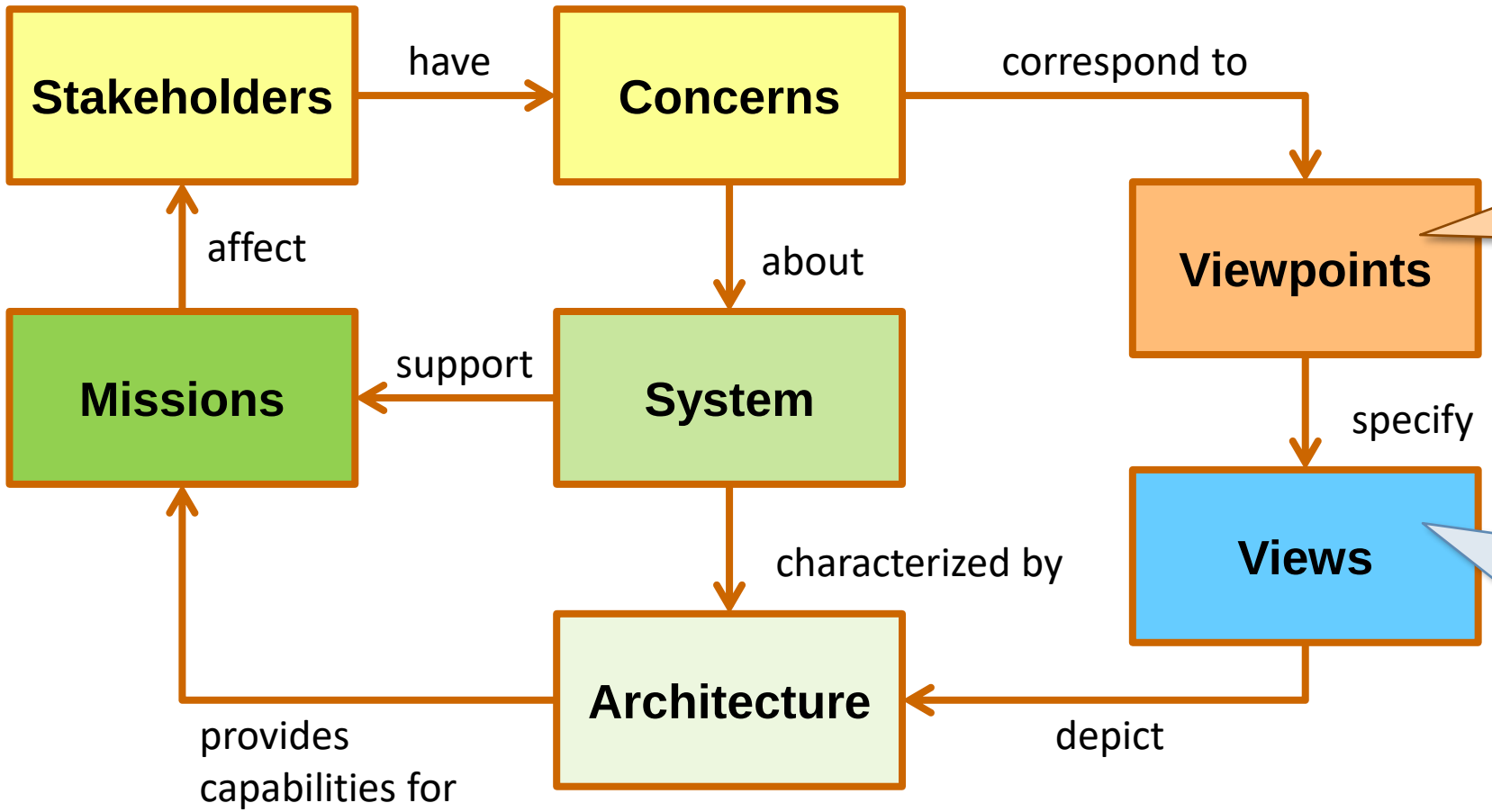
Models are created to represent the **System** and its **Architecture & Missions** along with relevant **Stakeholders** and their **Concerns**



The *Enterprise Architecture* defines the various **Missions** along with associated **Mission Objectives** and **Strategic Capabilities**



The UAF Standard Provides Stakeholder-Based Viewpoints & Aspect-Oriented Views to Characterize an Architecture



UAF Viewpoints

- Strategic
- Operational
- Services
- Personnel
- Resources
- Security
- Projects
- Standards

UAF Aspects

- Motivation
- Taxonomy
- Structure
- Connectivity
- Processes
- States
- Sequences
- Information
- Parameters
- Constraints
- Roadmaps
- Traceability

The Two-Dimensional UAF Grid

Architecture Aspects

Stakeholder Viewpoints

UAF	Motivation Mv	Taxonomy Tx	Structure Sr	Connectivity Cn	Processes Pr	States St	Sequences Sq	Information If	Parameters Pm	Constraints Ct	Roadmap Rm	Traceability Tr
Architecture Management Am	Architecture Principles Am-Mv	Architecture Extensions Am-Tx	Architecture Views Am-Sr	Architectural References Am-Cn	Architecture Development Method Am-Pr		-	Dictionary Am-If	Architecture Parameters Am-Pm	Architecture Constraints Am-Ct	Architecture Roadmap Am-Rm	Architecture Traceability Am-Tr
Summary & Ove…												
Strategic St	Strategic Motivation St-Mv	Strategic Taxonomy St-Tx	Strategic Structure St-Sr	Strategic Connectivity St-Cn	Strategic Processes St-Pr	Strategic States St-St		Strategic		Strategic …nstraints St-Ct	Strategic Roadmaps: Deployment, Phasing St-Rm-D, -P	Strategic Traceability St-Tr
Operational Op	Requirements Rq-Mv	Operational Taxonomy Op-Tx	Operational Structure Op-Sr	Operational Connectivity Op-Cn	Operational Processes Op-Pr	Operati… State… Op-St		Operational Information Model Op-If	Environment En-Pm and Measurements Me-Pm and Risks Rk-Pm	…erational …nstraints Op-Ct	-	Operational Traceability Op-Tr
Services Sv		Services Taxonomy Sv-Tx	Services Structure Sv-Sr	Services Connectivity Sv-Cn	Services Processes Sv-Pr	Services States Sv-St	Services Sequences Sv-Sq			Services Constraints Sv-Ct	Services Roadmap Sv-Rm	Services Traceability Sv-Tr
Personnel Ps		Personnel Taxonomy Ps-Tx	Personnel Structure Ps-Sr	Personnel Connectivity Ps-Cn	Personnel Processes Ps-Pr	Personnel States Ps-St	Personnel Sequences Ps-Sq			Competence, Drivers, Performance Ps-Ct-C, -D, -P	Availability, Evolution, Forecast PS-Rm-A,-E,-F	Personnel Traceability Ps-Tr
Resources Rs		Resources Taxonomy Rs-Tx	Resources Structure Rs-Sr	Resources Connectivity Rs-Cn	Resources Processes Rs-Pr	Resources States Rs-St	Resources Sequences Rs-Sq	Resources Information Model Rs-If		Resources Constraints Rs-Ct	Resources Roadmaps: Evolution, Forecast Rs-Rm-E, -F	Resources Traceability Rs-Tr
Security Sc	Sc… Cont… Sc-Mv	Security Taxonomy …Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr	-				Security Constraints Sc-Ct	-	Security Traceability Sc-Tr
Projects Pj		…vity			Projects Processes Pj-Pr	-					Projects Roadmap Pj-Rm	Projects Traceability Pj-Tr
Standards Sd		Sd-Tx	Sd-Sr		-	-					Standards Roadmap Sd-Rm	Standards Traceability Sd-Tr
Actual Resources Ar	-	-	Actual Resources Structure, Ar-Sr	Actual Resources Connectivity, Ar-Cn	Simulation…					Evaluation	-	-

Processes Aspect of the Architecture Entity

Resources Viewpoint of Stakeholders

View Specification for the Resources Viewpoint & the Processes Aspect (Rs-Pr)

Capability Roadmap is Key for Identifying Gaps & Shortfalls

Table 7-1 Strategic Roadmap: Phasing

Capabilities Roadmap [St-Rm-Ph]

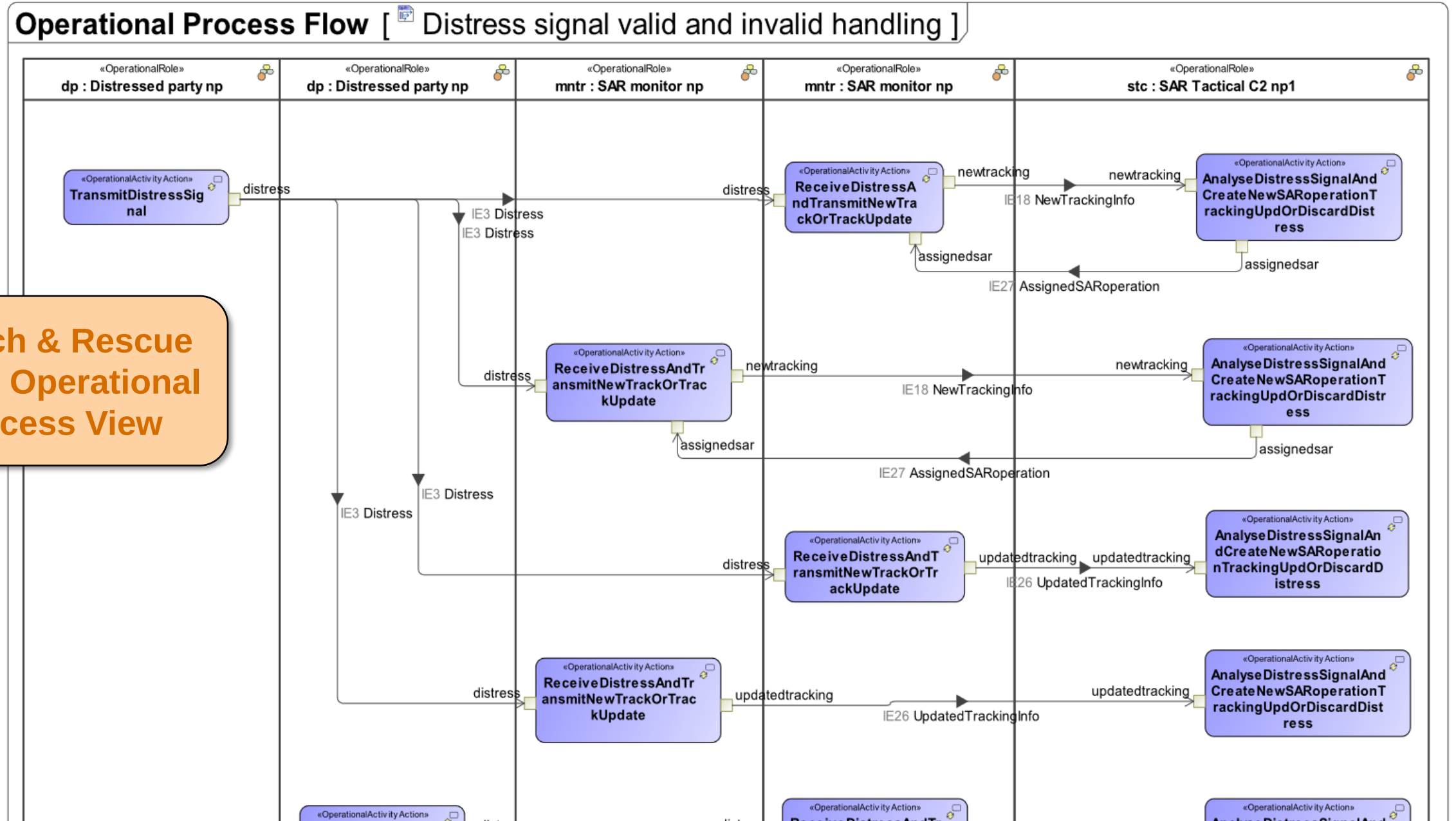
	2019												2020											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Assistance																								
[no measurements]	**Rescue Ship** (SAR Project 1 Sustainment)																							
Distress Signal Monitoring																								
[no measurements]	**Monitoring System** (SAR Project 1 Sustainment)																							
[no measurements]	**SAR HQ** (SAR Project 1 Sustainment)																							
Inform																								
[no measurements]	**C2 System** (SAR Project 1 Sustainment)																							
[no measurements]	**Monitoring System** (SAR Project 1 Sustainment)																							
[no measurements]	**SAR HQ** (SAR Project 1 Sustainment)																							
Land SAR																								
Maritime SAR Phase 1																								
[no measurements]	**Maritime Rescue Architecture v1** (SAR Project 1 Sustainment)																							
Maritime SAR Phase 2																								
Maritime SAR Phase 3																								
Maritime SAR Phase 4																								

Search & Rescue (SAR) Enterprise Architecture

(from the UAF Sample Model)

Operational Viewpoint Helps Identify Operational Impacts

Search & Rescue (SAR) Operational Process View



Progression from Architecture Drivers to Implementation and Deployment of Capabilities

The UAF modeling viewpoints facilitate a logical and systematic flow of architecting activities

I. ***Concerns drive a strategic plan***

II. ***The strategic plan deploys capabilities in phases addressing gaps and shortfalls***

III. ***Capabilities are implemented by conceptual operations***

IV. ***Concepts are implemented through services, resources and personnel***

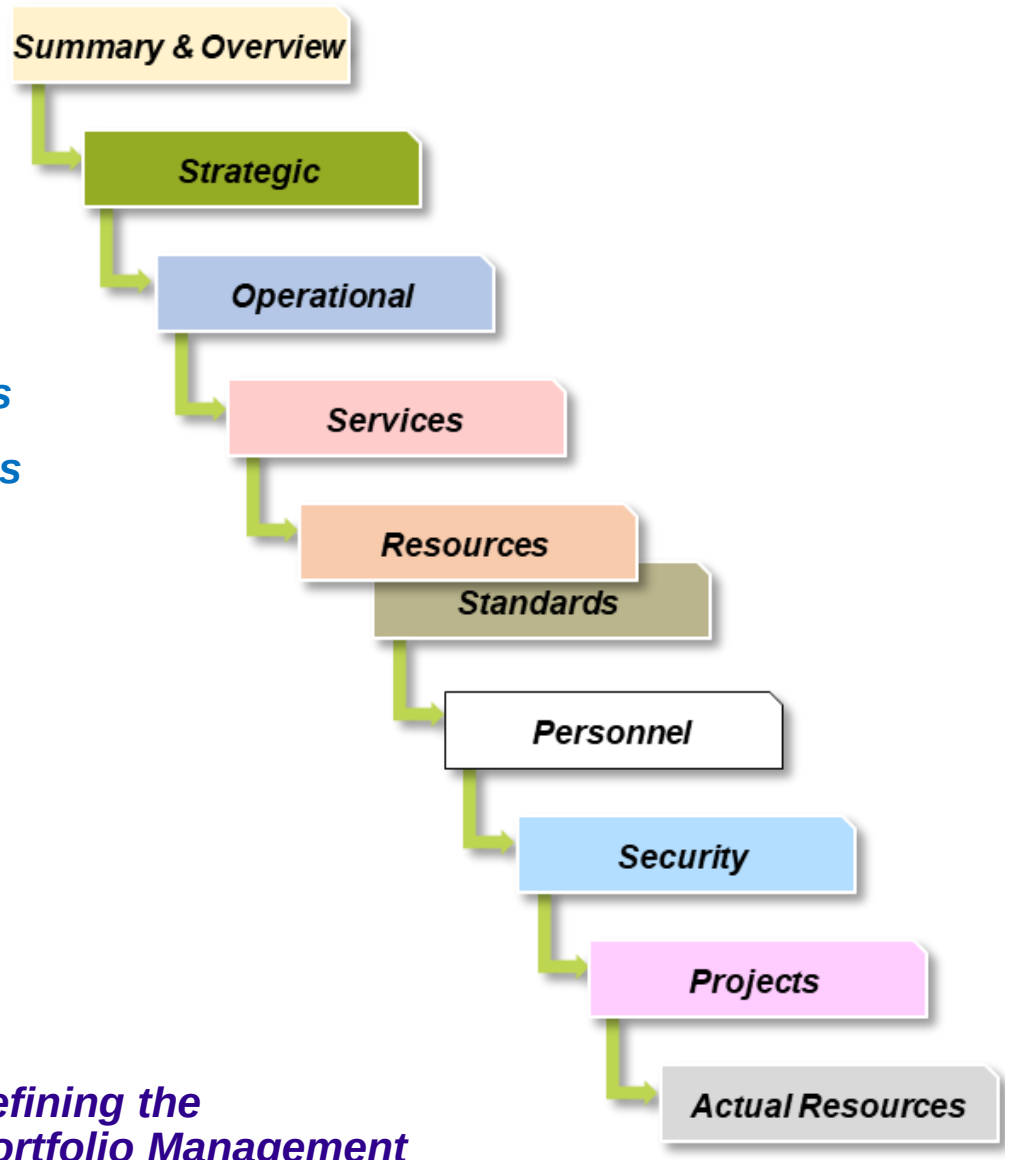
V. ***Resources comply with standards***

VI. ***Risk and threats are mitigated through security & protection controls (of resources and operations)***

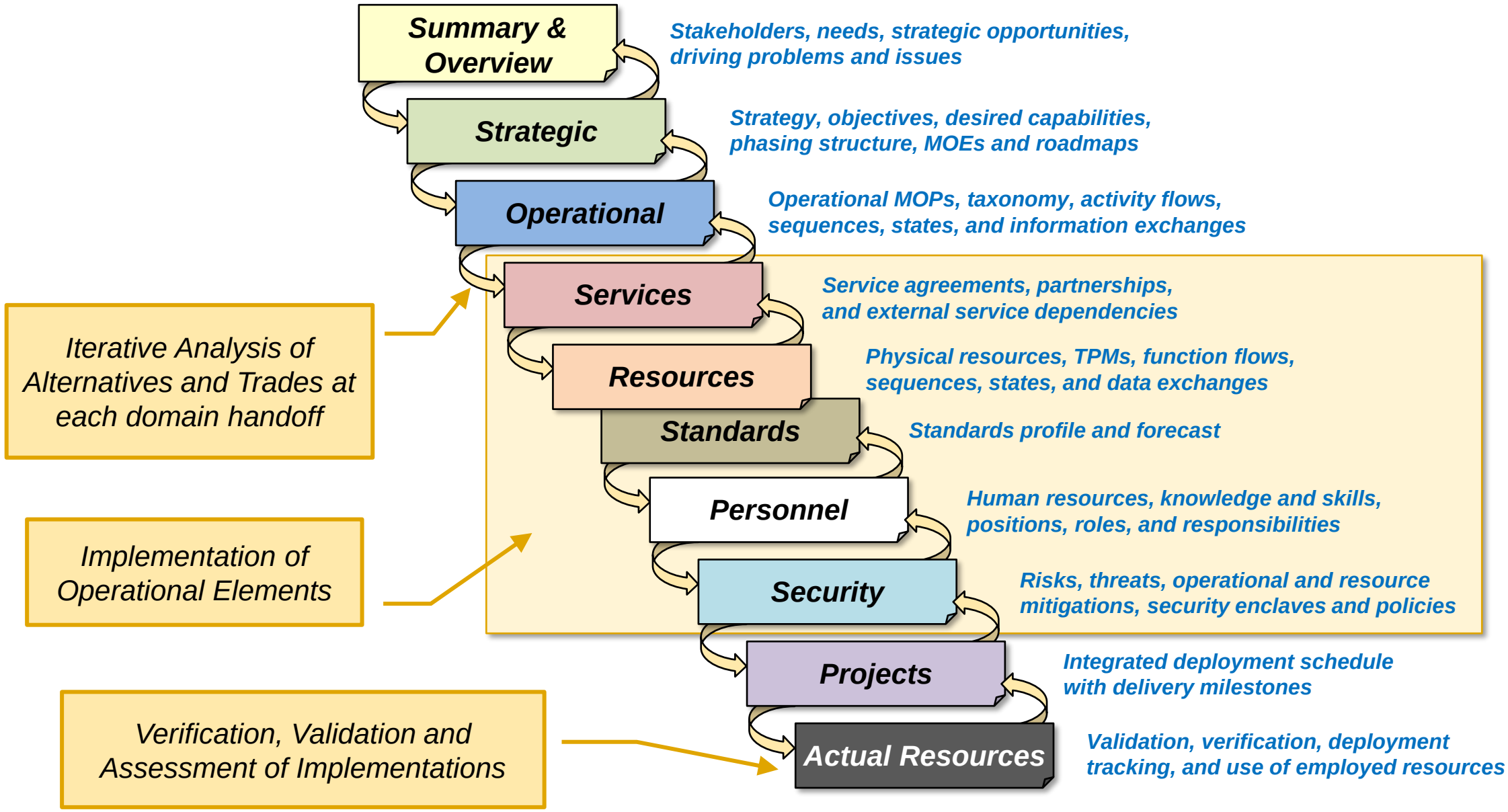
VII. ***Requirements are understood and communicated***

VIII. ***Plans deliver the resources***

IX. ***Resources are verified***

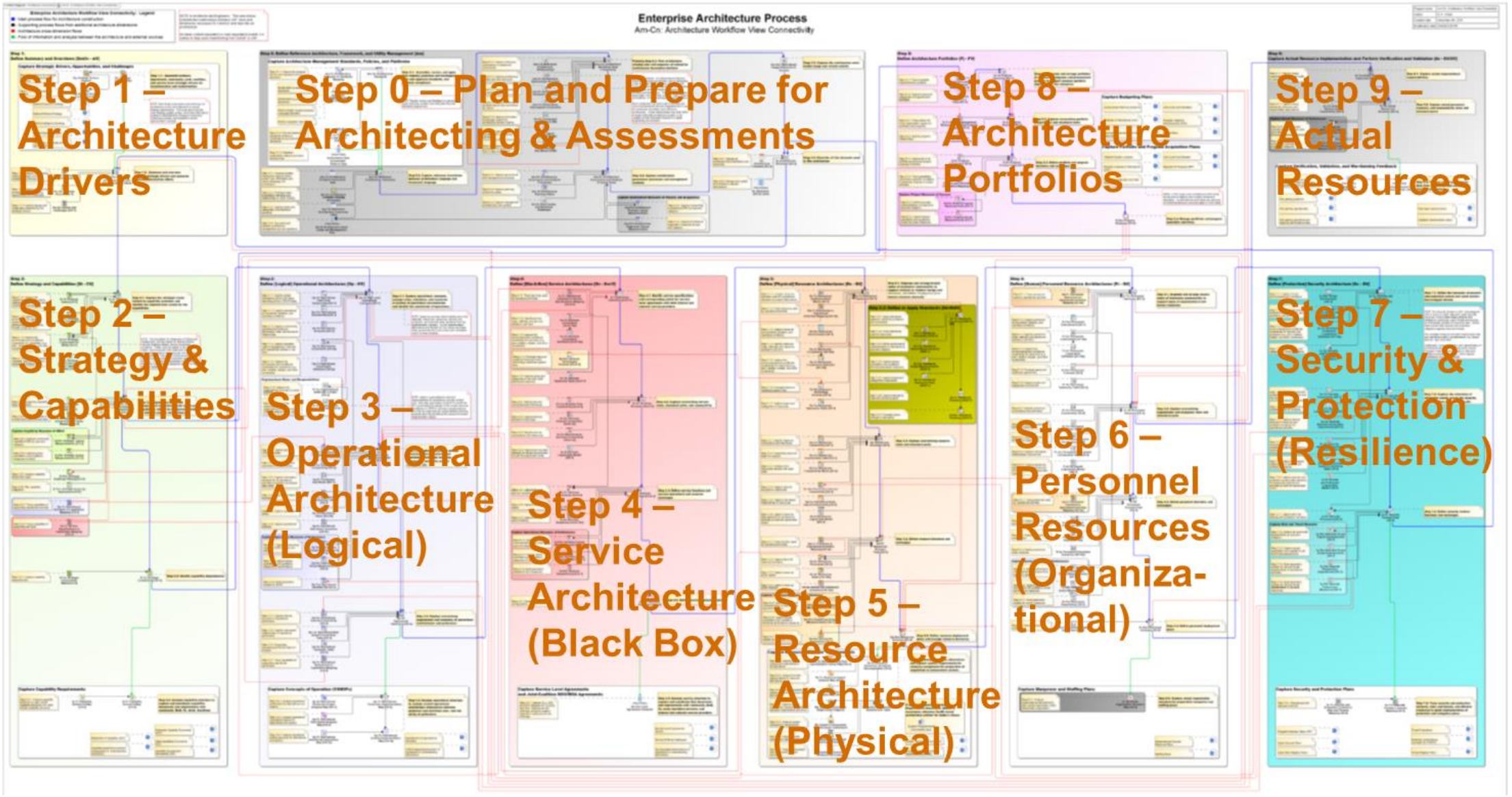


UAF provides a complete set of modeling domains as basis for defining the necessary architecture views of an Enterprise that can support Portfolio Management

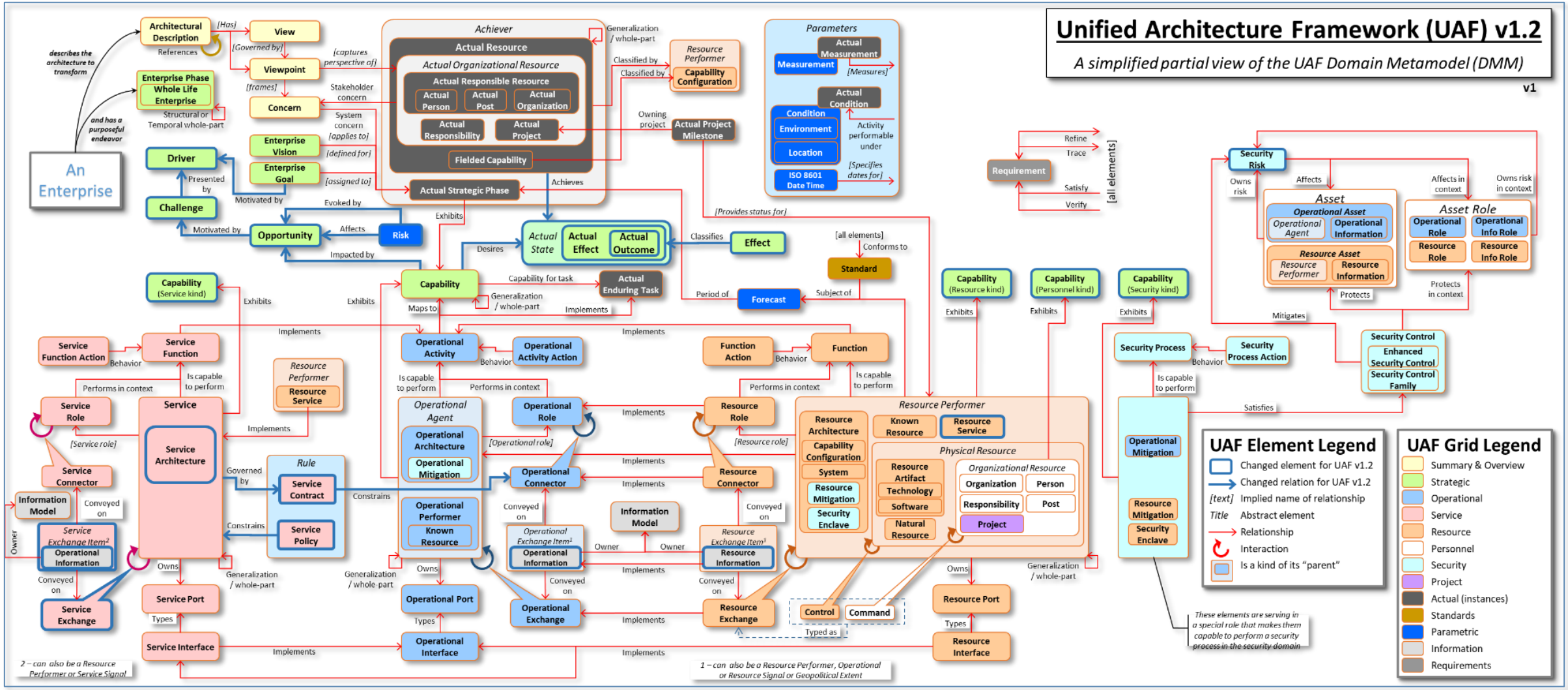

Summary & Overview
Stakeholders, needs, strategic opportunities, driving problems and issues
Strategic
Strategy, objectives, desired capabilities, phasing structure, MOEs and roadmaps
Operational
Operational MOPs, taxonomy, activity flows, sequences, states, and information exchanges
Services
Service agreements, partnerships, and external service dependencies
Resources
Physical resources, TPMs, function flows, sequences, states, and data exchanges
Standards
Standards profile and forecast
Personnel
Human resources, knowledge and skills, positions, roles, and responsibilities
Security
Risks, threats, operational and resource mitigations, security enclaves and policies
Projects
Integrated deployment schedule with delivery milestones
Actual Resources
Validation, verification, deployment tracking, and use of employed resources
Iterative Analysis of Alternatives and Trades at each domain handoff
Implementation of Operational Elements
Verification, Validation and Assessment of Implementations

Enterprise Architecture Guide for UAF

Standardizing the Modeling Workflow



Enterprise Modeling Ontology



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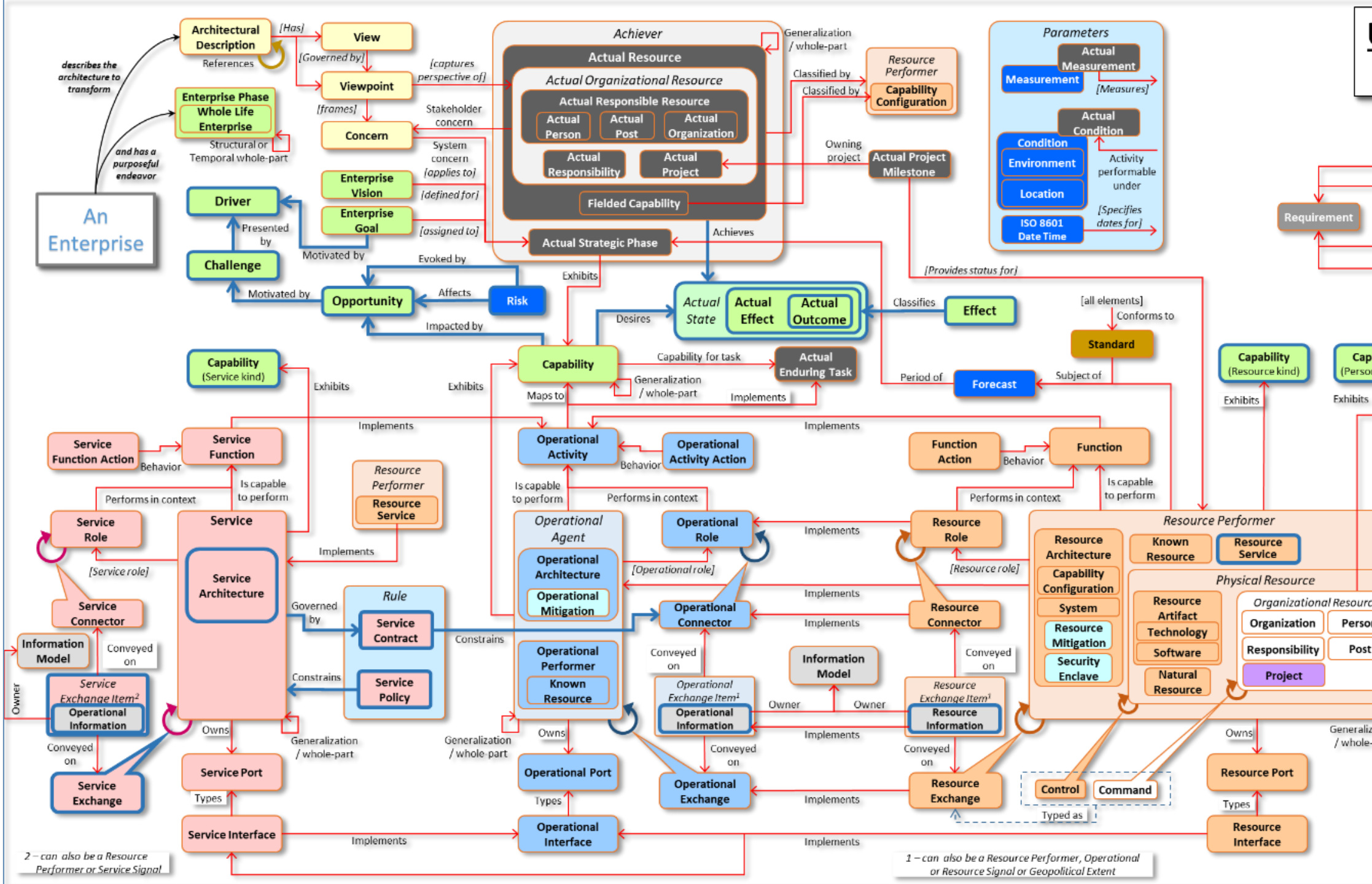
An Enterprise
describes the architecture to transform
and has a purposeful endeavor
Architectural Description
References
[Has]
View
[Governed by]
Viewpoint
[frames]
Concern
[captures perspective of]
Stakeholder concern
System concern
[applies to]
Enterprise Phase
Whole Life Enterprise
Structural or Temporal whole-part
Enterprise Vision
[defined for]
Enterprise Goal
[assigned to]
Achiever
Actual Resource
Actual Organizational Resource
Actual Responsible Resource
Actual Person
Actual Post
Actual Organization
Actual Responsibility
Actual Project
Fielded Capability
Generalization / whole-part
Classified by
Resource Performer
Capability Configuration
Owning project
Actual Project Milestone
Parameters
Actual Measurement
Measurement
[Measures]
Actual Condition
Condition
Environment
Location
ISO 8601 Date Time
Activity performable under
[Specifies dates for]
Requirement
Driver
Presented by
Challenge
Motivated by
Evoked by
Opportunity
Affects
Risk
Impacted by
Actual Strategic Phase
Achieves
Exhibits
[Provides status for]
Actual State
Actual Effect
Actual Outcome
Classifies
Effect
Desires
[all elements]
Conforms to
Standard
Capability (Service kind)
Capability
Capability for task
Actual Enduring Task
Generalization / whole-part
Maps to
Implements
Period of
Forecast
Subject of
Capability (Resource kind)
Service Function Action
Behavior
Service Function
Operational Activity
Operational Activity Action
Function Action
Function
Is capable to perform
Performs in context
Resource Performer
Resource Service
Service Role
[Service role]
Service
Service Architecture
Operational Agent
Operational Architecture
Operational Mitigation
Operational Performer
Known Resource
Operational Role
[Operational role]
Resource Role
[Resource role]
Resource Architecture
Capability Configuration
System
Resource Mitigation
Security Enclave
Known Resource
Physical Resource
Resource Artifact
Technology
Software
Natural Resource
Organizational Resource
Organization
Responsibility
Project
Service Connector
Operational Connector
Resource Connector
Rule
Service Contract
Service Policy
Governed by
Constrains
Information Model
Conveyed on
Service Exchange Item[2]
Operational Information
Owner
Operational Exchange Item[1]
Resource Exchange Item[1]
Resource Information
Service Exchange
Operational Exchange
Resource Exchange
Control
Command
Typed as
Owns
Service Port
Types
Operational Port
Resource Port
Service Interface
Operational Interface
Resource Interface
2 – can also be a Resource Performer or Service Signal
1 – can also be a Resource Performer, Operational or Resource Signal or Geopolitical Extent

Unified Architecture Framework (UAF) v1.2

A simplified partial view of the UAF Domain Metamodel (DMM)

v1