



# ***Enabling Enterprise Transformation Using Enterprise Architecture Principles and Concepts***

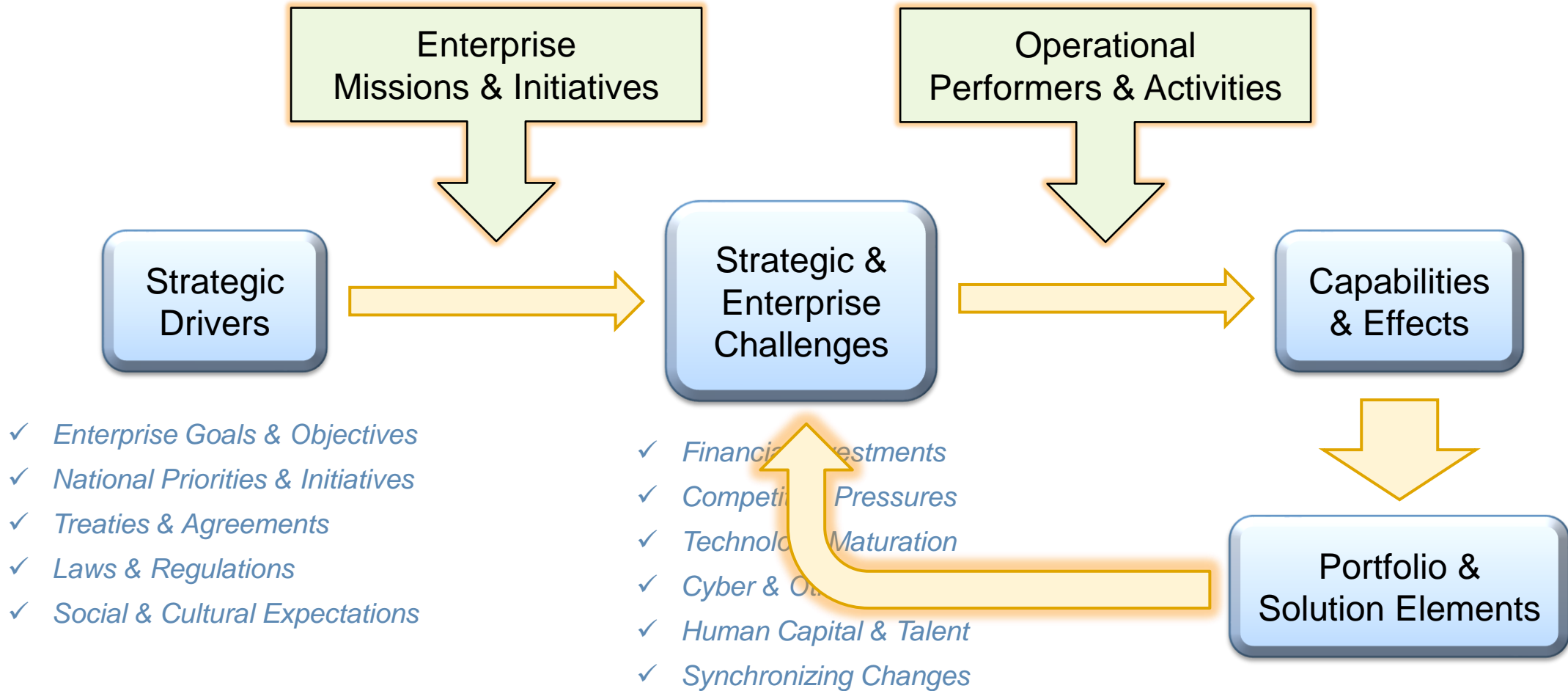
**James N Martin, PhD  
Distinguished Engineer  
Enterprise Systems Engineering  
The Aerospace Corporation**

***UAF Summit: Actionable  
Architecture in the 21st Century  
20 March 2024***



# Enterprise Transformation Considerations

Managing the Enterprise Portfolio to Maximize Mission Impact



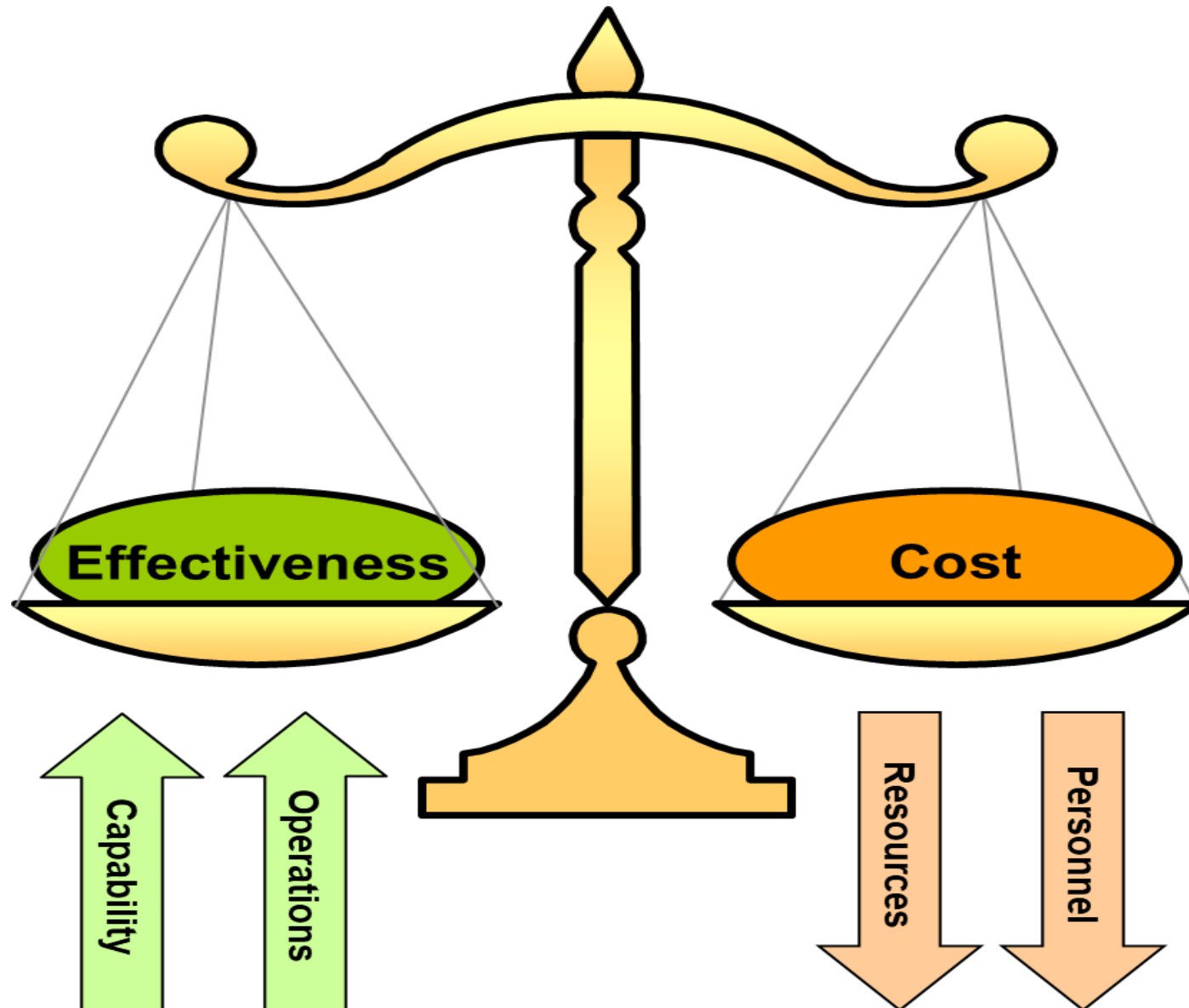
***If you don't proactively manage your Portfolio, then your Portfolio will manage you!***



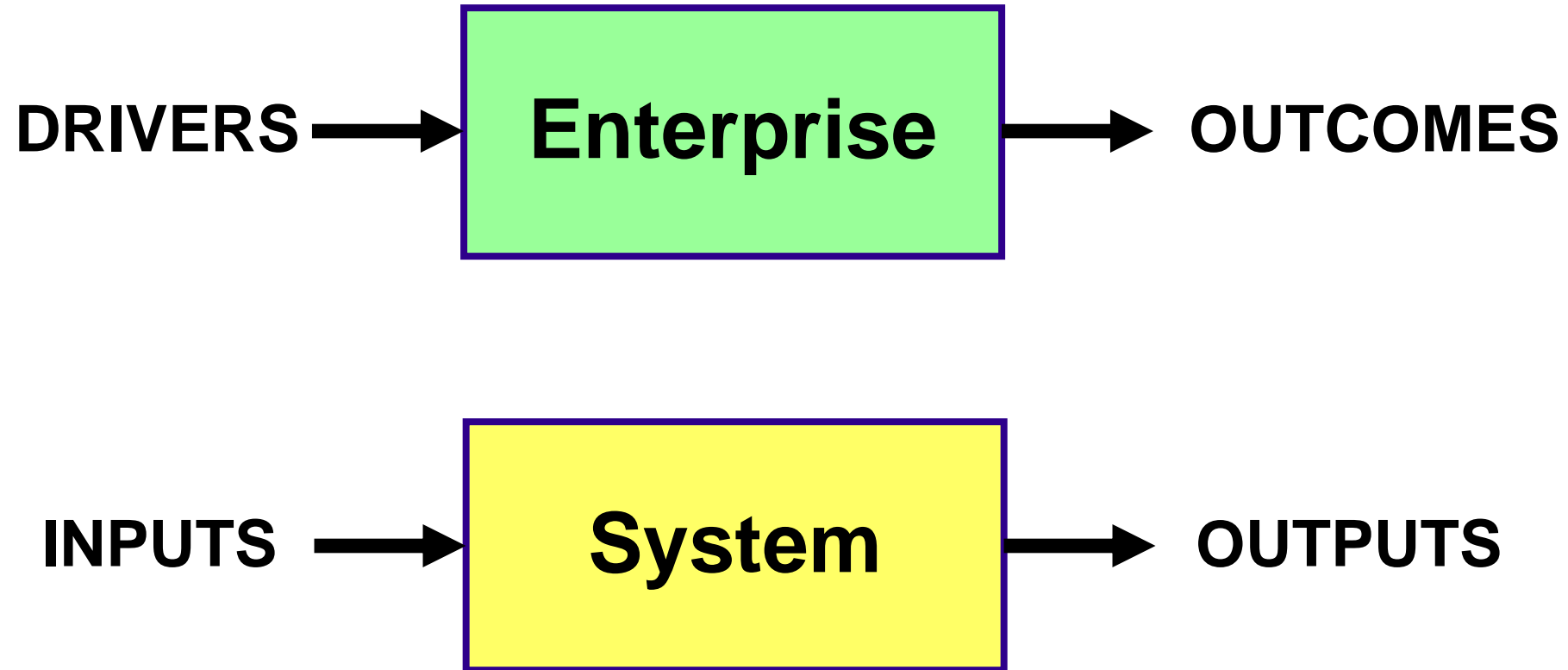


# Portfolio Management Examines Cost versus Effectiveness

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



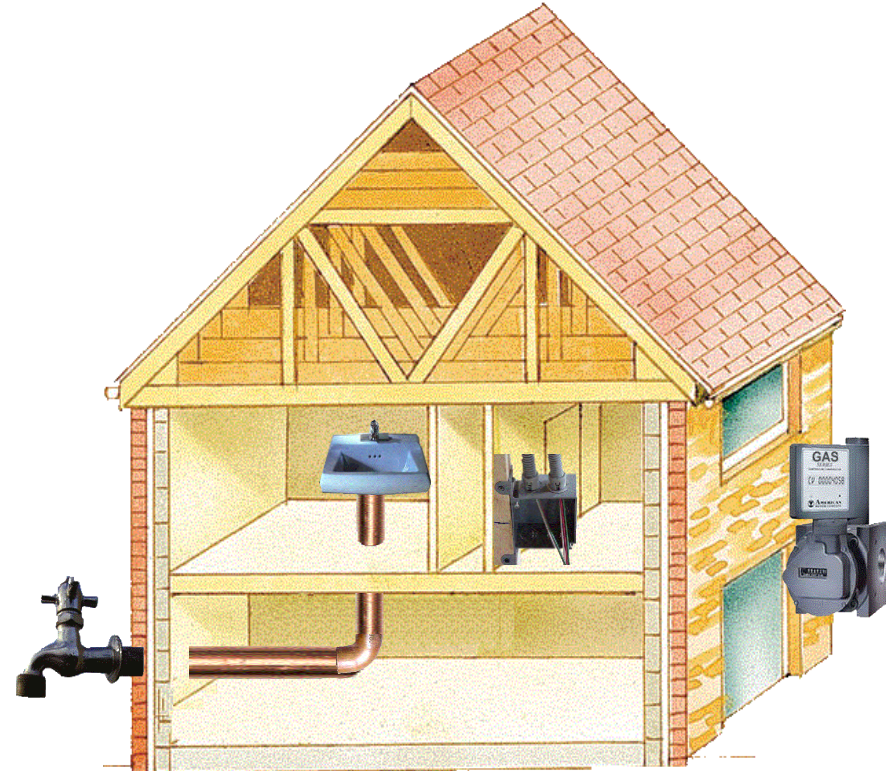
# *Systems vs. Enterprises*



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



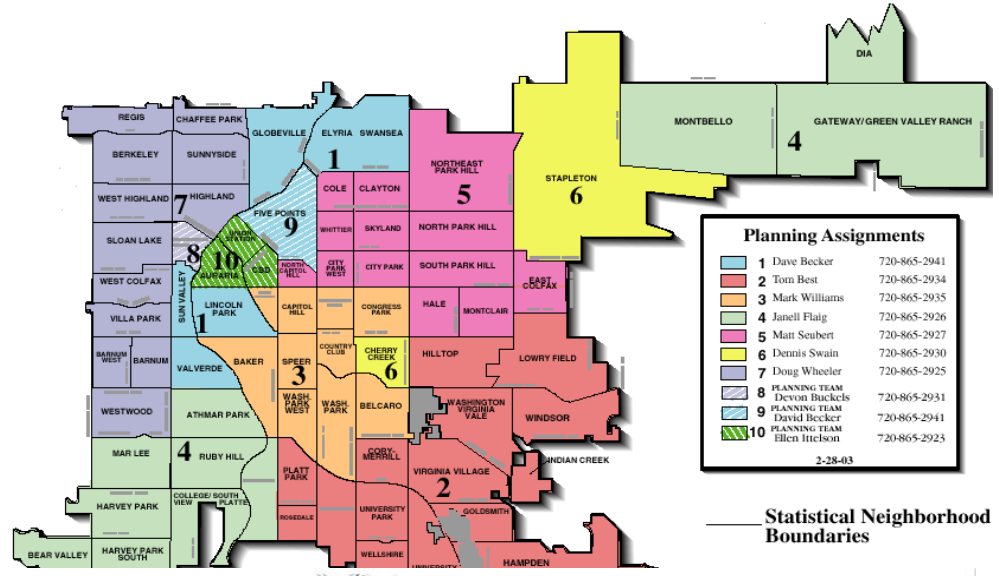
# *System Architecture is Like Blueprints for a Building*



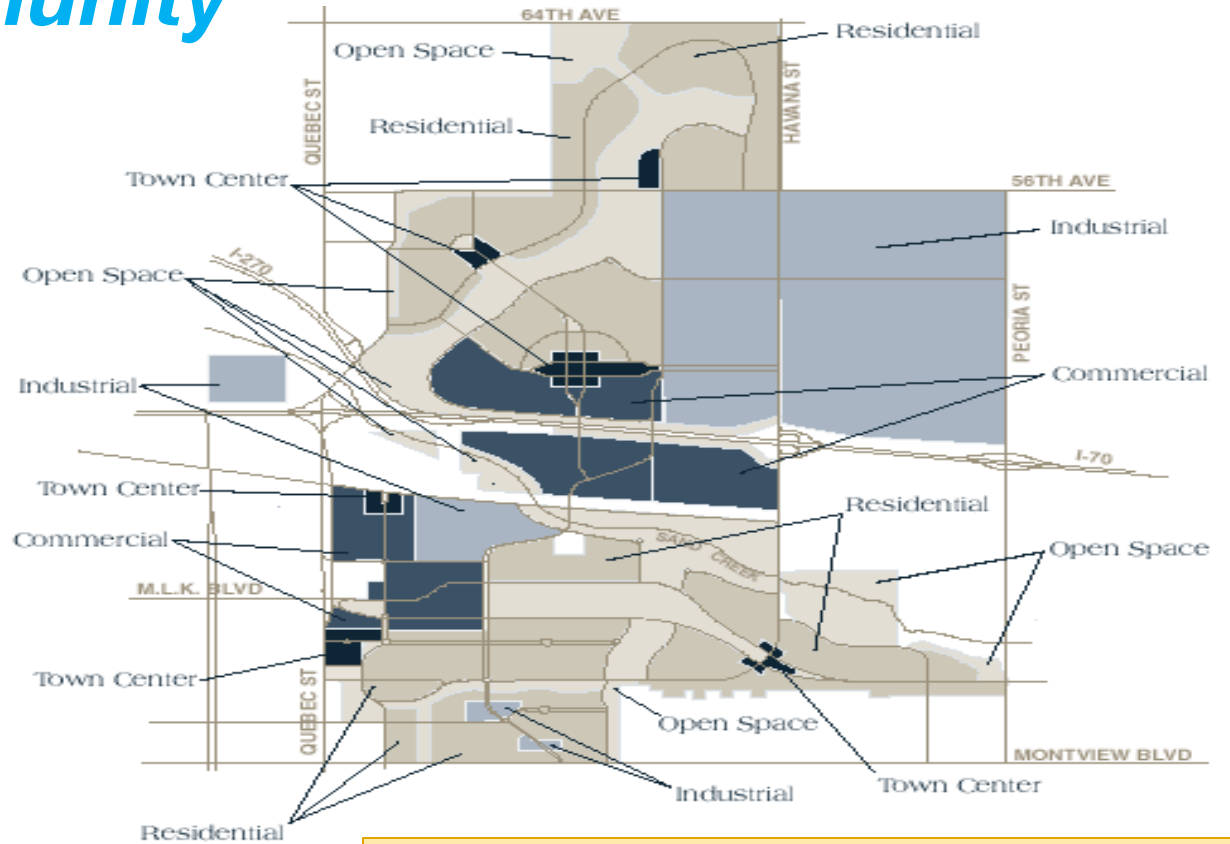
*Outputs for a System tend to be the same over its lifetime. The requirements are established early on and tend not to change very much. Results for a system are more readily predicted.*



# Enterprise Architecture is More Like Urban Planning for a Community



Statistical Neighborhood Boundaries



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

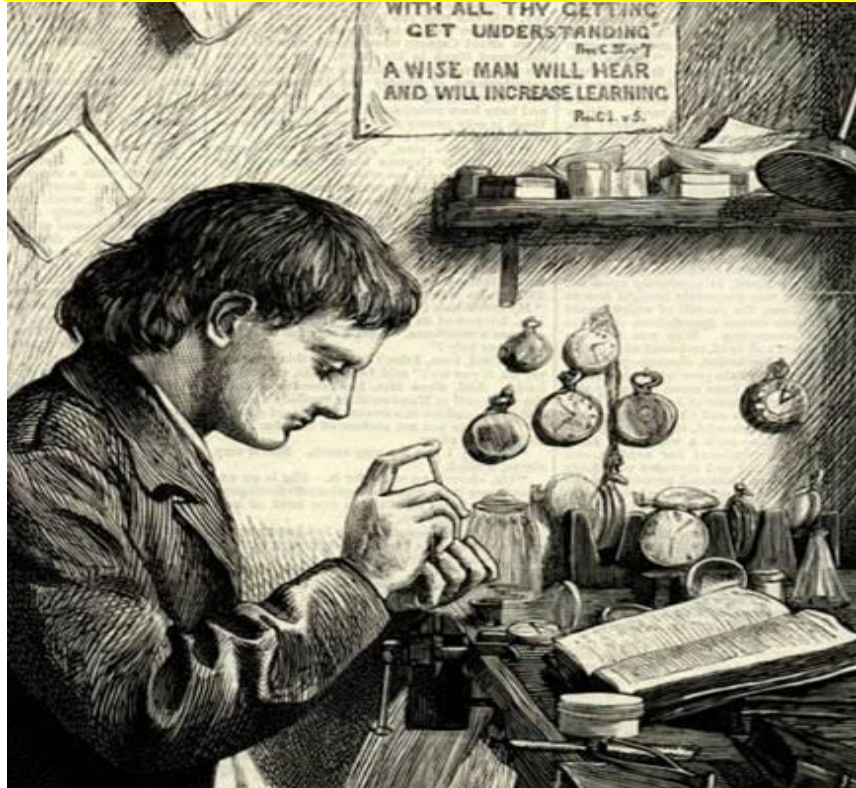
- ❖ Usually a "sequence" of outcomes is laid out in a Capability Roadmap
- ❖ The Enterprise can even change its own Objectives and Priorities!



# 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



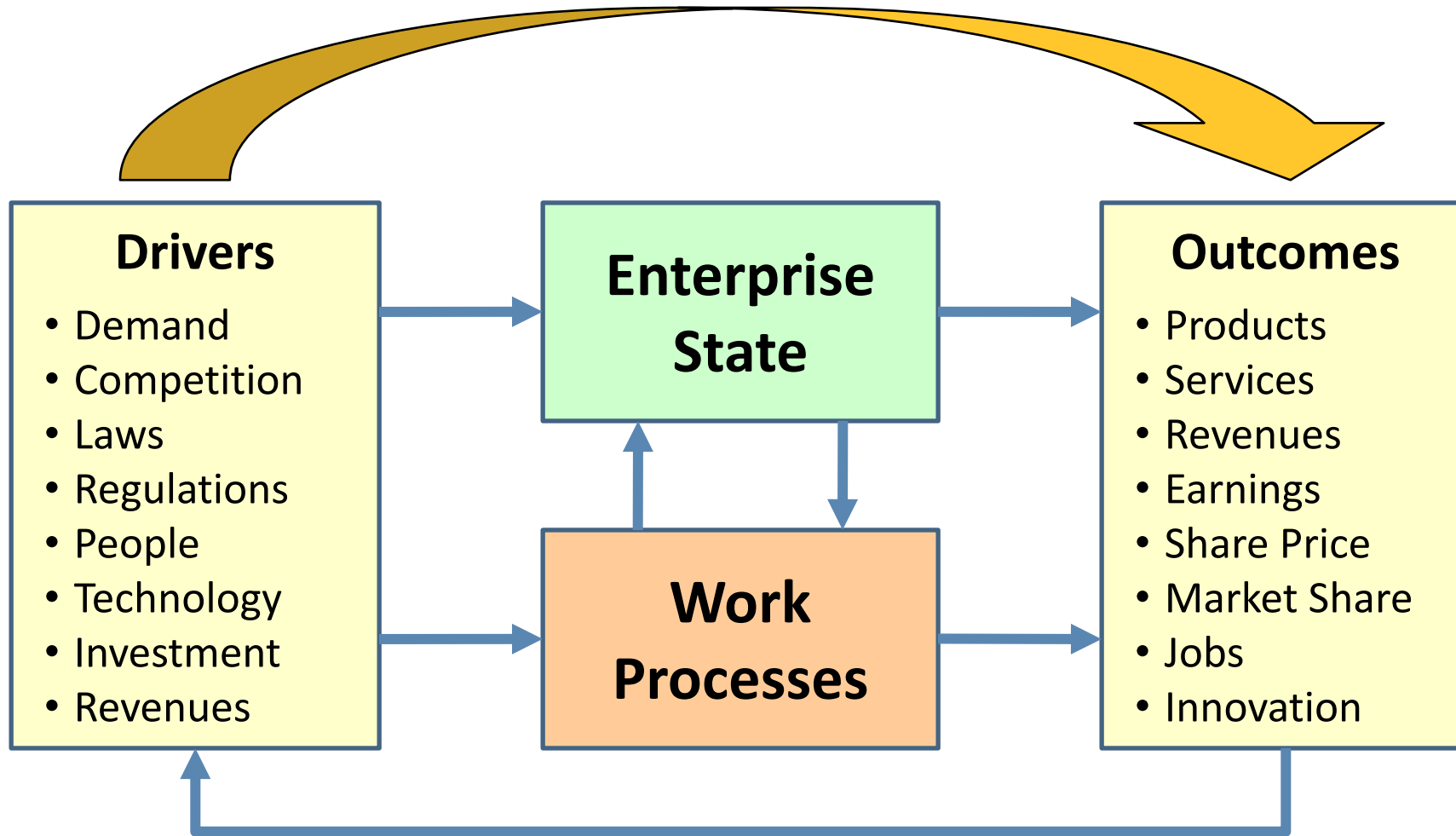
Dynamic: Constant Change  
Competitive: Crops compete  
Scale Free: 80-20 Rule





# Transforming the Enterprise to Achieve Desired Outcomes

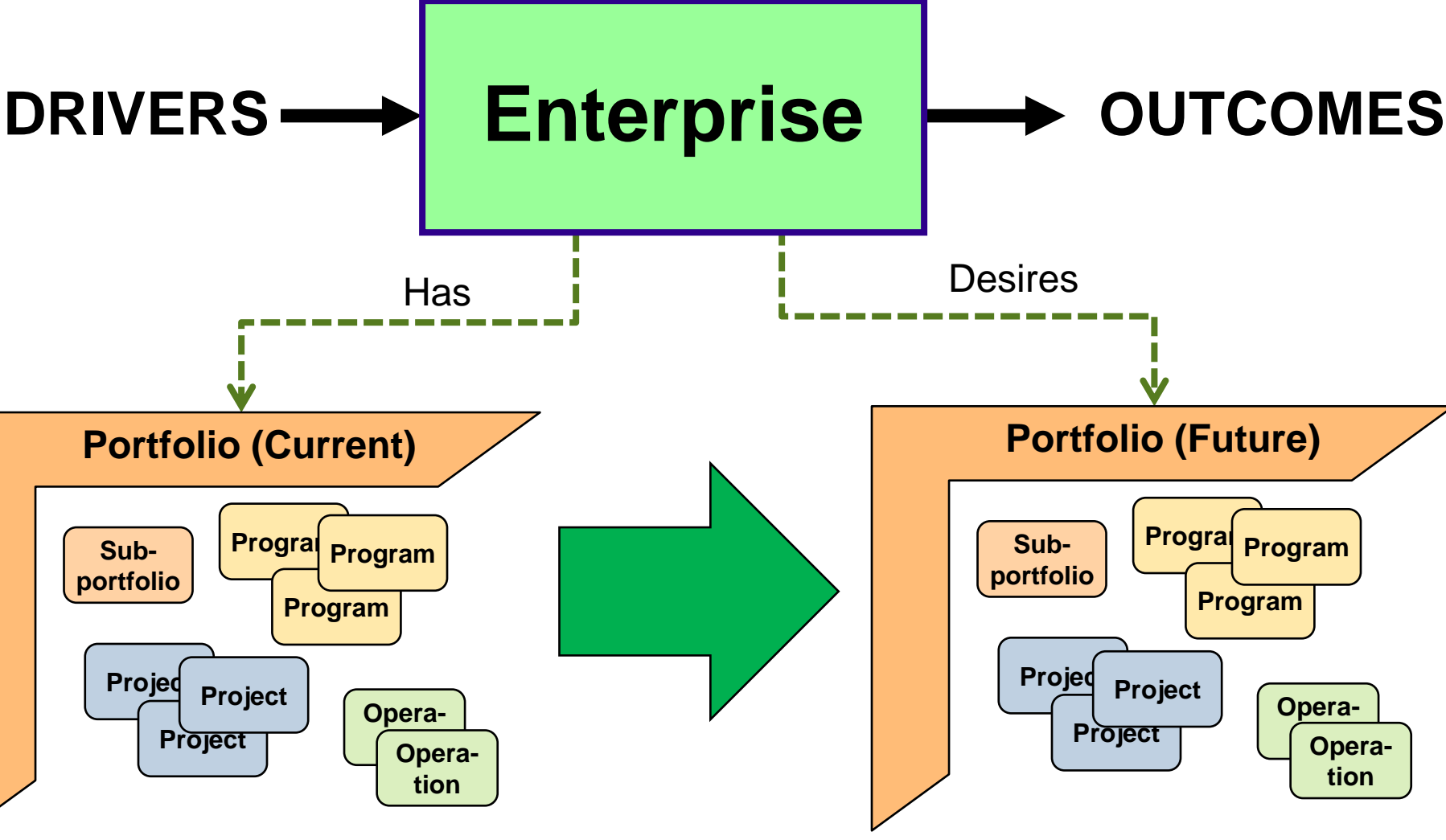
*Finding the Optimal States and the Right Processes*



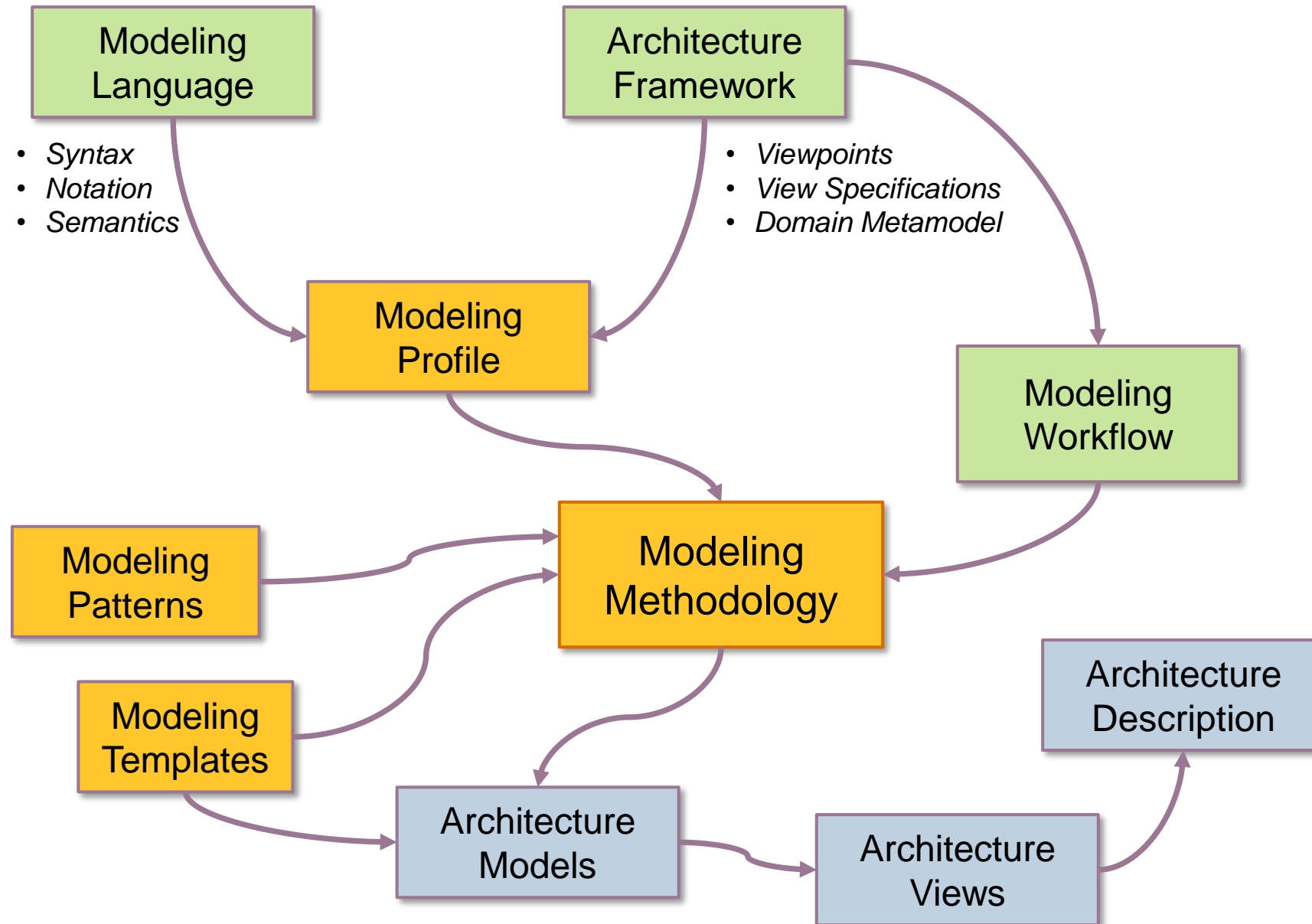
*Architecture Models can help understand the landscape and how to change things for the better*



# Portfolio Management



# The Modeling Landscape





# OMG Modeling Standards

## Modeling Languages



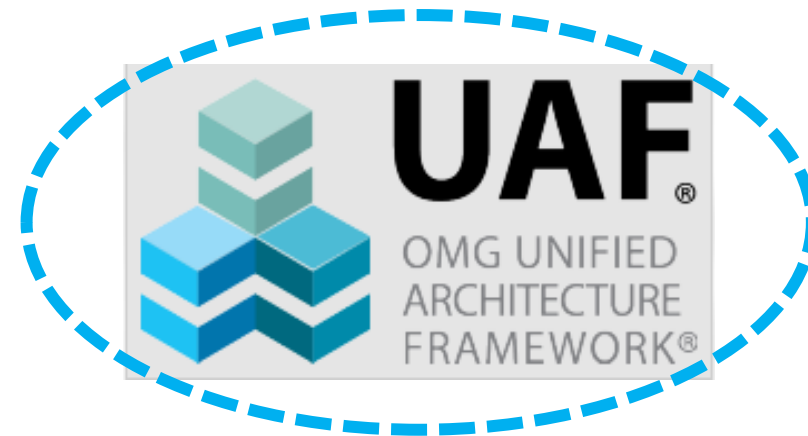
For modeling complex **Software Architectures** and applications



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



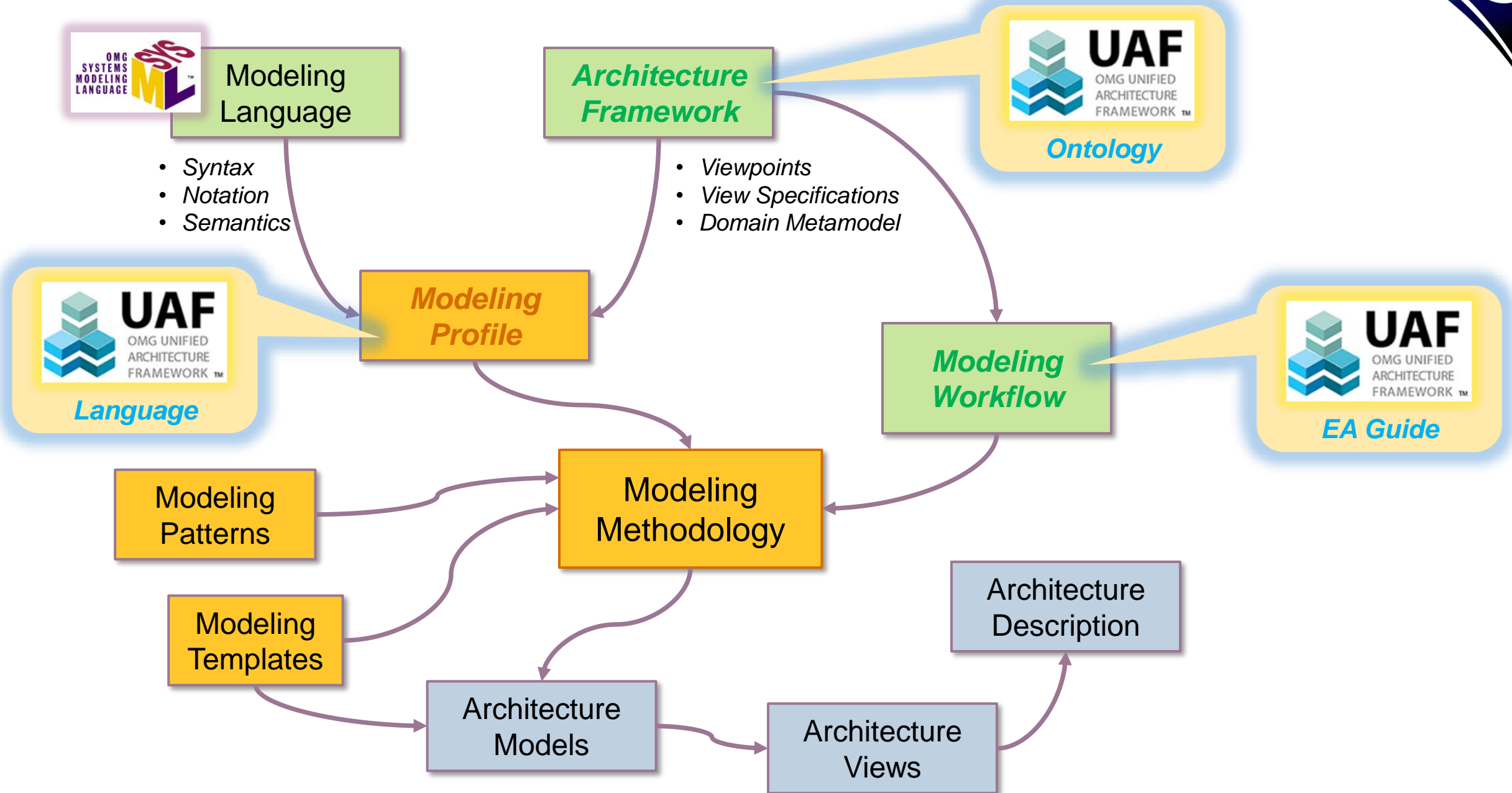
For modeling complex **Business Processes**



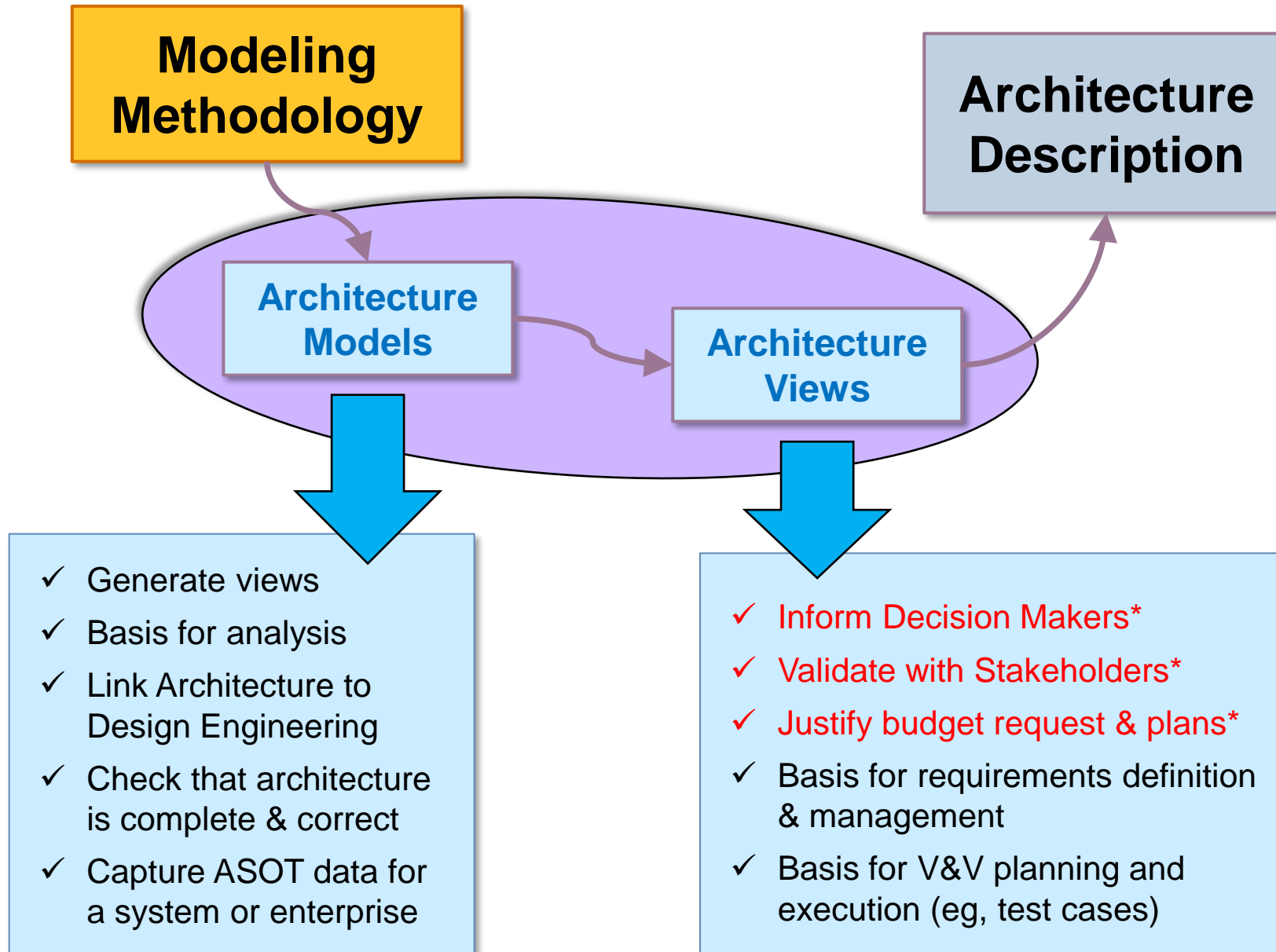
For modeling complex **Enterprise Architectures** that includes strategy, capabilities, operations, programs/projects, services, resources, security, personnel, organizations and standards



# Unified Architecture Framework (UAF)



# Primary Use Cases for Architecture Models & Views



*\* Use cases most relevant to Portfolio Management*



UAF UNIFIED ARCHITECTURE FRAMEWORK	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 Extension	Architecture	Architecture	Architecture	Architecture	Architecture	Architecture	Architecture Parameters Am-Pm	Architecture Constraints Am-Ct	Architecture Roadmap Am-Rm	Architecture Traceability Am-Tr
Performance						Ps-St	Ps-Sq		Environment En-Pm	Service Constraints Sv-Ct	Roadmap Sv-Rm	Traceability Sv-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	Measurements Me-Pm	Competence, Drivers, Performance Ps-Ct-C, -D, -P	Availability, Evolution, Forecast PS-Rm-A, -E, -F	Personnel Traceability Ps-Tr
Security Sc	Security Controls Sc-Mv	Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr	-	-		Risks Rk-P			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	-	-	-	-				Standards Roadmap Sd-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?*







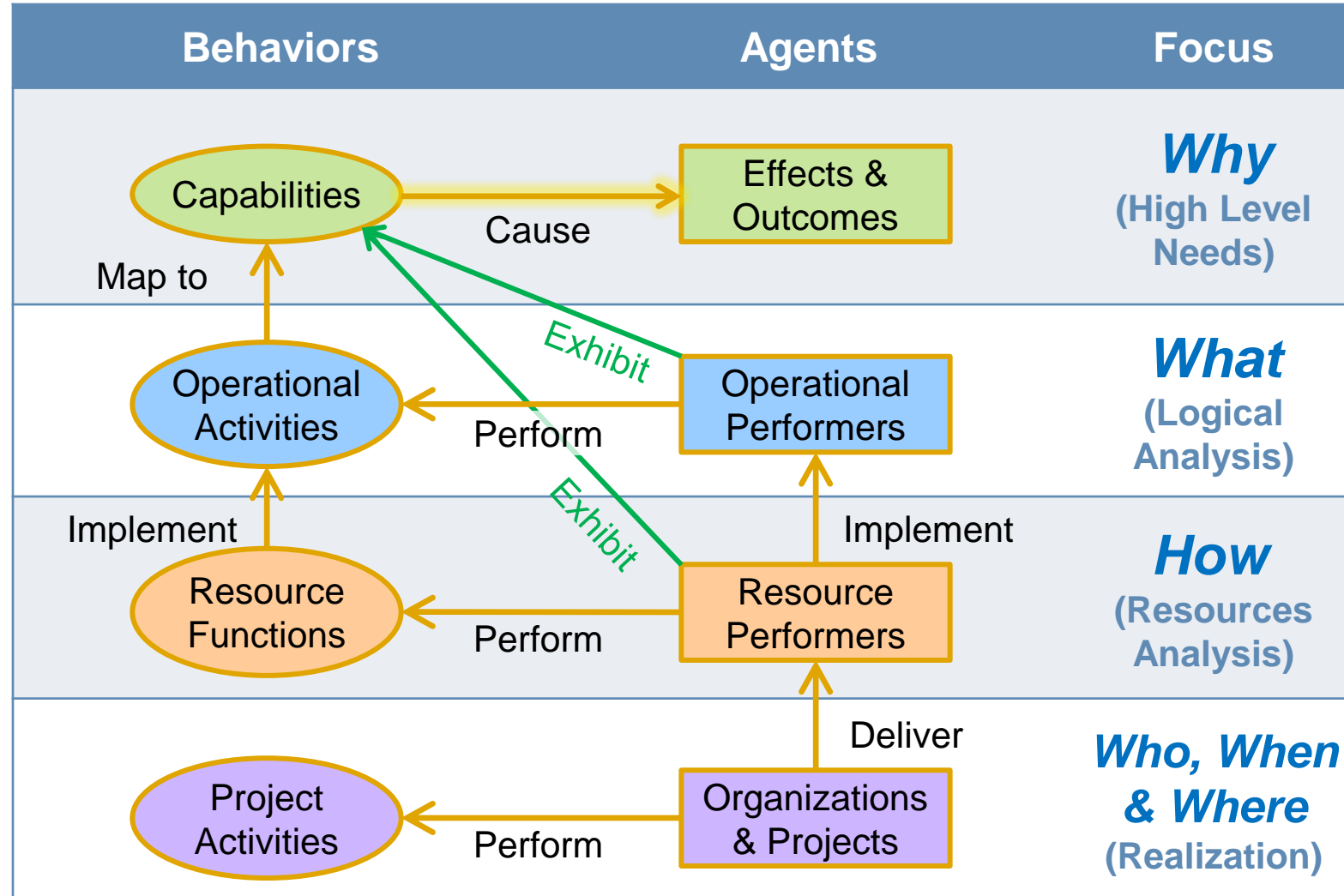
# The Four Layers of Enterprise Modeling

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

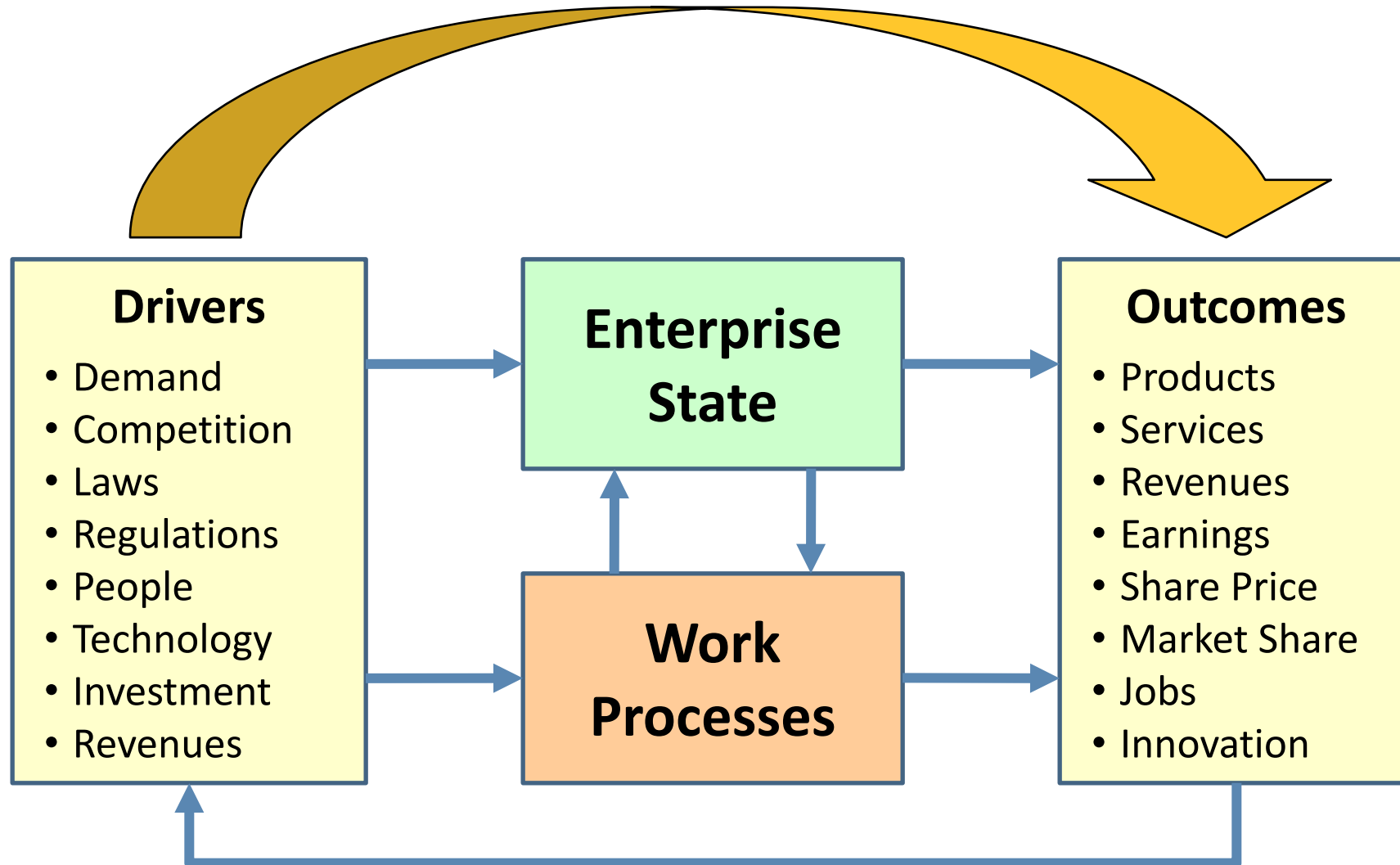
Behaviors	Agents	Focus
Capabilities	Effects & Outcomes	<b>Why</b> (High Level Needs)
Operational Activities	Operational Performers	<b>What</b> (Logical Analysis)
Resource Functions	Resource Performers	<b>How</b> (Resources Analysis)
Project Activities	Organizations & Projects	<b>Who, When &amp; Where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

# The Four Layers of Enterprise Modeling

Key Relationships Between Behaviors & Agents



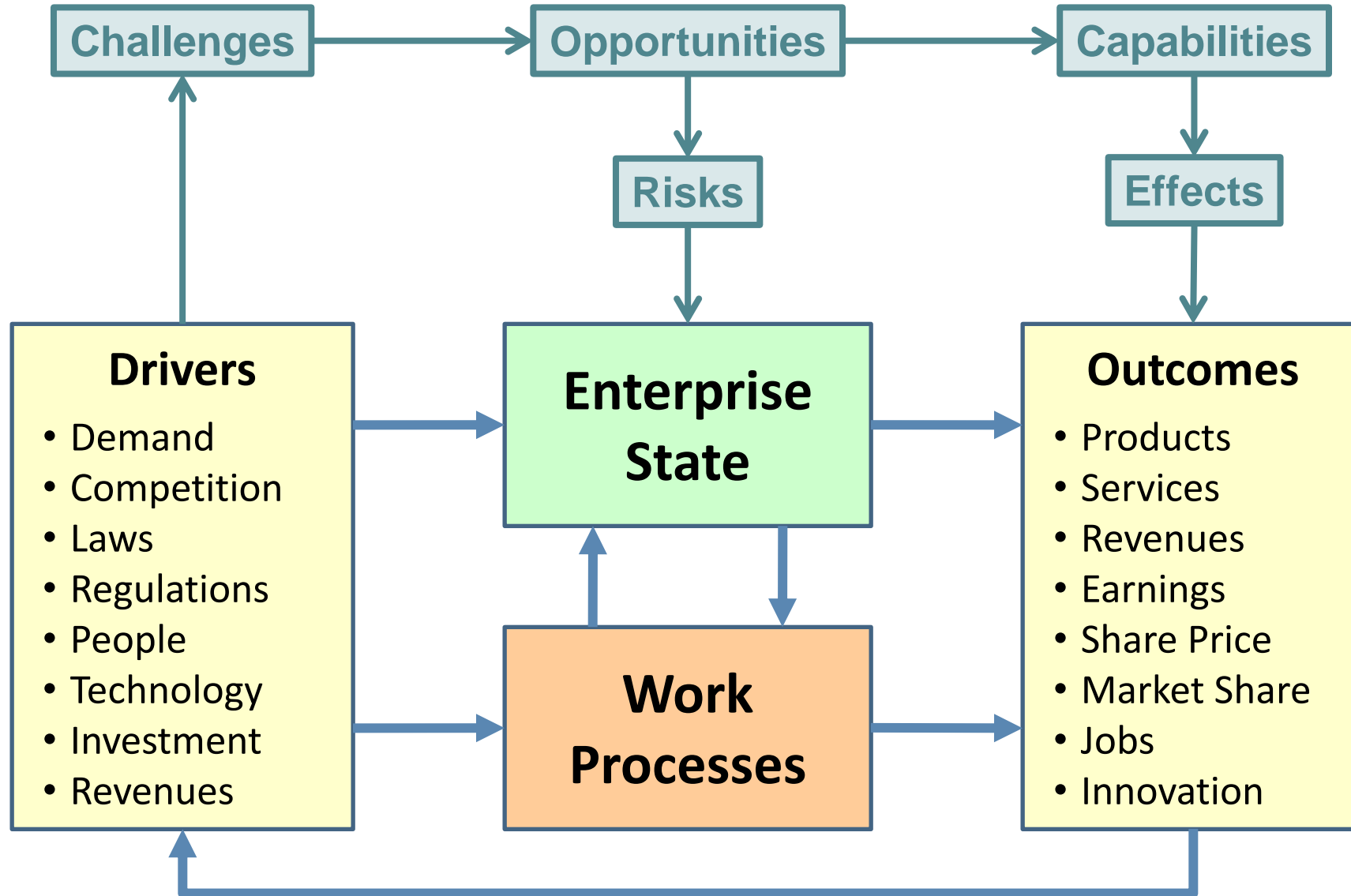
**Drivers** → **Challenges** → **Opportunities** →  
**Capabilities** → **Effects** → **Outcomes**







# Challenges & Opportunities to be Identified for Achieving Enterprise Transformation



# Identification of Capability Gaps and Shortfalls

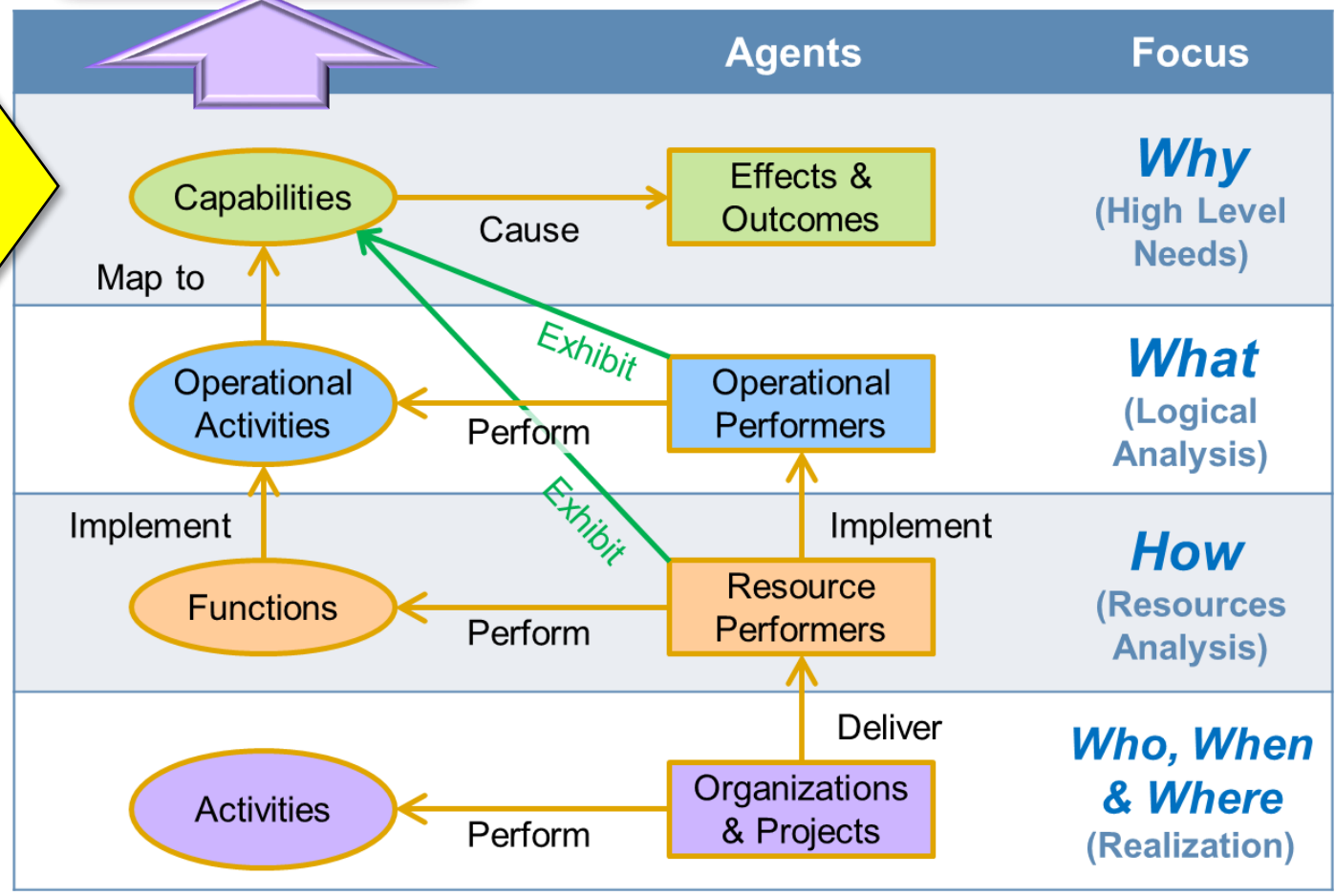
Focus on Enterprise Capabilities & Desired Effects for Portfolio Management



**Mission Impact**

✓ Drivers  
✓ Challenges  
✓ Opportunities

These items provide the proper Justification for new & improved Capabilities



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

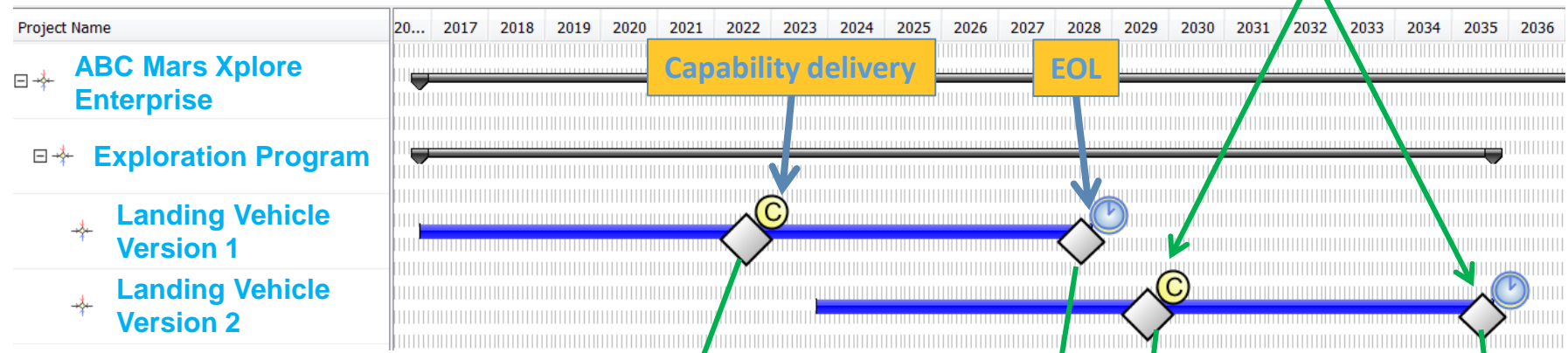


# System End of Life Before Next Delivery Causes a Capability Gap

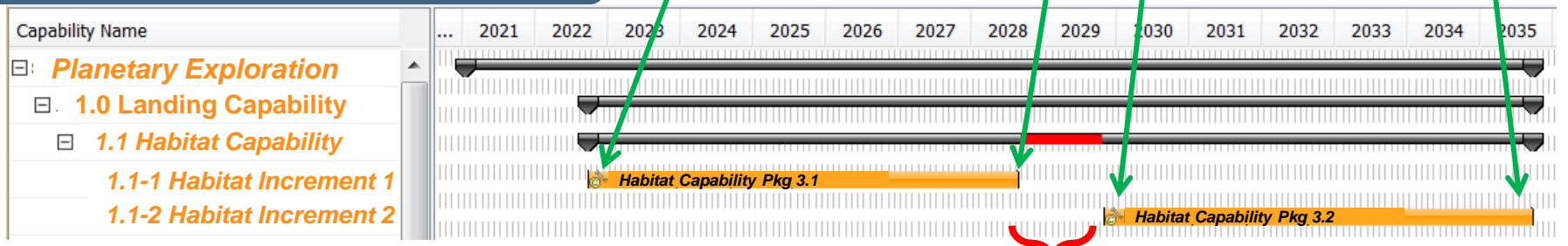
Roadmap views provide key insights into Portfolio change impacts

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)



Mars Exploration Enterprise Projects & Capabilities

Capability Gap

Enterprise Models of the Portfolio can highlight issues and potential problems

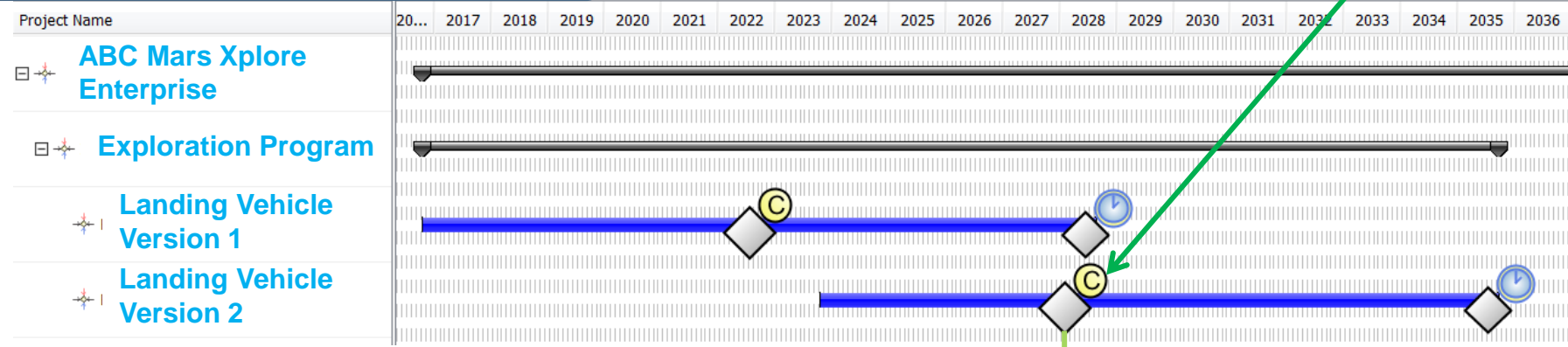




# Schedule Adjustment Closes Gap

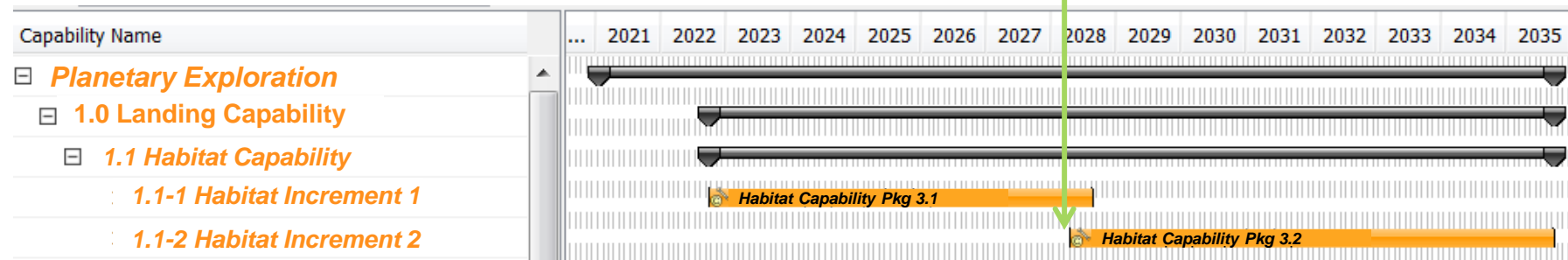
Changing the Portfolio further to achieve proper balance

## PV-2 Project Timelines (Pj-Rm)



Adjusting this milestone to the left closes the gap

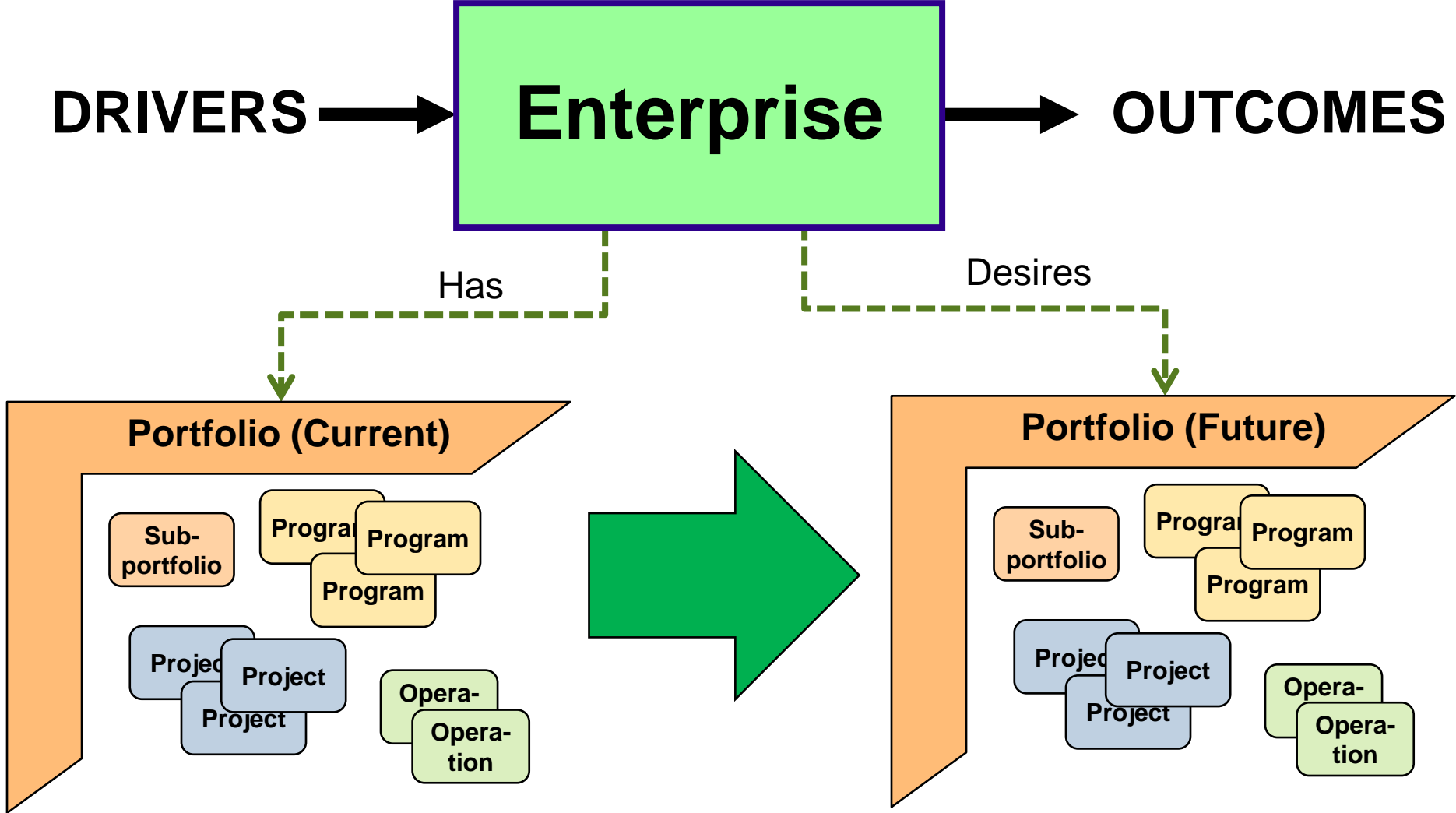
## CV-3 Capability Phasing (St-Rm)



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



# Identification of Capability Gaps and Shortfalls

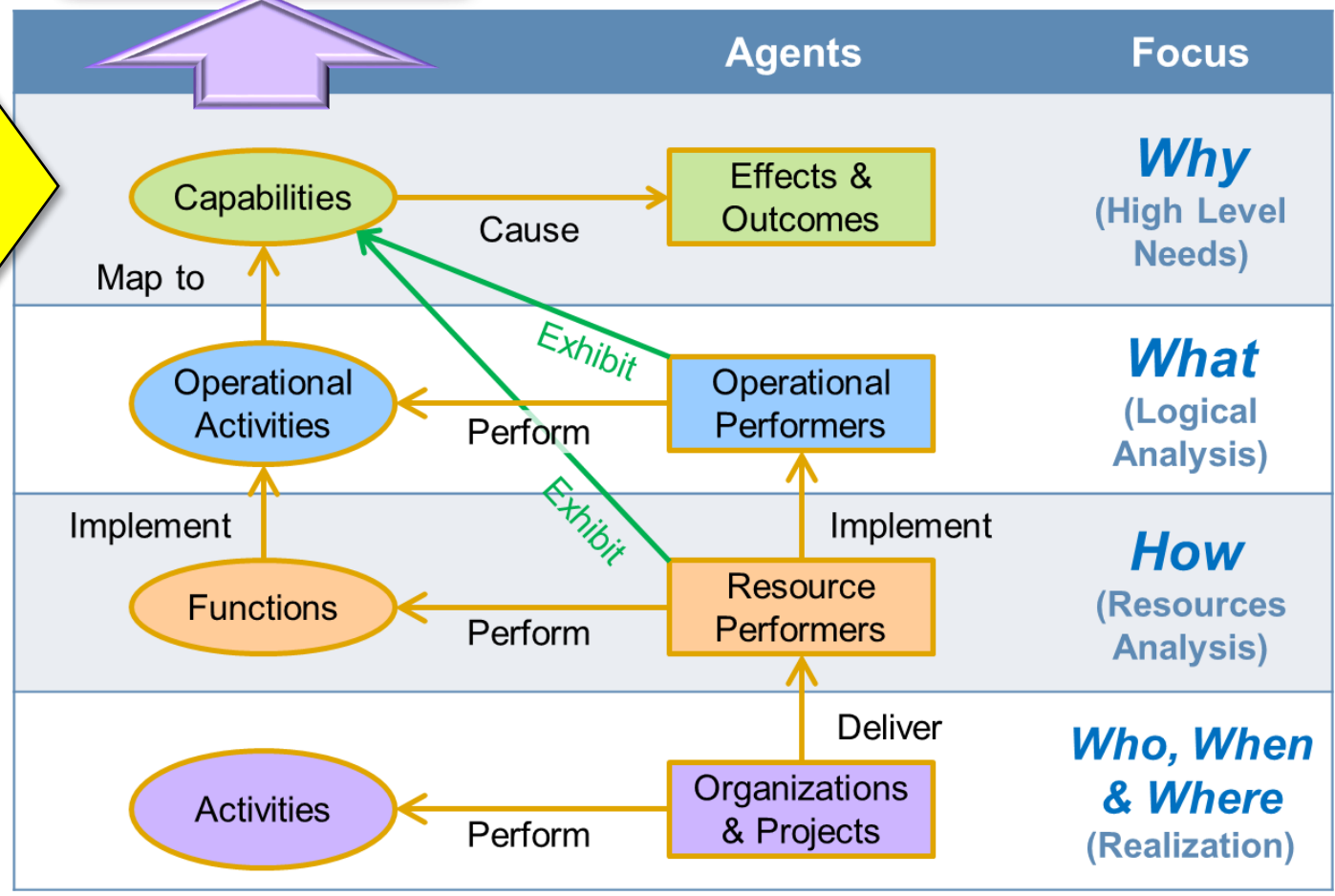
Focus on Enterprise Capabilities & Desired Effects for Portfolio Management



**Mission Impact**

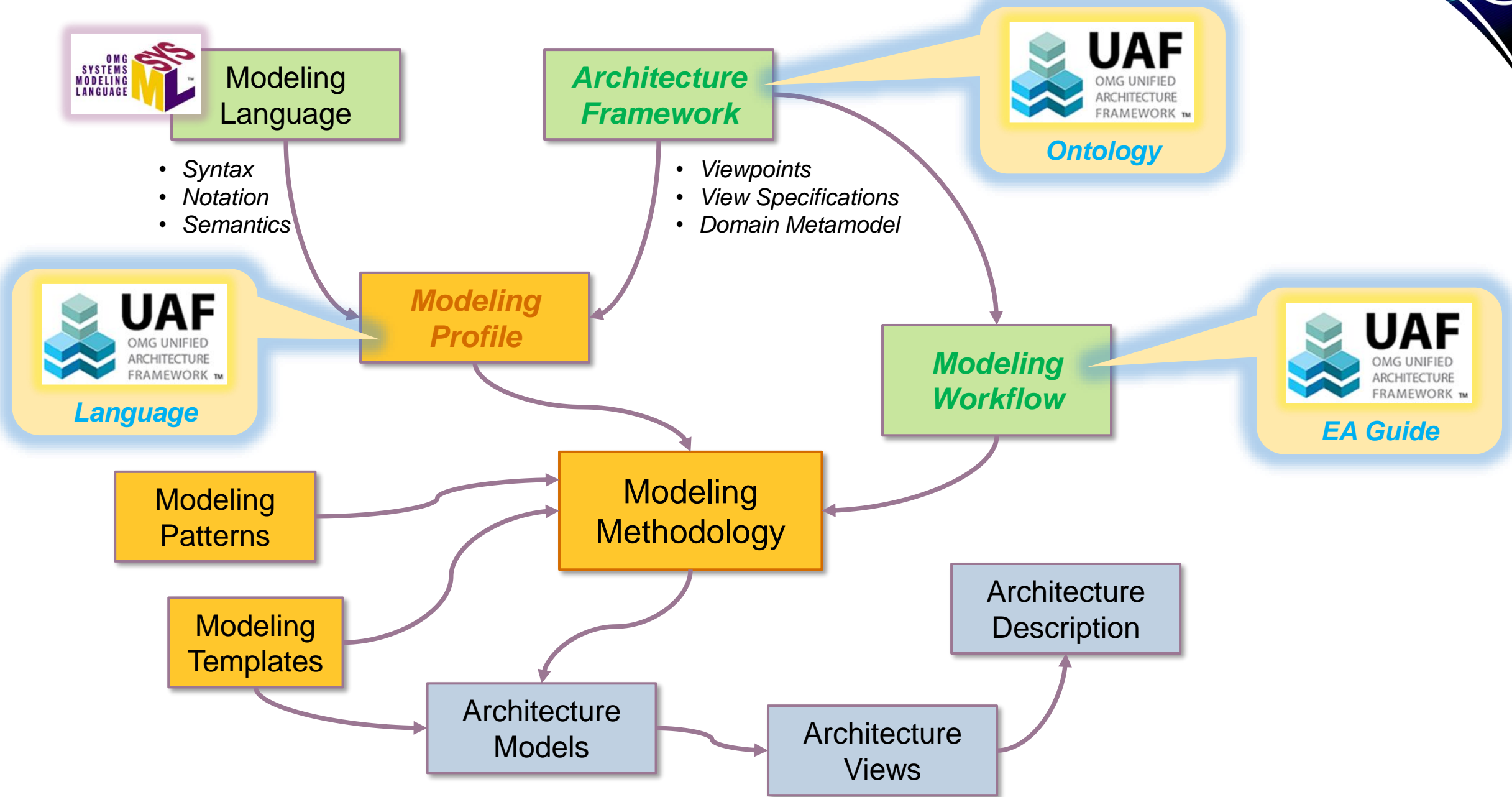
✓ Drivers  
✓ Challenges  
✓ Opportunities

These items provide the proper Justification for new & improved Capabilities



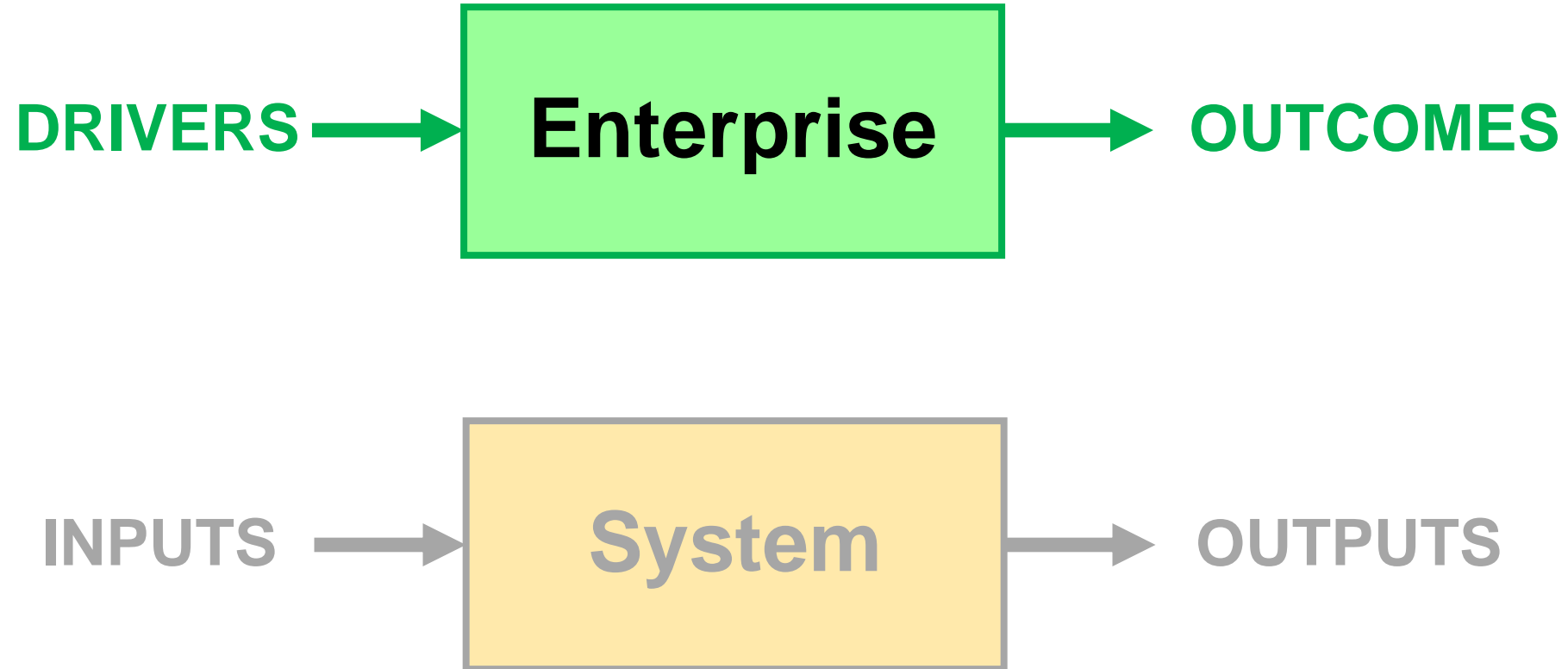
**Need to examine various factors that will help identify which Capabilities in the Enterprise have gaps and shortfalls with respect to causing desired Effects**

# Unified Architecture Framework





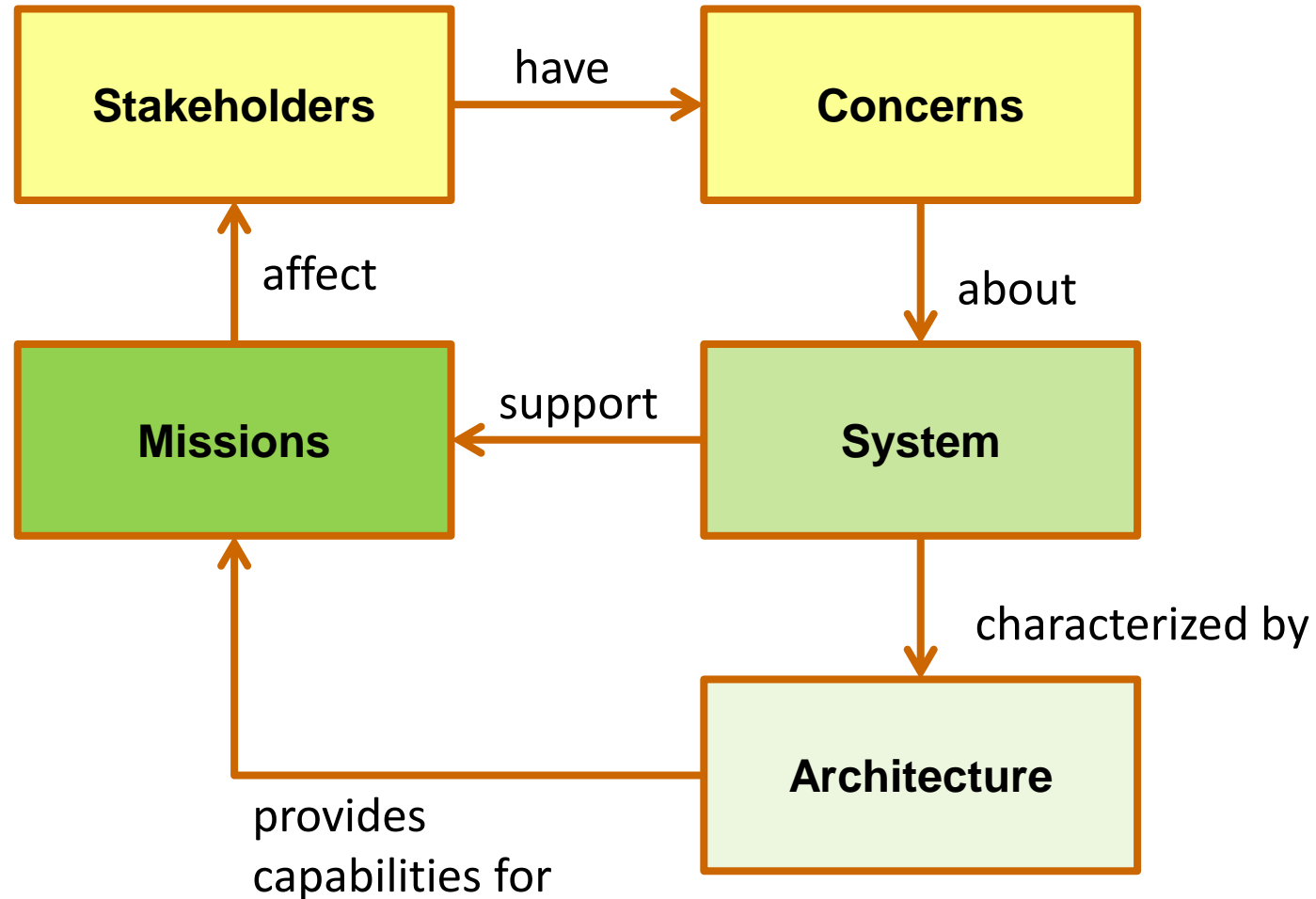
# *The Enterprise Mindset...*



*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...*

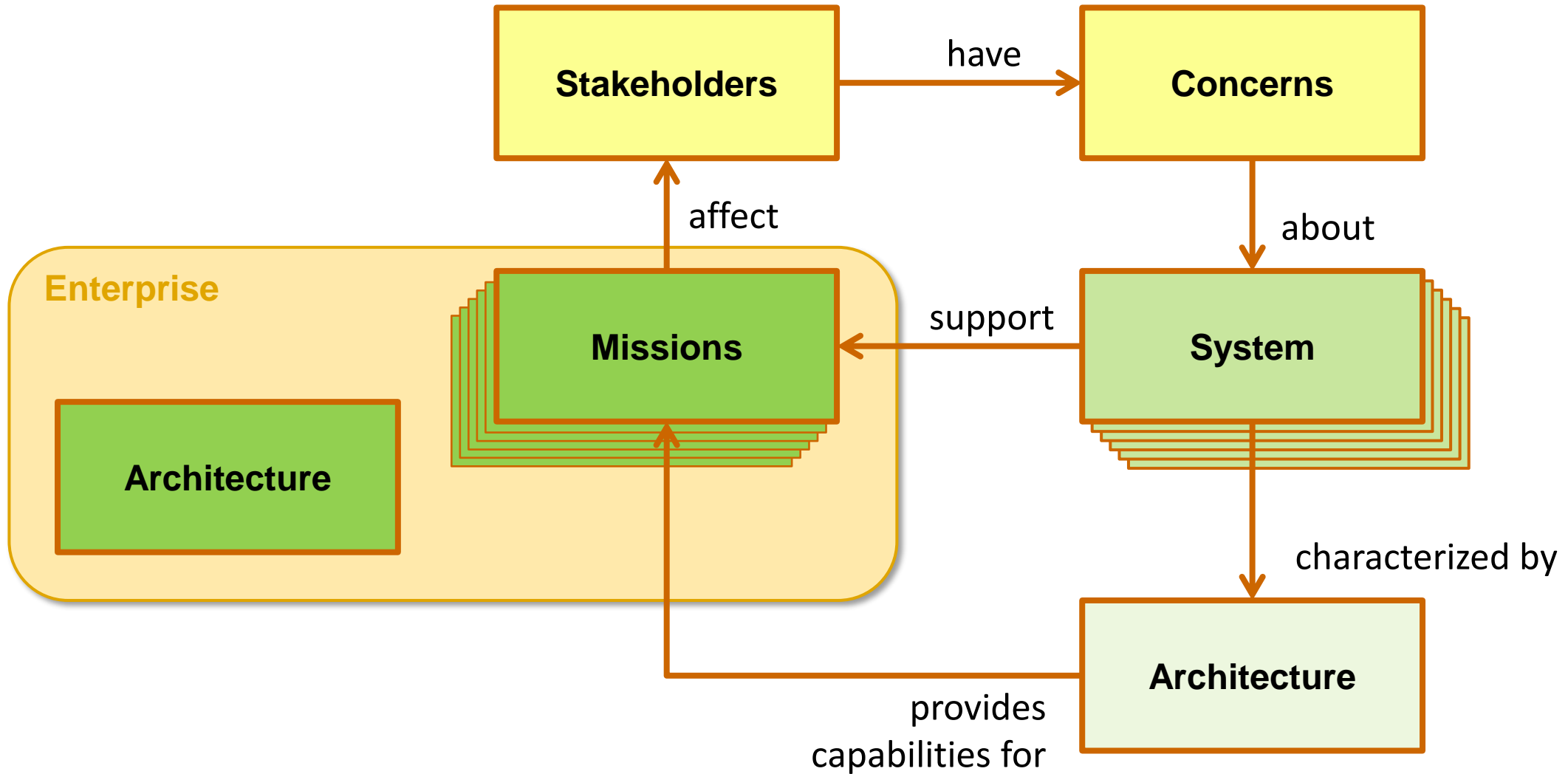


**Systems Engineering** defines an **Architecture** of the **System** that addresses **Stakeholder Concerns** regarding the relevant **Missions**



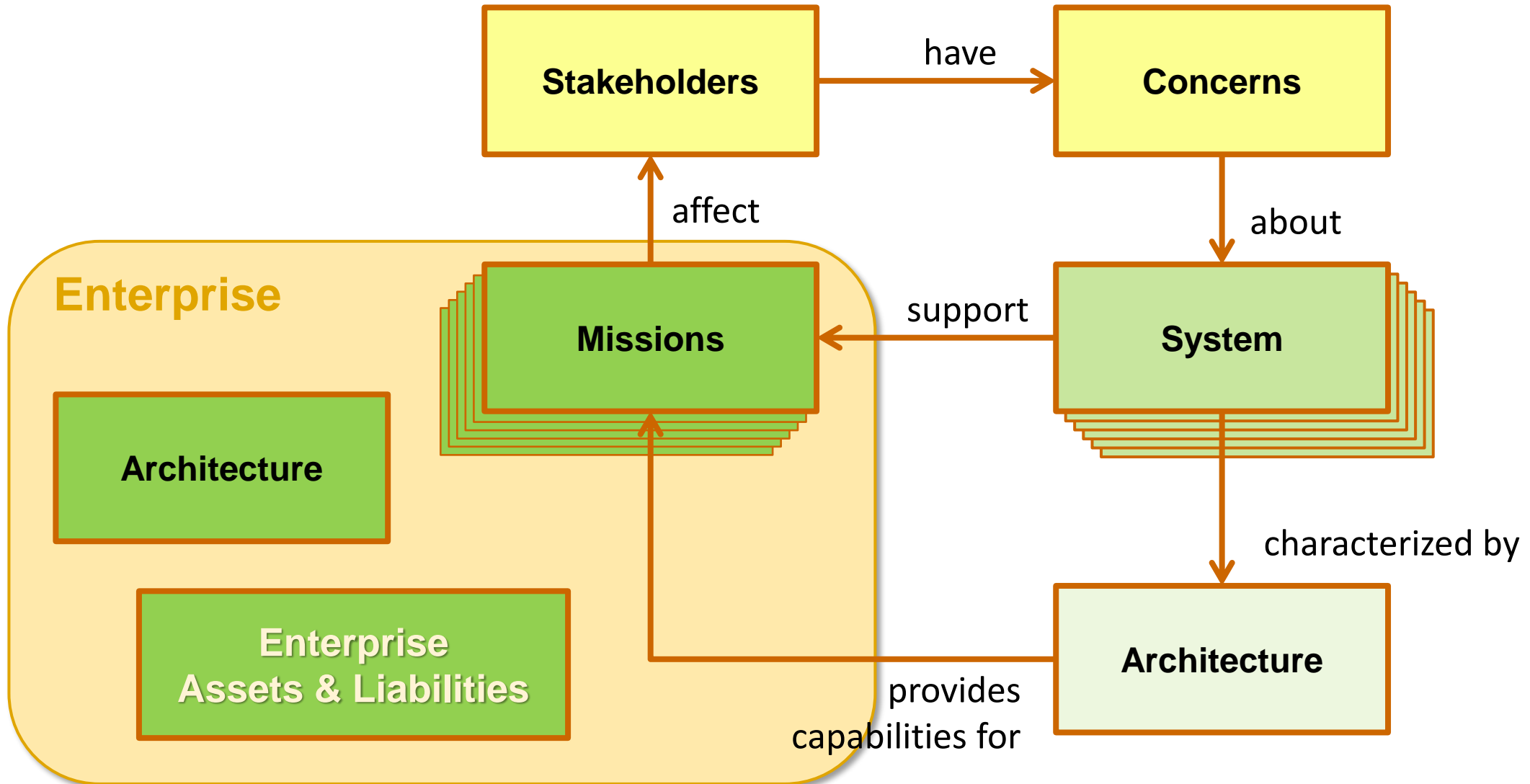


The **Enterprise Architecture** defines the various **Missions** along with associated **Mission Objectives** and **Strategic Capabilities**



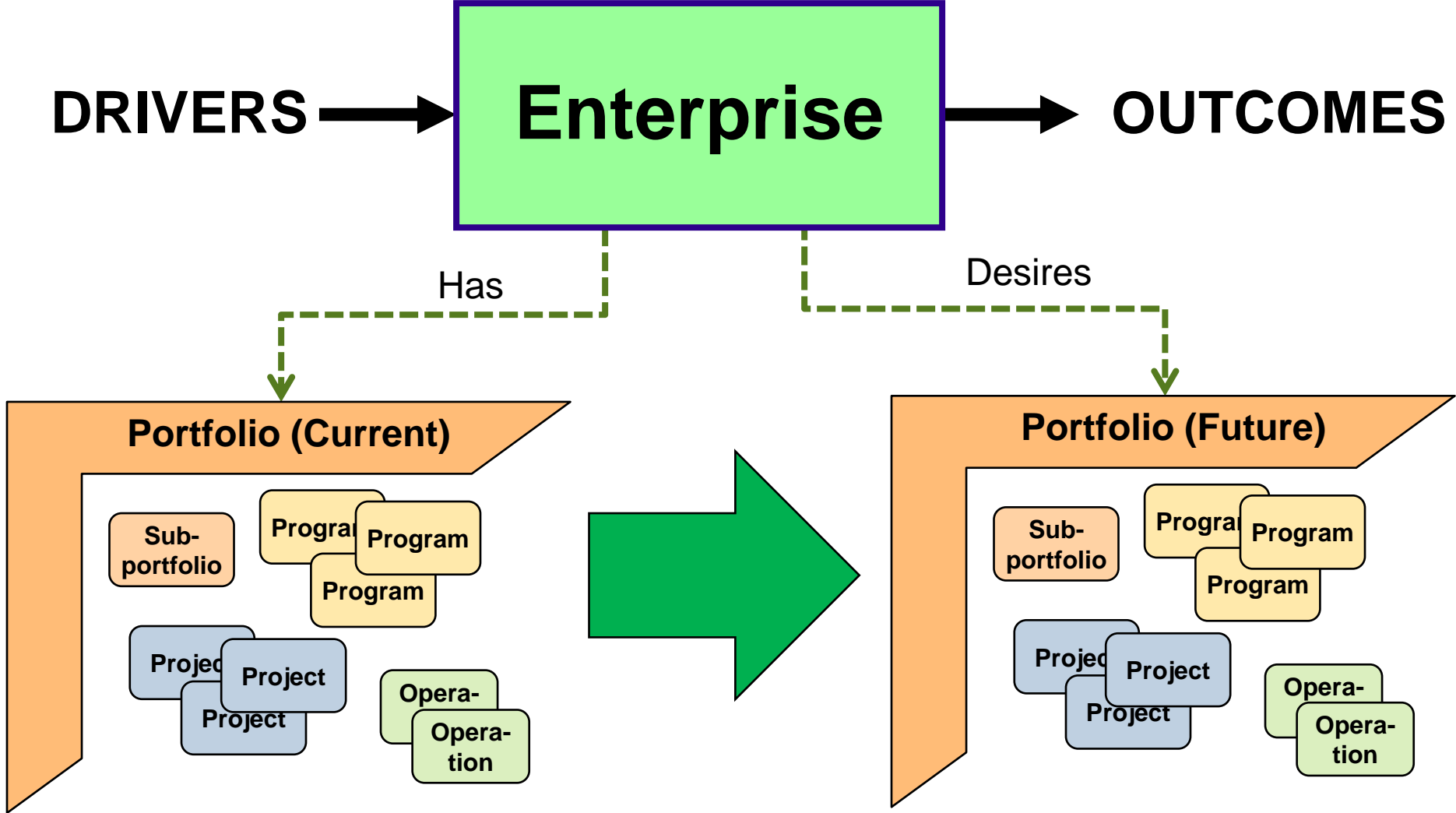


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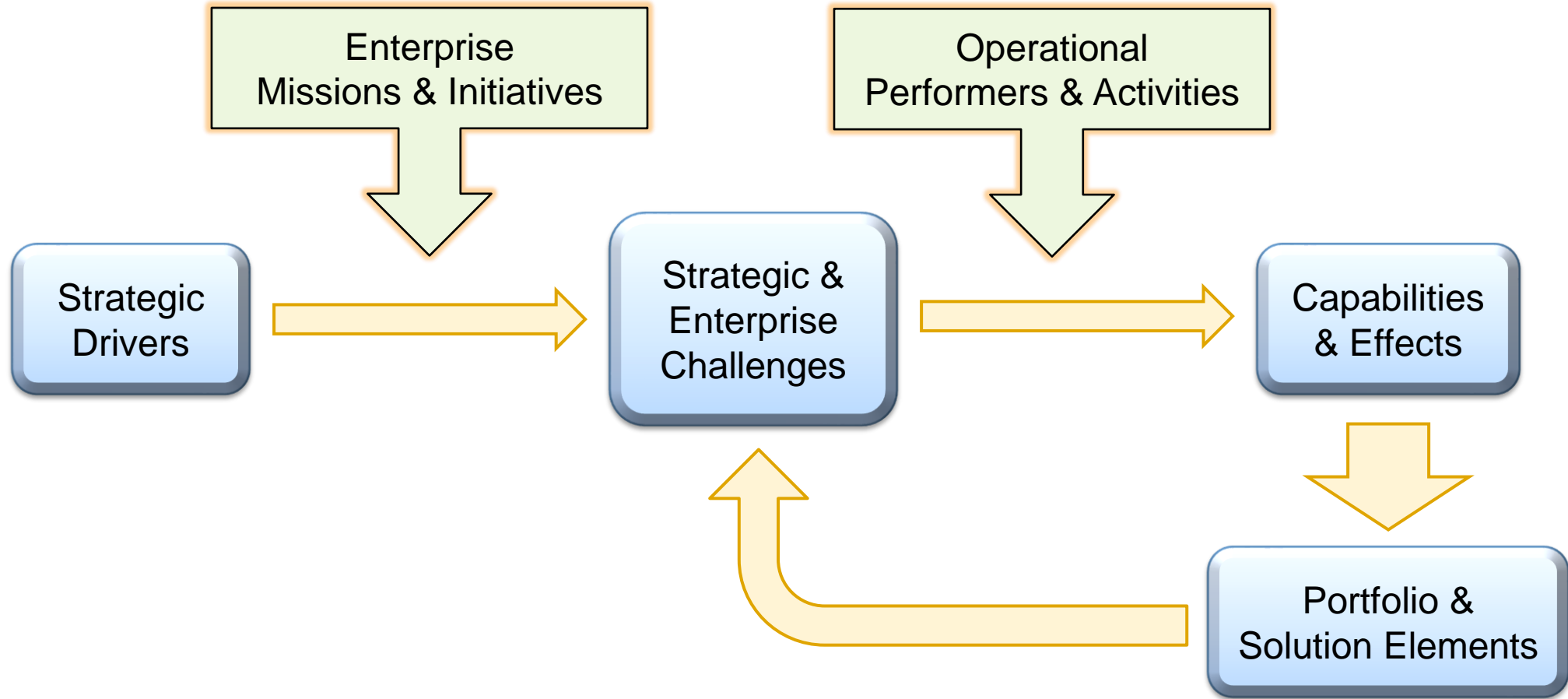
# Portfolio Management





# Enterprise Transformation Considerations

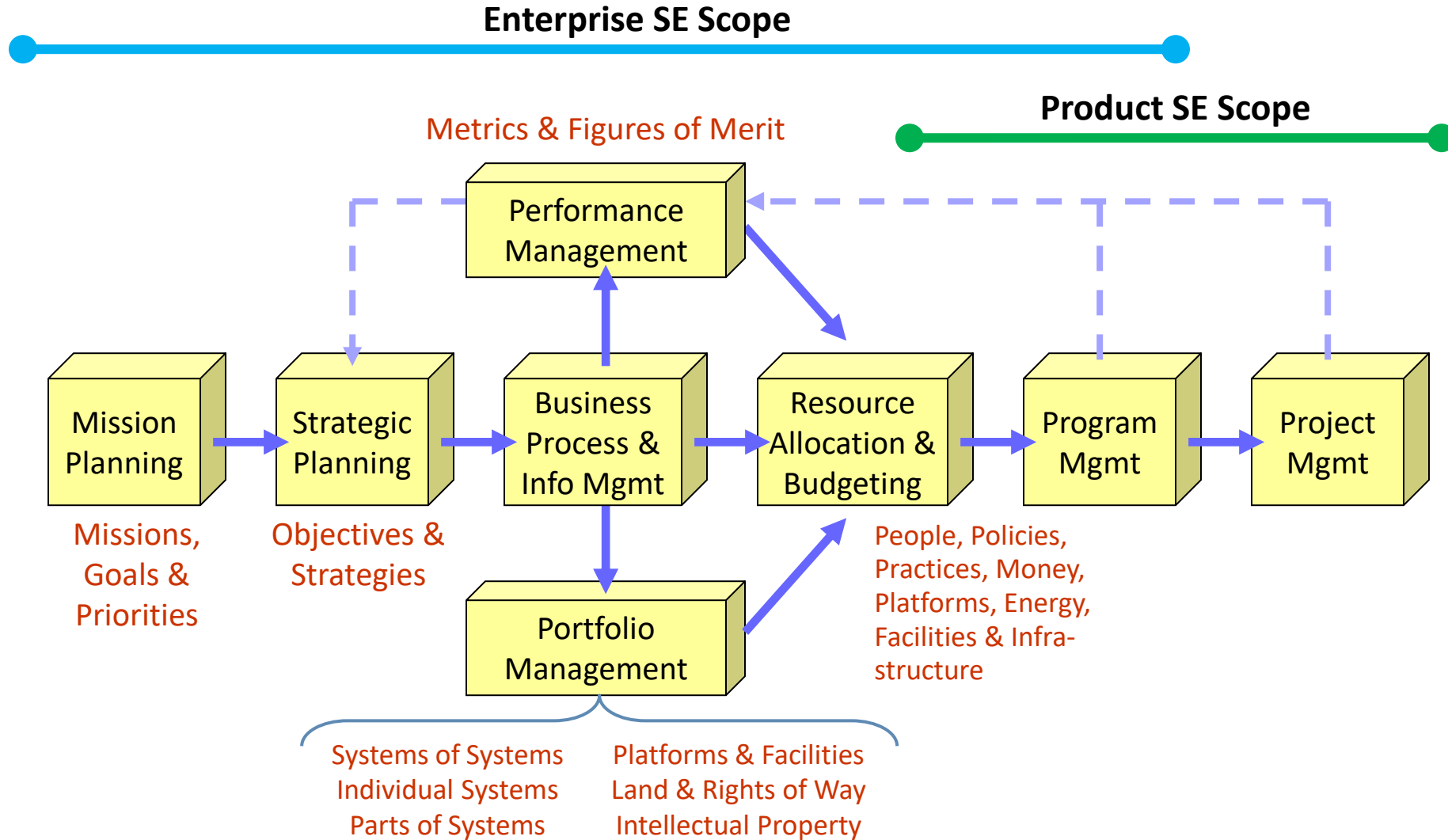
*Managing the Enterprise Portfolio to Maximize Mission Impact*



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

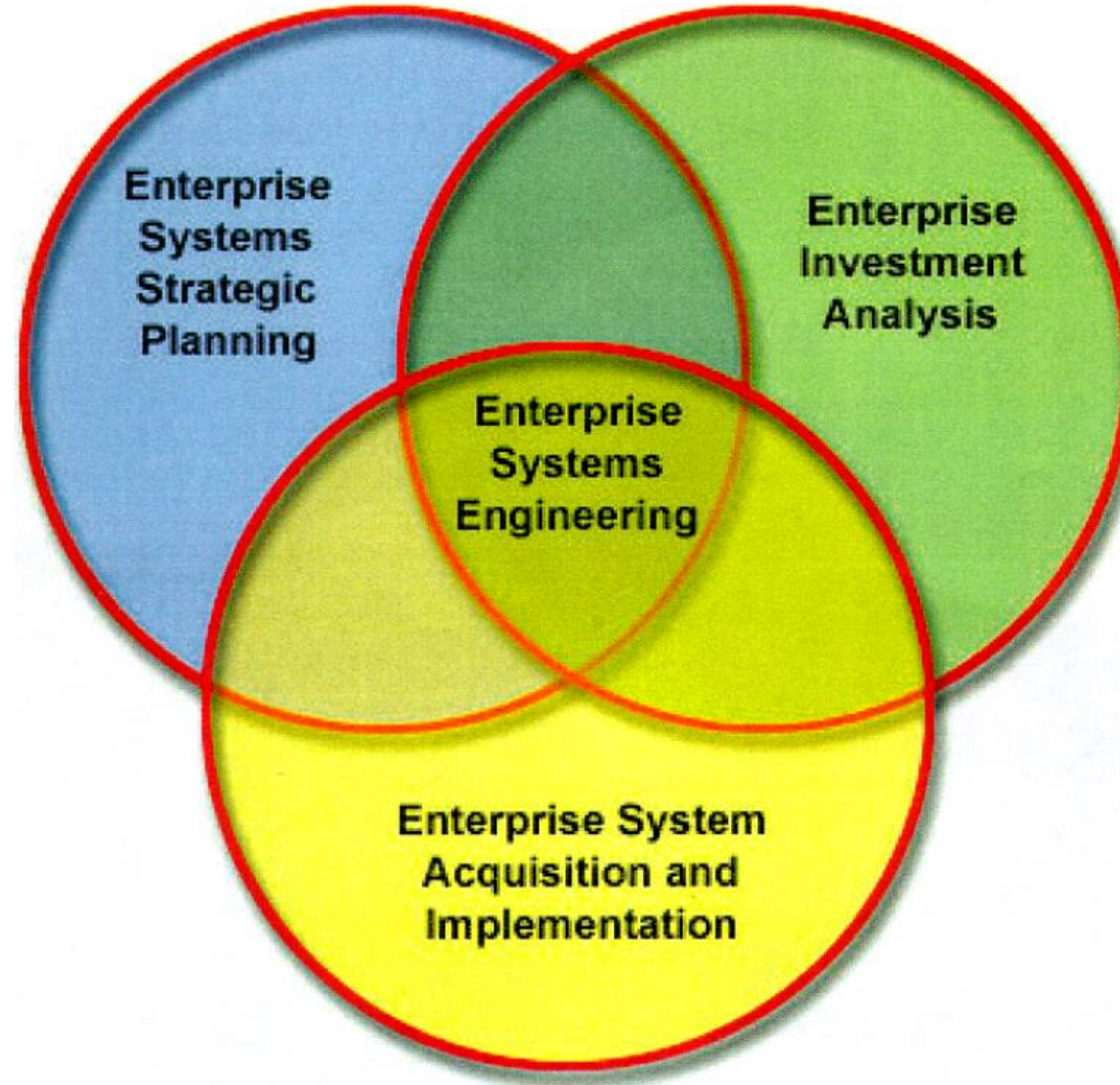


# Higher Level for the Scope of Enterprise SE



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

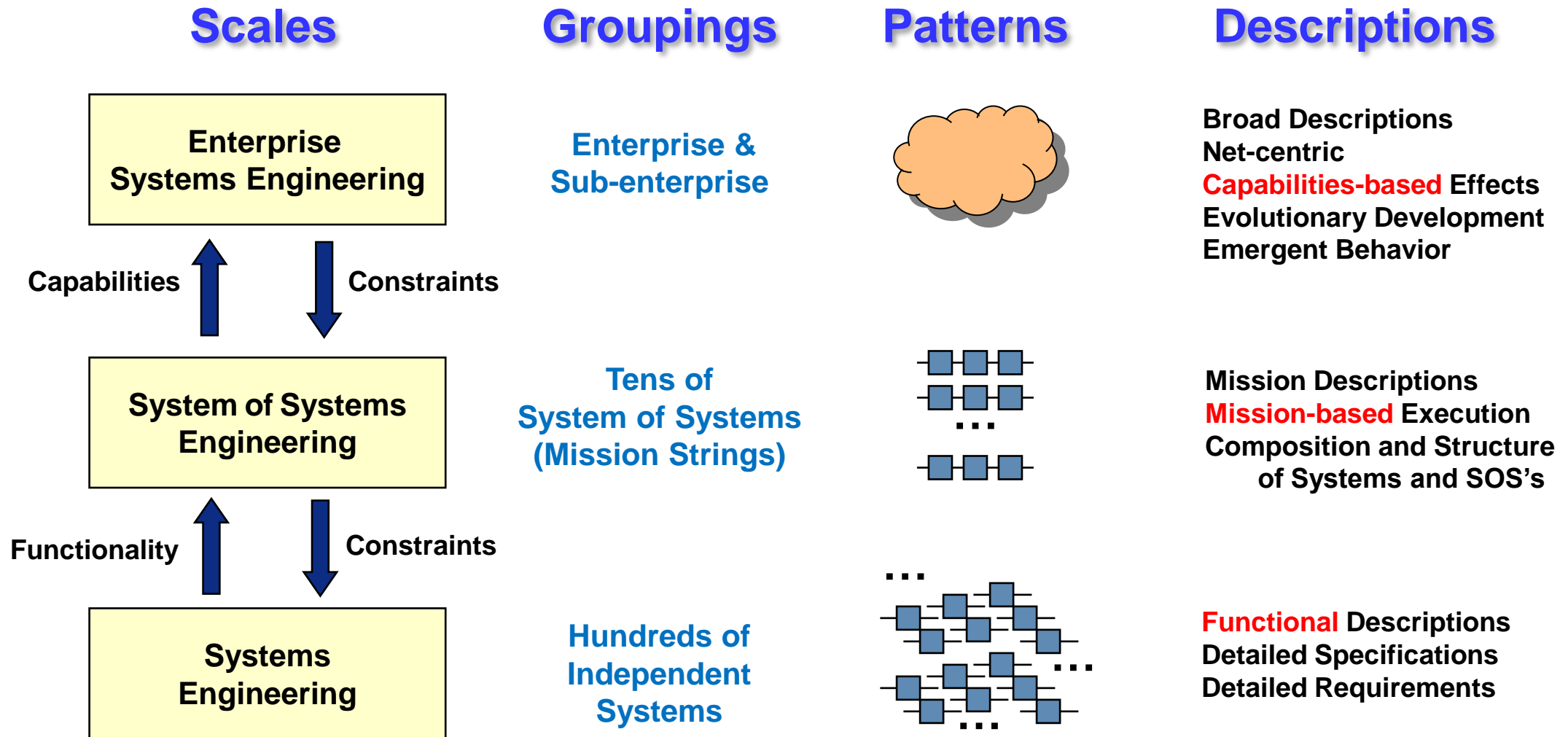
# Major Role of Enterprise SE



*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



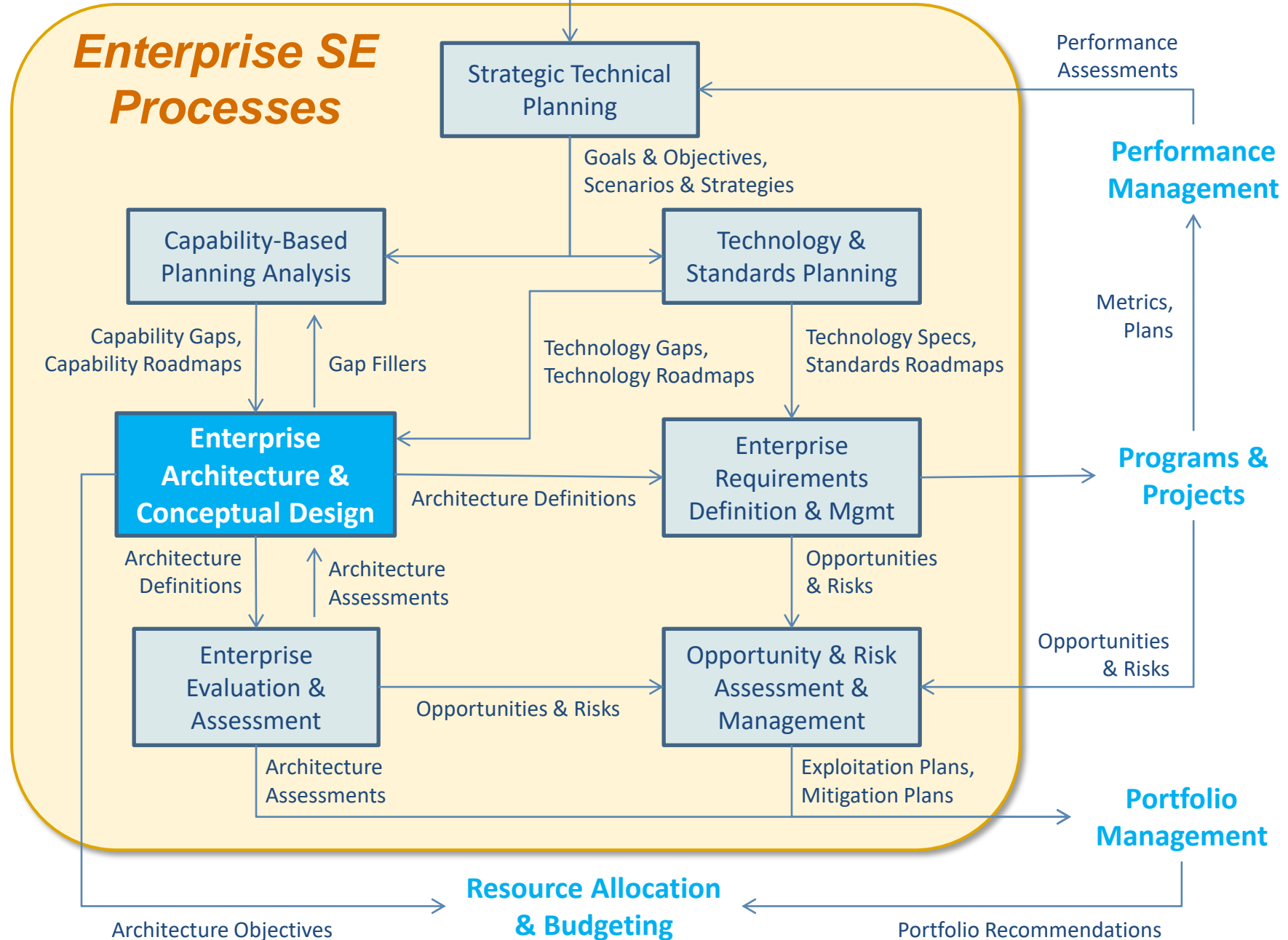
Source: DeRosa, Joseph K. 2005., "Enterprise Systems Engineering," Air Force Association, Industry Day, Day 1, Danvers, MA, 4 August 2005, <https://www.paulrevereafa.org/IndustryDay/05/presentations/index.asp>

# How Can SE Enable Enterprise Transformation?

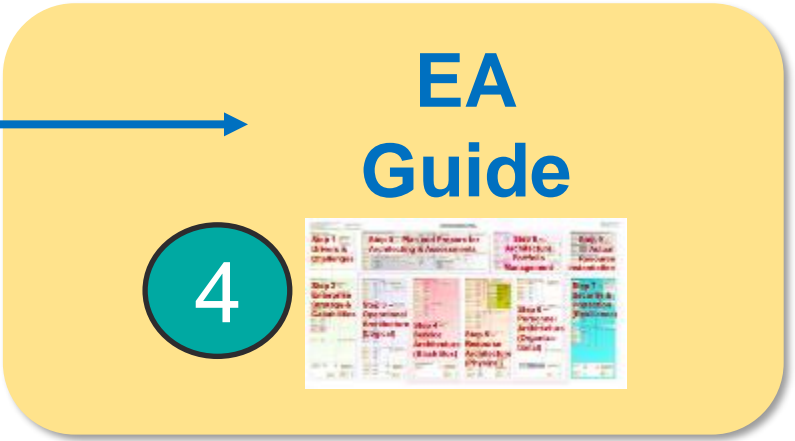


Executive Concerns	SE Enablers
Identifying <b>ends</b> , <b>means</b> , and <b>scope</b> and candidate changes	System complexity analysis to compare “as is” and “to be” enterprises
Evaluating changes in terms of process <b>behaviors</b> and <b>performance</b>	Organizational simulation of process flows and relationships
Assessing <b>economics</b> 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 <b>processes</b> and their integration	Enterprise architecting in terms of workflow, processes, and levels of maturity
Designing a strategy to change the <b>culture</b> for selected changes	Organizational and cultural change via leadership, vision, strategy, and incentives
Developing <b>transformation action</b> 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.



# Components of the UAF Specification (v1.2)

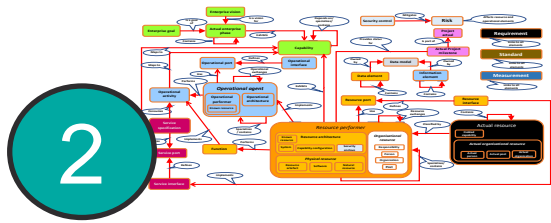


View Specifications organized in Viewpoints and Aspects (Grid)

	Security	Structure & Connectivity	Behavior	Information	Parameters	Constraints	Realms	Traceability
Strategic								
Operational								
Services								
Personal & Resources								
Security								
Projects								
Aspects								
Requirements								

1

UAF Domain MetaModel (DMM)



2

UAF Modeling Language\* (UAFML) based on SysML



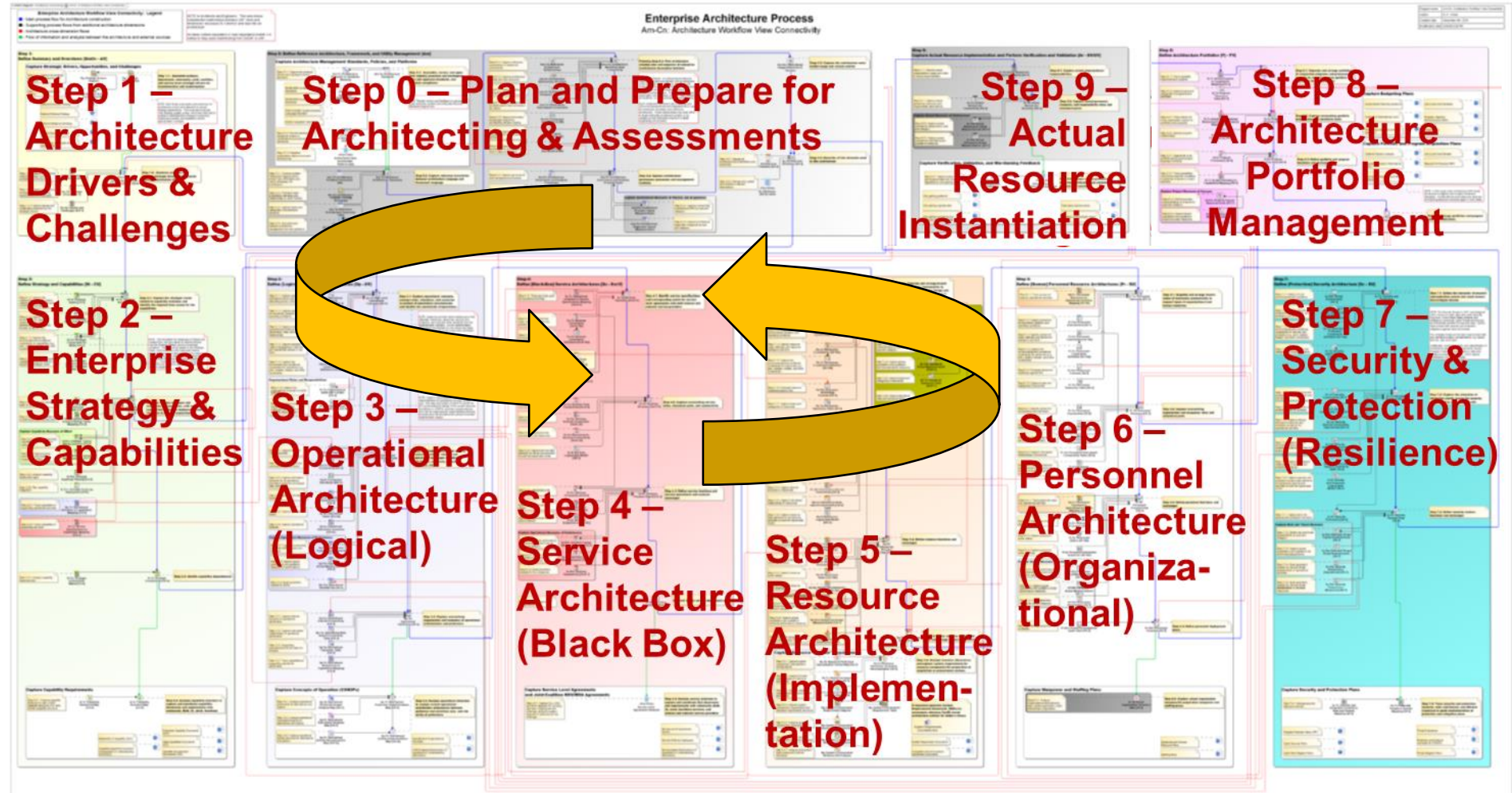
3

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



# Standardized Enterprise Architecture Workflow in UAF

*Establishes a Business Rhythm for Enterprise Transformation activities*



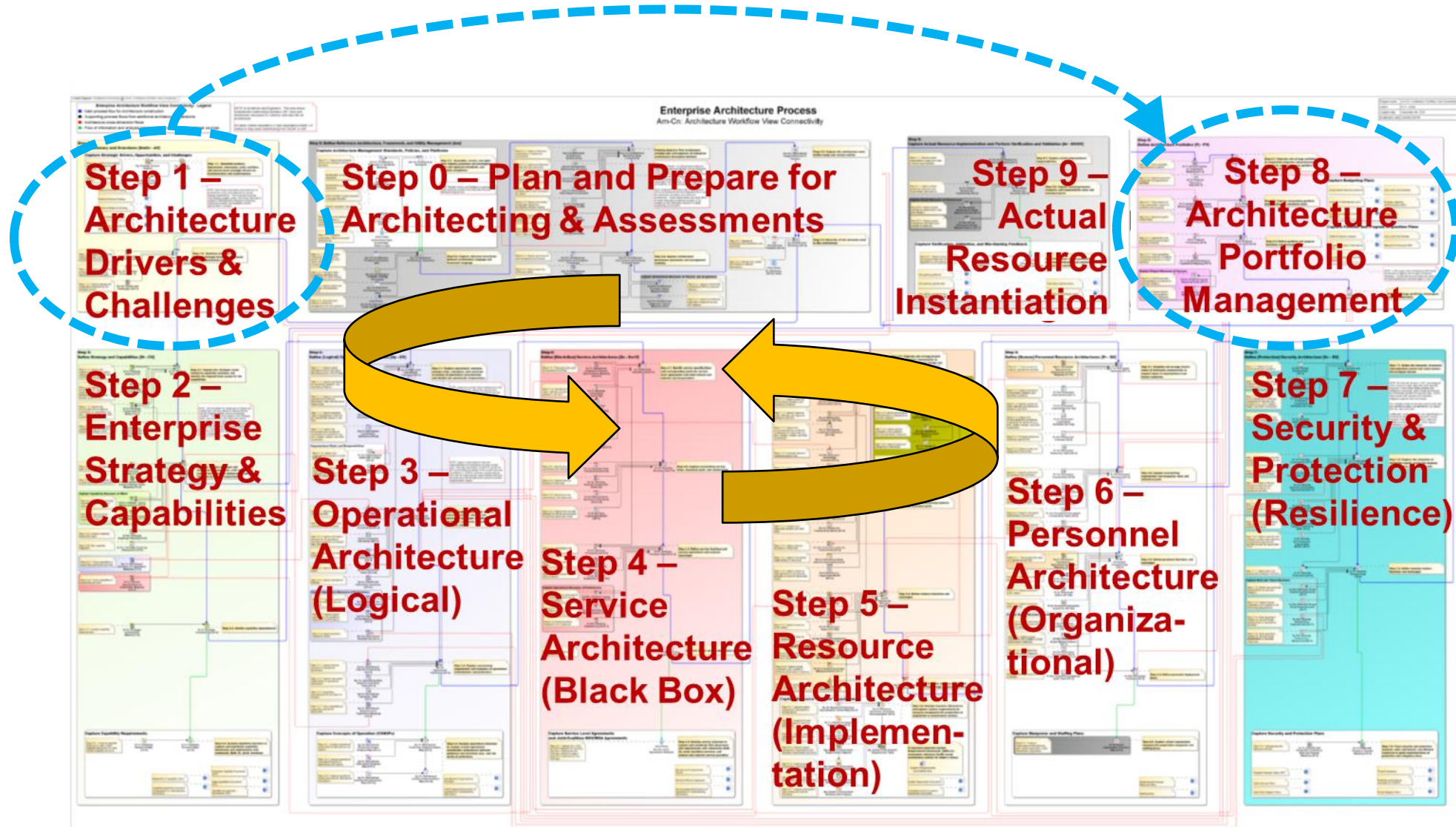
*Improves coordination and synchronization among the many players involved in Portfolio Management effort*





# Changing the Portfolio in Response to New Drivers & Challenges

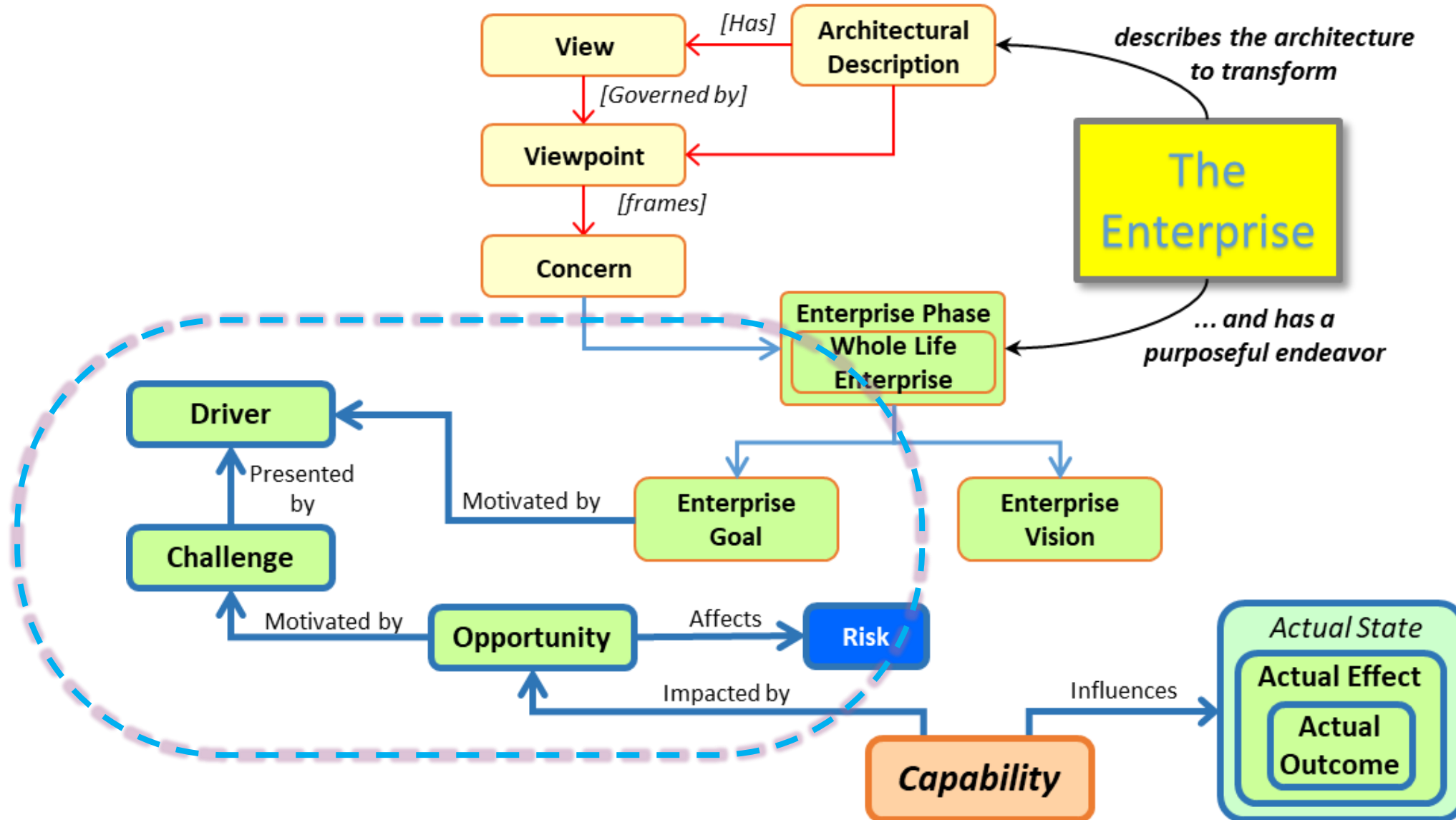
The Enterprise Architecture serves as the foundation for understanding impact of changes





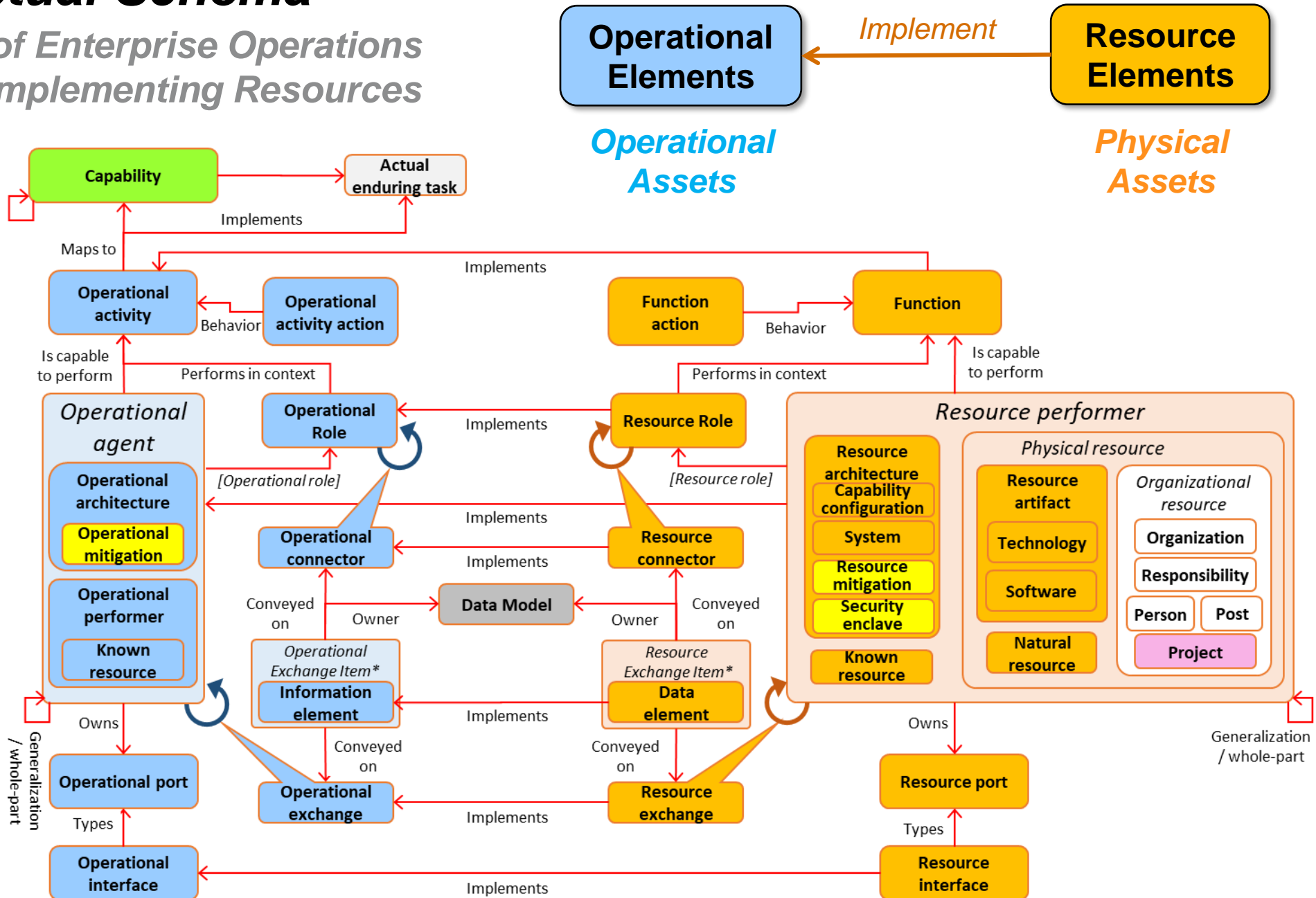
# What should motivate the Enterprise to change?

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



# Conceptual Schema

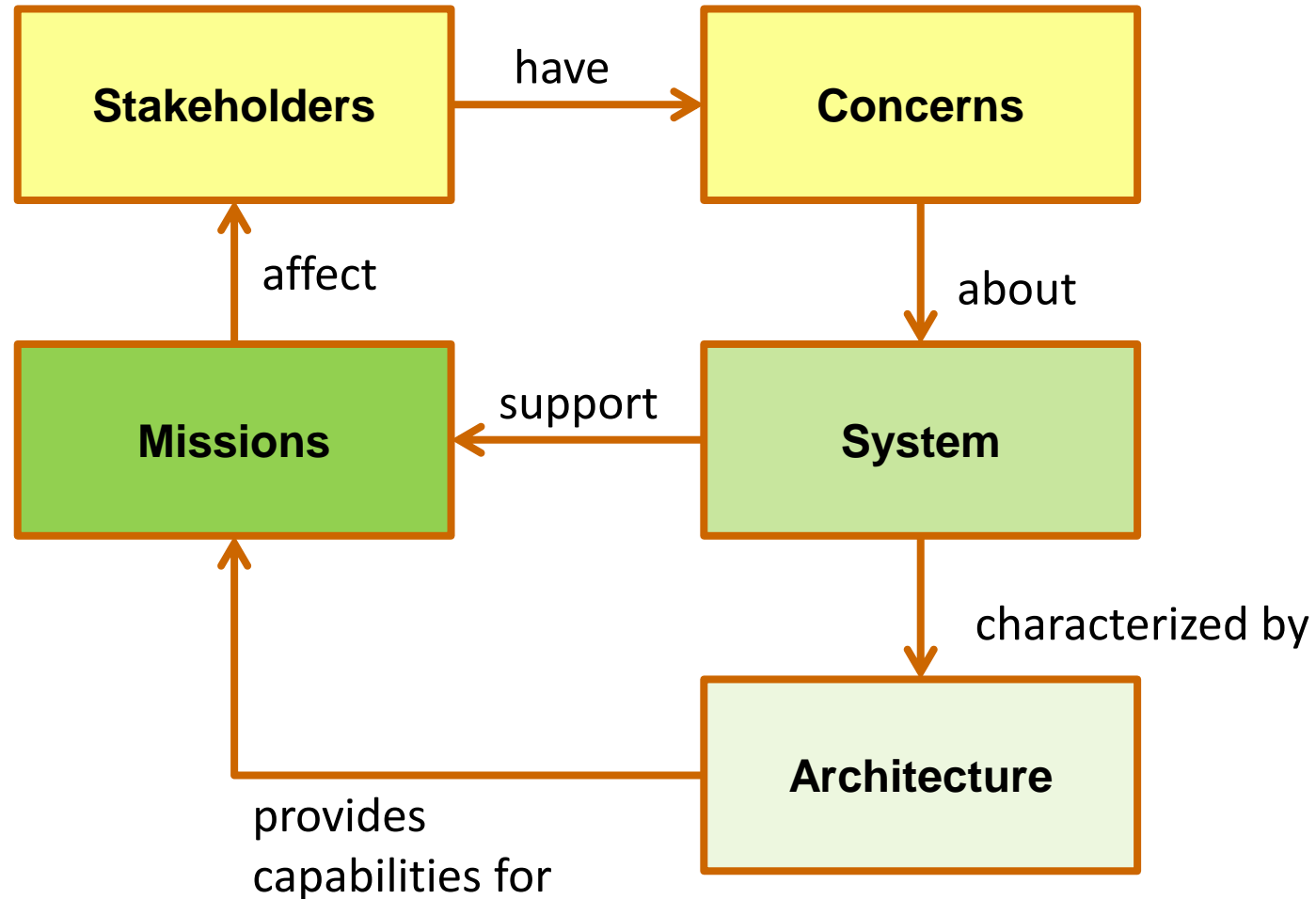
## Modeling of Enterprise Operations and their Implementing Resources



\* Can also be a Resource Performer, Signal or Geopolitical Extent

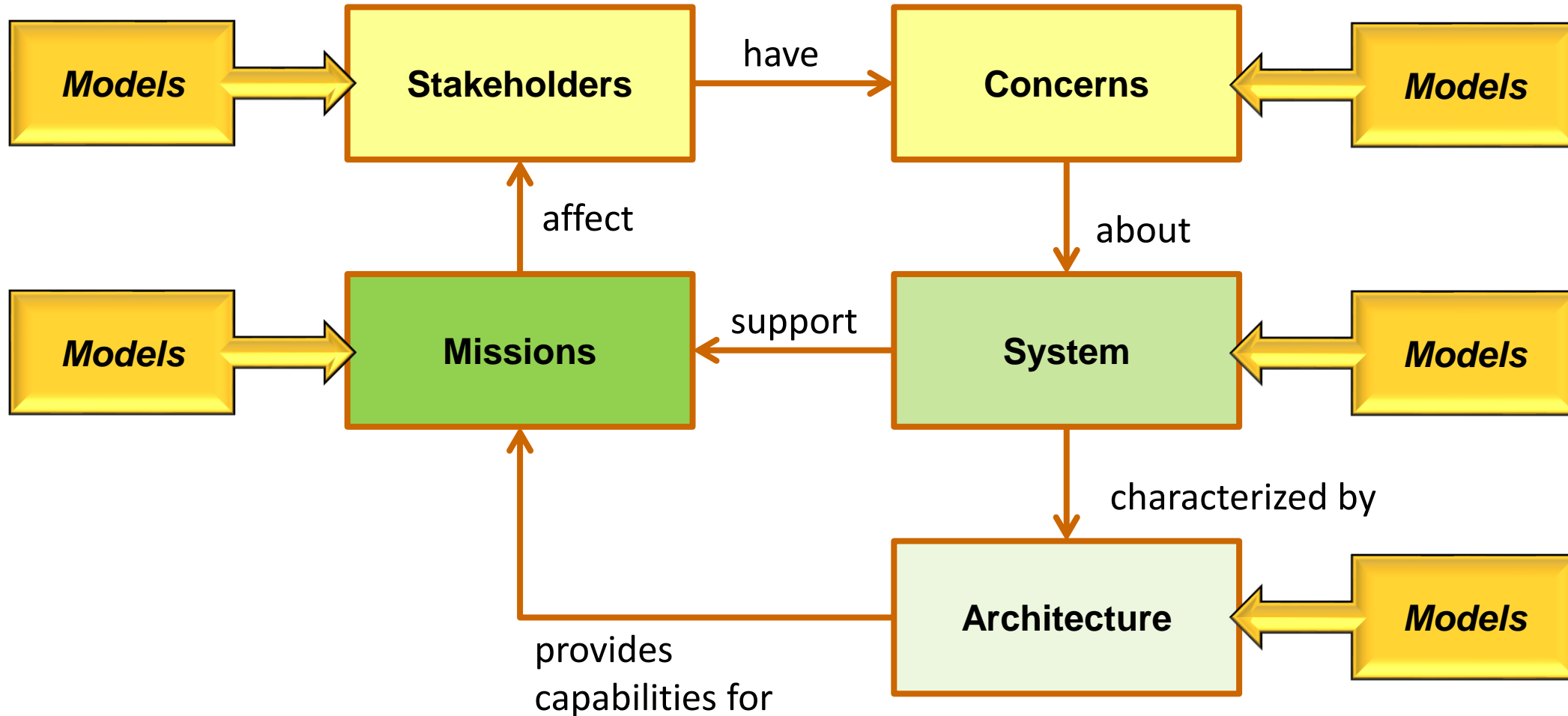


**Systems Engineering** defines an **Architecture** of the **System** that addresses **Stakeholder Concerns** regarding the relevant **Missions**





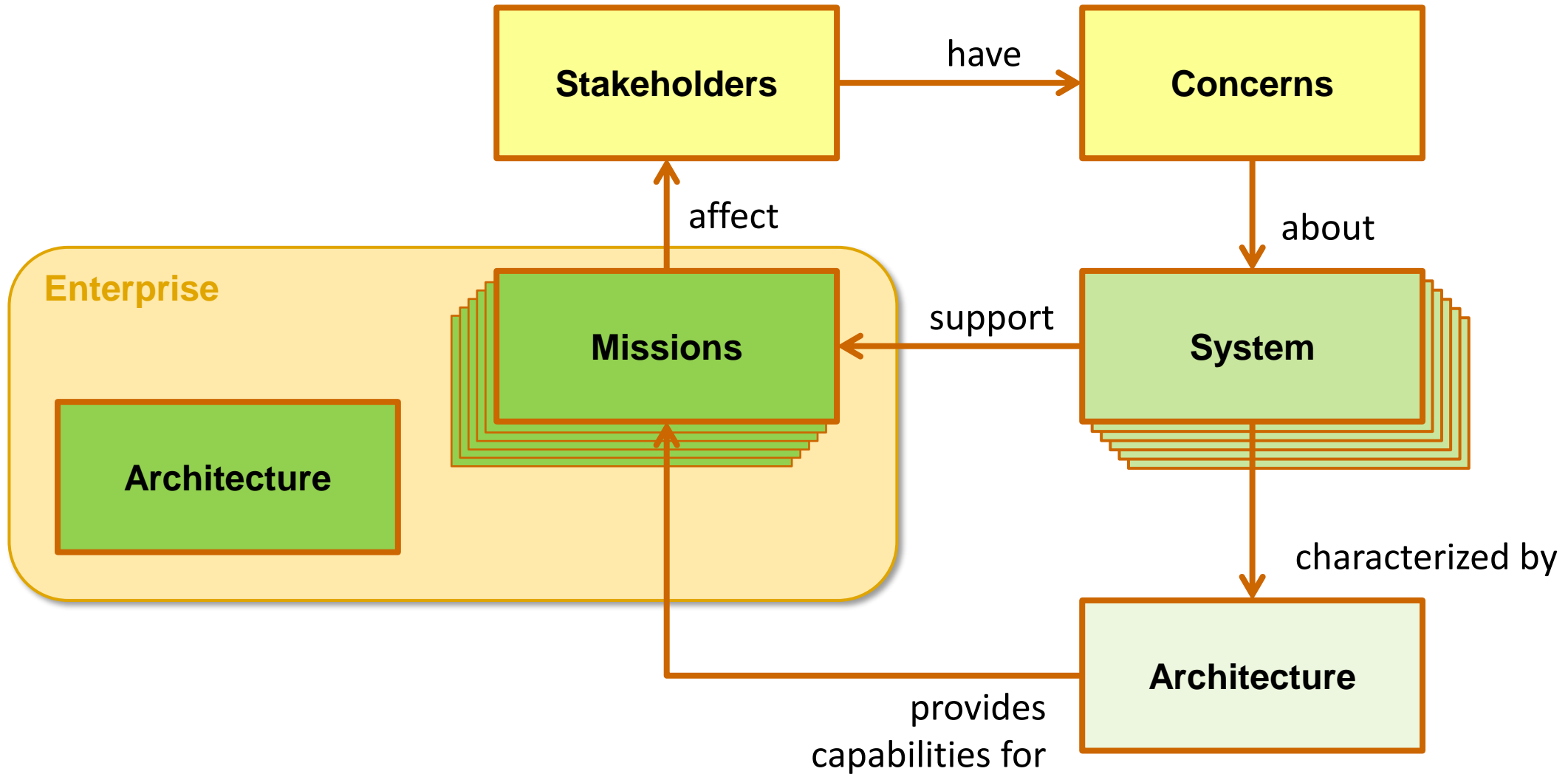
**Models** are created to represent the **System** and its **Architecture** & **Missions** along with relevant **Stakeholders** and their **Concerns**







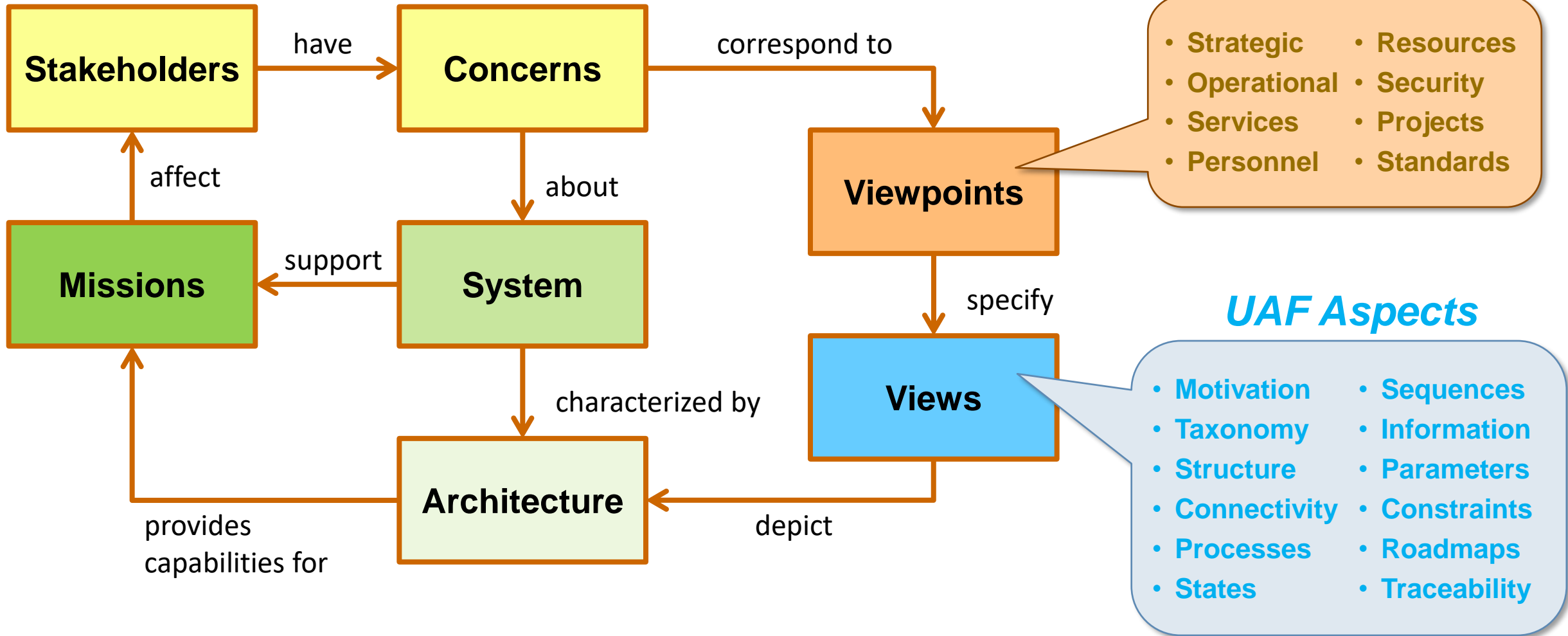
The **Enterprise Architecture** defines the various **Missions** along with associated **Mission Objectives** and **Strategic Capabilities**







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



# The Two-Dimensional UAF Grid

## Architecture Aspects

Stakeholder Viewpoints

UAF ORGANIZED ARCHITECTURE FRAMEWORK™	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 & Overview													
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 Sequences St-Sq	Strategic Information St-If	Strategic Parameters St-Pm	Strategic Constraints 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	Operational States Op-St	Operational Sequences Op-Sq	Operational Information Op-If	Environment En-Pm  and Measurements Me-Pm  and Risks Rk-Pm	Operational Constraints 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 Information Sv-If		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	Personnel Information Ps-If		Personnel Constraints Ps-Ct	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 Rs-If		Resources Constraints Rs-Ct	Resources Roadmaps: Evolution, Forecast Rs-Rm-E, -F	Resources Traceability Rs-Tr	
Security Sc	Security Constraints Sc-Mv	Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr	-	-	Security Information Sc-If	-	Security Constraints Sc-Ct	-	Security Traceability Sc-Tr	
Projects Pj	-	Projects Taxonomy Pj-Tx	Projects Structure Pj-Sr	Projects Connectivity Pj-Cn	Projects Processes Pj-Pr	-	-	Projects Information Pj-If	-	-	Projects Roadmap Pj-Rm	Projects Traceability Pj-Tr	
Standards Sd	-	Standards Taxonomy Sd-Tx	Standards Structure Sd-Sr	Standards Connectivity Sd-Cn	-	-	-	Standards Information Sd-If	-	-	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]**

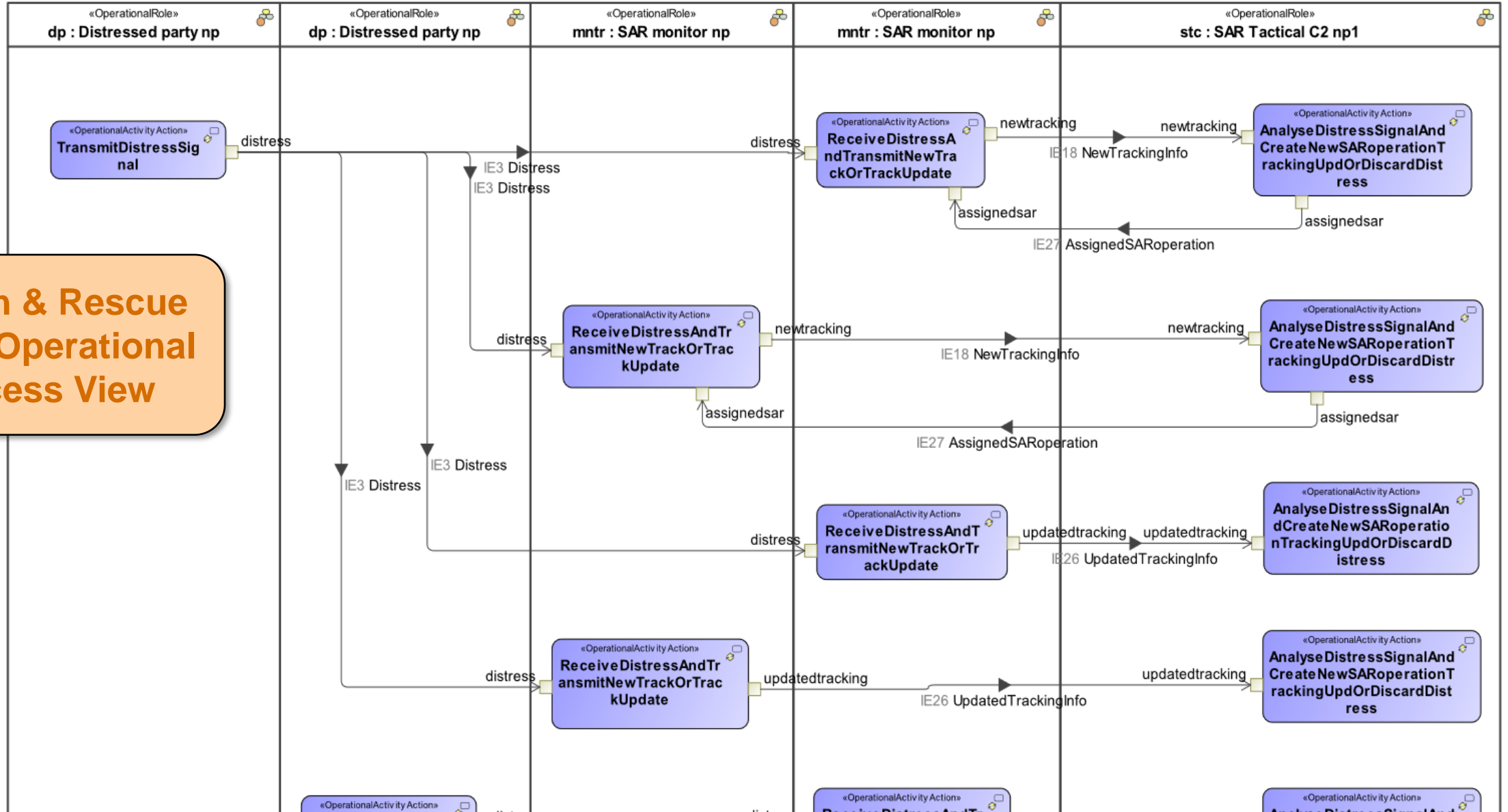
	2019												2020												
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
<b>Assistance</b>	█	█	█	█	█	█	█	█	█	█	█	█													
[no measurements]	<b>Rescue Ship</b> (SAR Project 1 Sustainment)																								
<b>Distress Signal Monitoring</b>	█	█	█	█	█	█	█	█	█	█	█	█													
[no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

**Search & Rescue (SAR)  
Enterprise Architecture**

*(from the UAF Sample Model)*

# Operational Viewpoint Helps Identify Operational Impacts

Operational Process Flow [ Distress signal valid and invalid handling ]



**Search & Rescue (SAR) Operational Process View**

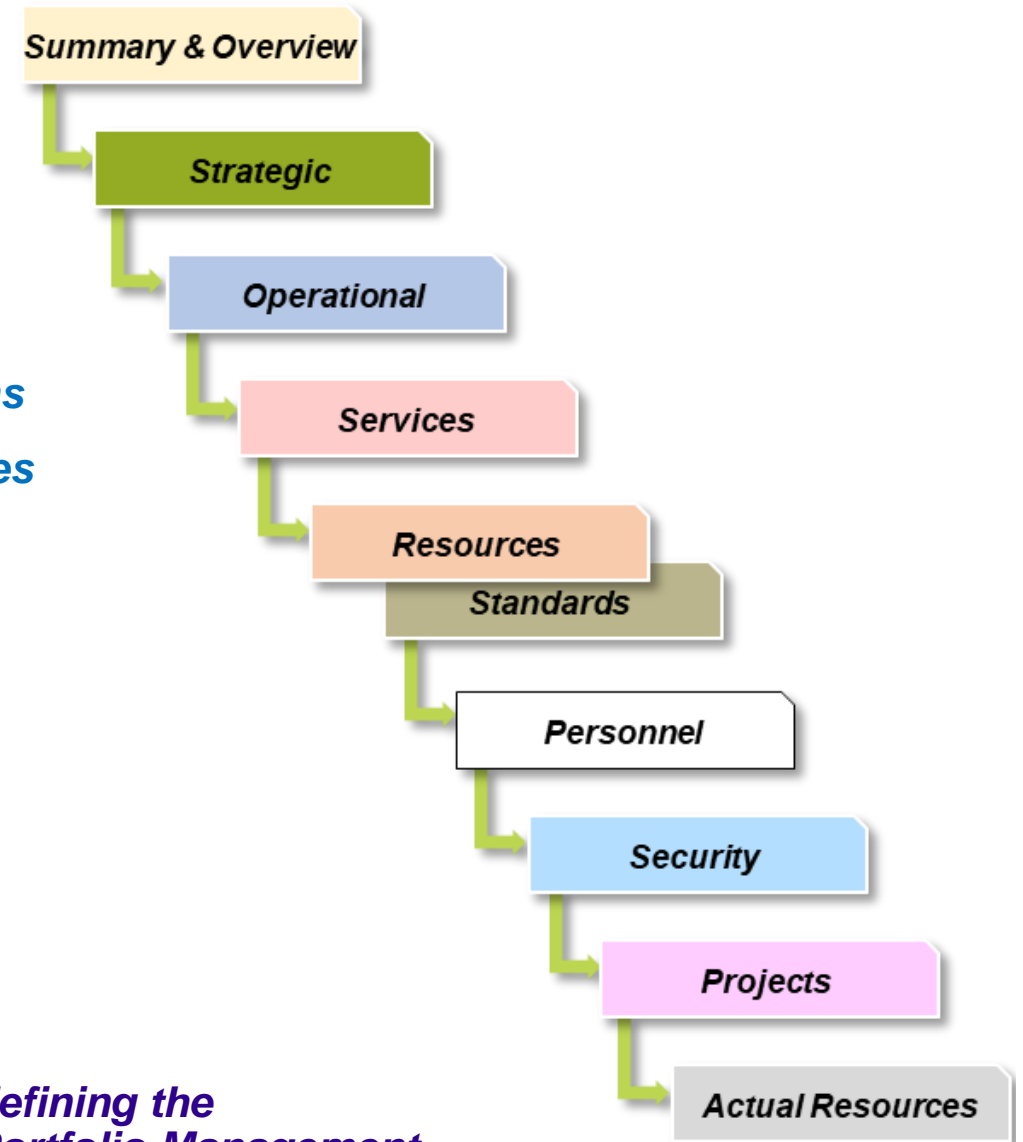


# Progression from Architecture Drivers to Implementation and Deployment of Capabilities

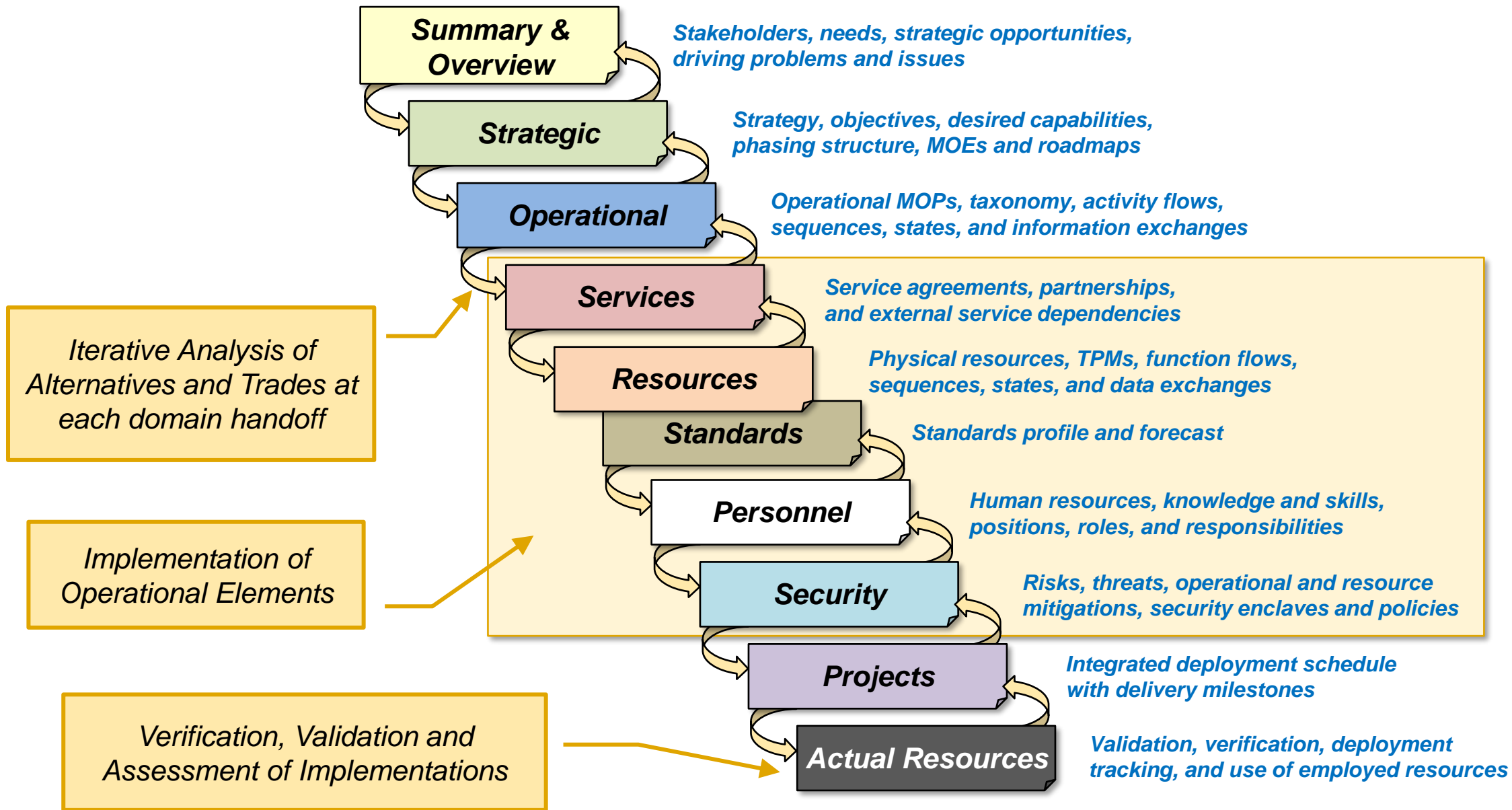
The UAF modeling viewpoints facilitate a logical and systematic flow of architecting activities

- 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***





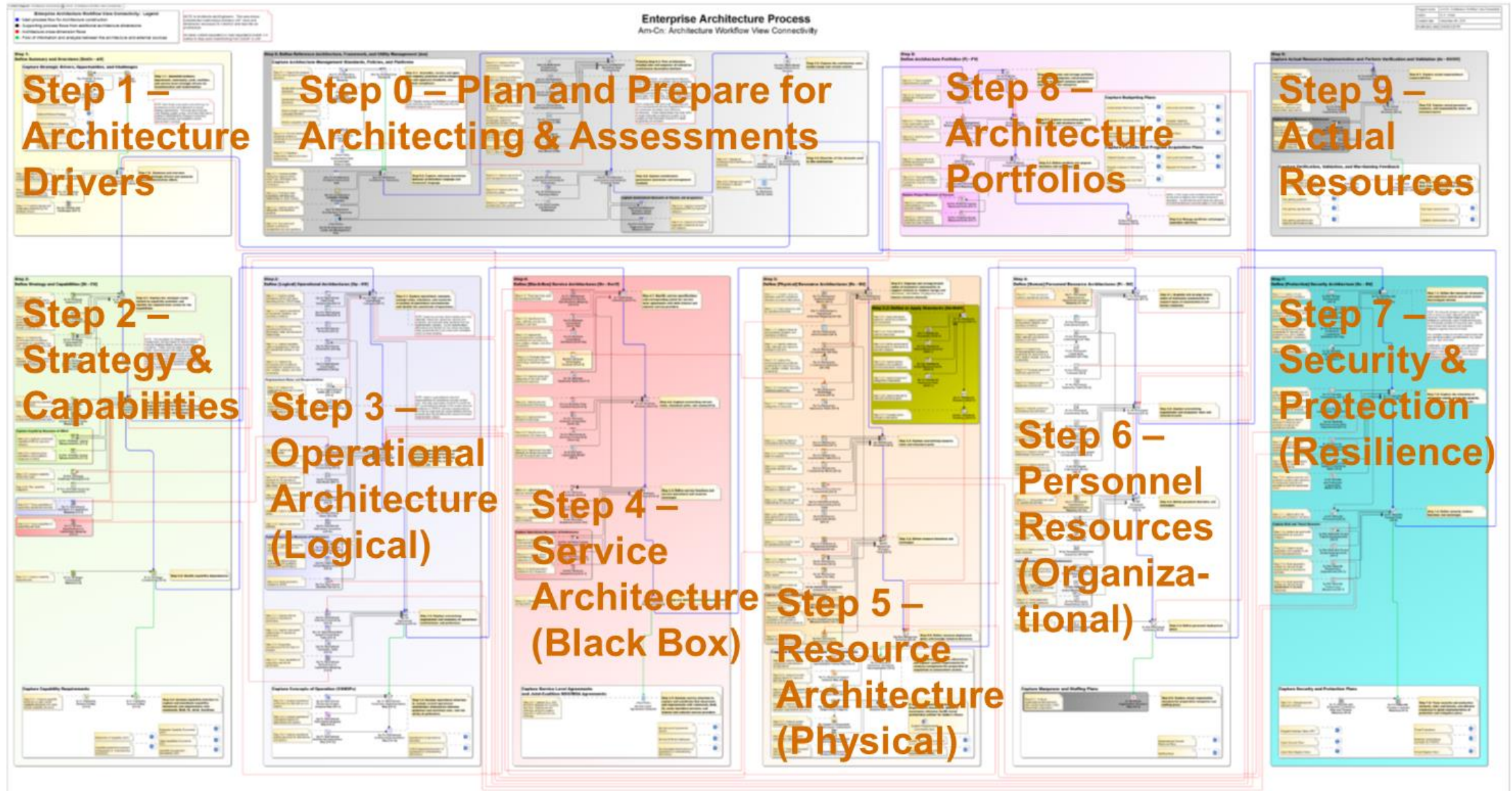




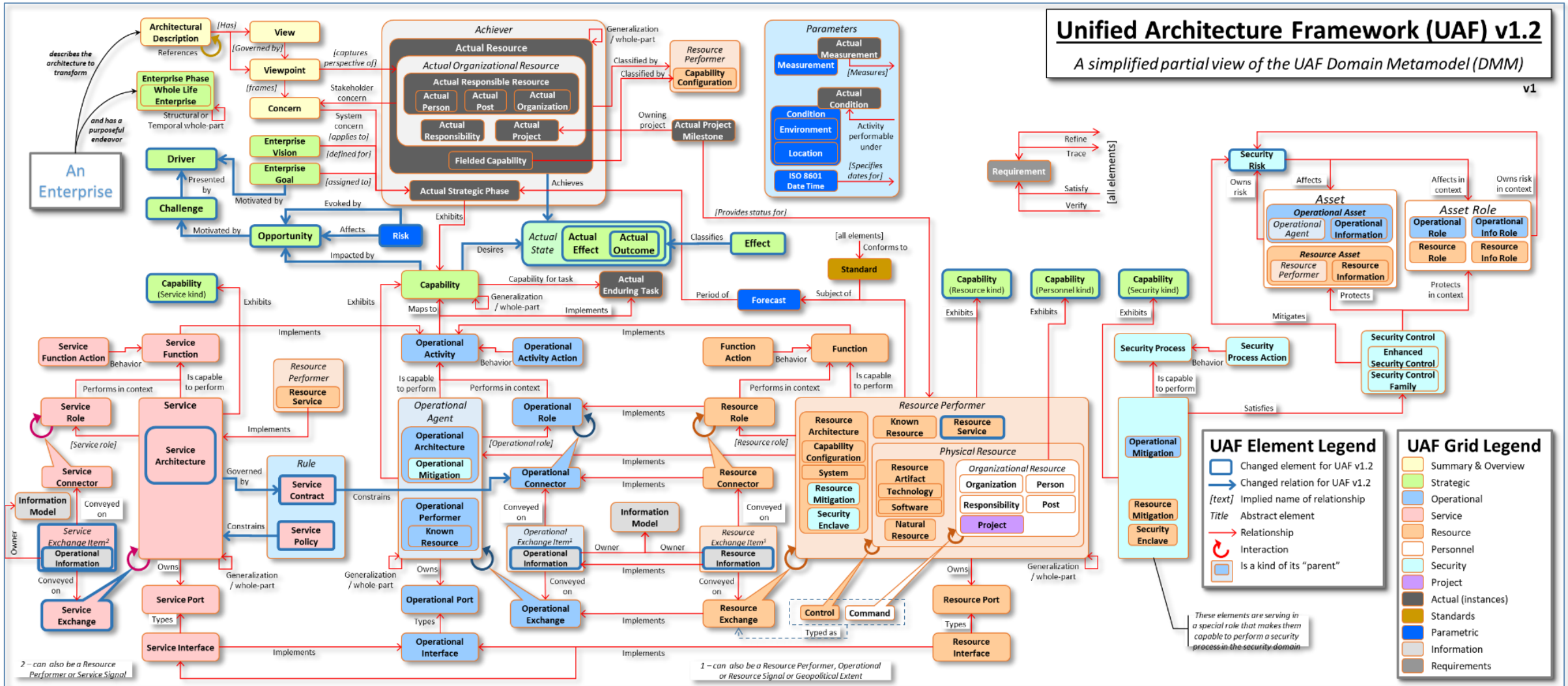


# Enterprise Architecture Guide for UAF

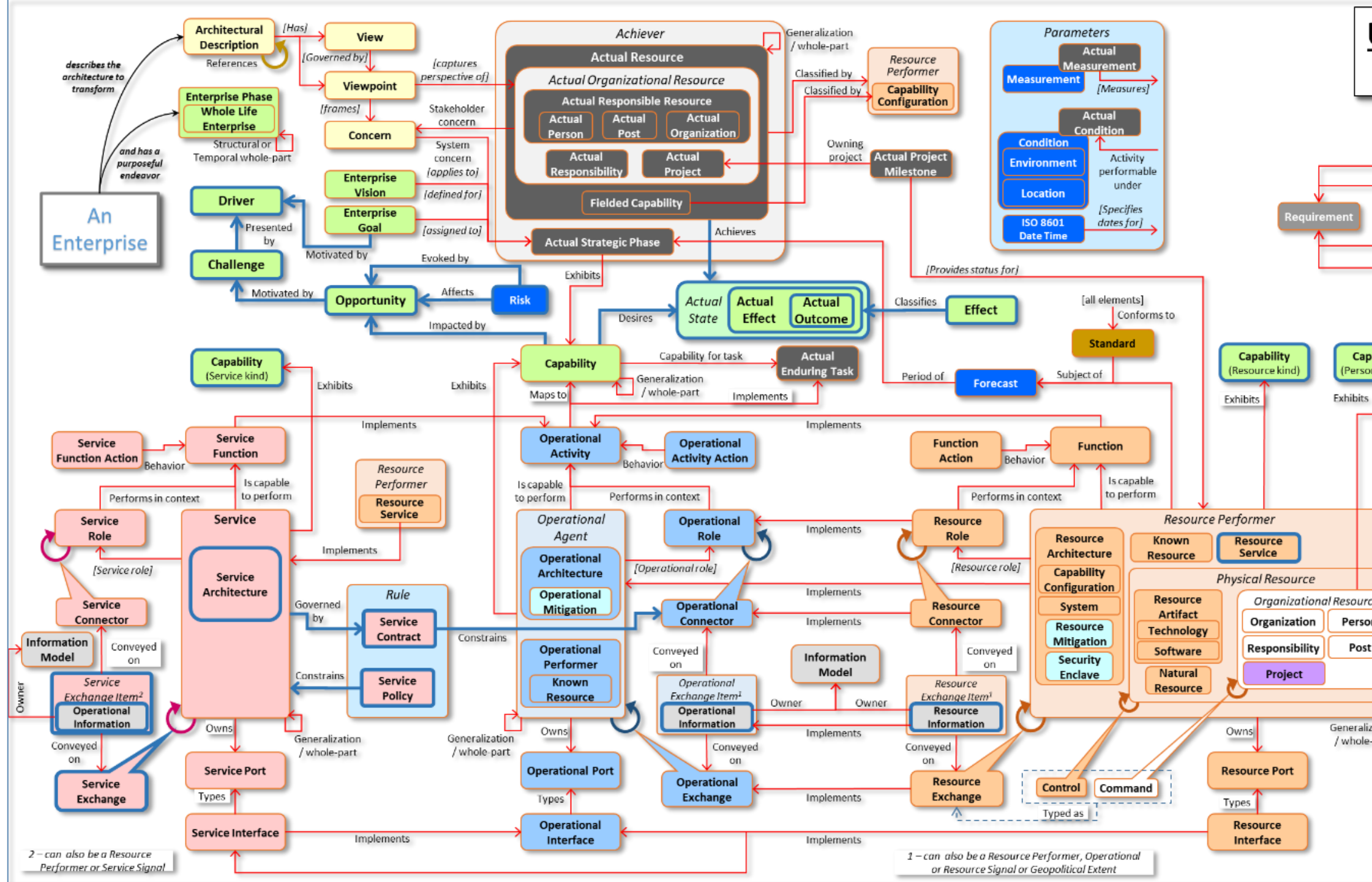
Standardizing the Modeling Workflow



# Enterprise Modeling Ontology



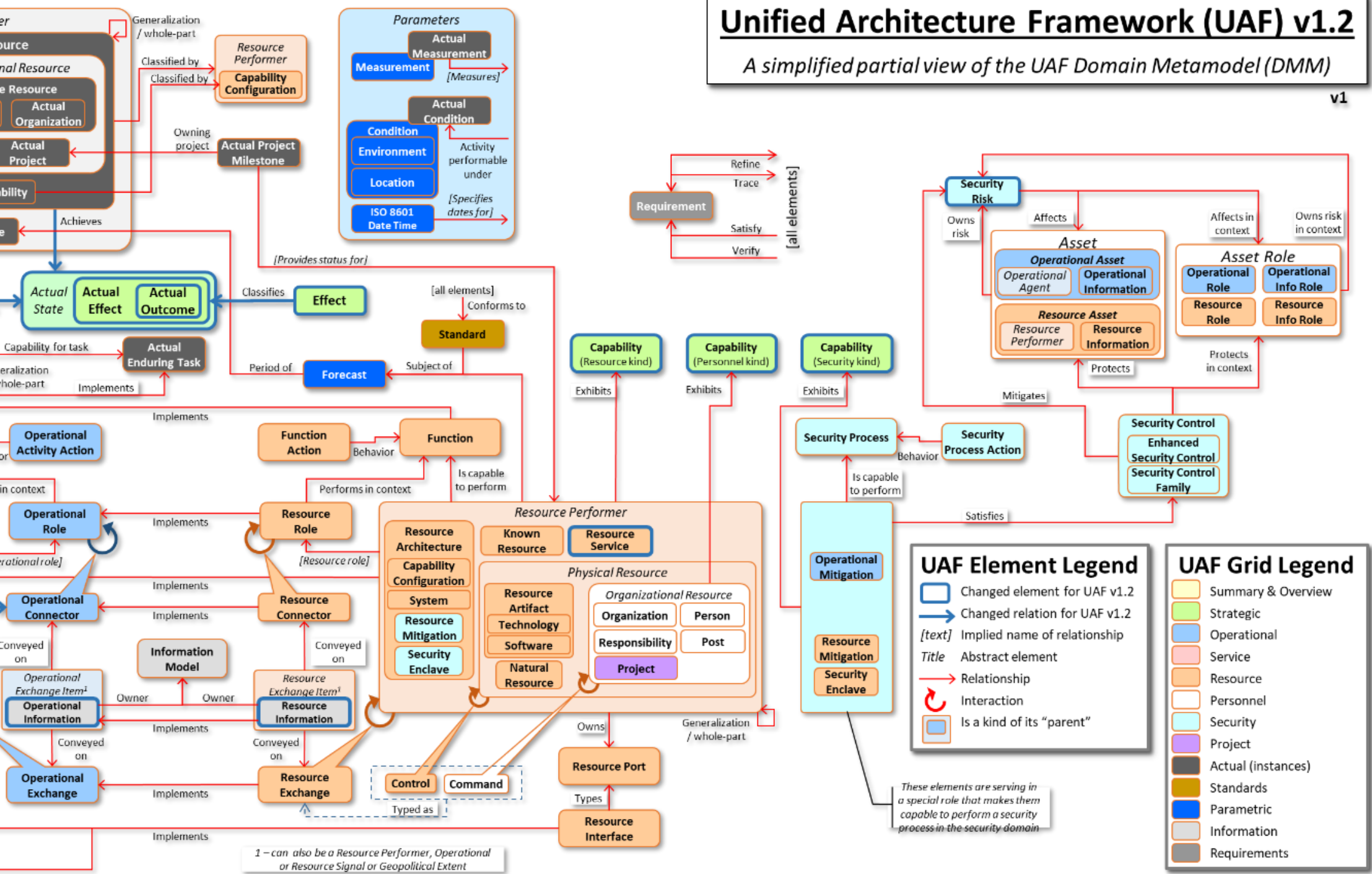




# Unified Architecture Framework (UAF) v1.2

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

v1



### UAF Element Legend

- Changed element for UAF v1.2
- Changed relation for UAF v1.2
- [text]* Implied name of relationship
- Title** Abstract element
- Relationship
- ↻ Interaction
- Is a kind of its "parent"

### UAF Grid Legend

- Summary & Overview
- Strategic
- Operational
- Service
- Resource
- Personnel
- Security
- Project
- Actual (instances)
- Standards
- Parametric
- Information
- Requirements

These elements are serving in a special role that makes them capable to perform a security process in the security domain

1 - can also be a Resource Performer, Operational or Resource Signal or Geopolitical Extent