INCOSE International Symposium
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Architecting in the Fourth Dimension Temporal Aspects of DoDAF 2.0

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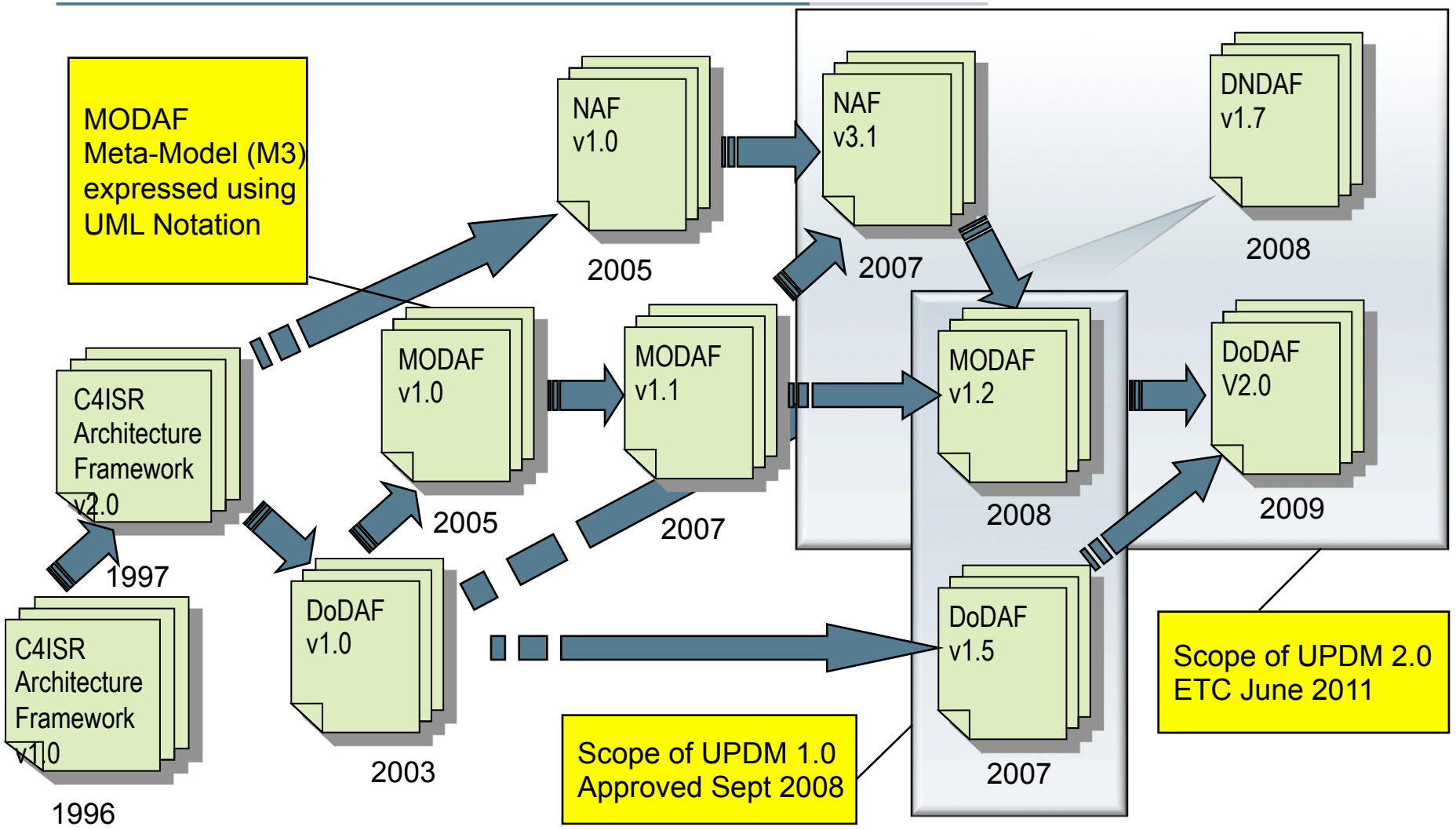
“Time is what keeps everything from happening at once”

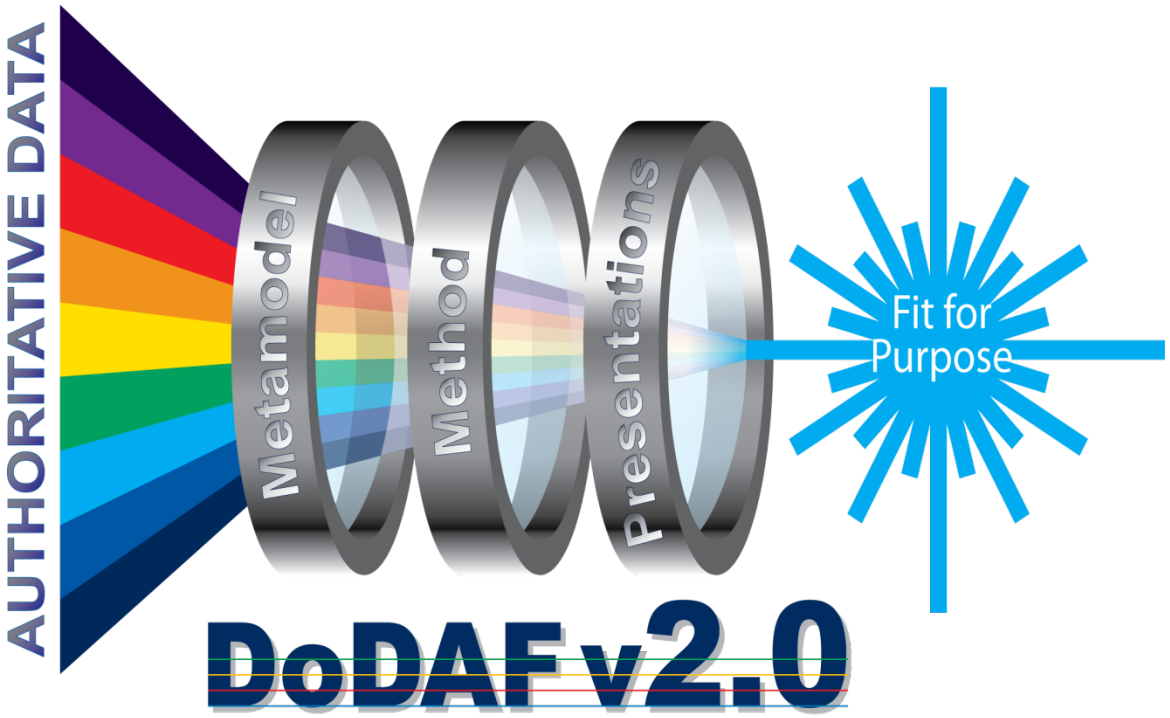
Raymond King Cummings, The Girl in the Golden Atom

Agenda

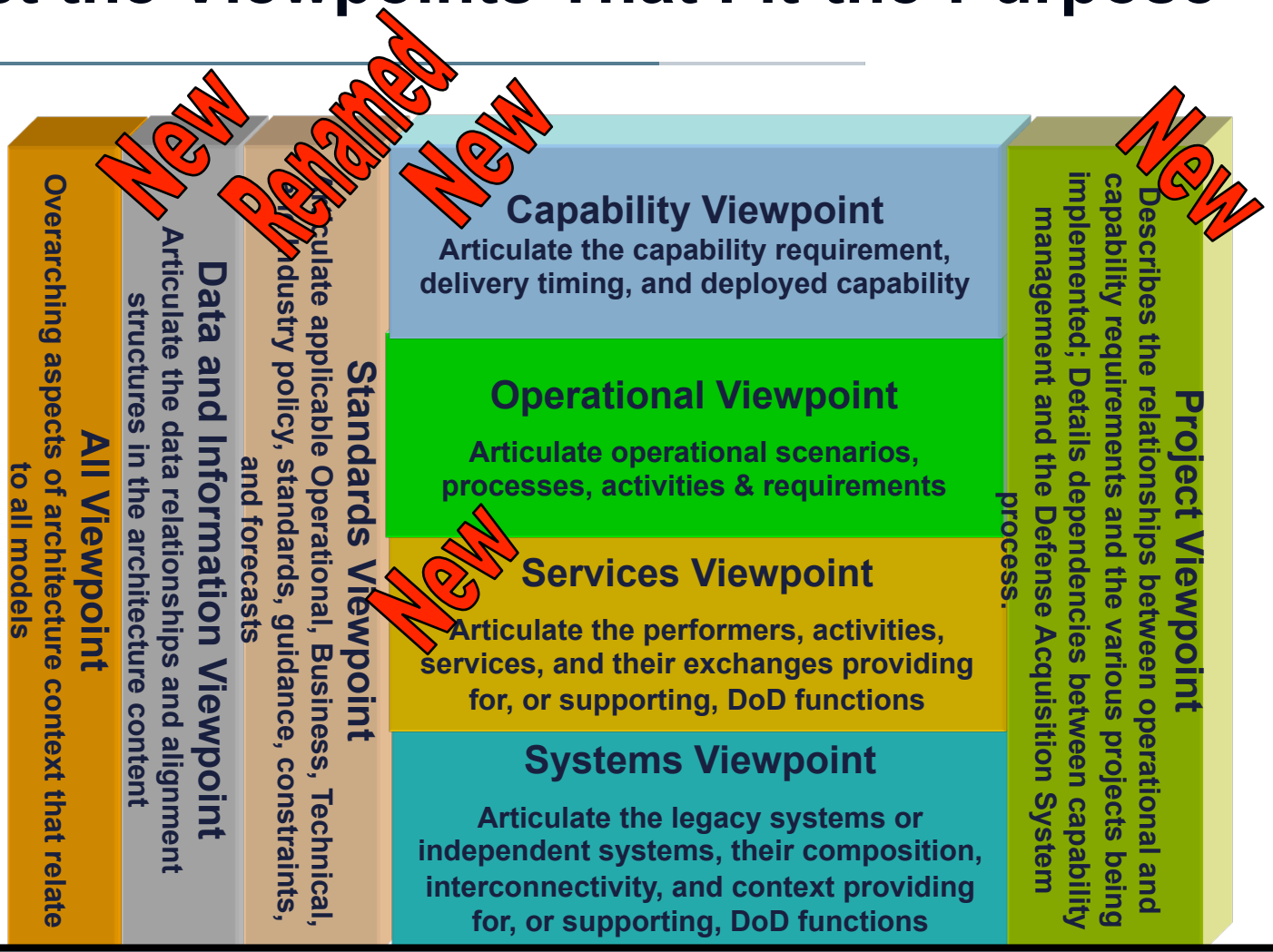
- DoDAF Background
- Ontologies
- The IDEAS Foundation
- Time and Architecture
- Examples
- Conclusion

Historical Development of AF's.





Select the Viewpoints That Fit-the-Purpose



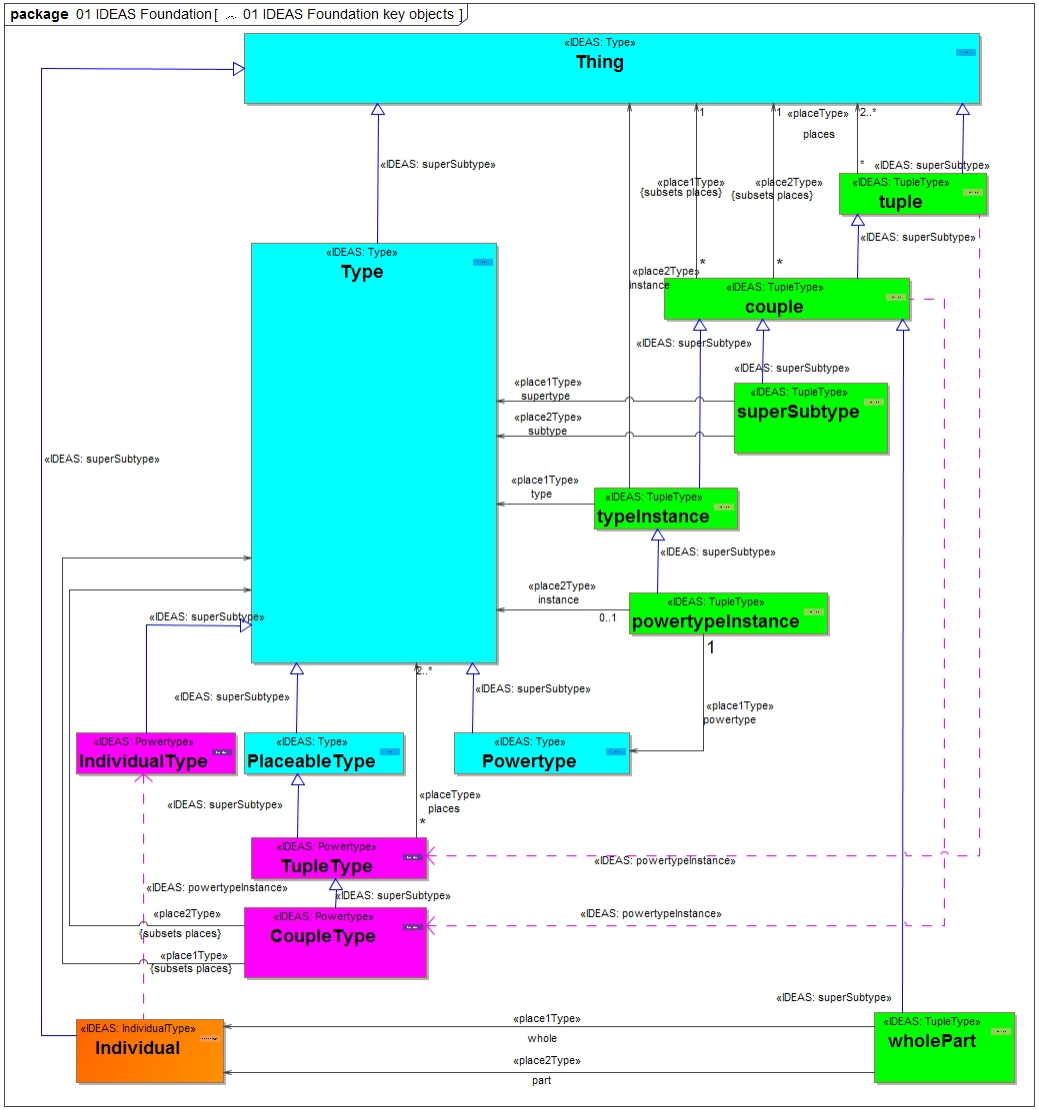
Architecture viewpoints are composed of data that has been organized to facilitate understanding.

Time is of the essence

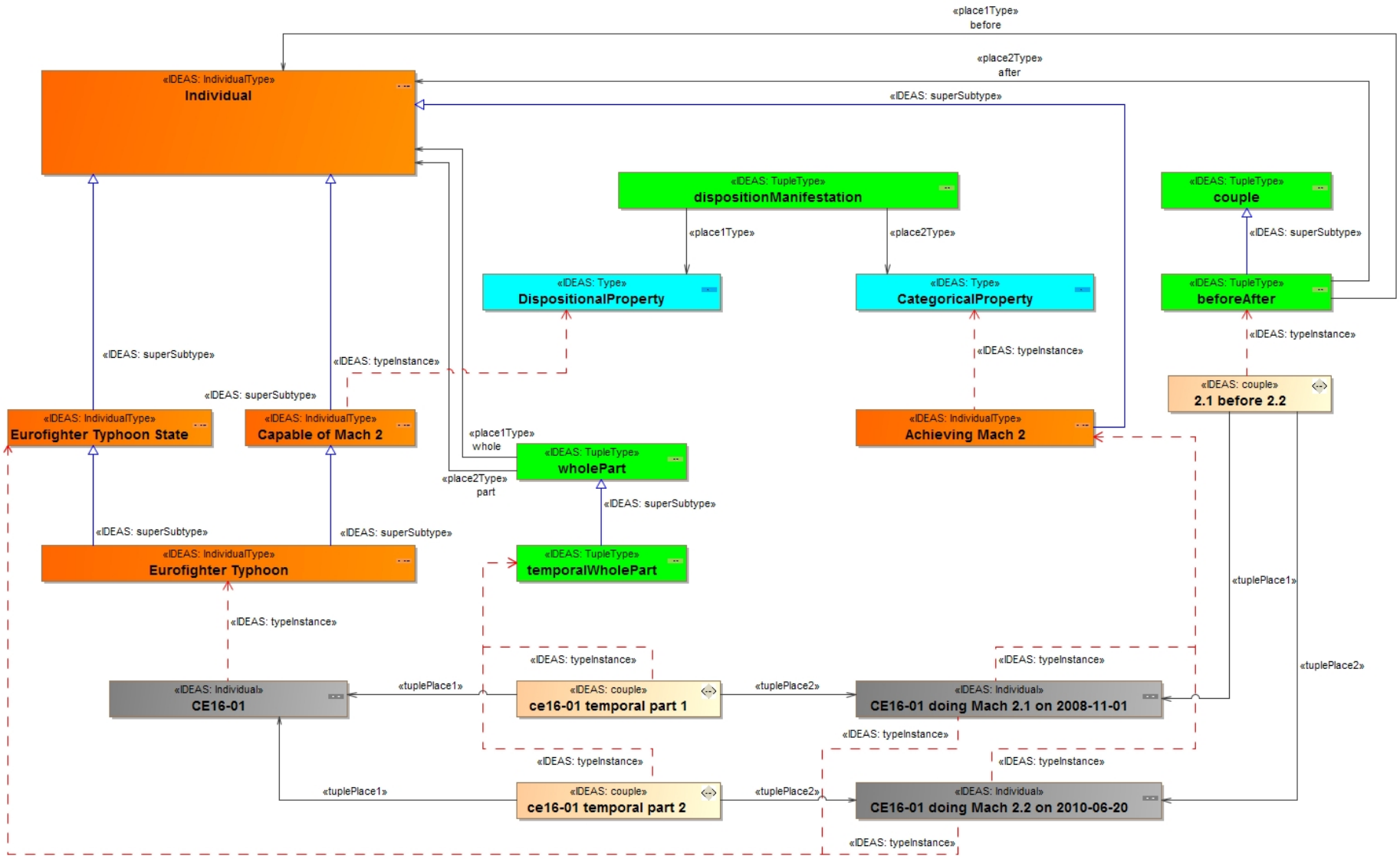
- Previously, modeling time DoDAF was less explicitly specified.
- DoDAF 2.0 provides time-based concepts in many ways
  - BeforeAfter (IDEAS foundation element)
  - BeforeAfterType (IDEAS foundation element)
  - Desired Effect (DM2 element)
  - TemporalWholePart (IDEAS foundation element)
  - TemporalWholePartType (IDEAS foundation element)
  - Work Streams
  - Project activity sequence
  - State modeling
  - Etc.

IDEAS - Top-Level Foundation

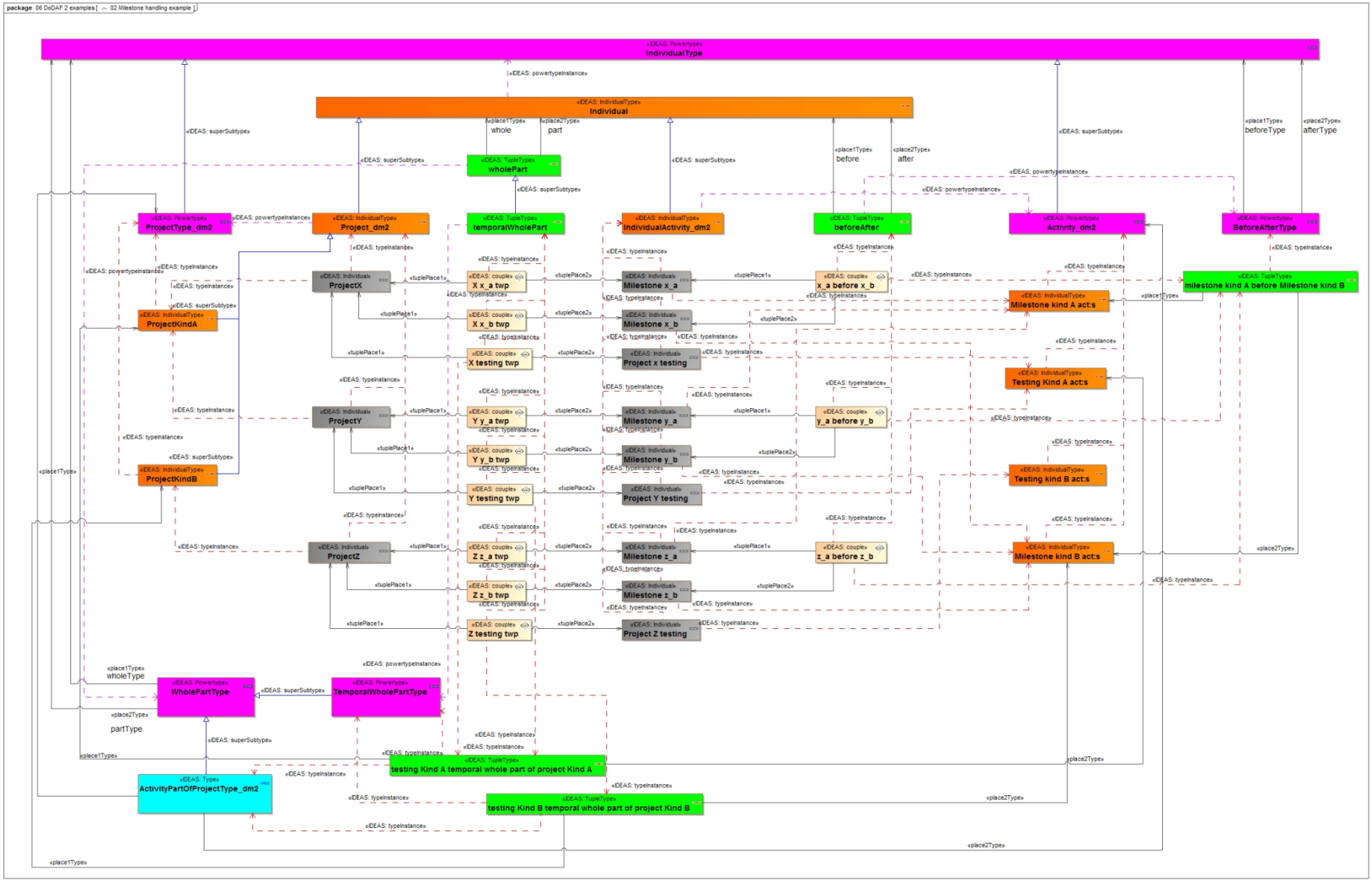
- Developed by an international group of computer scientists, engineers, mathemat hip.
- See http:// ki/IDEAS_Group
- IDEAS Fo ublished as domain sp stereotypes used is ve
- All elemer ances are members
- The mode es used are also elements etc.).
- Relationsh ents.
- The name escribes instances ontains all Things as



Some examples: whole-part and temporalWholePart



Temporal handling of Projects and Milestones



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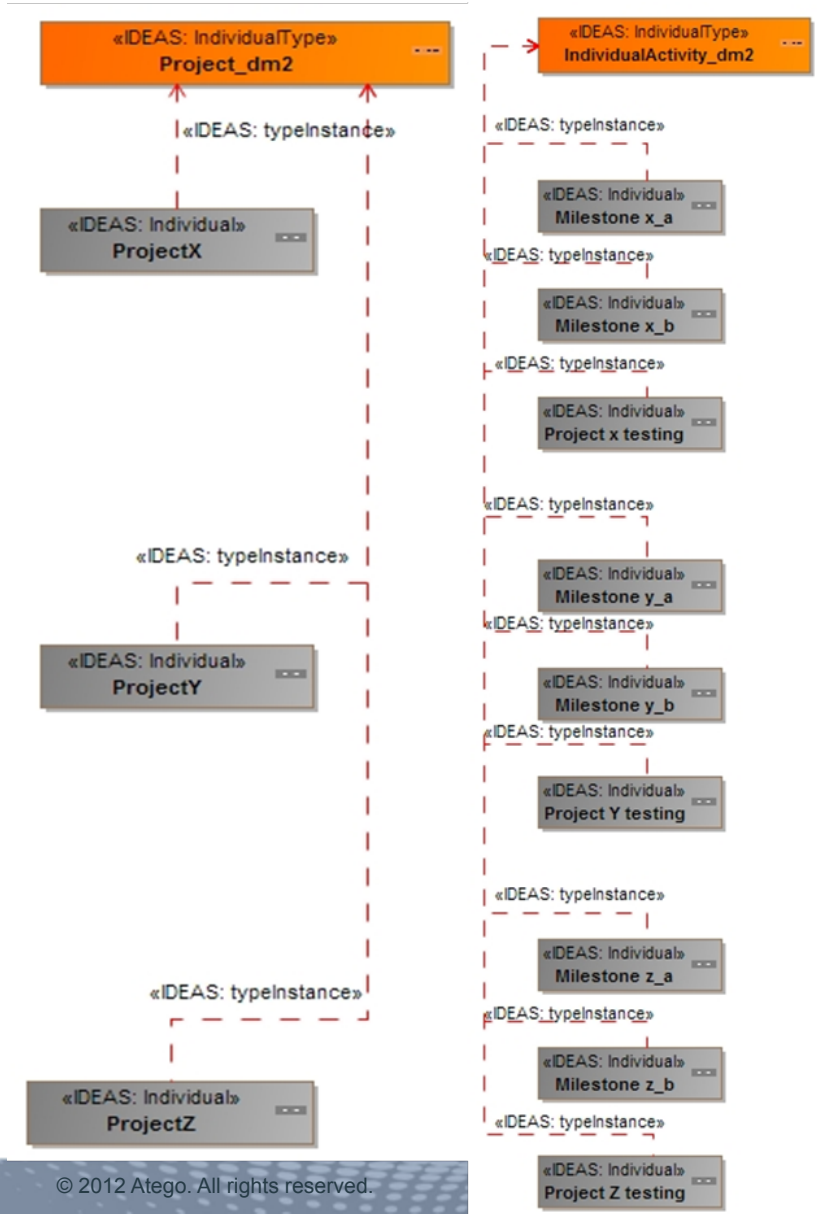
What!!

- The last slide seems totally unreadable.
- It is actually a very good example of a DoDAF 2 PV-2 view, i.e. a view that describes temporal relationships between projects and their parts.
- The view shows only a portion of elements that are instances of the 154 element types that are actually allowed in DoDAF 2 for a PV-2 view but what is does show is actually fairly understandable if looked at in detail.

Projects and activities



- A set of Individual projects are contained in the example model and a set of example activities.
- Since milestones are not a part of the DoDAF vocabulary activities have been chosen instead and there are a few different individual milestones as well as a completely different type of activity (testing) associated with each individual project.

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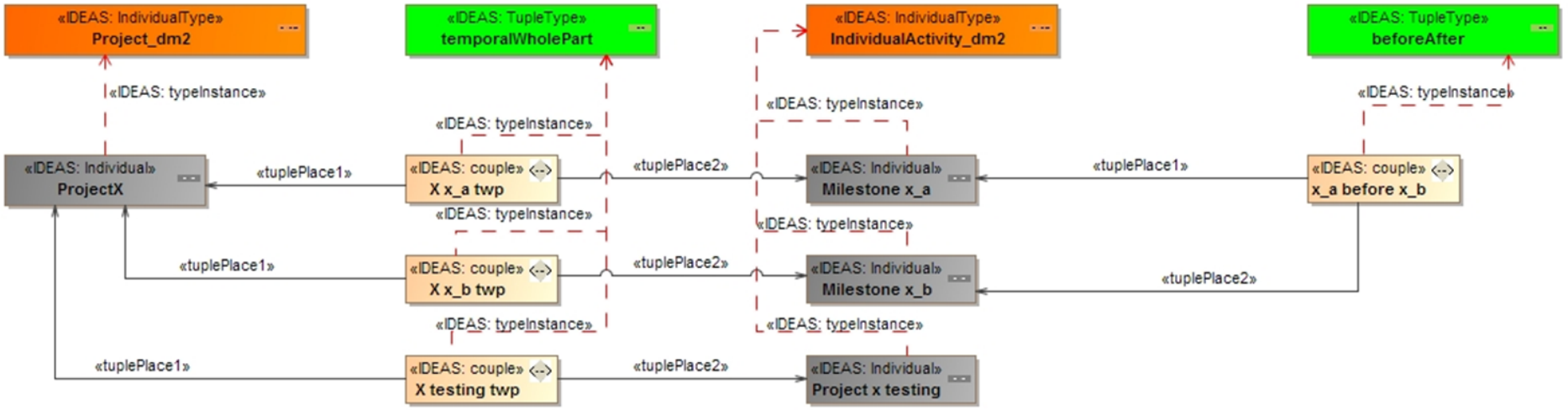
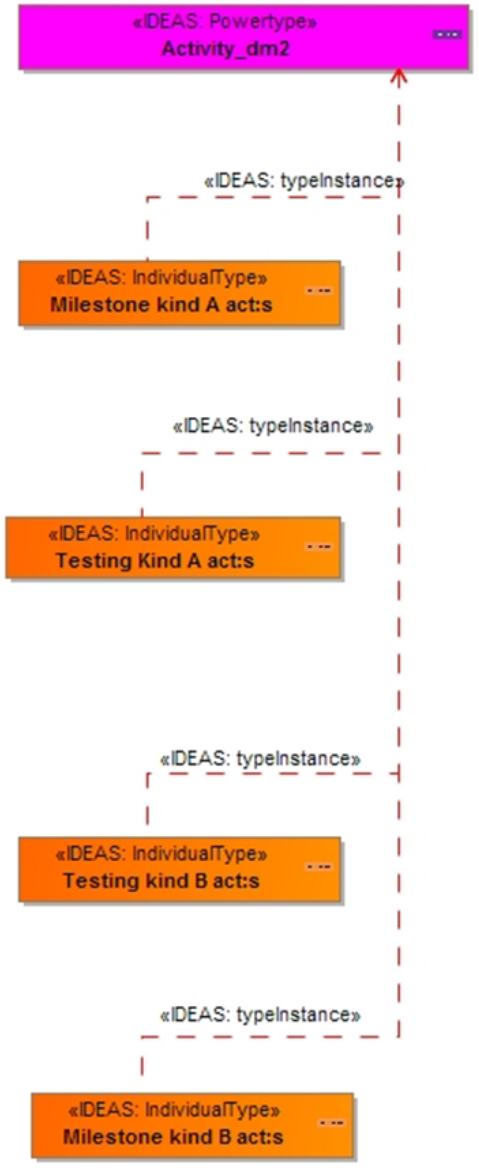
Temporal parts and before after



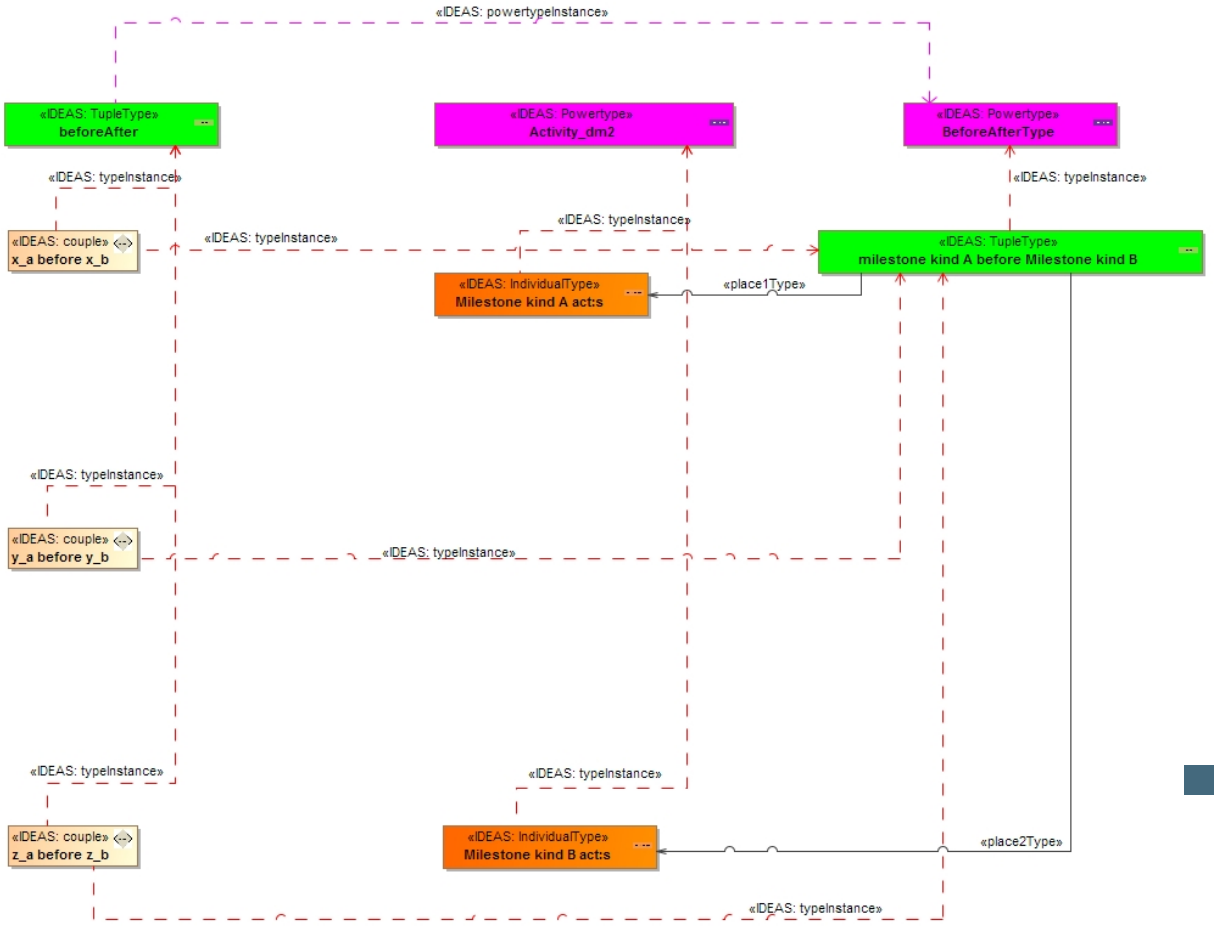
- The above shows project X with three different individual activities. Two of these are milestones and one is a testing activity.
- All three activities are temporal parts of the X project and before after is used to indicate that milestone a is before milestone b, note that there is no indication of the time interval in between.

Activity handling



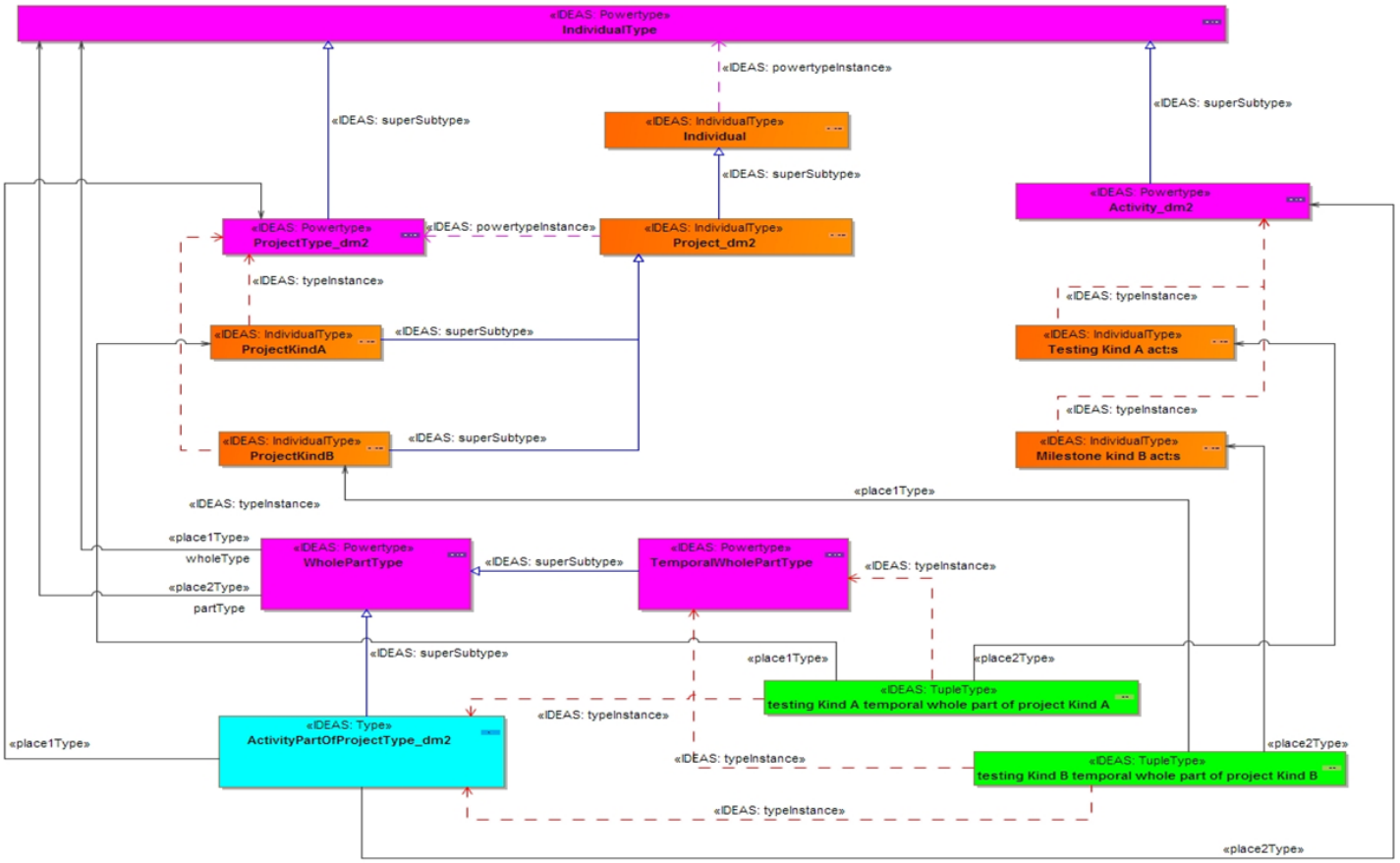
- Activity in DoDAF 2 is the set of all subsets of the set of all individual activities and therefore the four sets defined here are instances of the Activity subset.
- Testing Kind A activities contain: Project x testing and Project y testing.
- Testing Kind B activities contain: Project z testing
- Milestone Kind A activities contain: Milestone x_a, Milestone y_a and Milestone z_a
- Milestone Kind B activities contain: Milestone x_b, Milestone y_b and Milestone z_b

BeforeAfterType



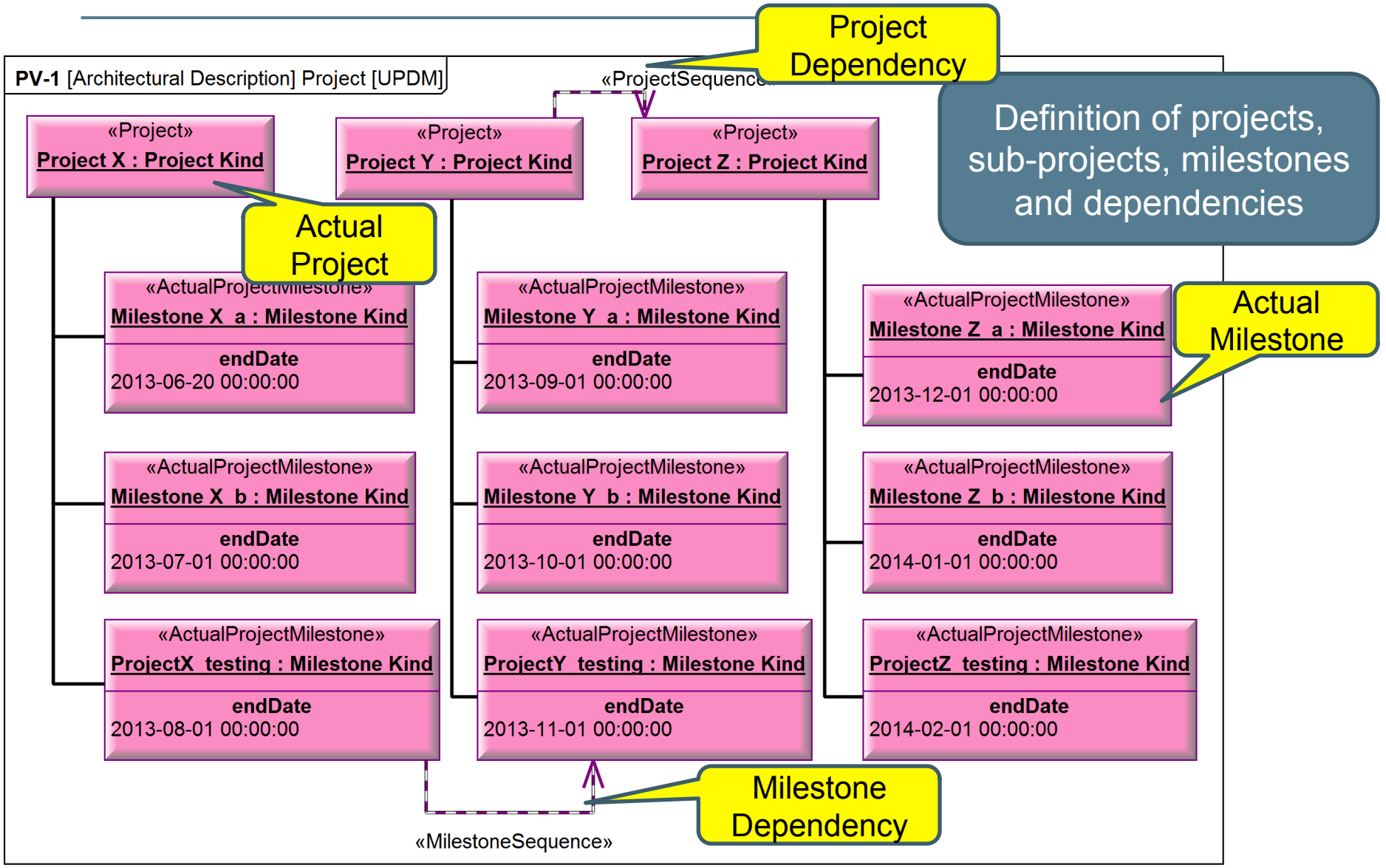
- Since all instances within Milestone Kind A activities occur (i.e. end) before all instances within Milestone Kind B activities an instance of BeforeAfterType can be created in the form of the element *milestone Kind A before Milestone Kind B.*
- This element contains all of the before after relationships defined in the example.

TemporalWholePartType



- As was shown previously, the testing activities can be combined into two distinct subsets that are instances of Activity (since it contains all possible subsets).
- This also means that instances of TemporalWholePartType can be created that contain the relationships that deal with temporal whole parts for testing Kind A and testing kind B.
- These in turn are instances of the DM2 element activityPartOfProjectType.

The Project View in UPDM: 3 Projects, 3 Milestones



The Unified Profile for DoDAF and MODAF (UPDM)

- UPDM is a standardized way of expressing DoDAF and MODAF artefacts using UML and SysML
  - UPDM is *NOT* a new Architectural Framework
  - UPDM is not a methodology or a process
  - UPDM implements DoDAF 2.0, MODAF & NAF
- UPDM was developed by members of the OMG with help from industry and government domain experts.
- UPDM is a DoD mandated standard and has been implemented by multiple tool vendors.

Time and Architecture

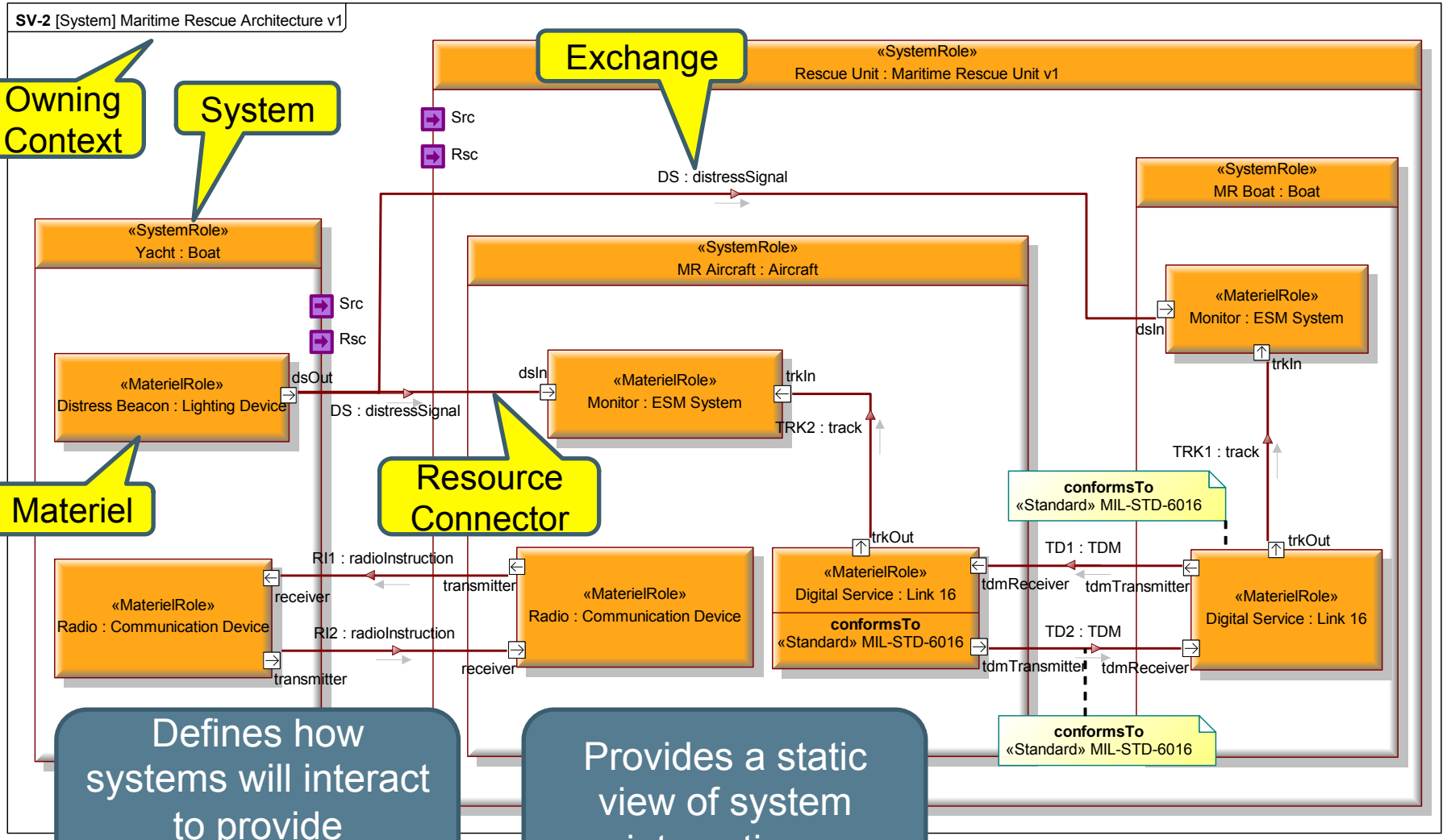
Time in DoDAF

- Sequence of events
- System changes over time
- Use of a system changing over time
- Different systems supporting a capability over time
- A system supporting different capabilities at different phases of its lifecycle
- System states showing time dependent behavior
- Time dependent activity sequences
- Modeling processing time, latency, transport time etc.
- Scheduling deployment of systems over time
- Personnel deployment and competency assessment
- Data Lifecycles
- Integrating system acquisition cost, deployment cost etc. to show total cost of ownership.
- Modeling product variants
- Showing cost vs. time vs. capability
- Etc.

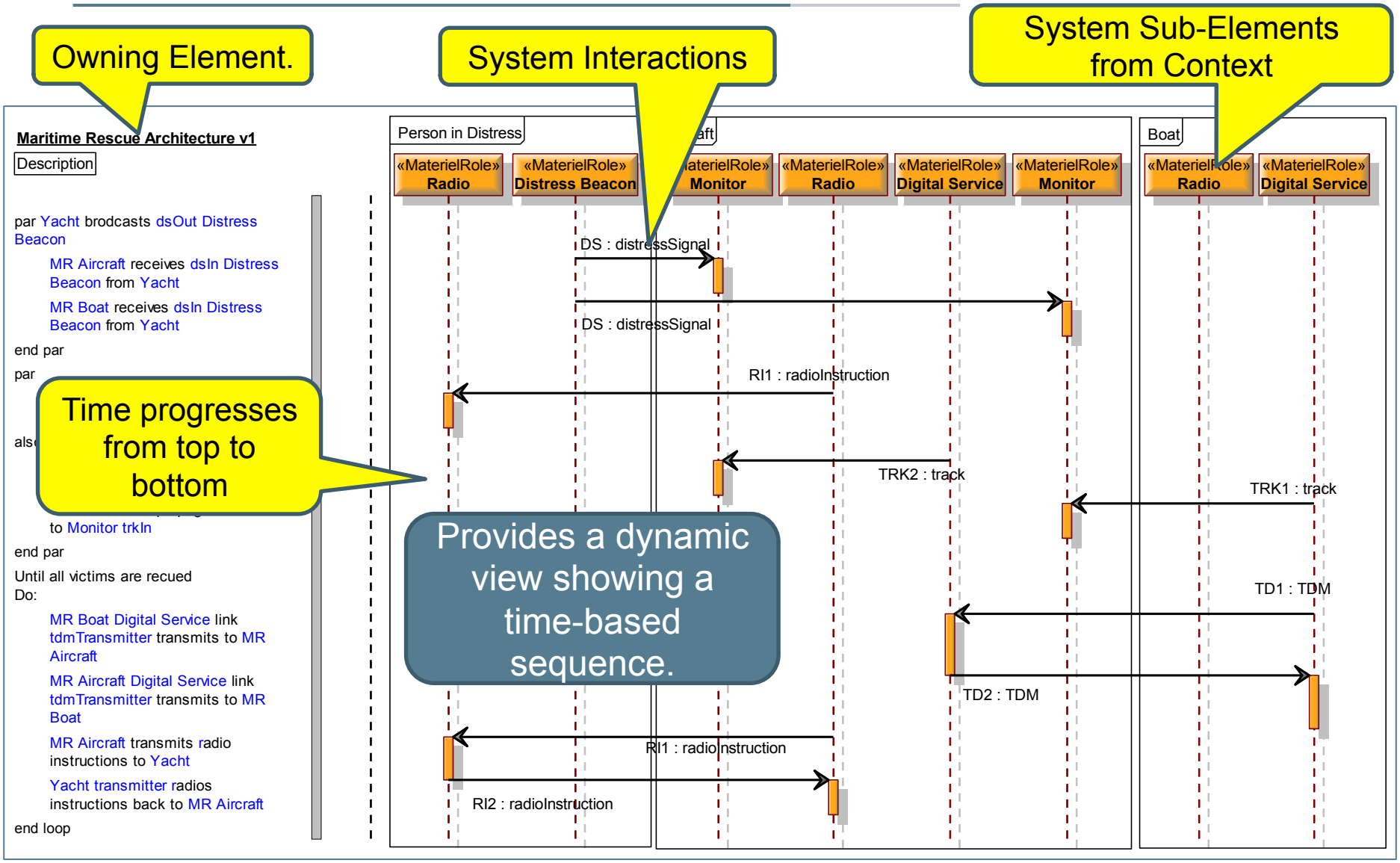
Sequence of Events

- SV-10c Resource Event Trace Description
- Shows interactions in time order that have been created on SV-1 and SV-2 diagrams.
  - Dynamic (SV-10c) vs. Static View (SV-1, SV-2)
- Shows how resources interact
  - Exchange of information between resources
  - Elements on the diagram are parts of the owning element
  - Sequence of exchanges
  - Time
- Interaction between Systems Node Roles, Organization Roles, Post Roles, System Roles and Software Roles
- Also shows behavioral interactions such as events and operations
- Similar to OV-6c View

SV-2: Resource Interaction Specification



SV-10c: System Event Trace Description



Modeling processing time, latency, transport time etc.

- Timing information can be added to enhance analysis
  - Processing duration
  - Transmission delay
  - Latency
  - Etc.
- Simulation can verify timing and behavior

SV-10c: System Event Trace Description
With added timing information

Maritime Rescue Architecture v1

Description

par Yacht brodcasts dsOut Distress Beacon

- MR Aircraft receives dsIn Distress Beacon from Yacht
- MR Boat receives dsIn Distress Beacon from Yacht
- Process Message

end par

Process Message

par

- ACK
- MR Aircraft transmits radio instructions to Yacht

also par

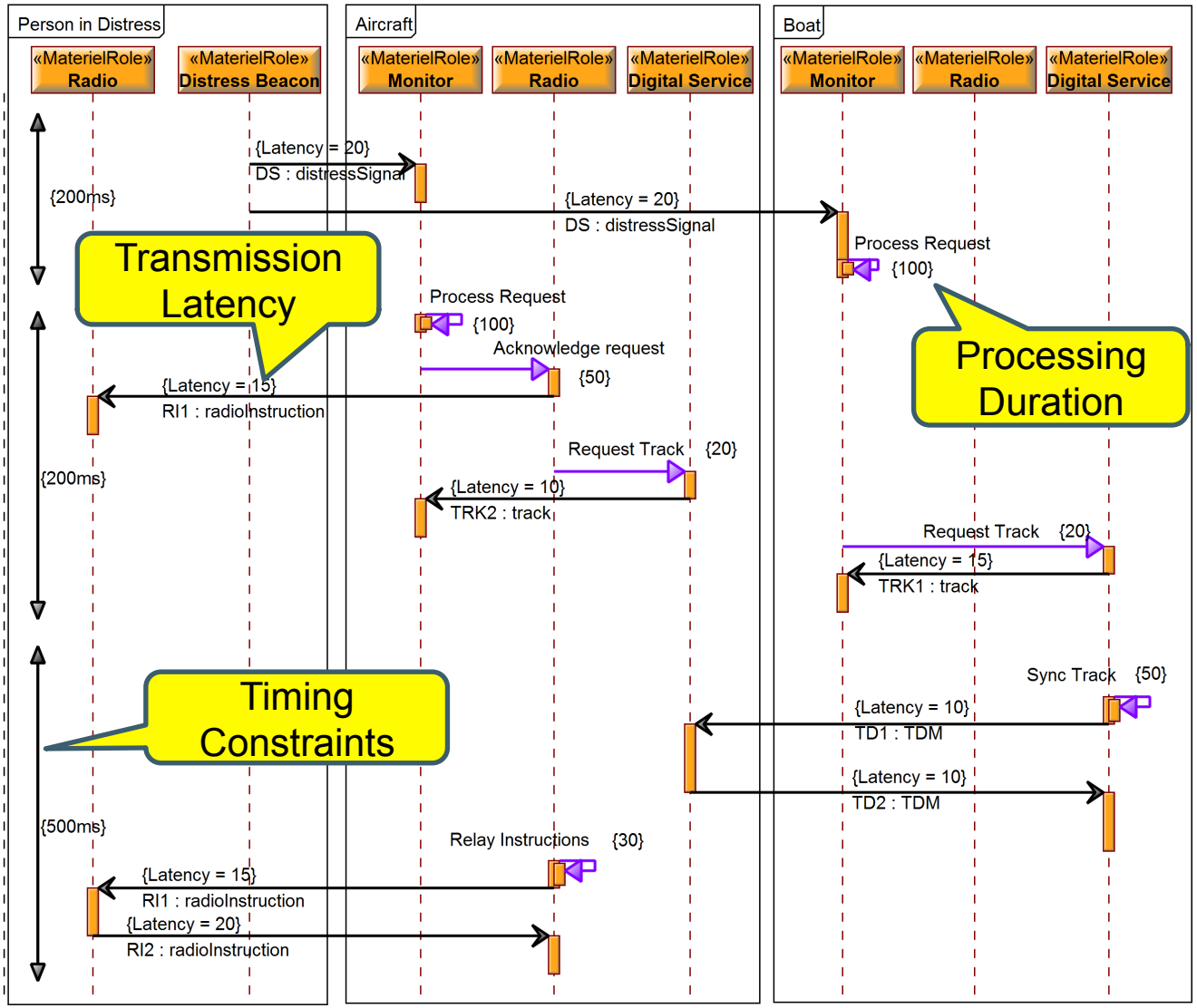
- Track
- tdmTransmitter propagates trkOut to Monitor trkIn
- Request Track
- tdmTransmitter propagates trkOut to Monitor trkIn

end par

Until all victims are recued
Do:

- Track Sync
- MR Boat Digital Service link tdmTransmitter transmits to MR Aircraft
- MR Aircraft Digital Service link tdmTransmitter transmits to MR Boat
- Relay Instructions
- MR Aircraft transmits radio instructions to Yacht
- Yacht transmitter radios instructions back to MR Aircraft

end loop



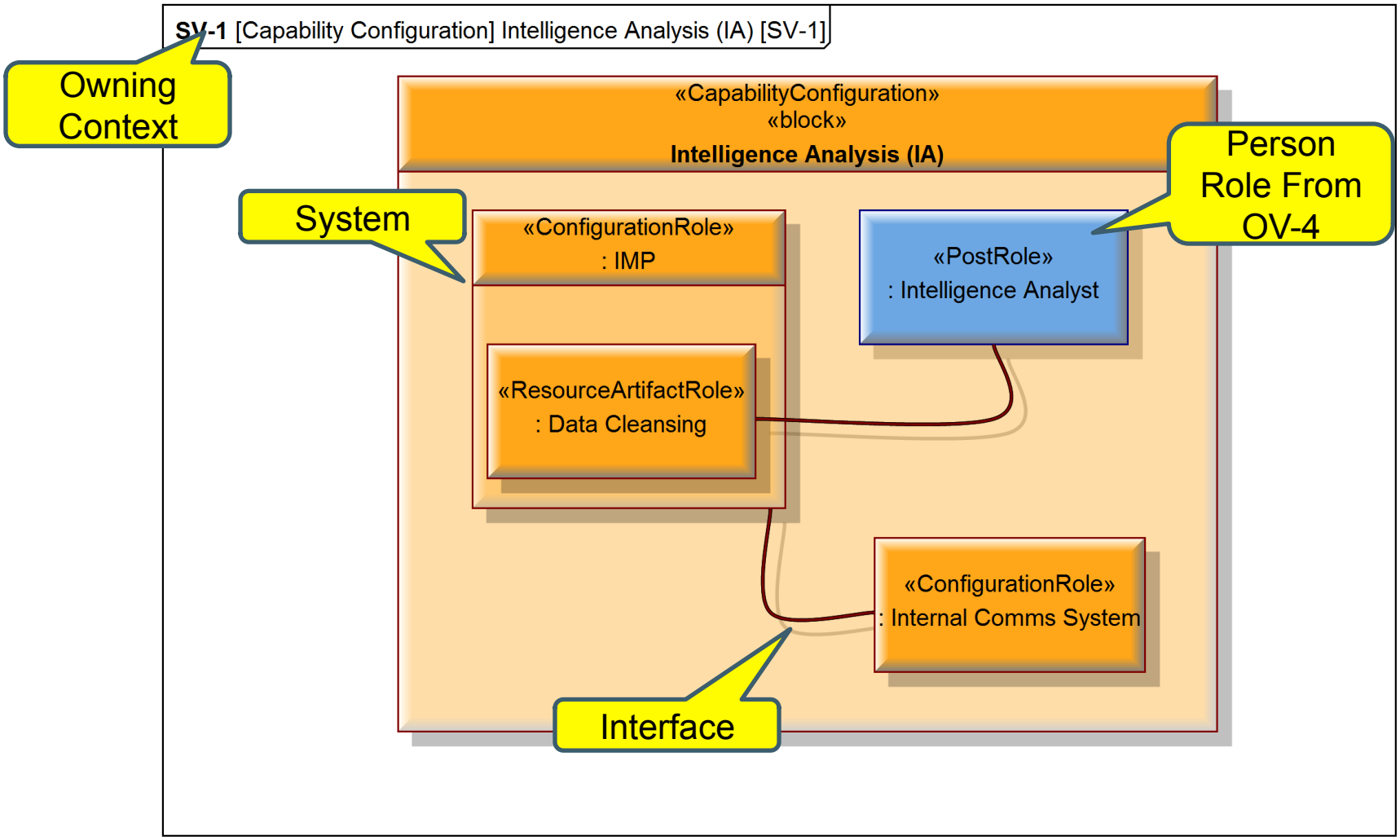
Systems Changing over Time

- The paradox of the Ship of Theseus – Plutarch
  - If you take all the parts of a system (Theseus' ship) and replace them, is it the same ship?
- Abe Lincoln's axe
  - Lincoln was well known for his ability with an axe, and axes associated with his life are held in various museums.
  - Are they all "Abe Lincoln's Axe"?
- Systems change over time
  - System lifecycle of design, manufacture, deployment, maintenance, retirement
  - Changes for mission-based configurations
  - Changes due to maintenance
  - Etc.

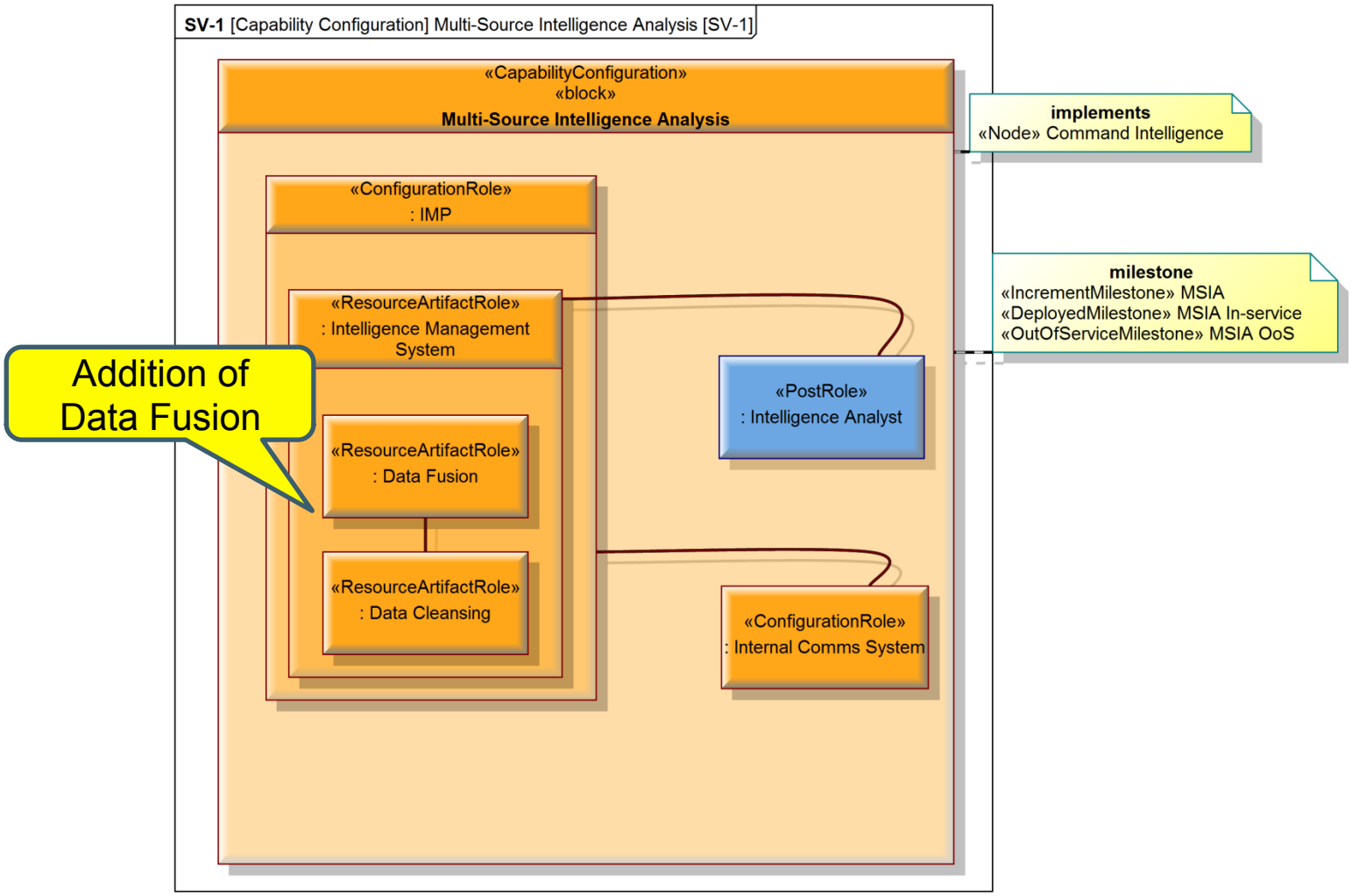
System Changes over Time

- SV-1/SV-2 Resource interaction specification are used to define system structure
- Shows how resources (systems, roles, posts and organizations) interact
- Created from systems, system nodes and organizations
- Defined system configurations can be linked to project deployments

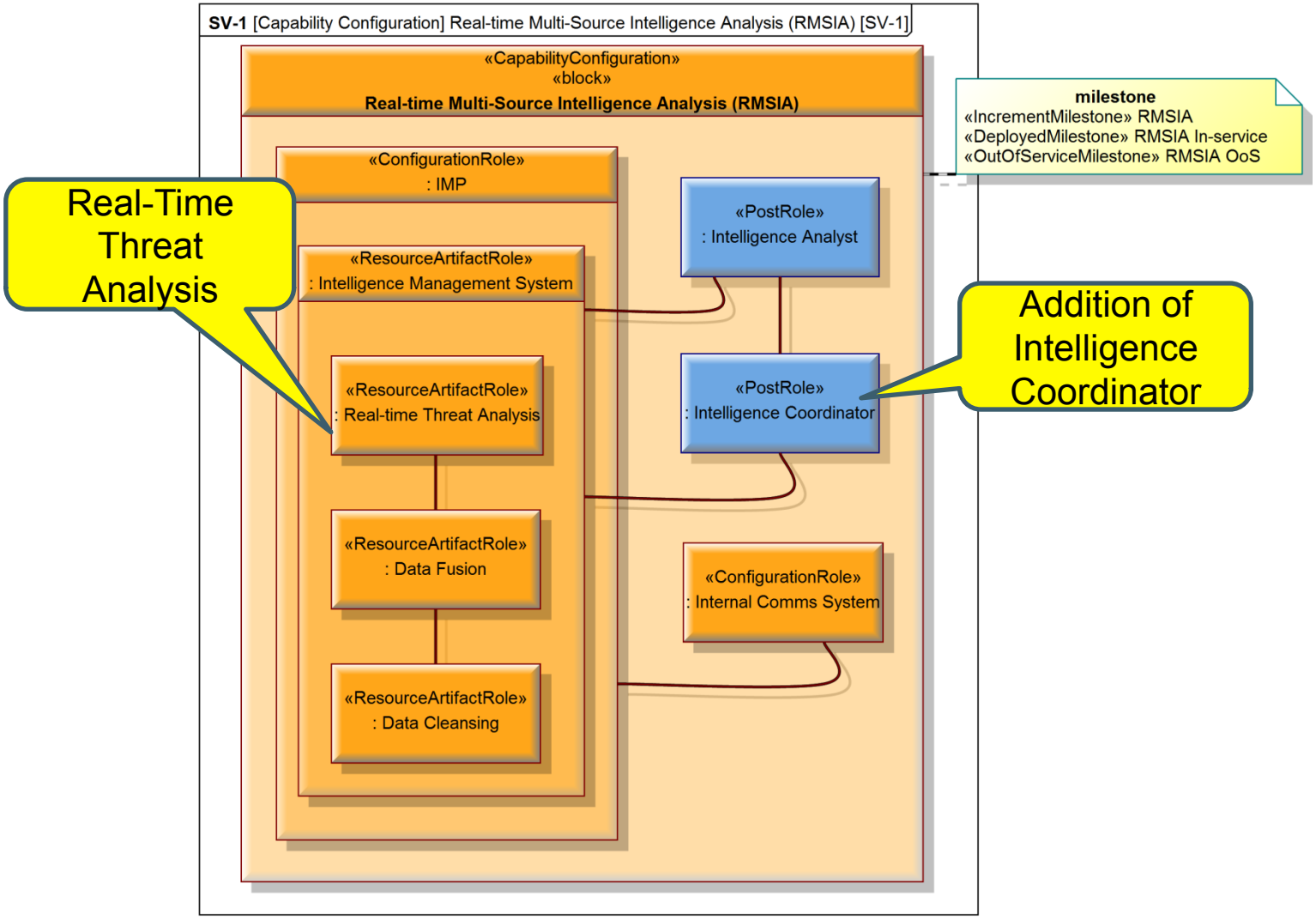
SV-1: Resource Interaction Specification Version 1: Intelligence Analysis



SV-1: Resource Interaction Specification
V2: Multi-Source Intelligence Analysis



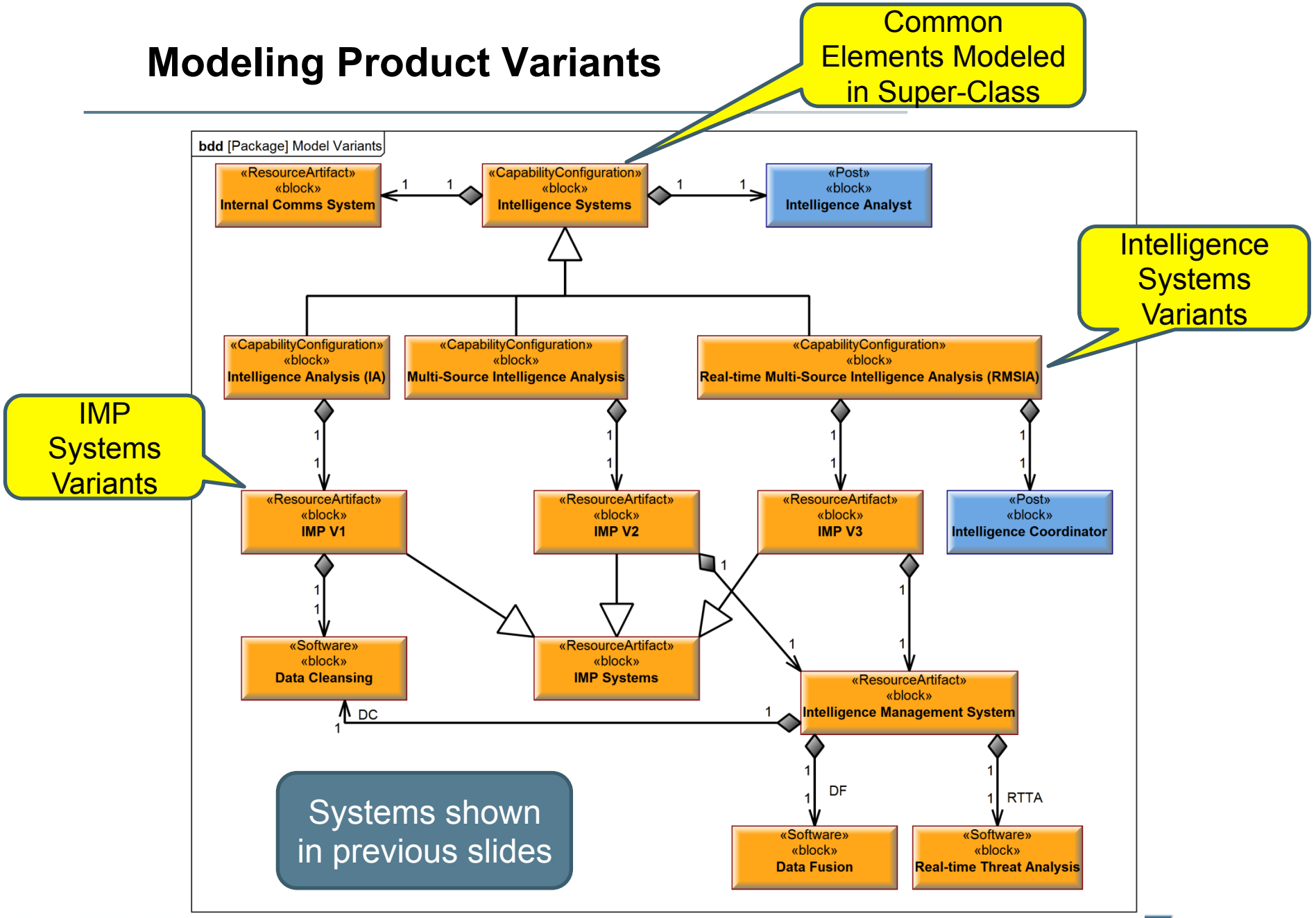
SV-1: Resource Interaction Specification



Modeling product variants

- No Replication of Work:
  - Common elements defined once and reused
    - Parts
    - Interfaces
    - Functions
- Similar model elements should be modeled only once, in the family model
  - Enforced re-use
- Maturing standards for variability modeling
- Compatibility with all views defined in SysML
  - Requirements, Structure, Behavior, Parametrics
  - Variability Methods are more then a combinatory re-use of structural components

Modeling Product Variants



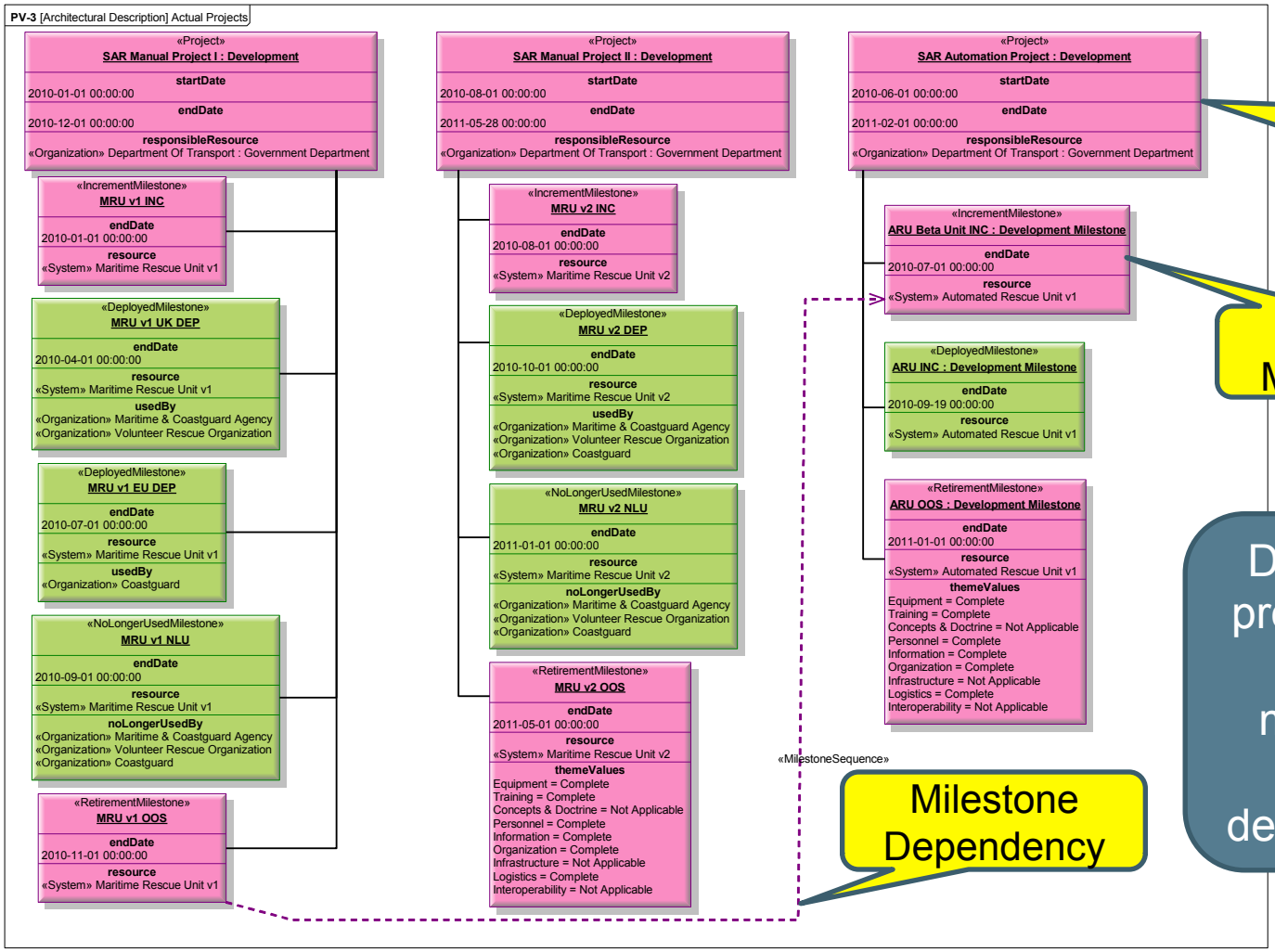
Project Views: Scheduling deployment of systems over time

- Contains information about programs, projects, portfolios, or initiatives and relating that information to capabilities and other programs, projects, portfolios, or initiatives.
- PV-1: Project Portfolio Relationships
  - It describes the dependency relationships between the organizations and projects and the organizational structures needed to manage a portfolio of projects.
- PV-2: Project Timelines
  - A timeline perspective on programs or projects, with the key milestones and interdependencies.
- PV-3: Project to Capability Mapping
  - A mapping of programs and projects to capabilities to show how the specific projects and program elements help to achieve a capability.

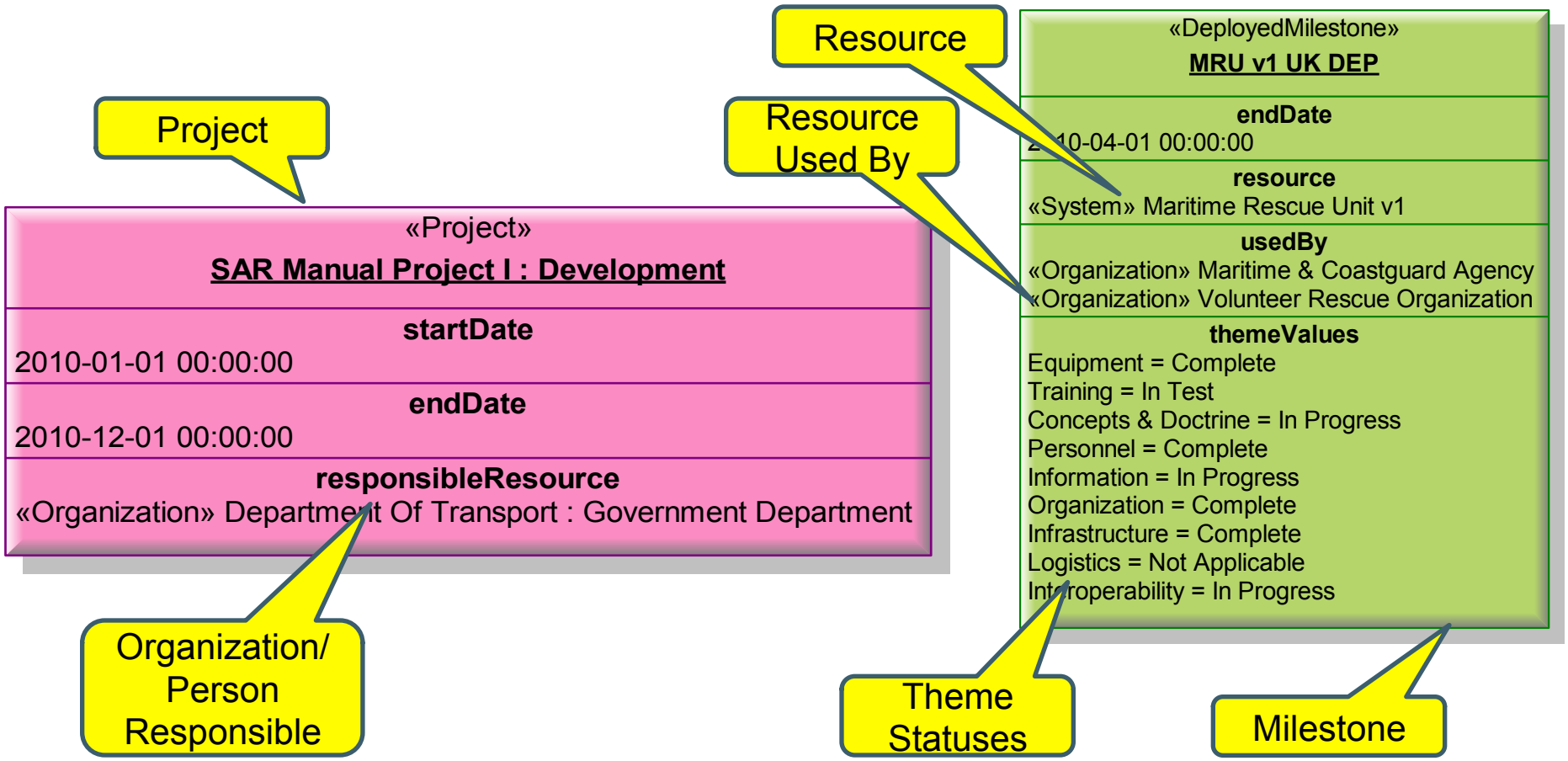
Scheduling deployment of systems over time

- A PV-1 Actual Projects defines Projects, Actual Project Milestones, Deployed Milestones, Increment Milestones, No Longer Used Milestones, Retirement Milestones, Project Sequences and Milestone Sequences.
- Links are created between the Project and its actual Milestones.
- Milestone sequences link Milestones
- Project sequences link Projects
- Specify responsible resources (people, organizations) for projects
- Specify resources to be deployed etc., and organizations that use the resource for milestones.

Scheduling deployment of systems over time PV-1



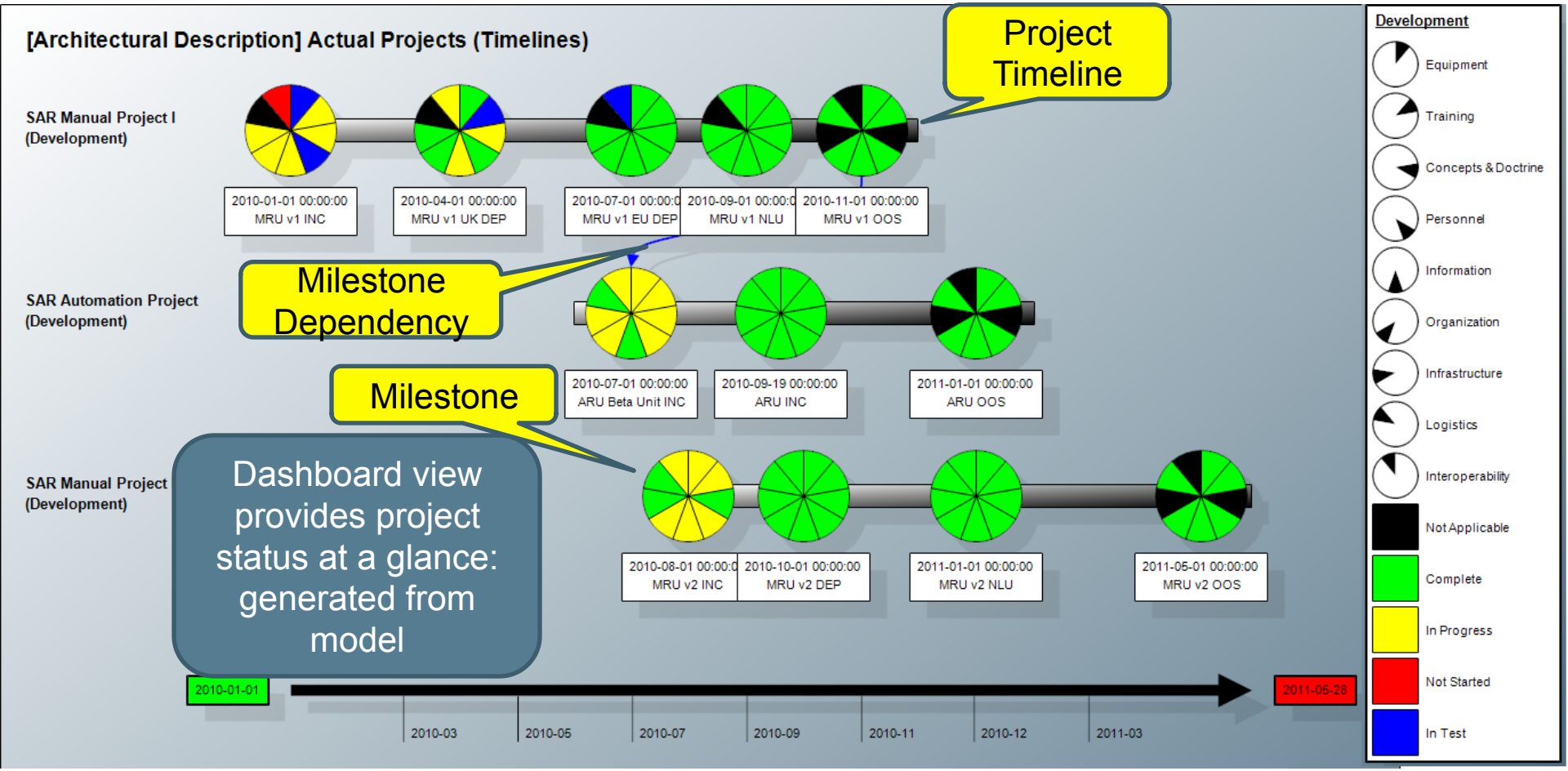
Scheduling deployment of systems over time PV-1 Detail



Scheduling deployment of systems over time
PV-2 Project Timelines

- A PV-2 provides a timeline perspective on projects and their relationship to Systems.
  - There is no set format for this view. Each tool has implemented the PV-2 diagram in its own way.
- The PV-2 is populated using live data from the model.
- It contains project timelines, project milestones statuses, and project and milestone sequences.

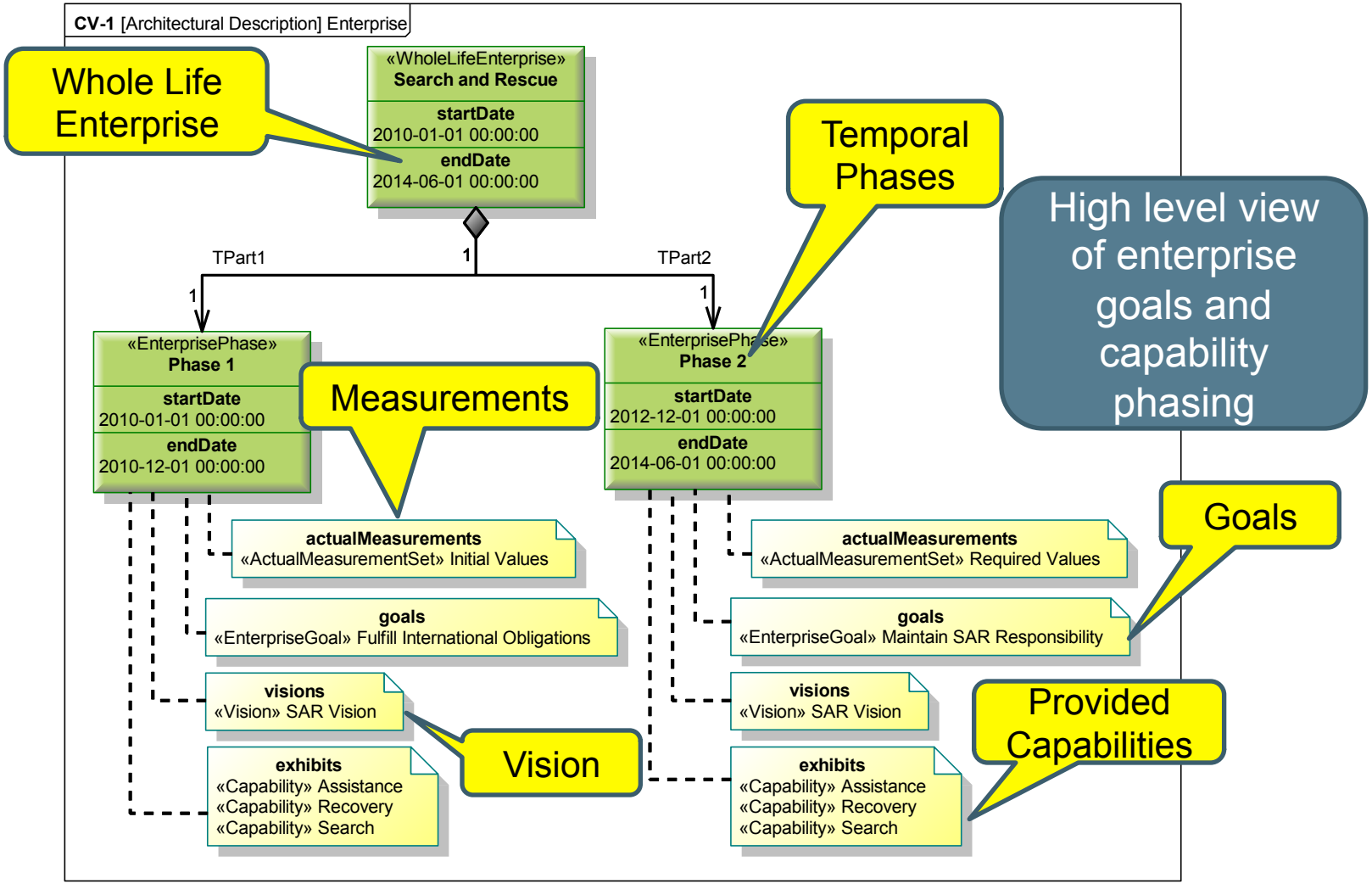
Scheduling deployment of systems over time
PV-2 Project Timelines



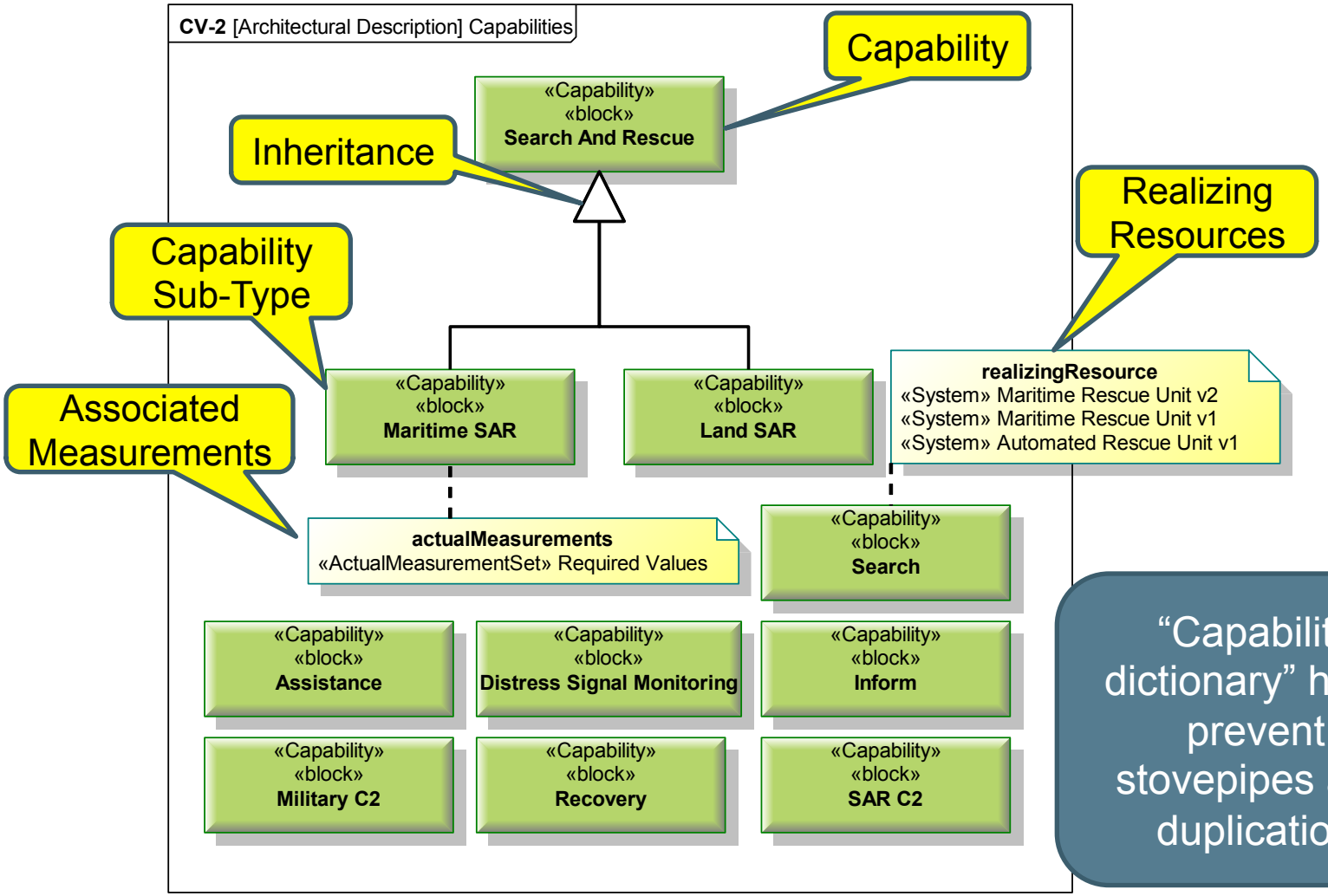
Different systems support the same capability over time Capability Views

- Defines capabilities, capability dependencies and relationships
- Provides high-level view of expected capability within each time frame
- Shows the intersection between capabilities, systems, system metrics, etc. over time
- Used for:
  - Capability overlap/gap analysis
  - Identification of high-level capability issues

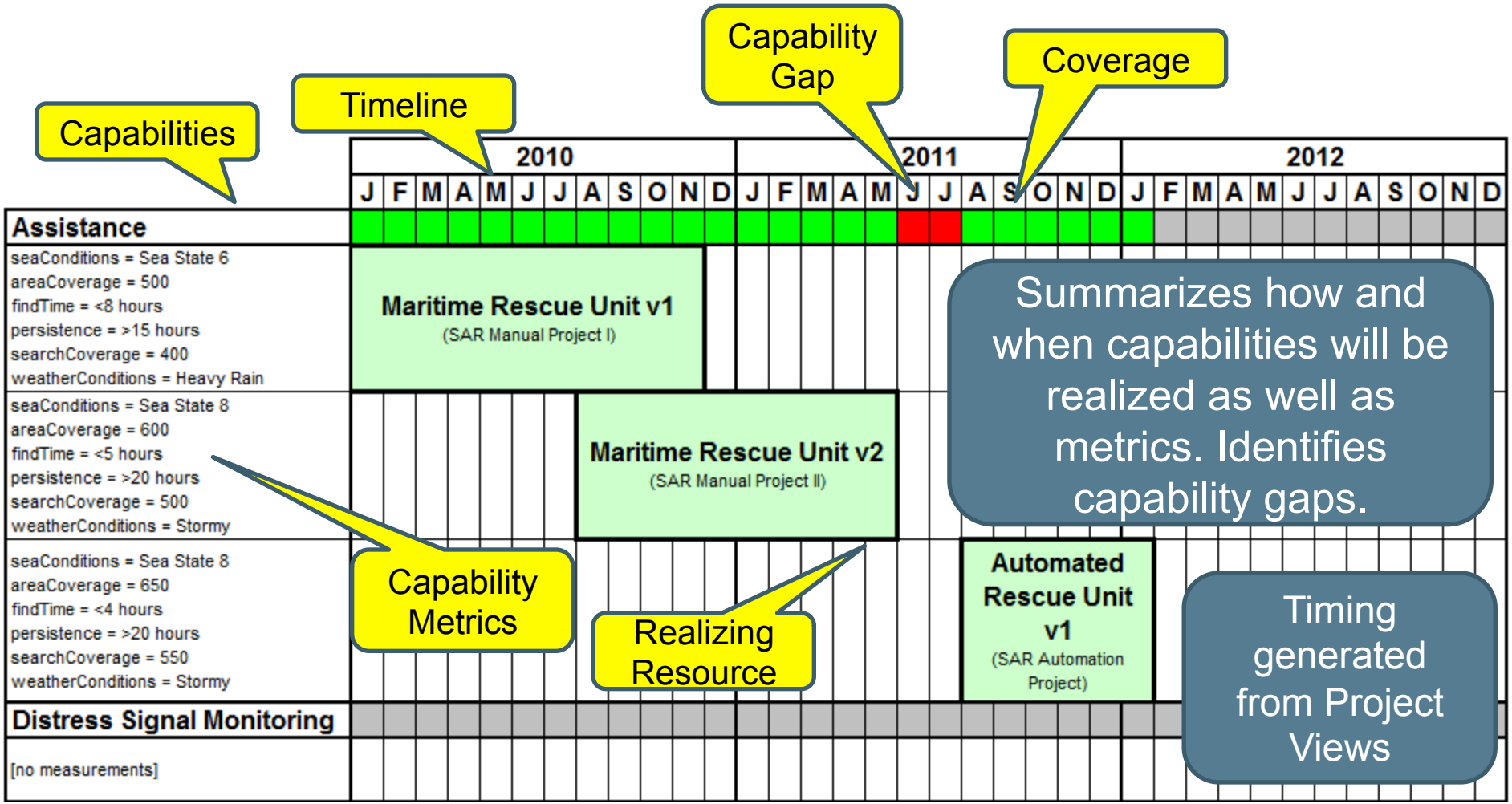
CV-1 Capability Vision



CV-2 Capability Taxonomy



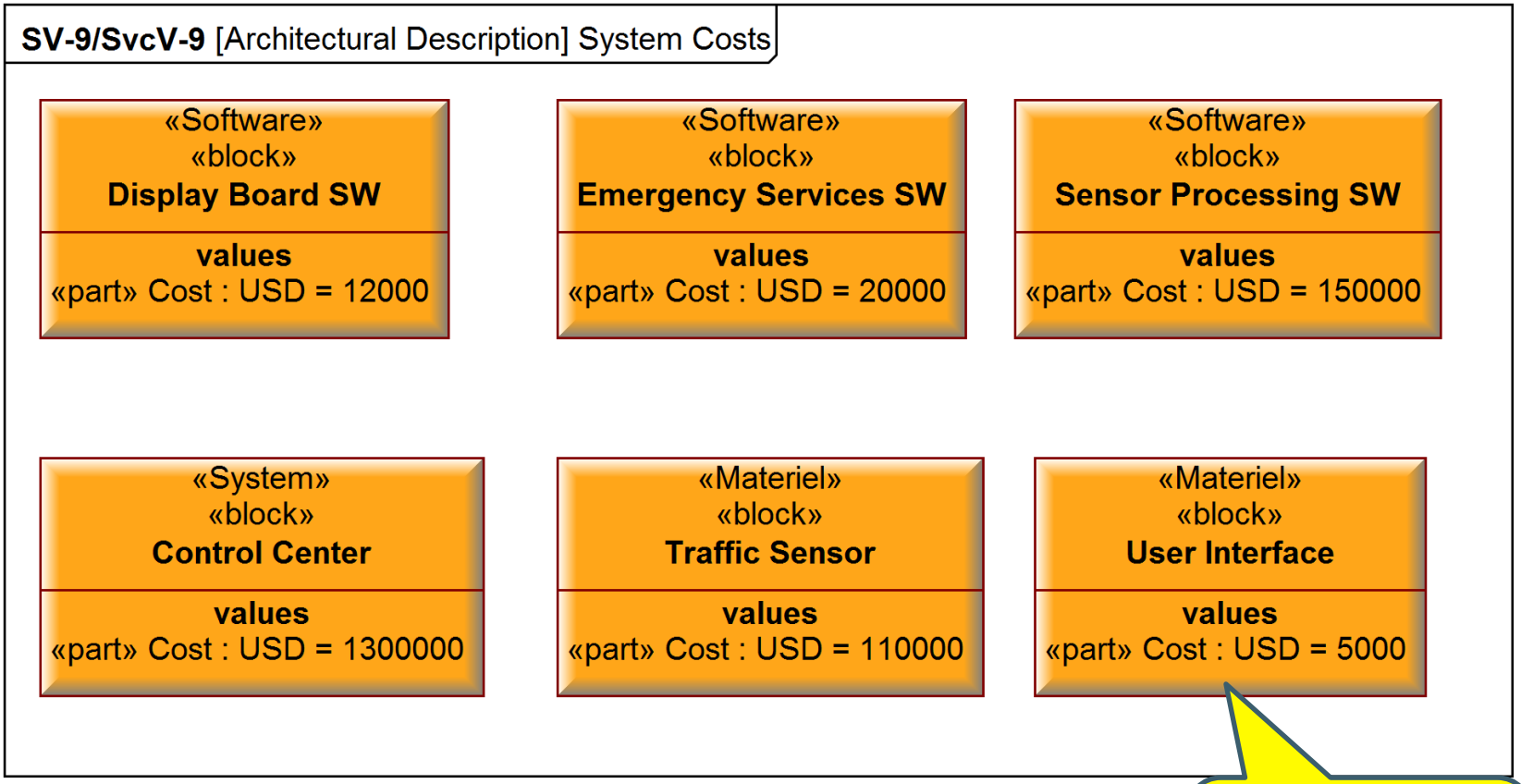
CV-3/StV-3 Capability Phasing (Fragment)



Total Cost and Cost Over Time

- DoDAF/SysML provide a means to add value properties to model elements
  - Size, Weight, Power, Cost, etc.
- A system is an aggregation of its parts.
  - Therefore, the total number of each type of part can be calculated
  - If the cost of each part is known, the total cost of the system can be calculated
  - Running costs can also be defined for the system for sub-systems as well as people
  - Project views provide a means to show system deployment schedules, therefore running costs can be calculated as well.

System View Showing Individual System Costs



Summary of System Costs

	A	B	C	D	E	F	G
1	Name	Quantity	Cost (in USD)				
2			Estimate	No Margin	Margin (%)	With Margin	Budget
3	Traffic Context (Autoville Traffic Management Architecture::System View	n/a	50000000	51799000	12.00%	58014880	600000000
4	Control Center (Autoville Traffic Management Architecture::System Vie	1	1000000	1649000	20.00%	1978800	1300000
5	Control Room (Autoville Traffic Management Architecture::System Vie	1	0	649000	10.06%	714300	782000
6	Control Room Operator (Autoville Traffic Management Architecture::	2	0	0	0.00%	0	0
7	Control System (Autoville Traffic Management Architecture::System	1	0	645000	10.06%	709900	777000
8	Display Board SW (Autoville Traffic Management Architecture::Syst	1	10000	10000	10.00%	11000	12000
9	Emergency Services SW (Autoville Traffic Management Architecture	1	15000	15000	10.00%	16500	20000
10	Sensor Processing SW (Autoville Traffic Management Architecture::	1	100000	100000	10.00%	110000	150000
11	Traffic Control SW (Autoville Traffic Management Architecture::Syst	1	100000	100000	10.00%	110000	120000
12	Traffic Data Archive SW (Autoville Traffic Management Architecture	1	10000	10000	10.00%	11000	15000
13	Traffic Display SW (Autoville Traffic Management Architecture::Syst	1	100000	100000	10.00%	110000	110000
14	Traffic Event SW (Autoville Traffic Management Architecture::Syste	1	120000	120000	10.00%	132000	130000
15	Traffic Flow Calculation SW (Autoville Traffic Management Architec	1	50000	50000	10.00%	55000	60000
16	Traffic Prediction SW (Autoville Traffic Management Architecture::S	1	0	0	0.00%	0	0
17	Traffic Report Generation SW (Autoville Traffic Management Archit	1	20000	20000	12.00%	22400	25000
18	Traffic Signal SW (Autoville Traffic Management Architecture::Syste	1	20000	20000	10.00%	22000	25000
19	Video Processing SW (Autoville Traffic Management Architecture::S	1	100000	100000	10.00%	110000	110000
20	Web Presence SW (Autoville Traffic Management Architecture::Syst	1	0	0	0.00%	0	0
21	Weather Processing SW (Autoville Traffic Management Architecture	1	0	0	0.00%	0	0
22	User Interface (Autoville Traffic Management Architecture::System V	2	2000	4000	10.00%	4400	5000
23	City Planning (Autoville Traffic Management Architecture::System View	1	0				0
24	Emergency Services (Autoville Traffic Management Architecture::Syster	1	0				0
25	Event Venue (Autoville Traffic Management Architecture::System View	1	0				0
26	Internet (Autoville Traffic Management Architecture::System Views::Re	1	0				0
27	Mass Media (Autoville Traffic Management Architecture::System Views	1	0				0
28	Road Maintenance (Autoville Traffic Management Architecture::System	1	0	0	0.00%	0	0

Generated report from system configuration.

Modeling Cost vs. Time vs. Capability (1)

- Capability Goals
  - How do individual projects contribute to capability outcomes?
  - Over what timeframes are the capability outcomes realized?
- Maintenance of Capability
  - When a platform or piece of equipment reaches its planned withdrawal date will there be a new platform/piece of equipment available to replace it?
- Capability Over Time
  - What capability is available at any given point in time?
  - What platforms/equipment/organizations provide the capability?
- Tolerance
  - How much can I move things before it starts to have an impact?
- Committees and Approvals Schedule
  - What impact do changes have on committees and approvals?

Architecture-based Decision Support for Capability Development
Gary Bulluss and Kevin O'Shea
Joint Decision Support Centre, Joint Operations Division
Defence Science and Technology Organisation

Showing cost vs. time vs. capability (2)

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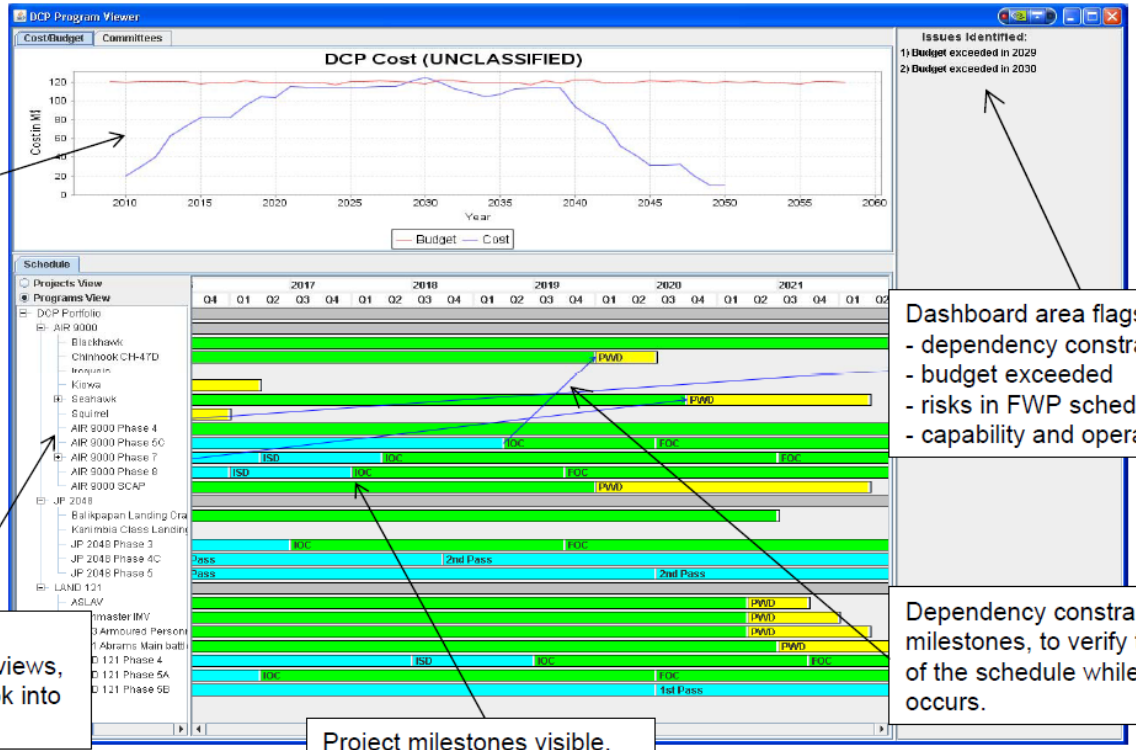
Custom Visualisation



Cost vs Budget visualisation and analysis.

Structured view of projects. High level views, with the ability to look into lower-level details.

Project milestones visible.

Dashboard area flags all issues:
- dependency constraints broken
- budget exceeded
- risks in FWP schedule
- capability and operational issues

Dependency constraints between milestones, to verify the achievability of the schedule while shuffling occurs.

Note: Project names are from the public DCP. Schedules and costings are fictitious.

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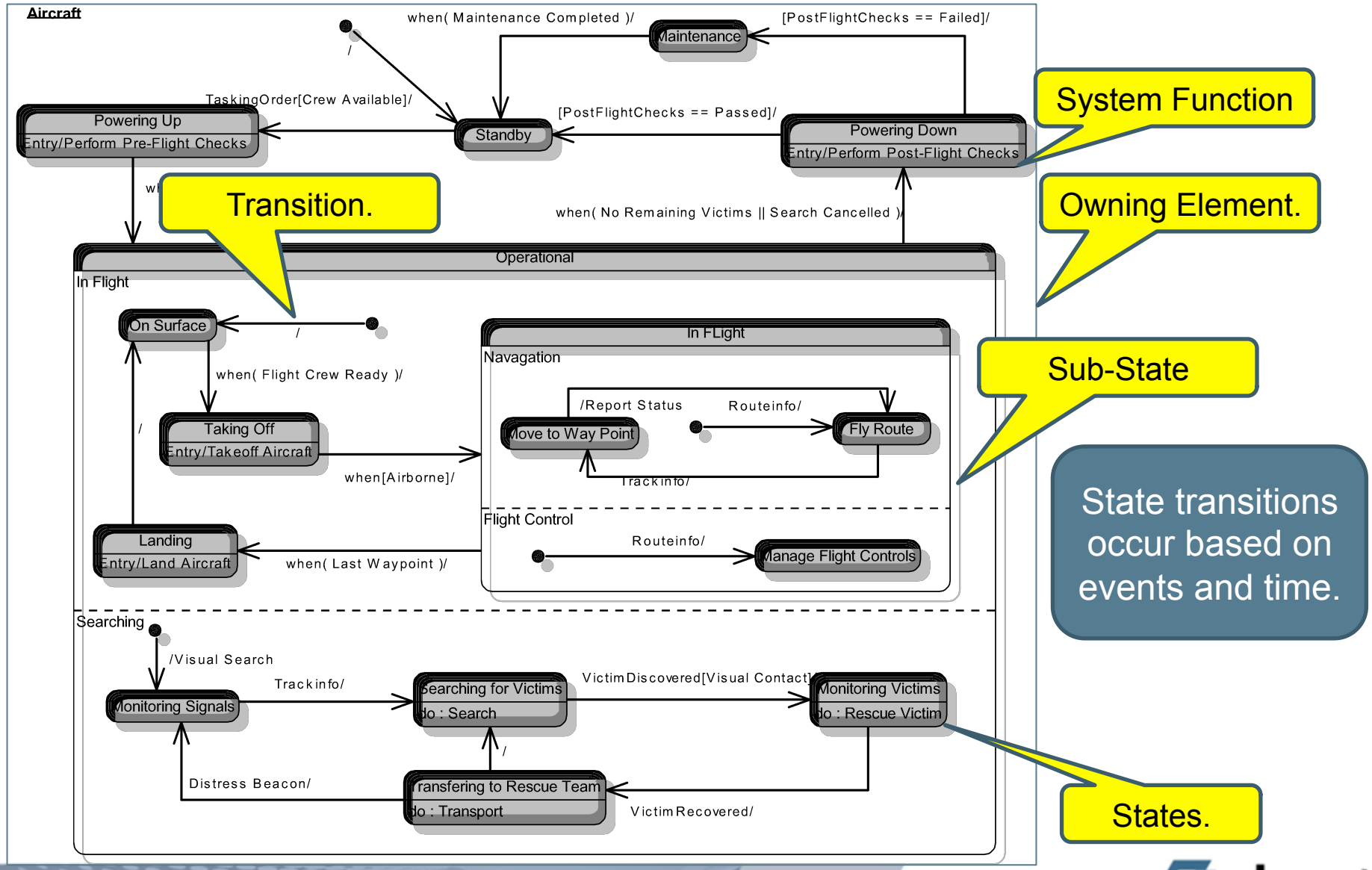
System states showing time dependent behavior SV-10b Resource State Transition Description

- Shows states within a resource
  - Shows resource state changes
- One diagram per resource (System nodes and systems)
- Shows events passed to and from resources

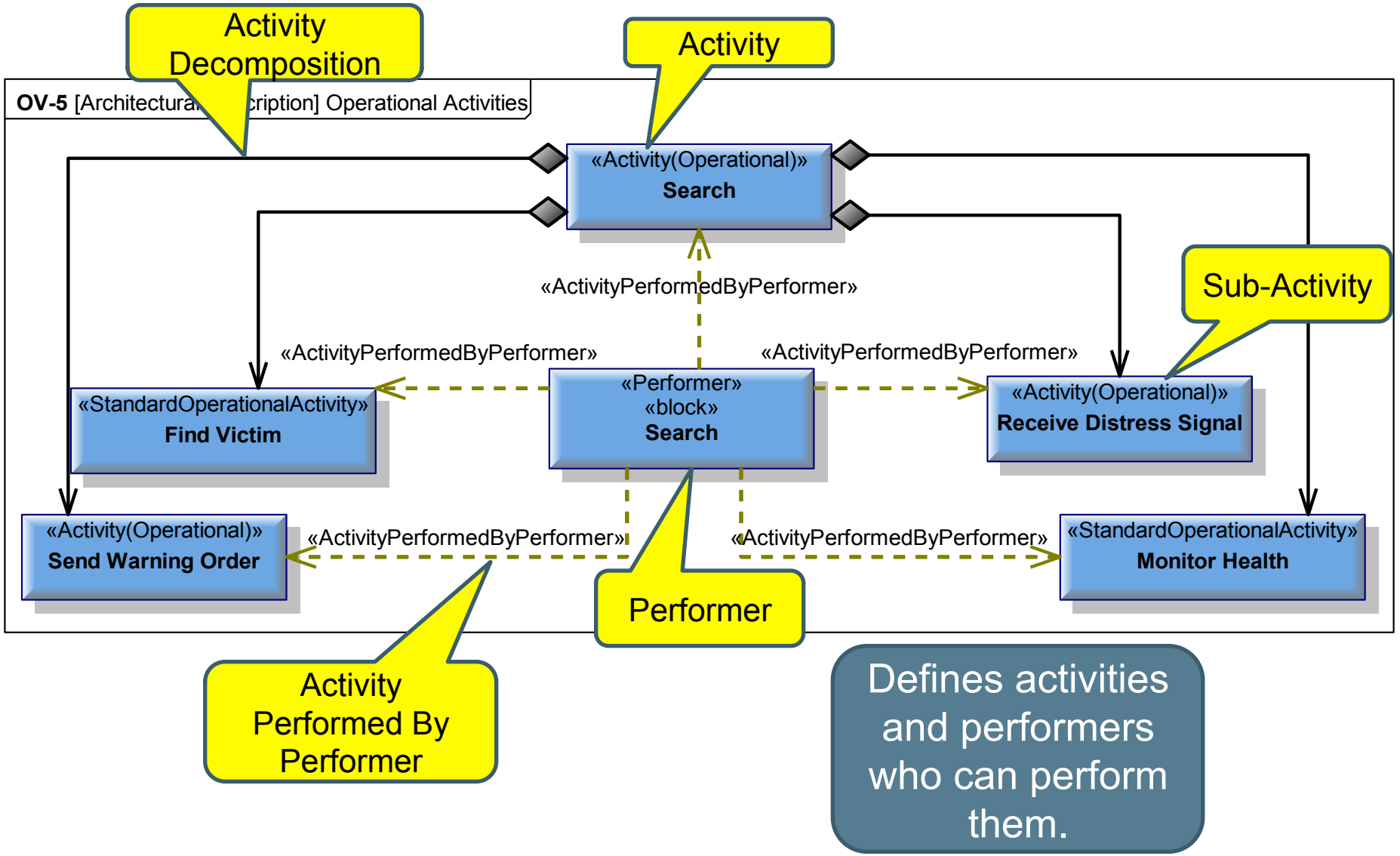
SV-10b: System State Transition Description



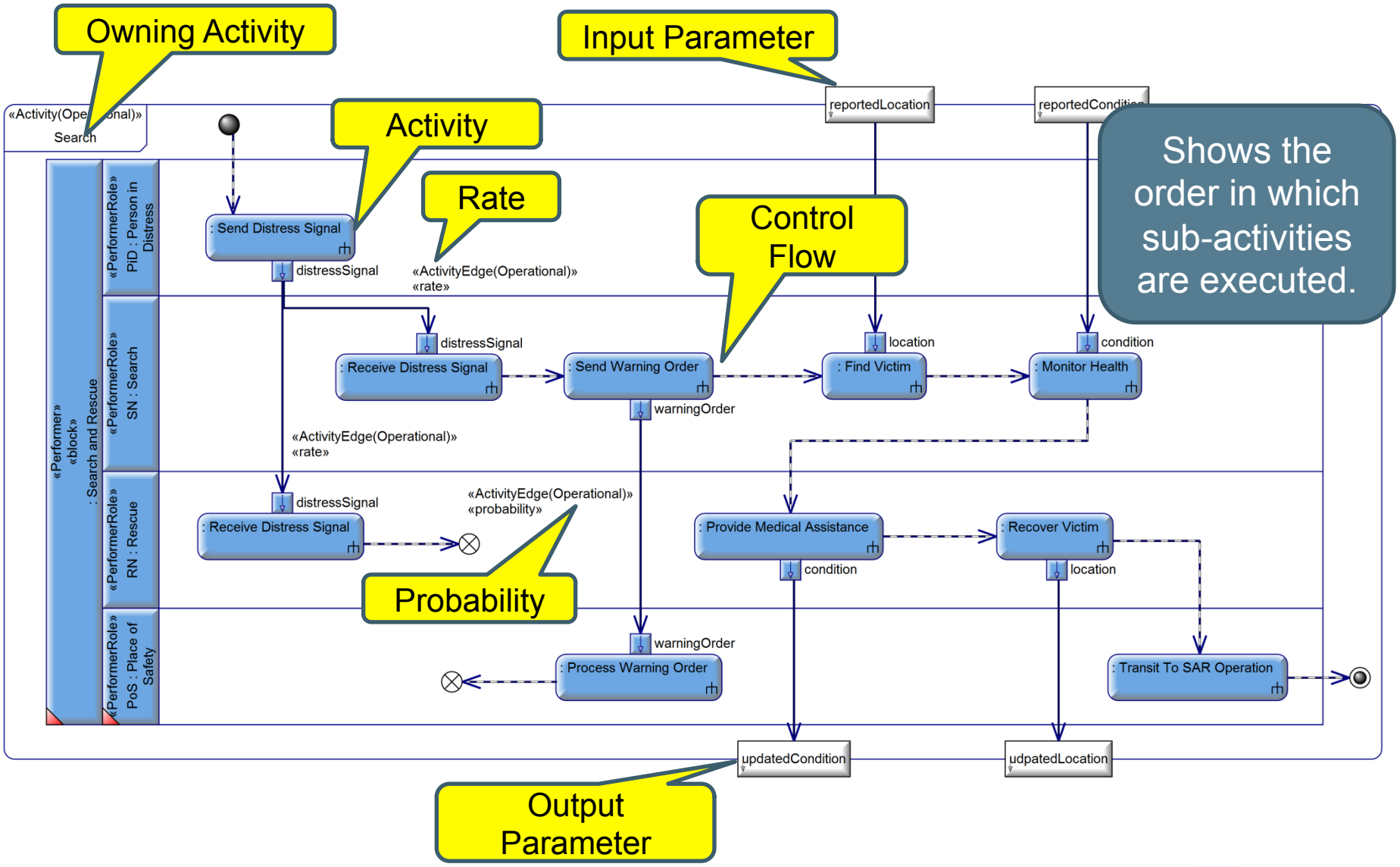
Time Dependent Activity Sequences
OV-5 Operational activity model

- Shows operational activities and their relationships
- Class diagrams
  - Activity hierarchies
  - Performing nodes
  - Created from an Architectural Description
- Activity diagrams
  - Activity sequence execution order
  - Swimlanes
  - Events
  - Interactions
  - Created from an operational activity
- Created from an Architectural Description

OV-5 Activity Hierarchy Diagram



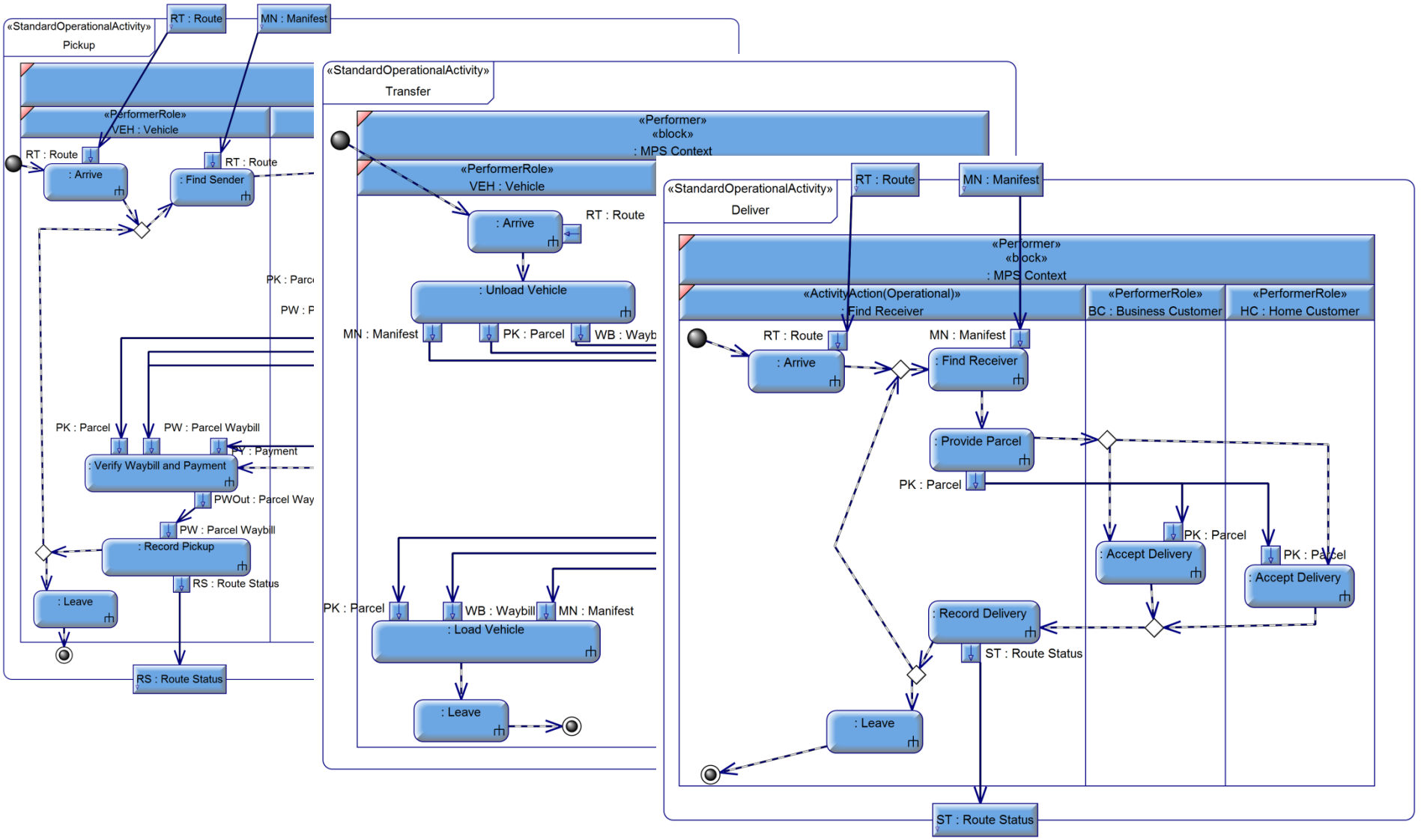
OV-5 Search Activity Diagram



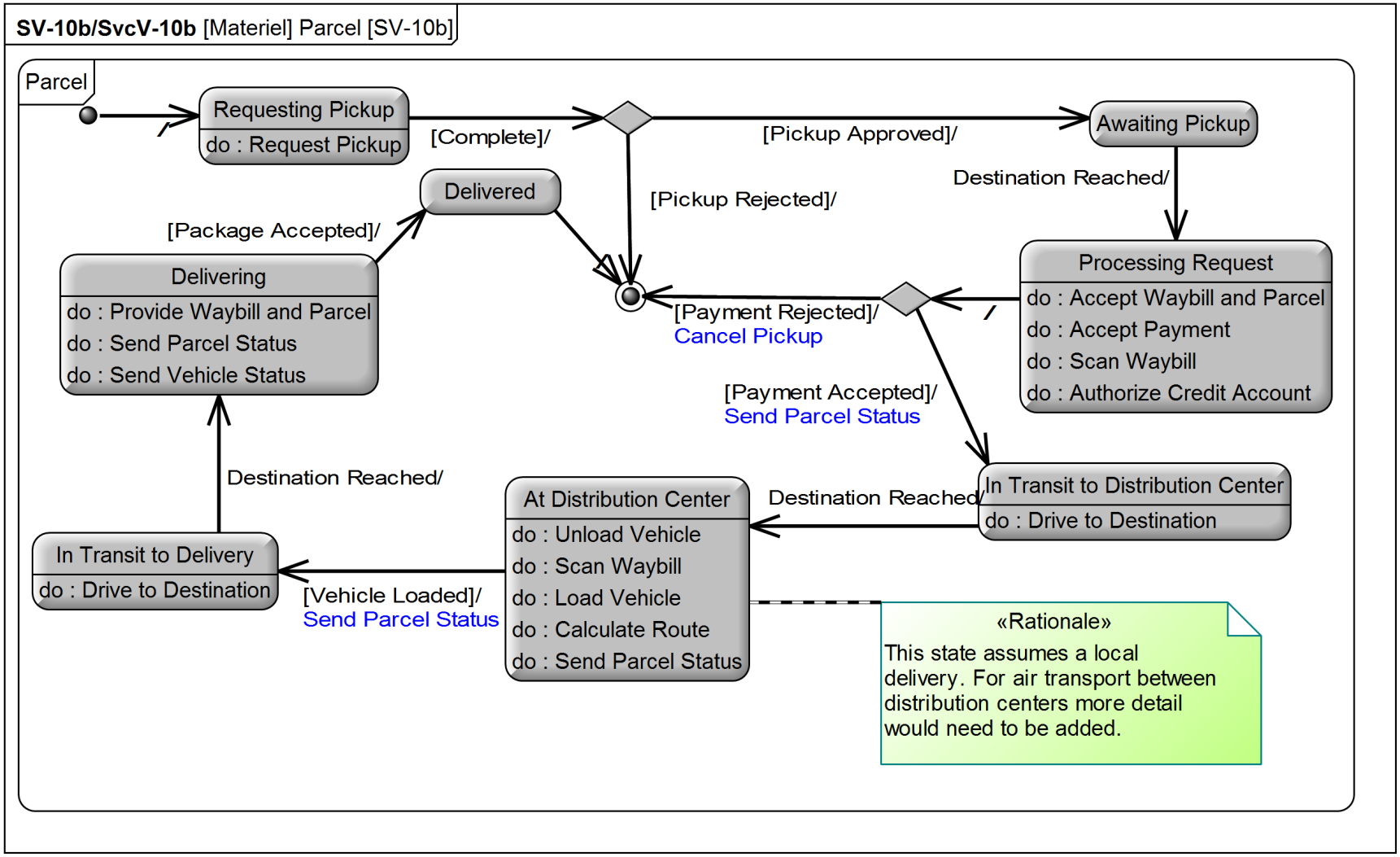
Data Lifecycles

- Data changes over time
  - Data transformation (Activities)
  - Data Fusion (Activities/Data modeling)
  - Data lifecycle (State Machines)
  - Case management (State machines/Activities/Sequence)
  - Data flow (Activities)
  - Data sequencing (Sequence/Structure)
  - Etc.

Data management lifecycles – Data Processing



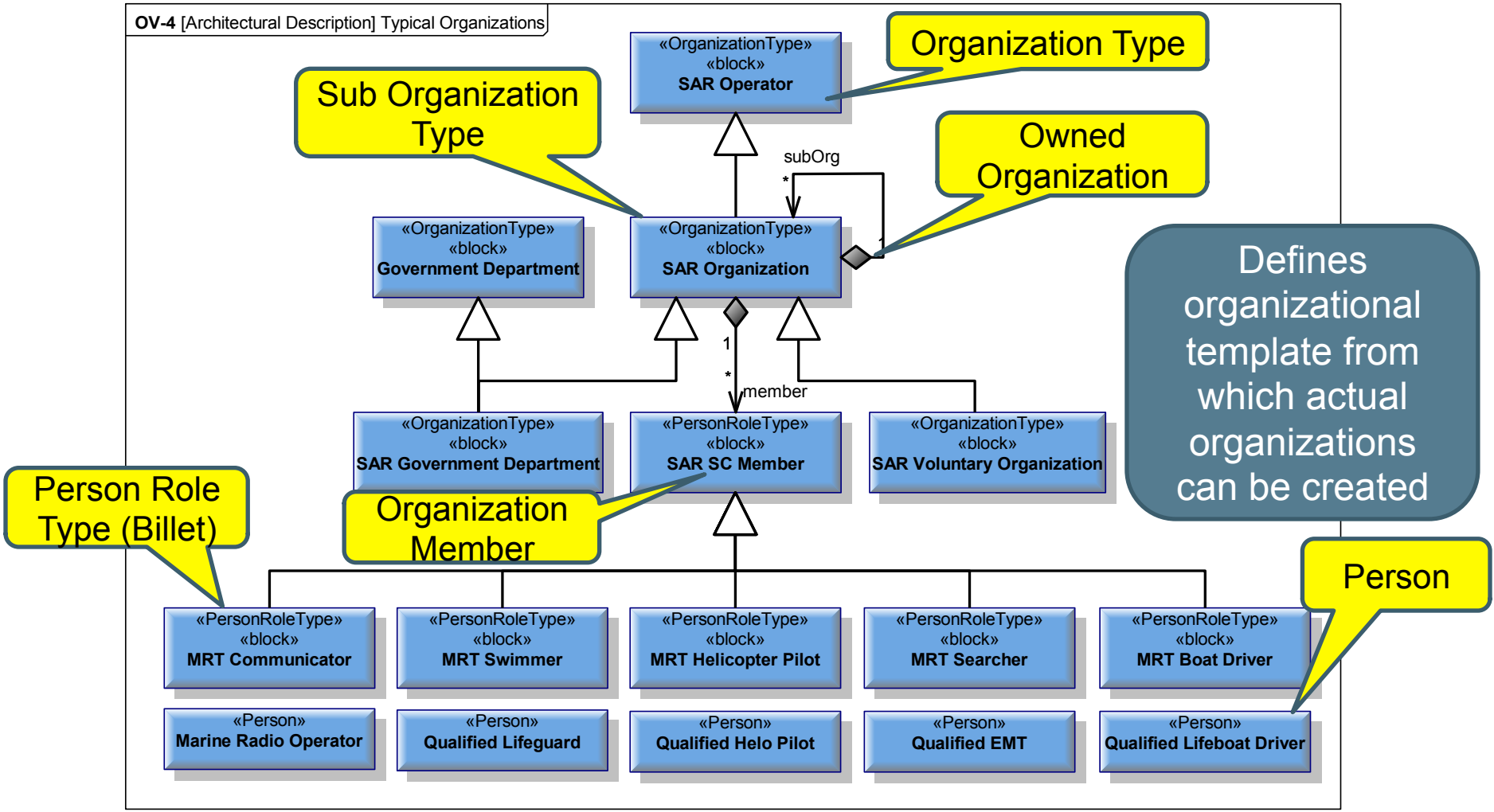
Data management lifecycles – State Based



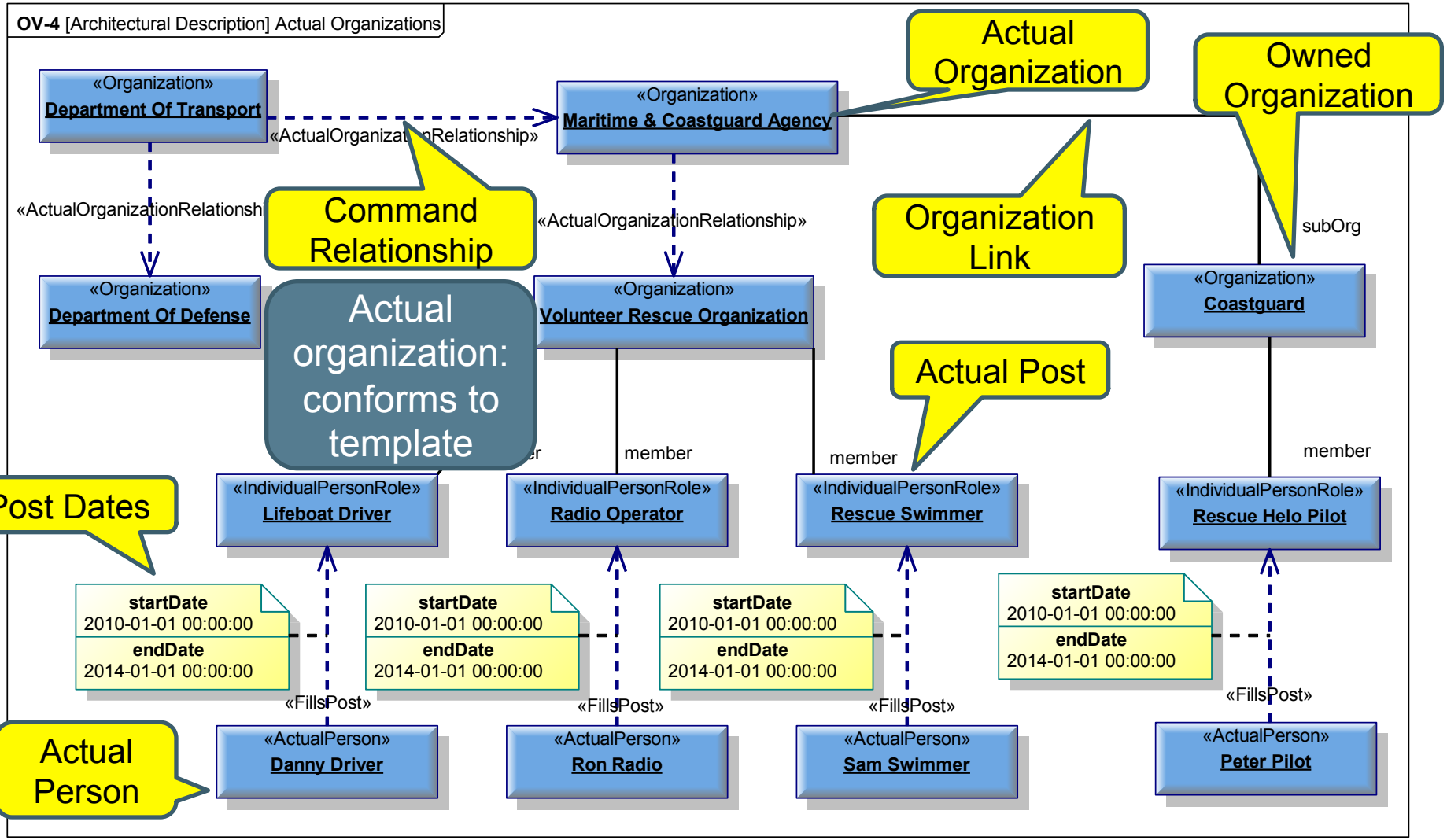
Personnel deployment and competency assessment

- DoDAF 2.0 allows the definition of
  - People
  - Competencies/Skills
  - Competency Forecasts
  - Job Specifications
  - Competency Forecasts
  - Job Allocations
  - Job deployment report
  - Etc.

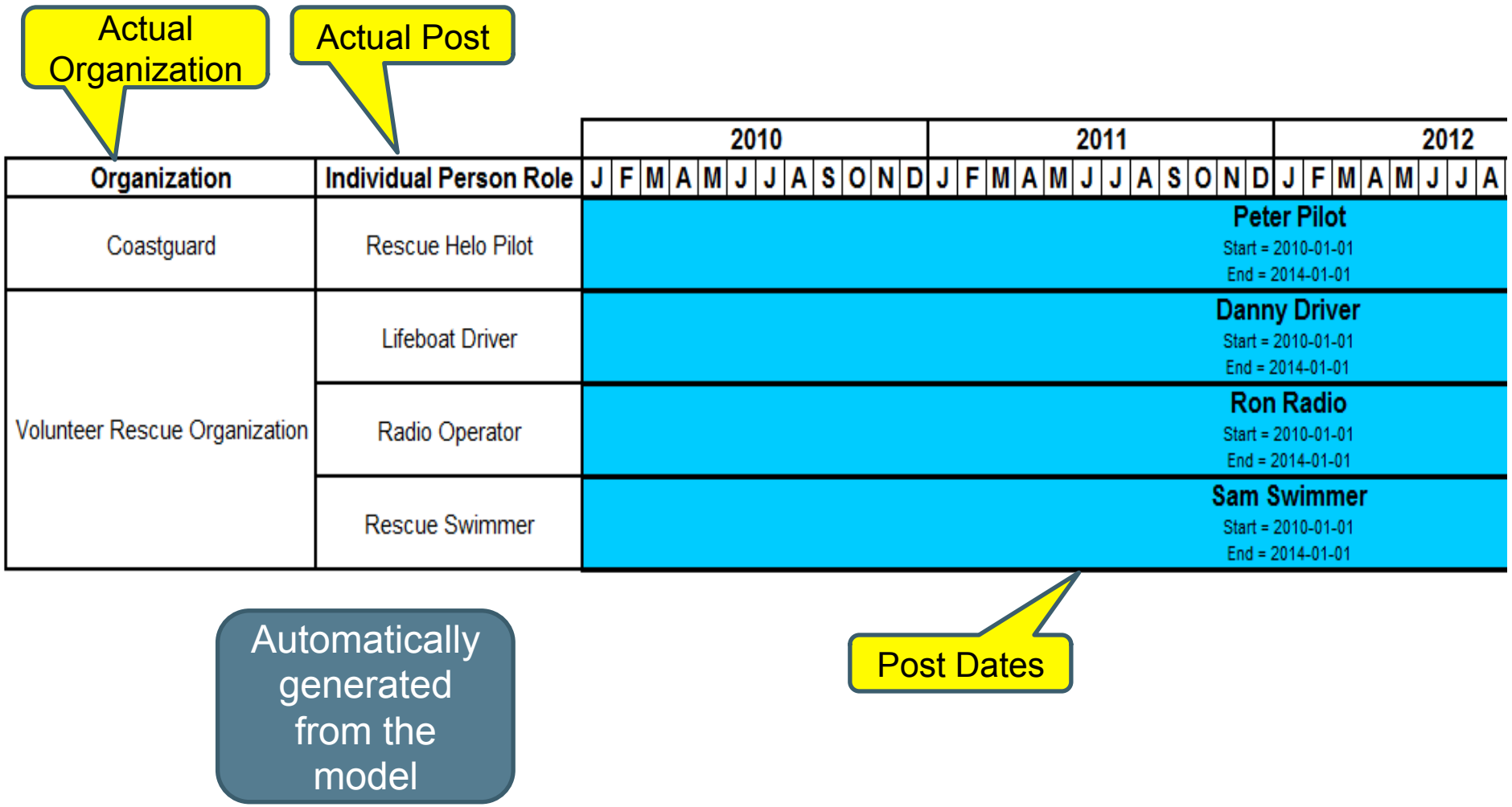
OV-4 Organizational Template



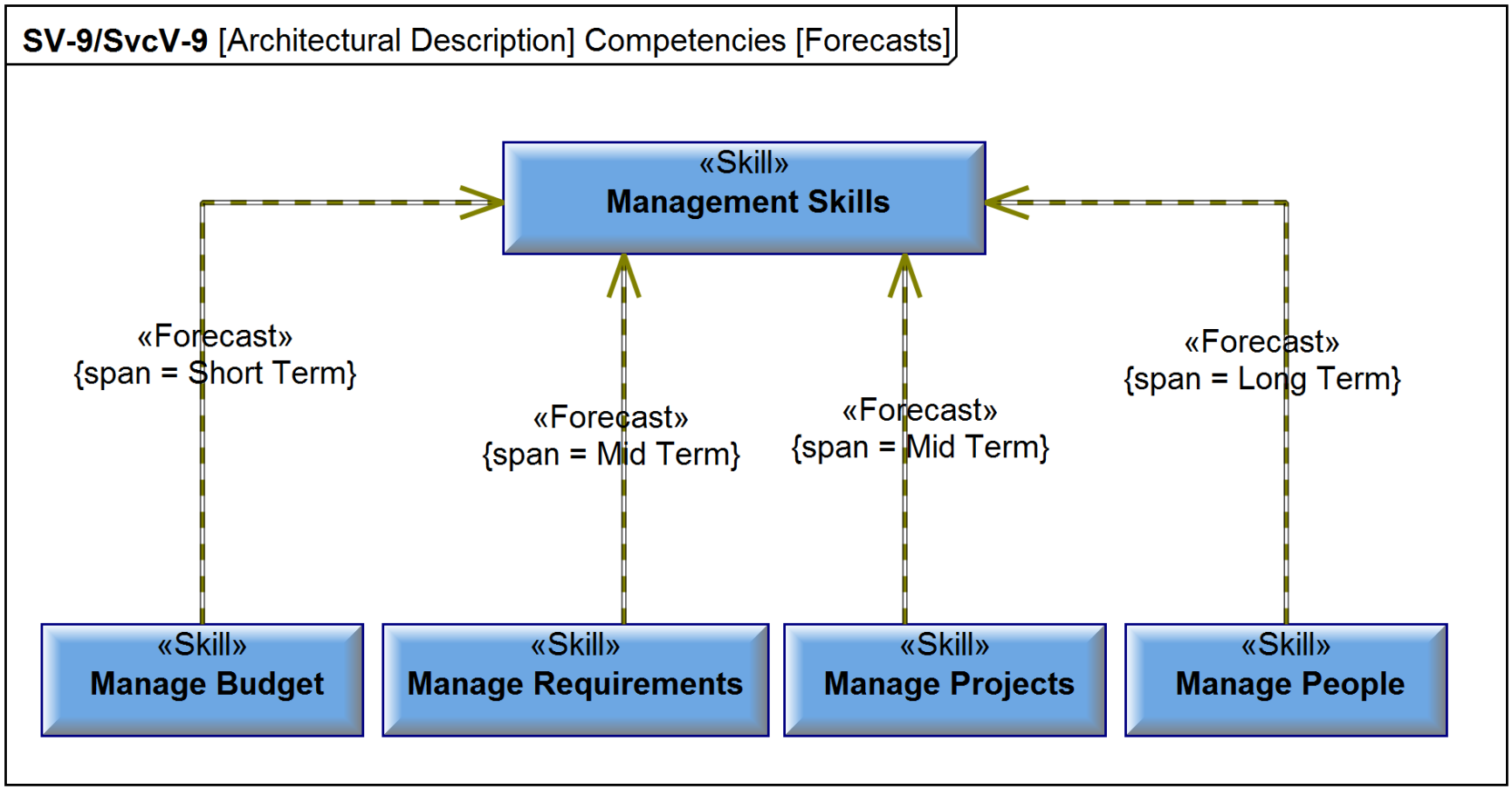
Personnel deployment and competency assessment
OV-4 Actual Organizations



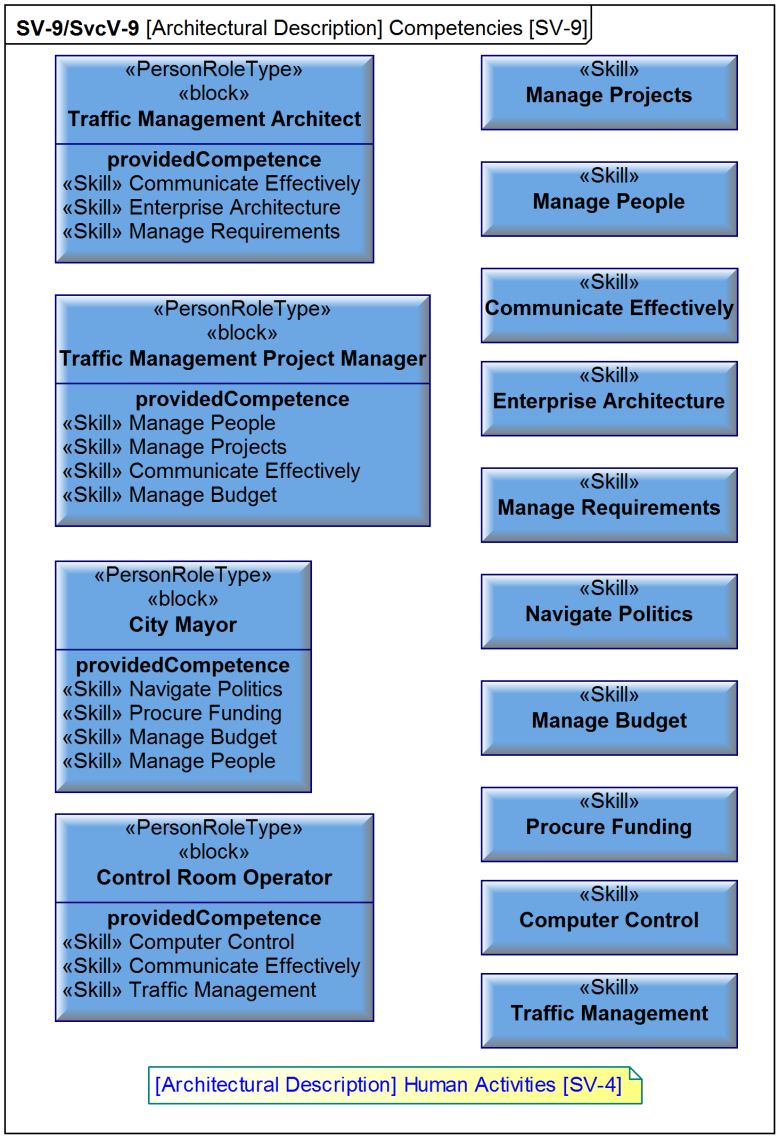
Personnel deployment and competency assessment
OV-4: Actual Organizations Report

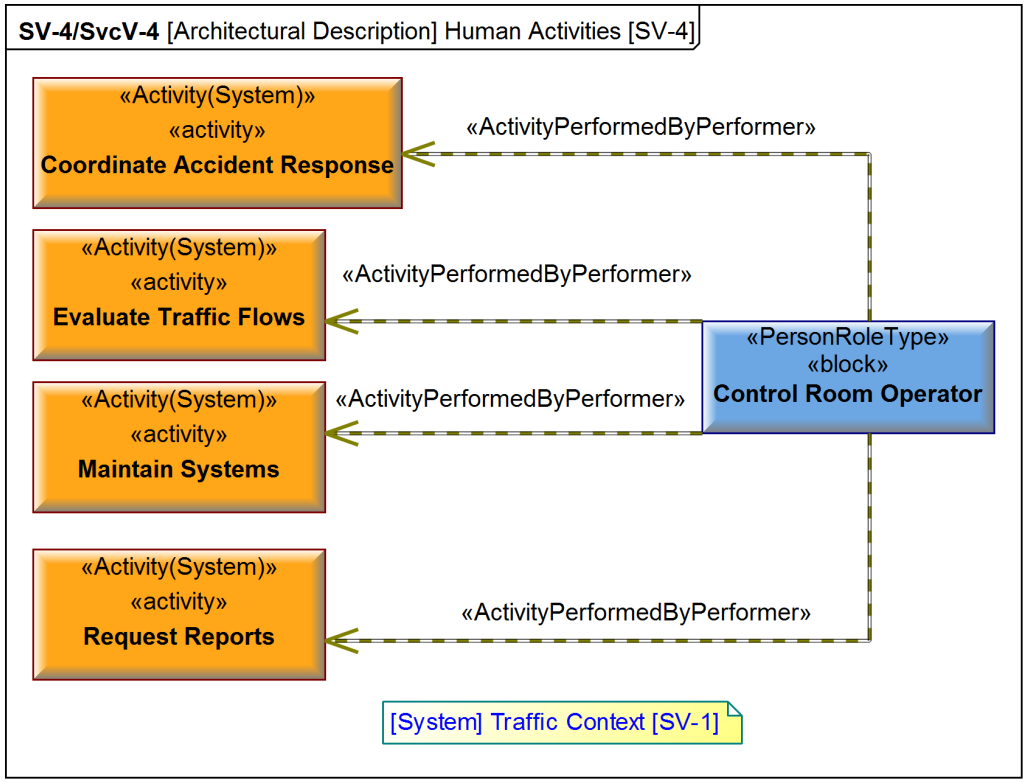


Personnel deployment and competency assessment
Competency Forecasts



Personnel deployment and competency assessment
Definition and Assignment of Competencies and Tasks





Conclusion and Summary

- The latest versions of frameworks such as MODEM and DoDAF 2.0 are based on the ontological concepts in the IDEAS foundation objects.
- These concepts provide the detail necessary to express temporal concepts in precise and testable ways.
- Using tools implementing the UPDM standard, architects now have the tools to build the complex models needed to manage both government and industrial enterprises.
- UPDM tools provide the means to develop these architectures in a more easily accessible format than pure 4-D ontology modeling.
- If the ontological basis is retained the presentation format should not matter and the end goal of semantic interoperability between users using completely different tools with completely different ways of presenting the architecture can be achieved.

Questions, Comments, Discussion?