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SysML - System Modeling Language

Benefits for the Complex Systems of IIoT

Matthew Hause
PTC Engineering Fellow, GTM Technical Specialist

THINGS are Changing

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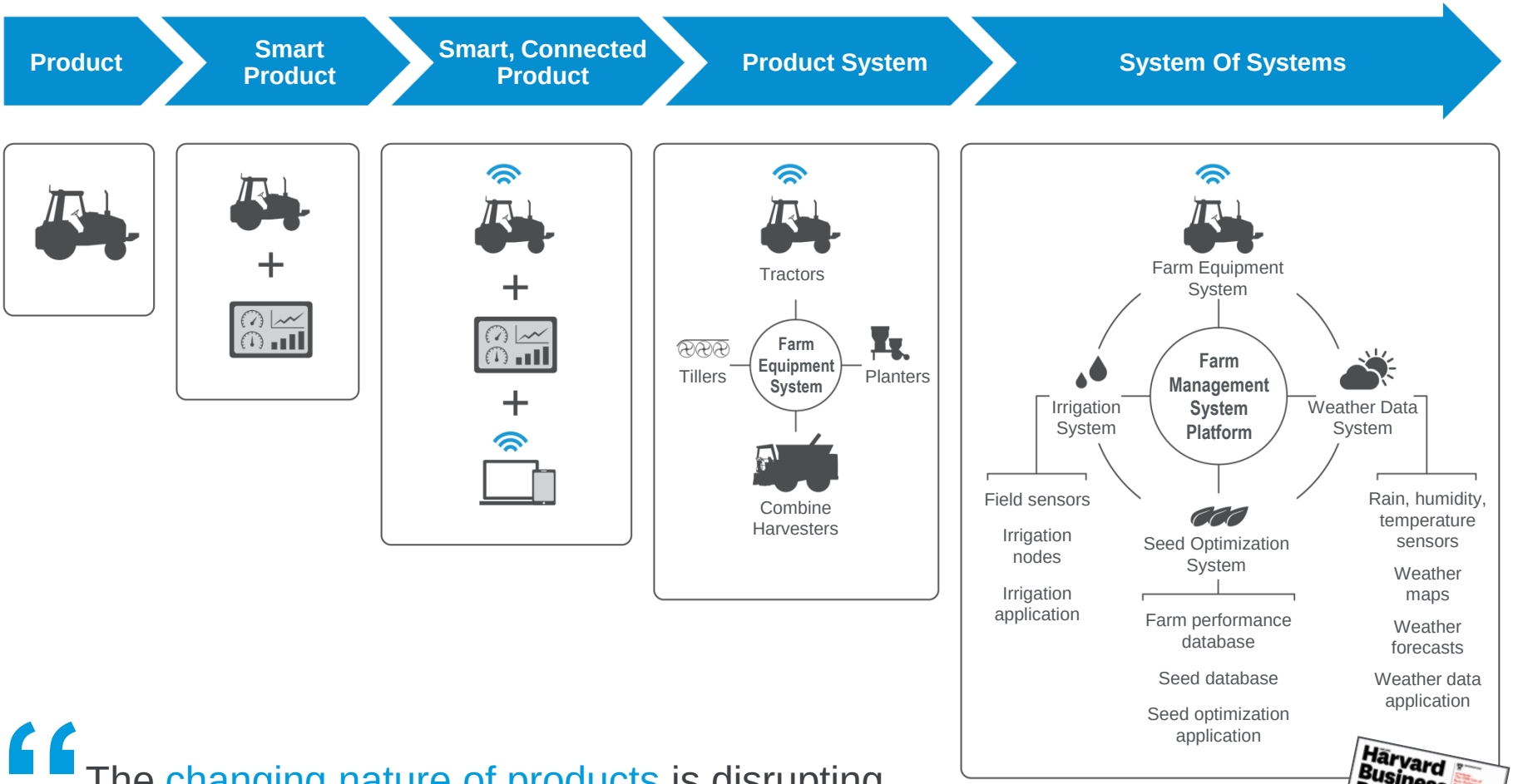
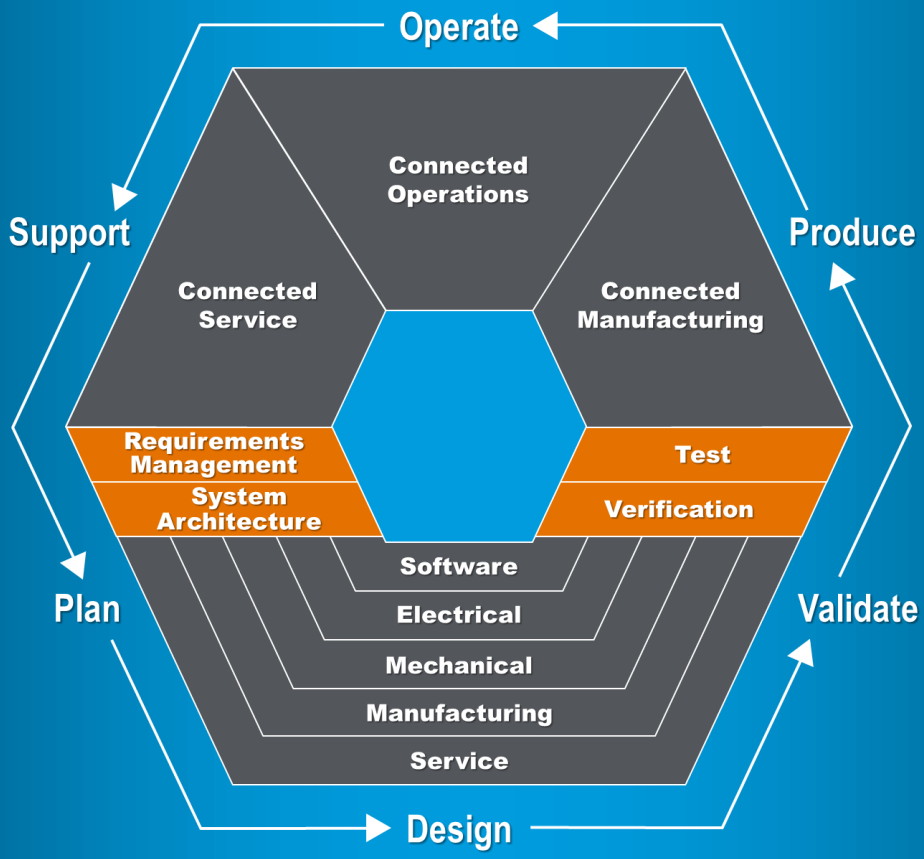


“The changing nature of products is disrupting value chains, forcing companies to rethink and retool nearly everything they do internally.”

Systems Engineering is…

A **holistic**, **multi-disciplinary** and collaborative approach to designing and maintaining **complex** systems.



Model-Based Engineering

INCOSE
International Council on Systems Engineering

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- Model-based Systems Engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing through-out development and later lifecycle phases." (INCOSE, 2007).
- Modeling is at the heart of all aspects of the development effort
  - Covers the complete product and project lifecycle
  - Has a direct effect on any generated artifacts.
  - MBE encompasses architecture, systems and software development.

Changes in Systems Engineering Practice

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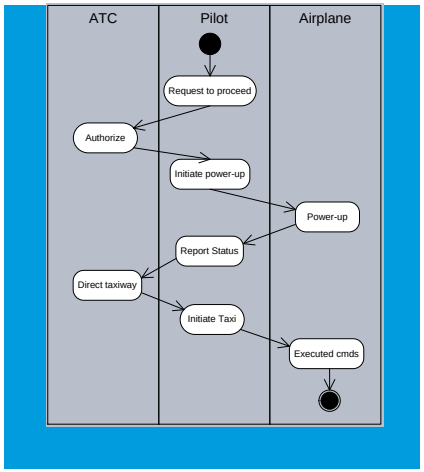
Change from Document centric to Model centric

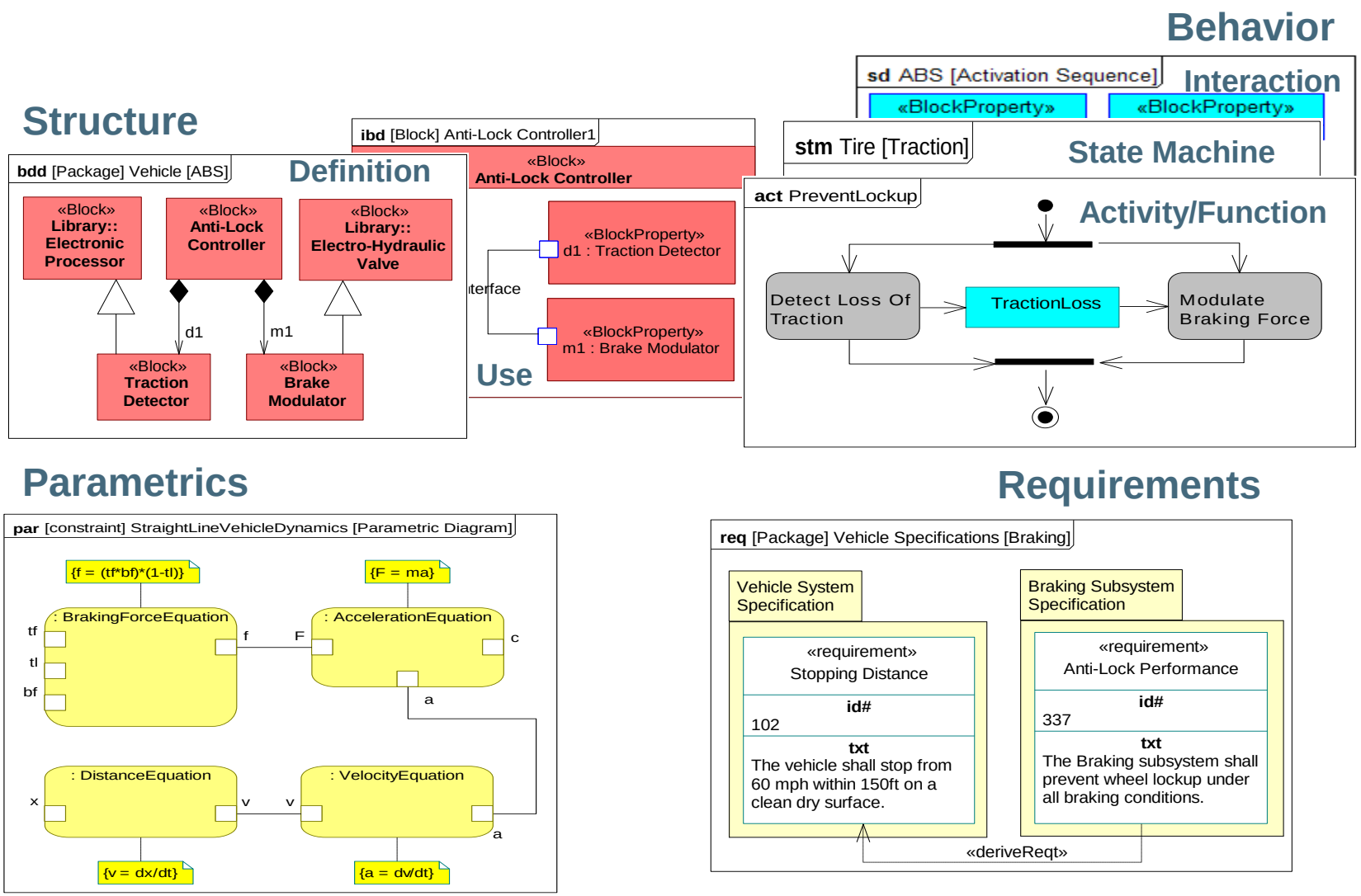
Requirement Specifications
Interface Definitions
System Architecture
System Functionality
Trade-off Analysis
Test Specifications
Etc.



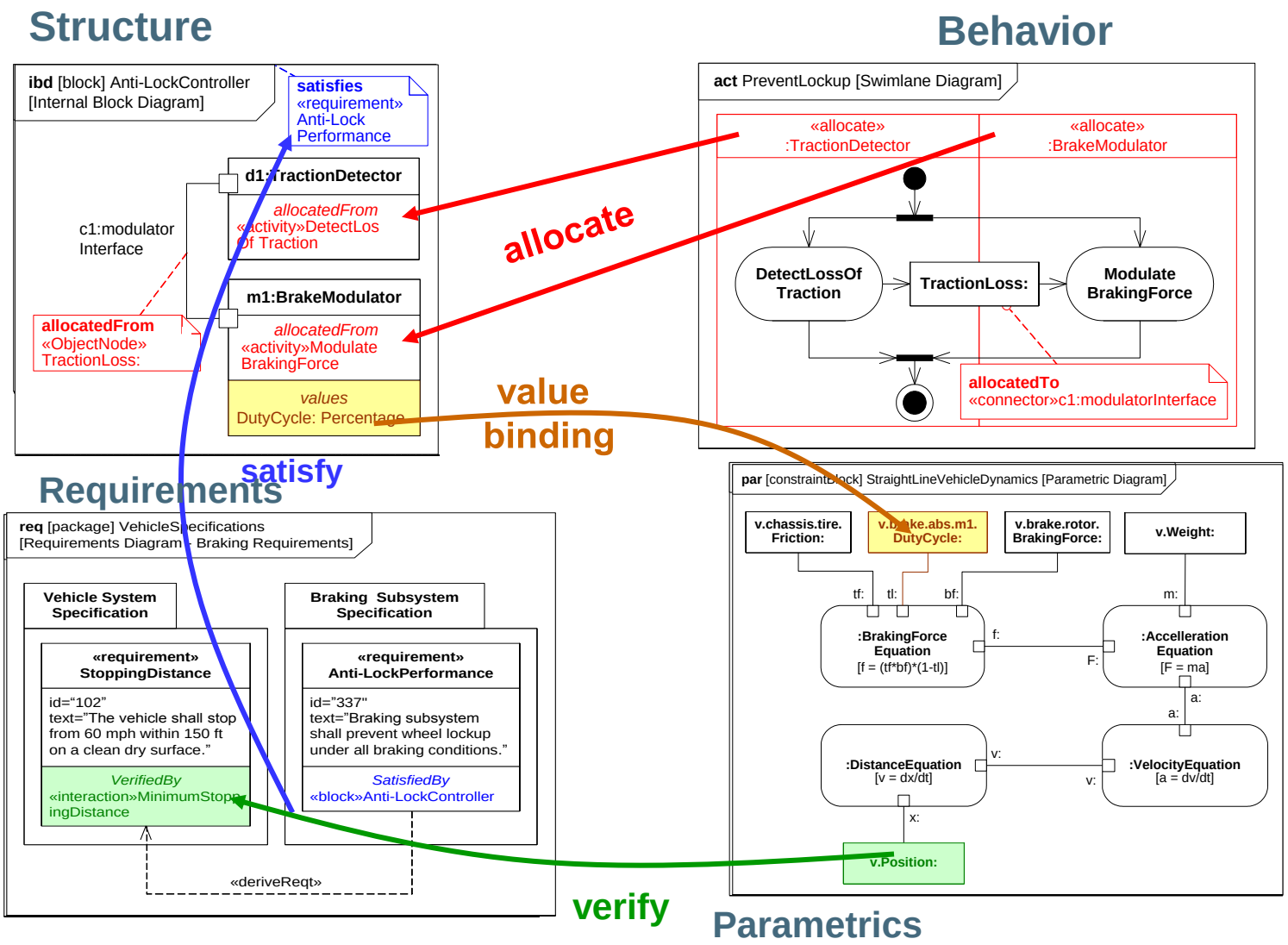
Old Approach

New Approach

The Four Pillars of SysML



Cross Connecting Model Elements

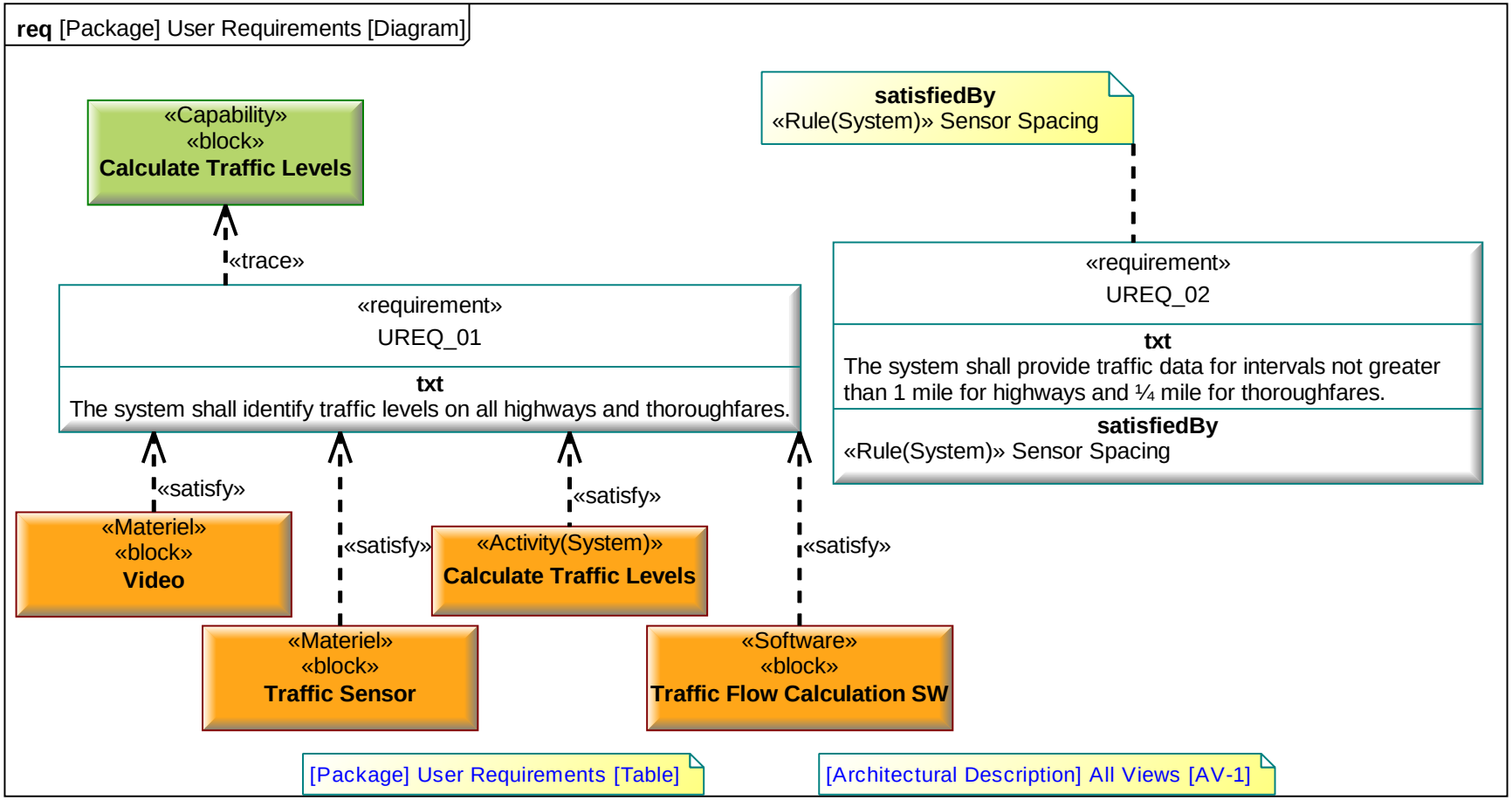


Problem Statement for Traffic Management System

- 1. General Background

The city of Autoville has just elected a new city council with a mandate to reduce traffic on the highways and thoroughfares. After receiving a grant of $200M from the federal government, they have decided to acquire a traffic management system to help them identify areas and times of high traffic density so they can take measures to alleviate the effects of it. The city of Autoville has 100 miles of highway with 10 interchanges and 300 miles of thoroughfares with 100 major intersections. Systems will include controlled parking facilities, availability monitoring and dissemination, emergency management, traffic control and prediction, and support for electric vehicles.

SysML Requirements Diagram



Requirements Traceability Table

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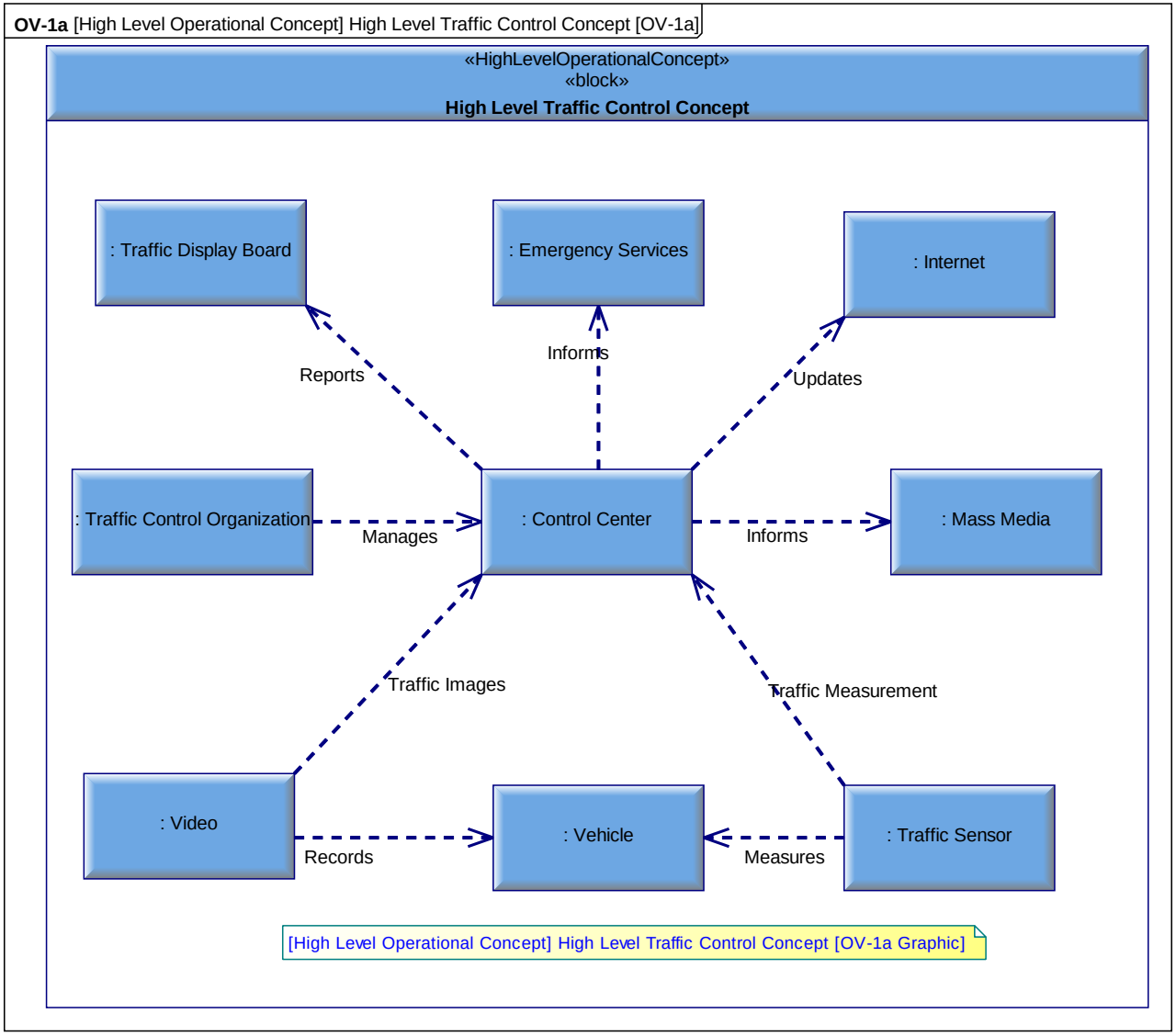
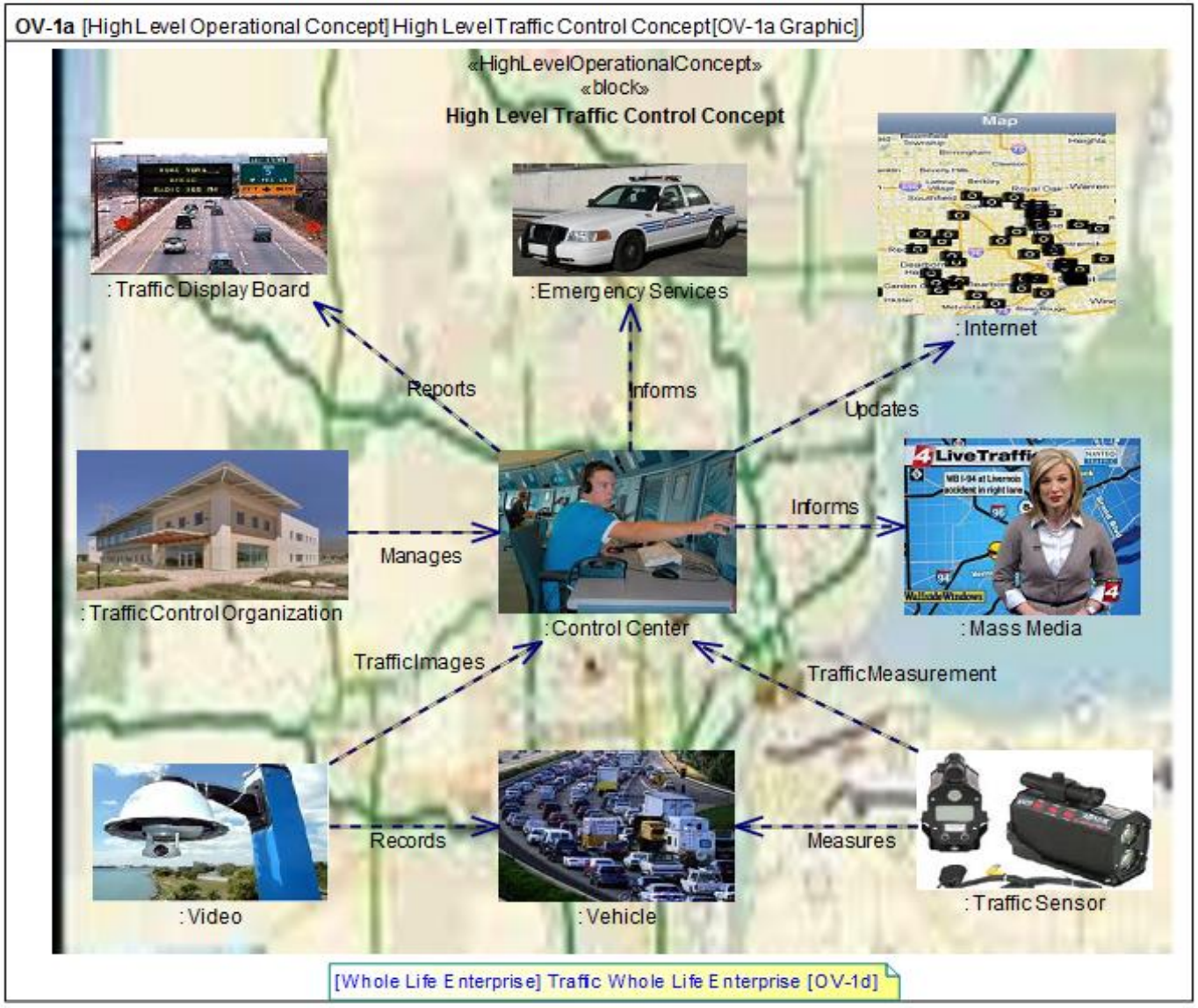
A	B	C	D	E	F
[Package] User Requirements [Table]					
	Name	**Txt**	**Rationale**	**Satisfied By**	**Traces To**
	UREQ_01	The system shall identify traffic levels on all highways and thoroughfares.		«Software» Traffic Flow Calculation SW (Autoville Traffic Management Architecture::System Views::Resources::Software) «Materiel» Video (Autoville Traffic Management Architecture::System Views::Resources::Materiel) «Materiel» Traffic Sensor (Autoville Traffic Management Architecture::System Views::Resources::Materiel) «Activity(System)» Calculate Traffic Levels (Autoville Traffic Management Architecture::System Views::System Activities::System Software Activities)	«Capability» Calculate Traffic Levels (Autoville Traffic Management Architecture::Enterprise Views::Capabilities)
	UREQ_02	The system shall provide traffic data for intervals not greater than 1 mile for highways and ¼ mile for thoroughfares.		«Rule(System)» Sensor Spacing (Autoville Traffic Management Architecture::System Views::Resources::Materiel::Traffic Sensor)	
	UREQ_03	The system shall provide traffic data that is no more than 5 minutes old.		«Rule(System)» Update Rate (Autoville Traffic Management Architecture::System Views::Resources::Materiel::Traffic Sensor) «Rule(System)» Traffic Data Update Interval (Autoville Traffic Management Architecture::System Views::System Activities::System Software Activities::Send Traffic Report)	
	UREQ_04	The system shall record traffic data for 30 days.		«Software» Traffic Data Archive SW (Autoville Traffic Management Architecture::System Views::Resources::Software) «Rule(System)» Traffic Data Archive Capacity (Autoville Traffic Management Architecture::System Views::Resources::Software::Traffic Data Archive SW)	

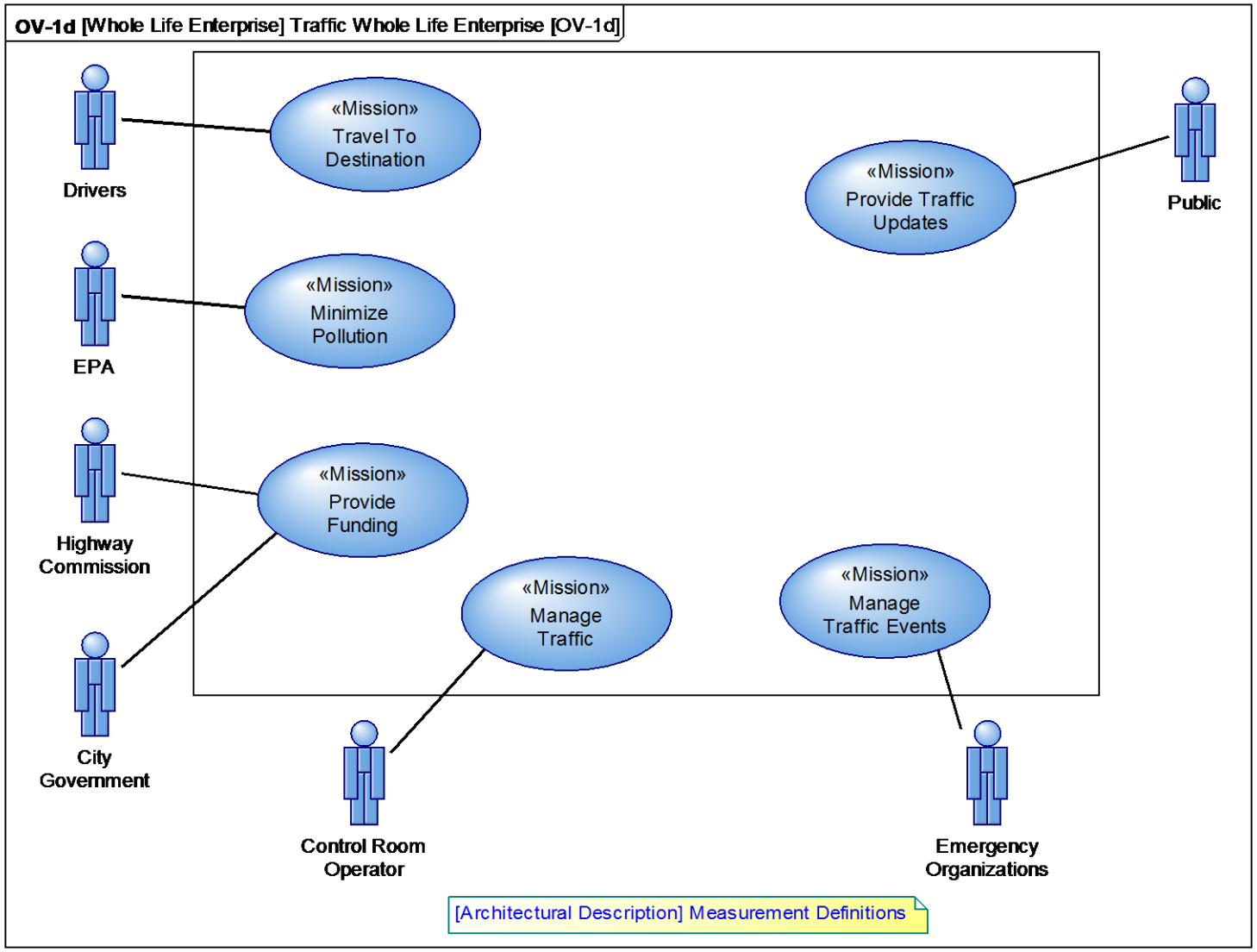
Operational Concept with Boxes



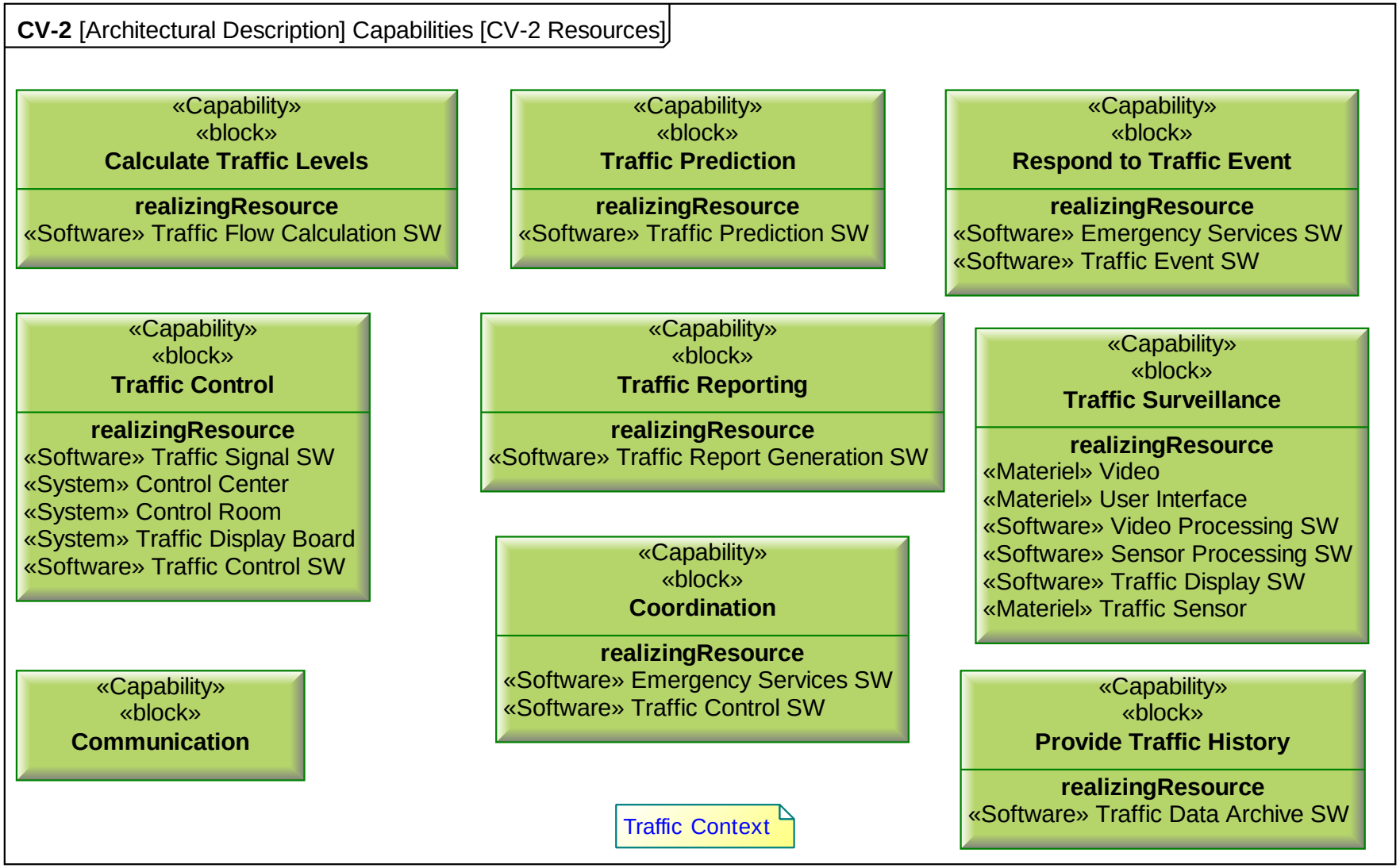
Operational Concept with Graphics



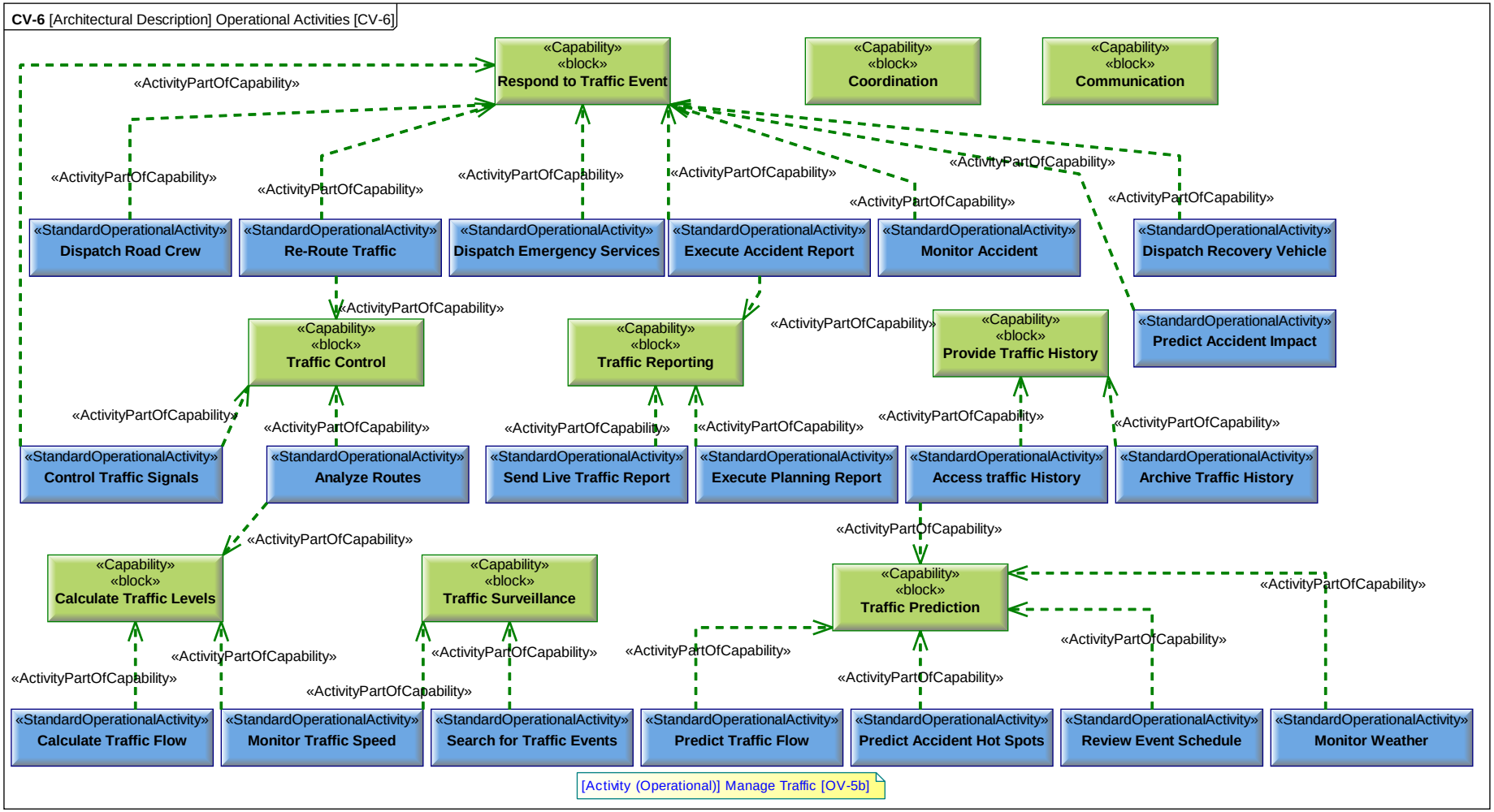
Traffic Management Use Cases and Stakeholders



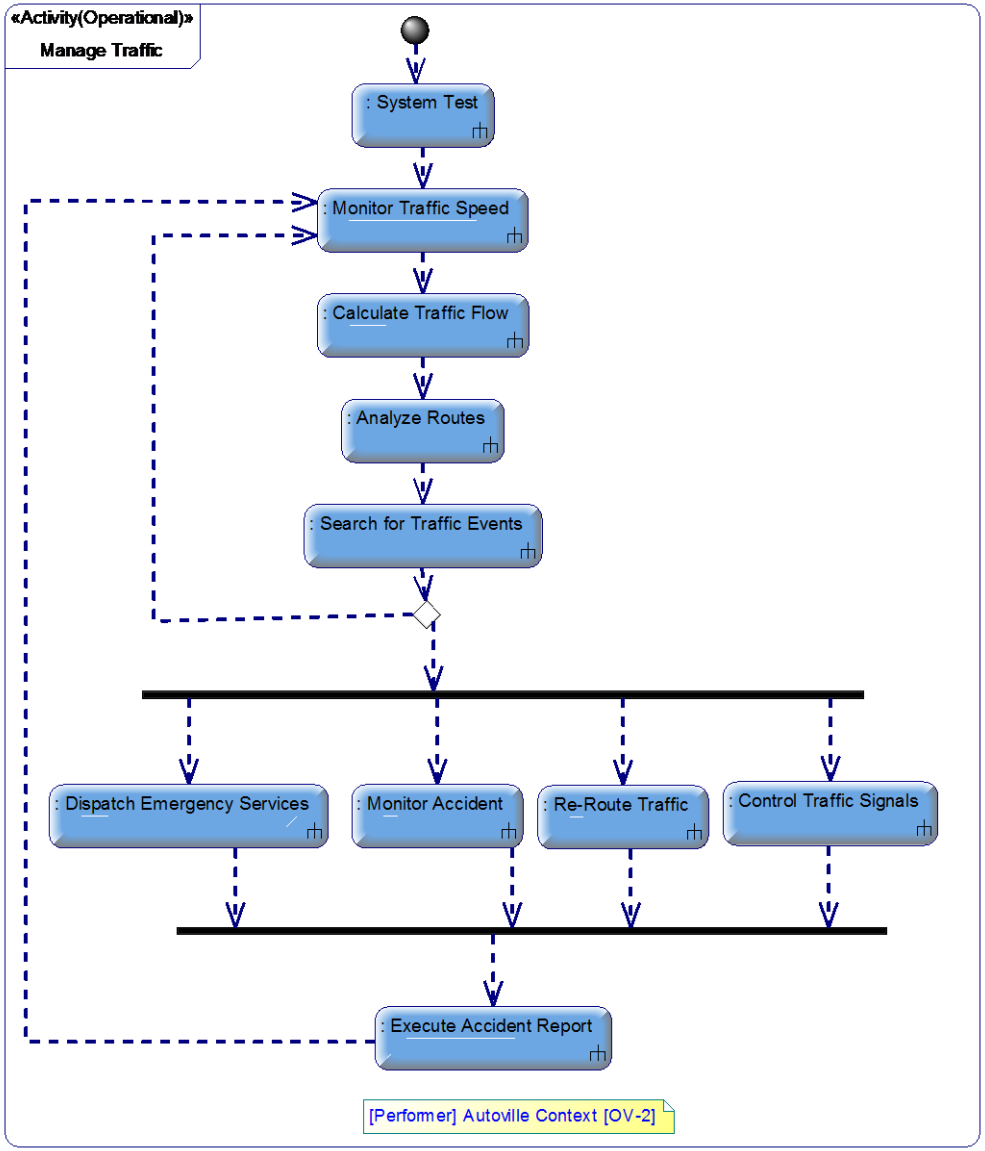
Capability Taxonomy with Implementing Resources



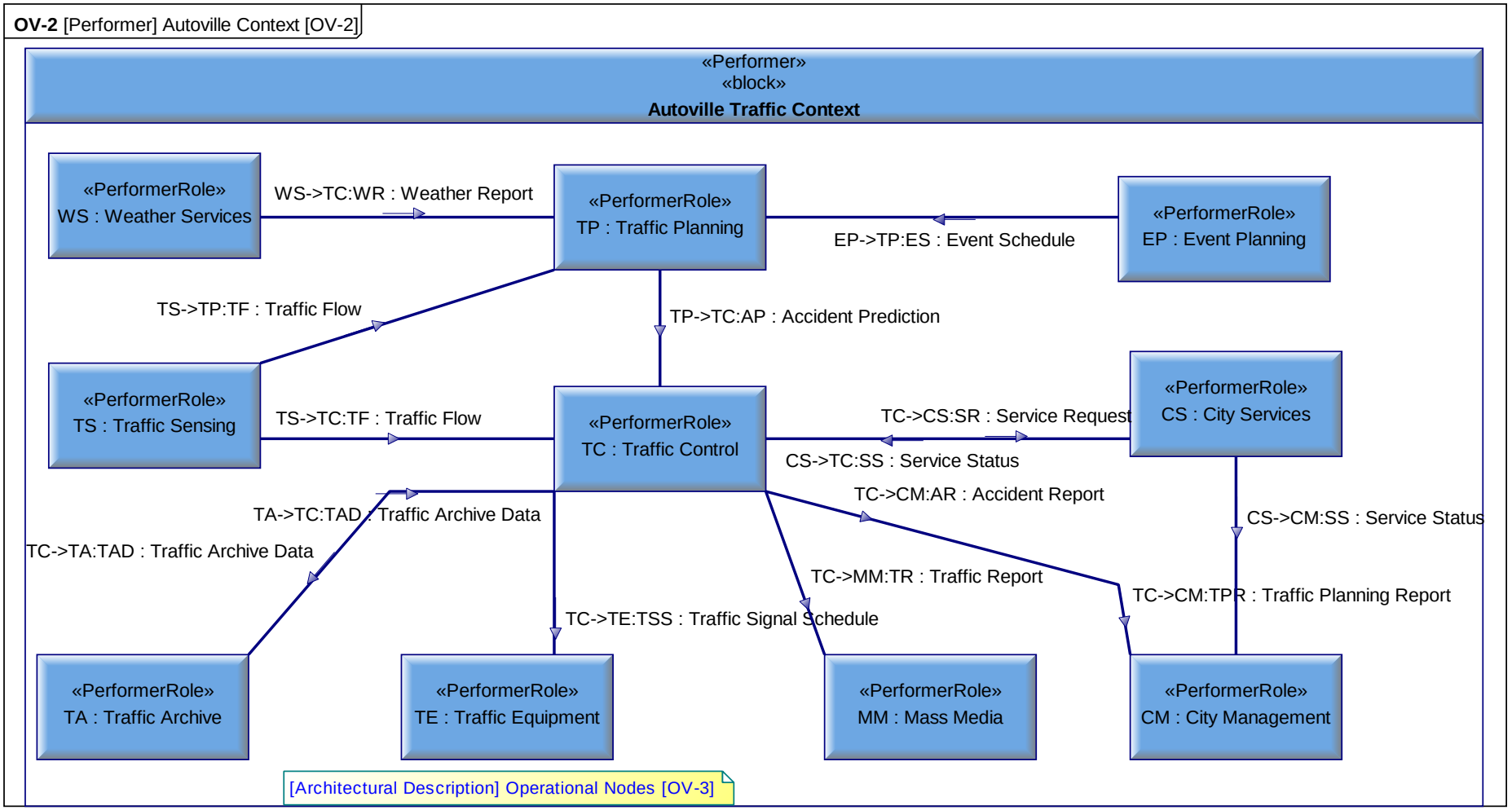
Capability to Activity Mapping



Manage Traffic Activity Sequence



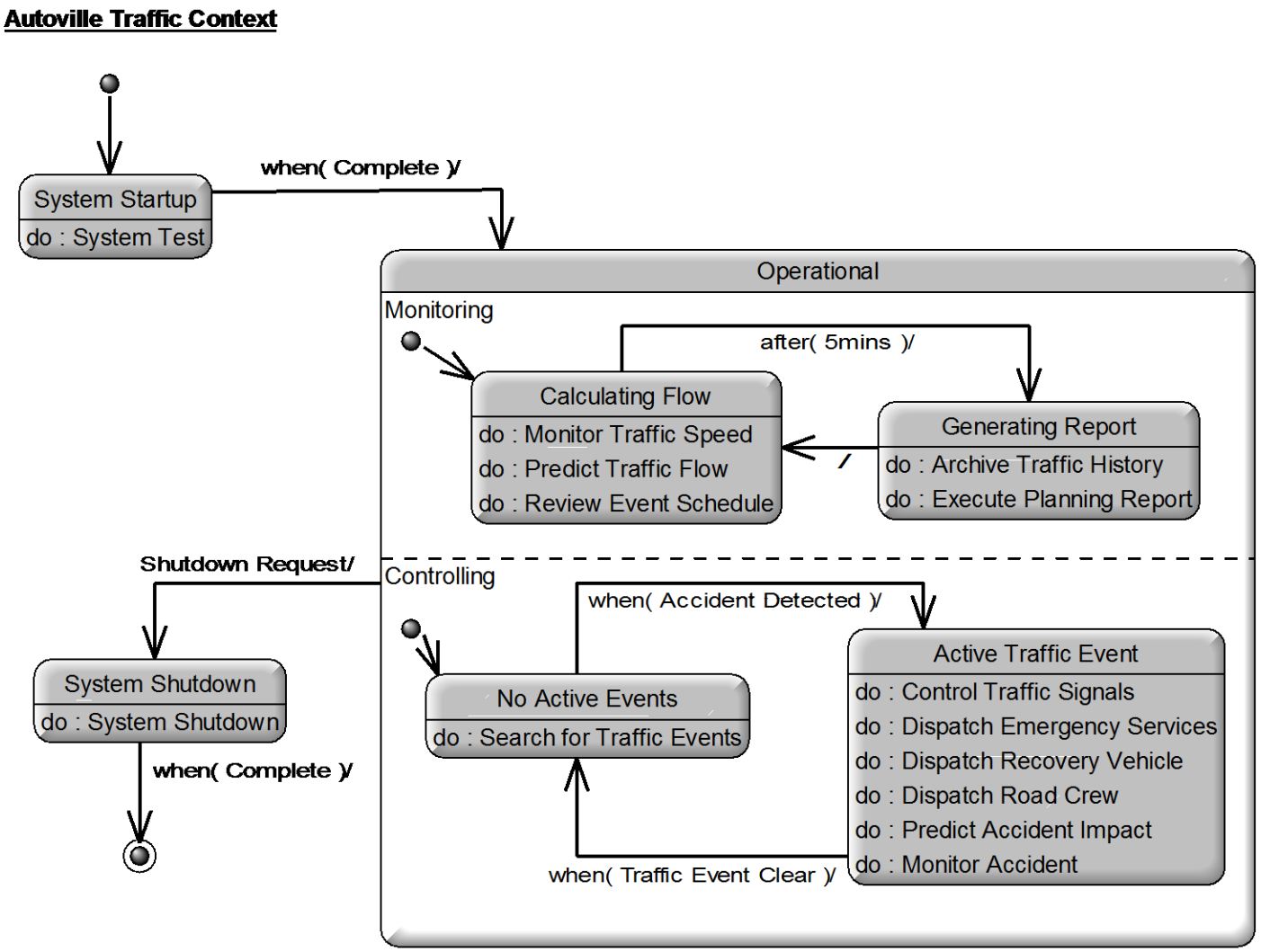
Operational Structure



Interaction Summary (ICD)

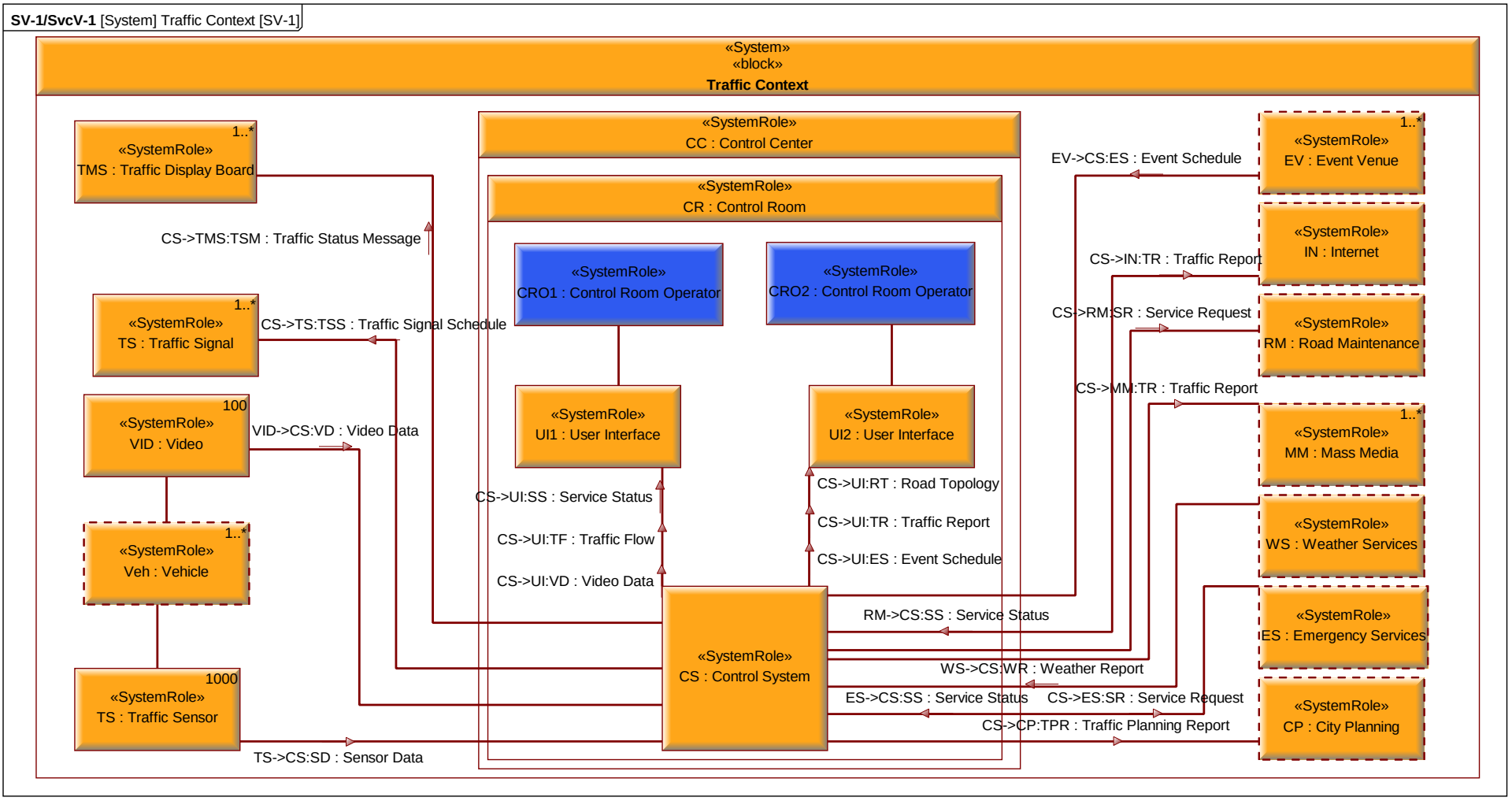
Information Exchange		Producer		Needline	Consumer	
Name	Conveyed	Perfomer	Activity (Operational)	Name	Perfomer	Activity (Operational)
CS->CM:SS	«Information Element» Service Status	«Performer» City Services		CS - CM	«Performer» City Management	
CS->TC:SS	«Information Element» Service Status	«Performer» City Services		CS - TC	«Performer» Traffic Control	
EP->TP:ES	«Information Element» Event Schedule	«Performer» Event Planning		EP - TP	«Performer» Traffic Planning	
TA->TC:TAD	«Information Element» Traffic Archive Data	«Performer» Traffic Archive		TA - TC	«Performer» Traffic Control	
TC->CM:AR	«Information Element» Accident Report	«Performer» Traffic Control		CM - TC	«Performer» City Management	
TC->CM:TPR	«Information Element» Traffic Planning Report	«Performer» Traffic Control		CM - TC	«Performer» City Management	
TC->CS:SR	«Information Element» Service Request	«Performer» Traffic Control		CS - TC	«Performer» City Services	
TC->MM:TR	«Information Element» Traffic Report	«Performer» Traffic Control		TC - M	«Performer» Mass Media	
TC->TA:TAD	«Information Element» Traffic Archive Data	«Performer» Traffic Control		TA - TC	«Performer» Traffic Archive	
TC->TE:TSS	«Information Element» Traffic Signal Schedule	«Performer» Traffic Control		TC - TE	«Performer» Traffic Equipment	
TP->TC:AP	«Information Element» Accident Prediction	«Performer» Traffic Planning		TP - TC	«Performer» Traffic Control	
TS->TC:TF	«Information Element» Traffic Flow	«Performer» Traffic Sensing		TS - TC	«Performer» Traffic Control	
TS->TP:TF	«Information Element» Traffic Flow	«Performer» Traffic Sensing		TP - TS	«Performer» Traffic Planning	
WS->TC:WR	«Information Element» Weather Report	«Performer» Weather Services		WS - TP	«Performer» Traffic Planning	

Operational Modes

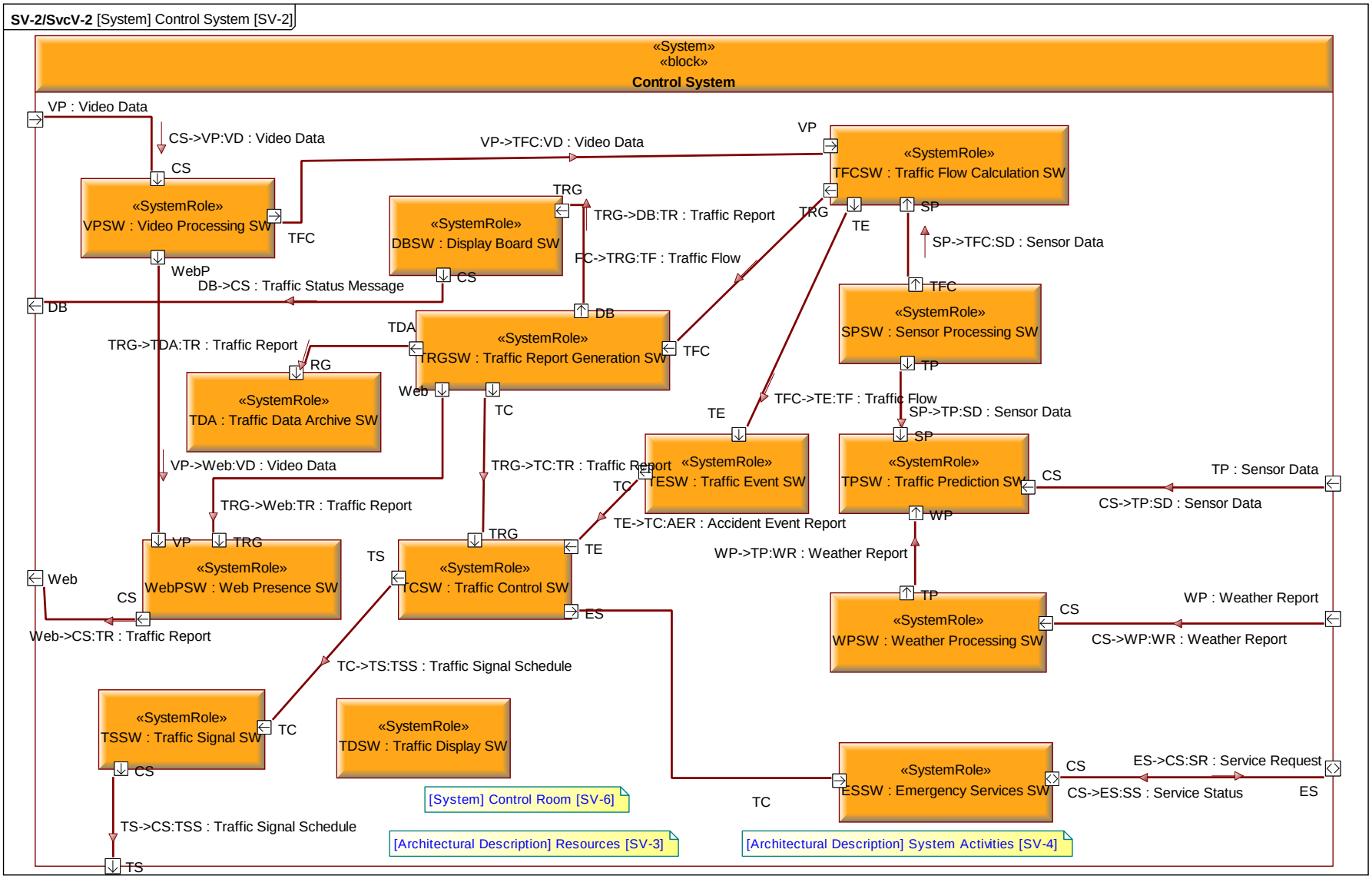


[Architectural Description] Typical Organizations [OV-4 Typical]

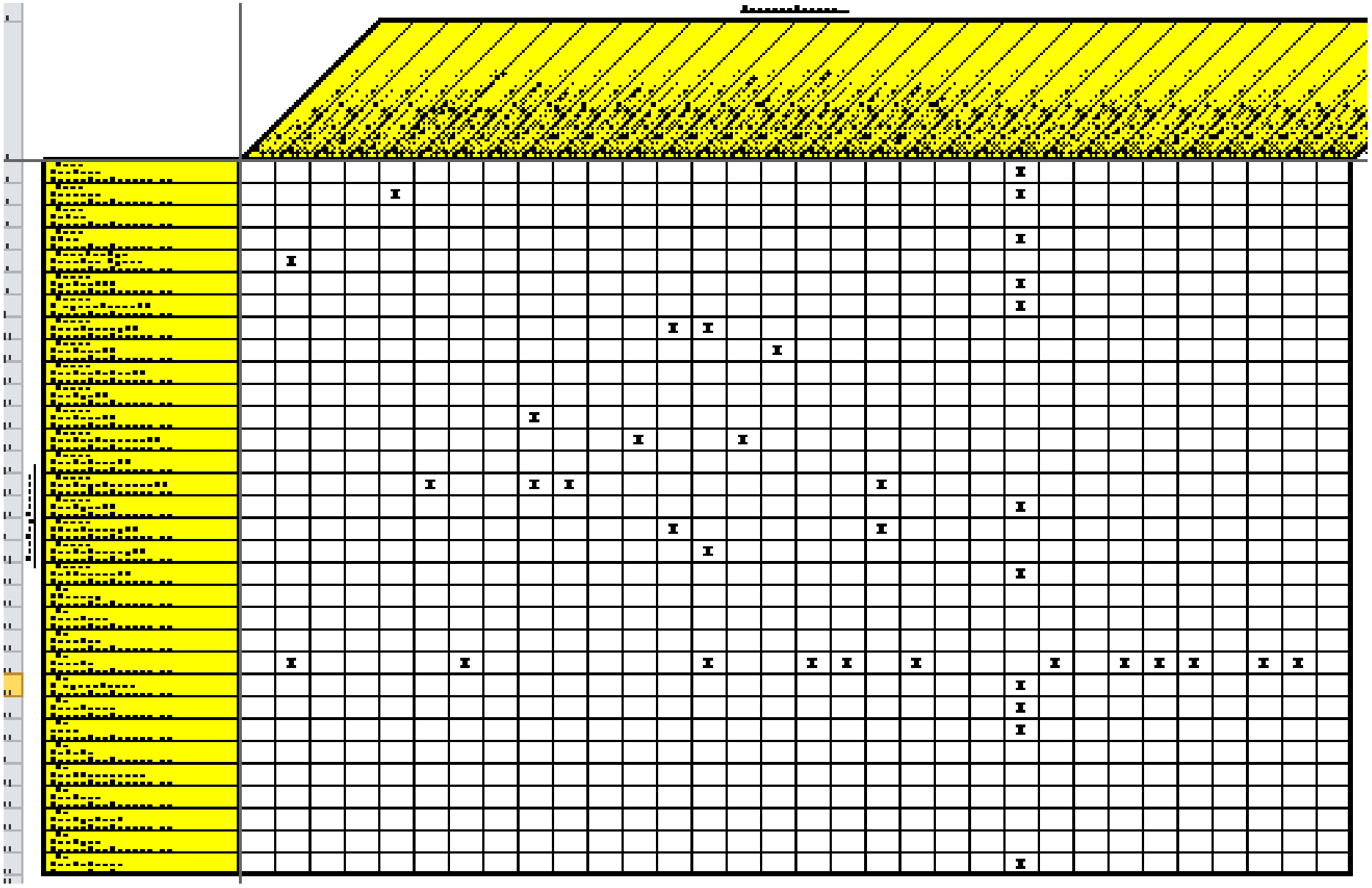
Traffic Management Systems



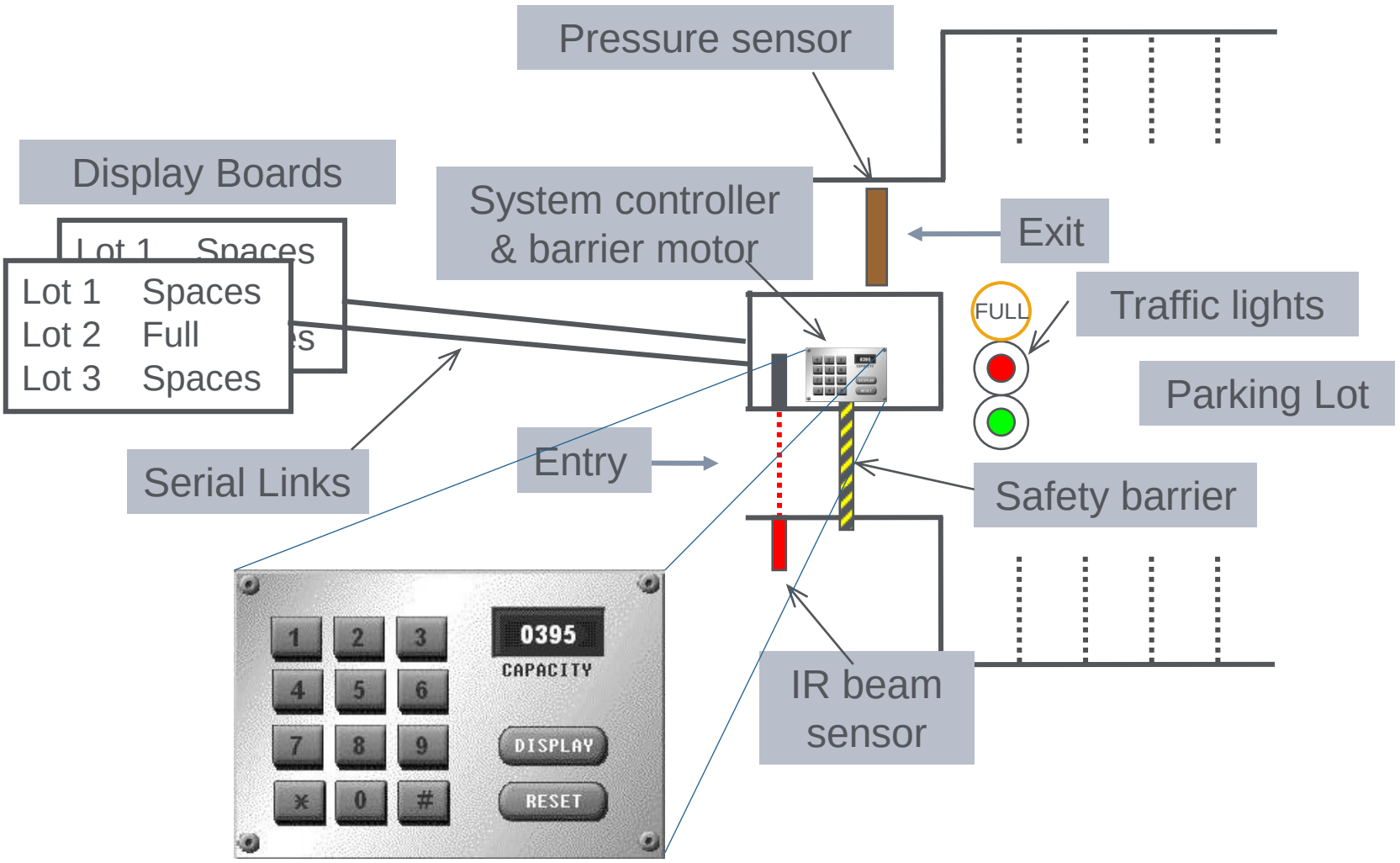
Software Interfaces and Interactions



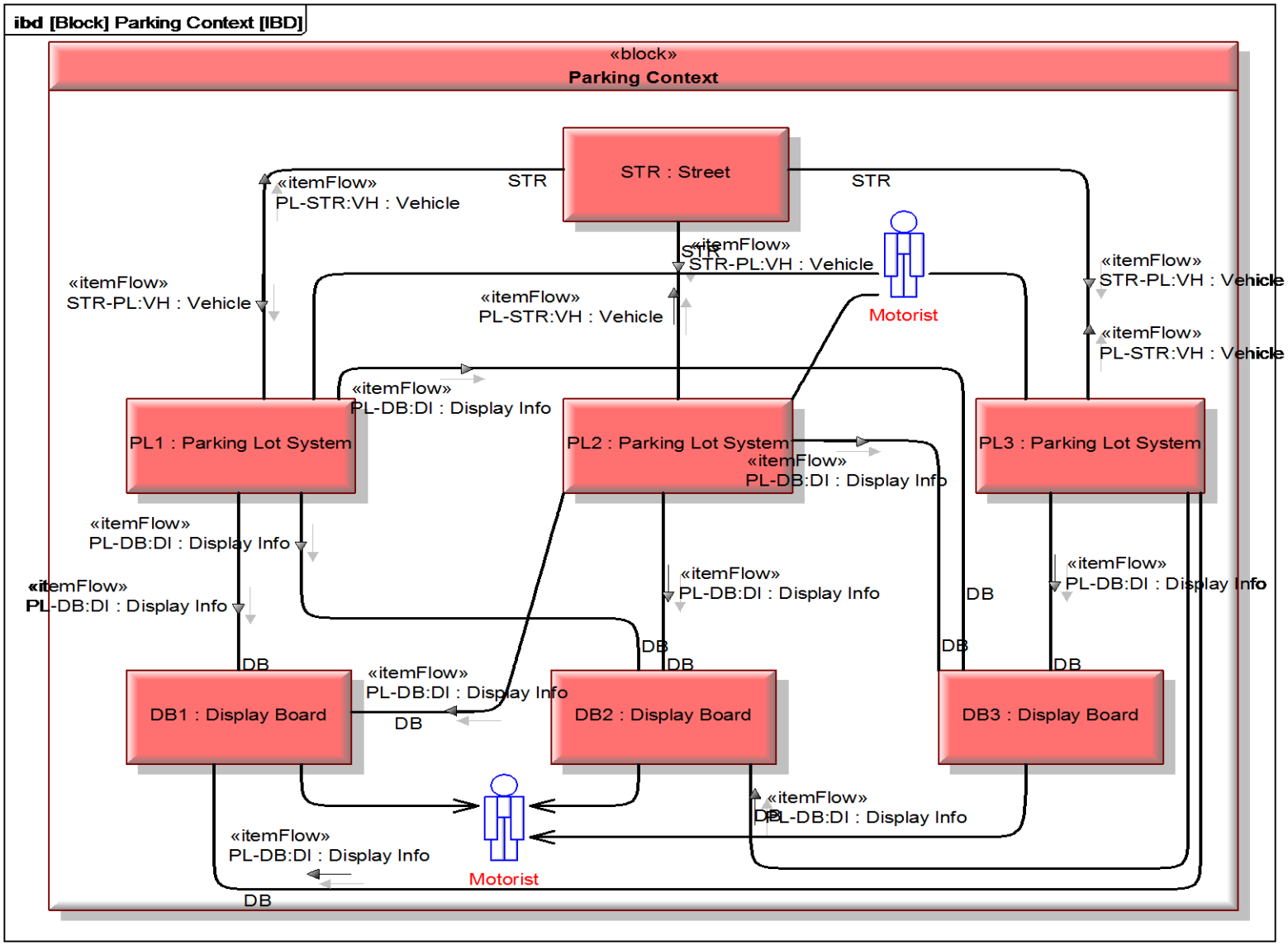
System Connection Matrix – N^2



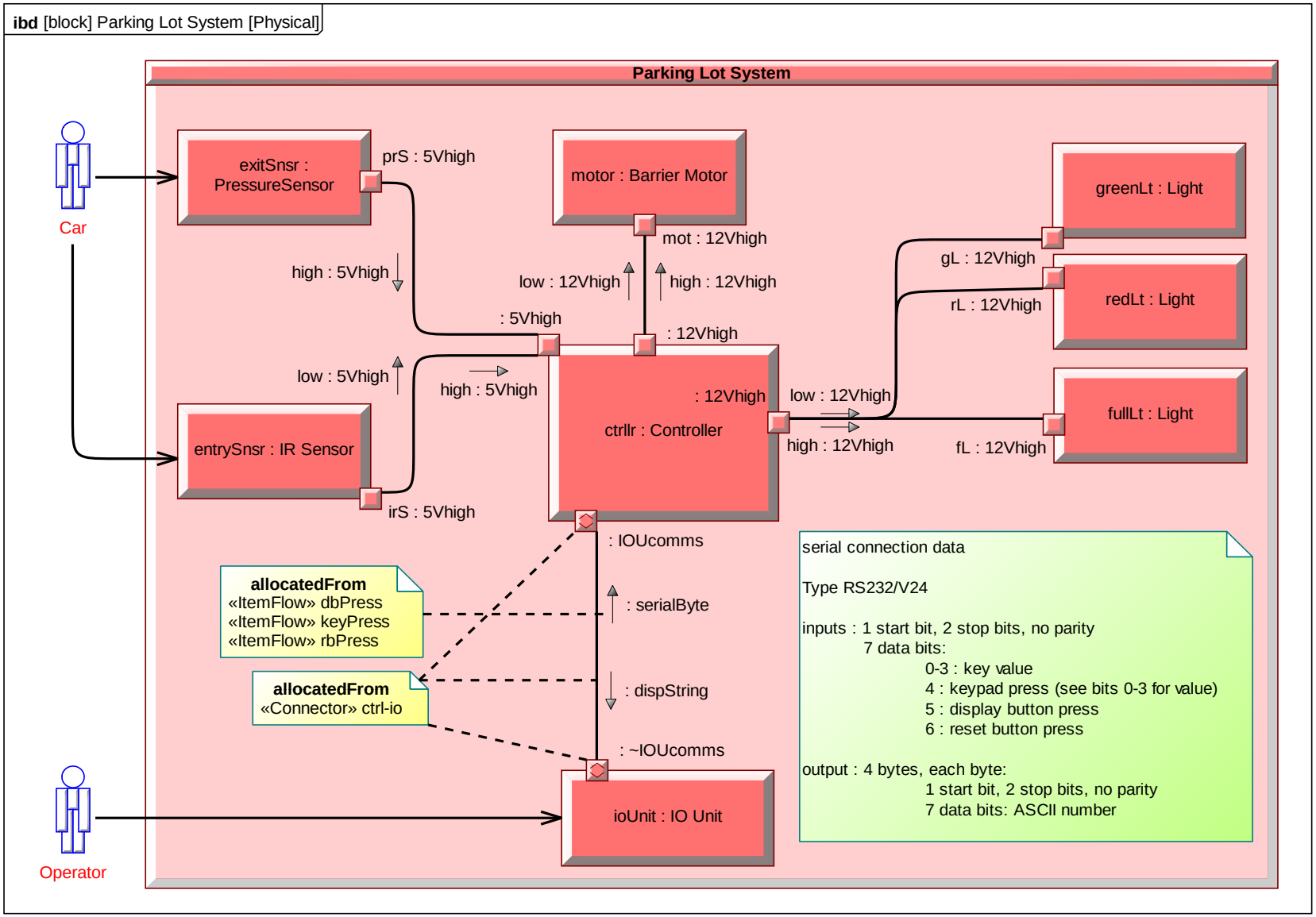
Parking Lot System With Charging Stations



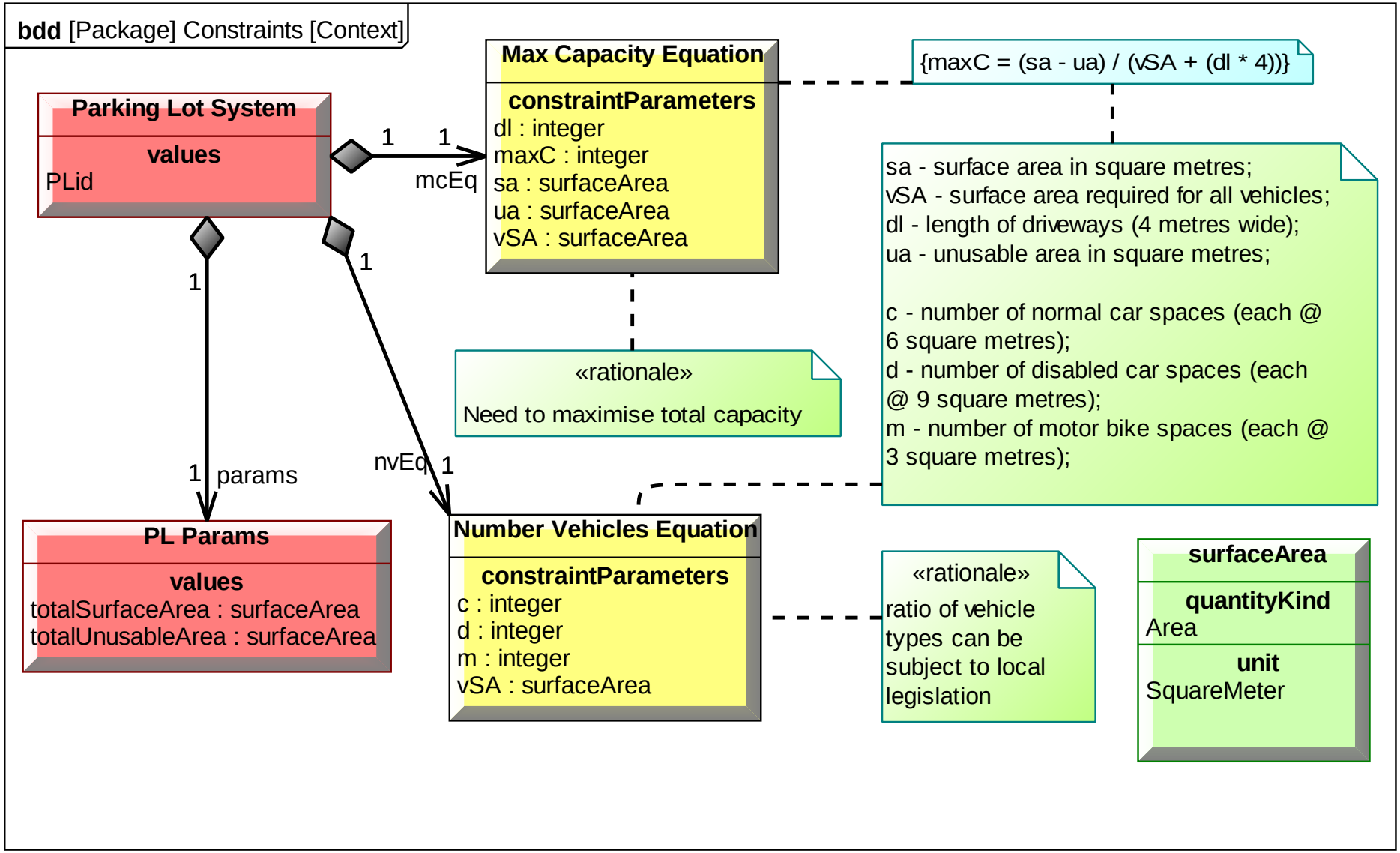
Parking Control Context



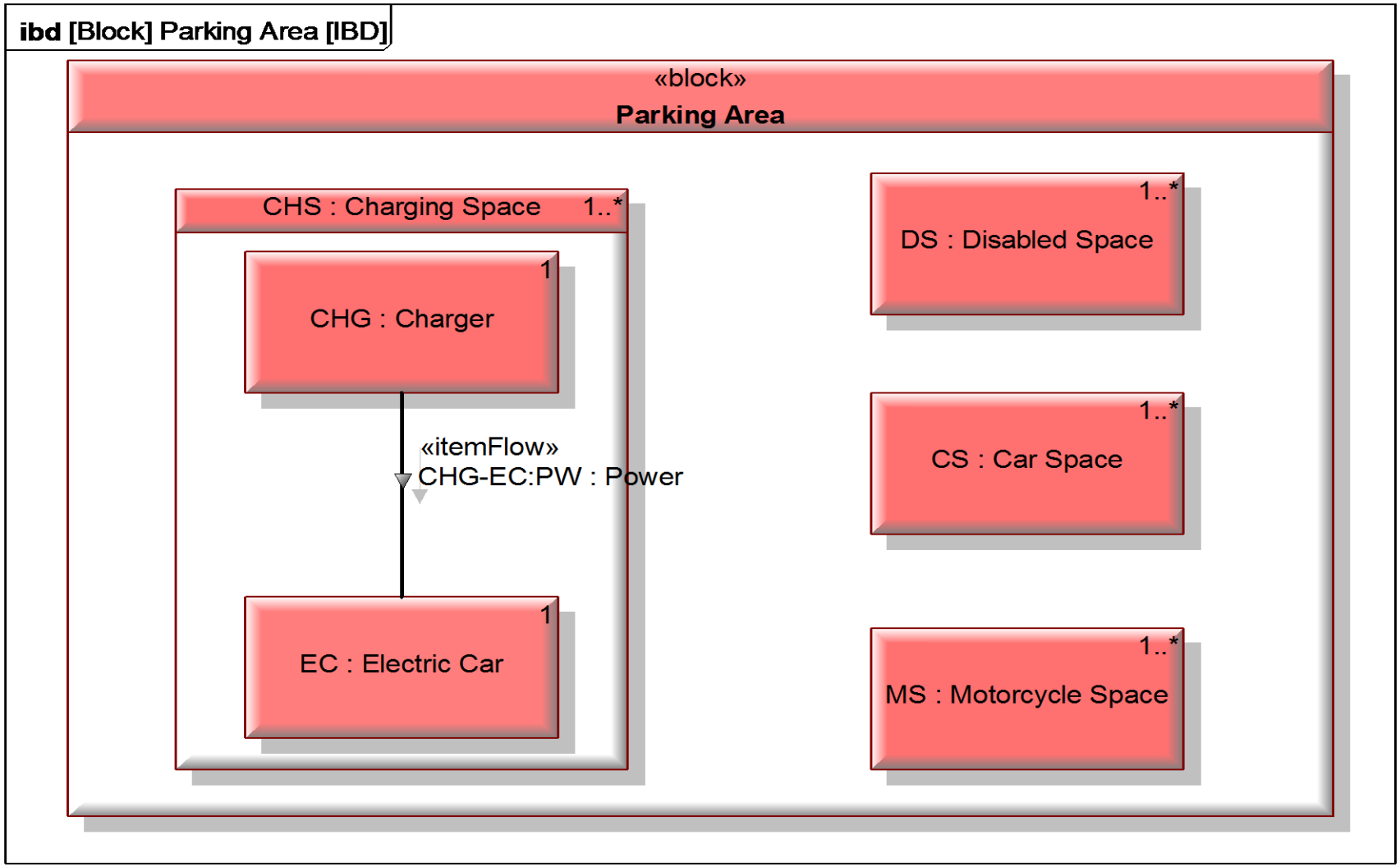
Parking Lot System Model



Example - Parametrics Context



Parking Area with Charging Space



ThingWorx Platform

ThingWorx
A PTC Business

IoT Platform

Connectivity
Connectivity and Device Management

Device Cloud
Private Device Cloud

Application Enablement
Application Enablement Platform

Composer
Rapid Application Development and Graphical User Interface Builder

Federated Deployments
Deploy how you like

Marketplace
Smart Extensions and Applications

Cassandra
Big data for operational data

ColdLight
Machine learning and predictive analytics

Predictive Analytics COLDLIGHT A PTC Business

Augmented Reality*

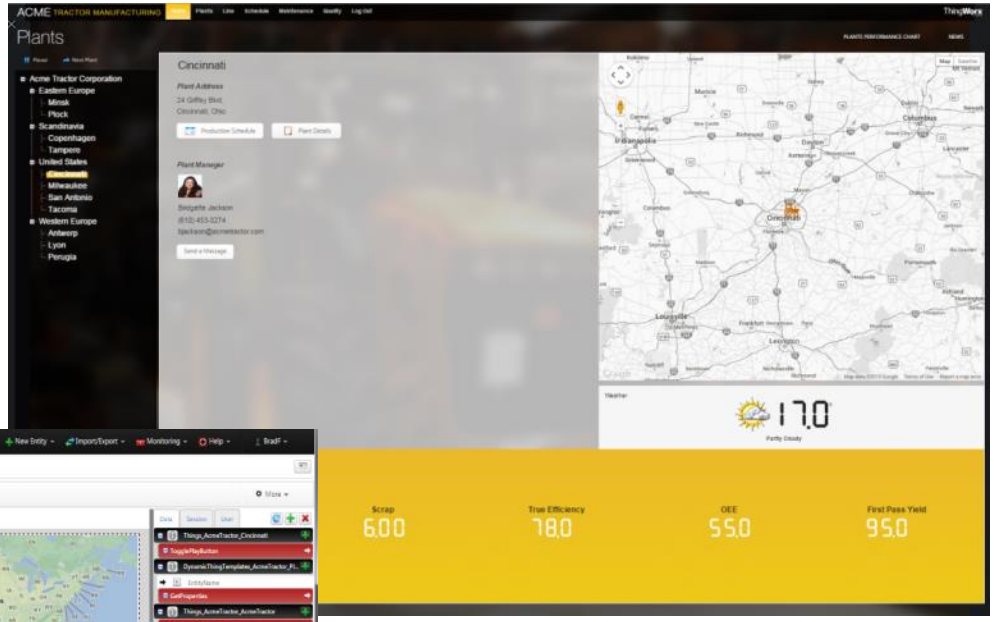
*Beta

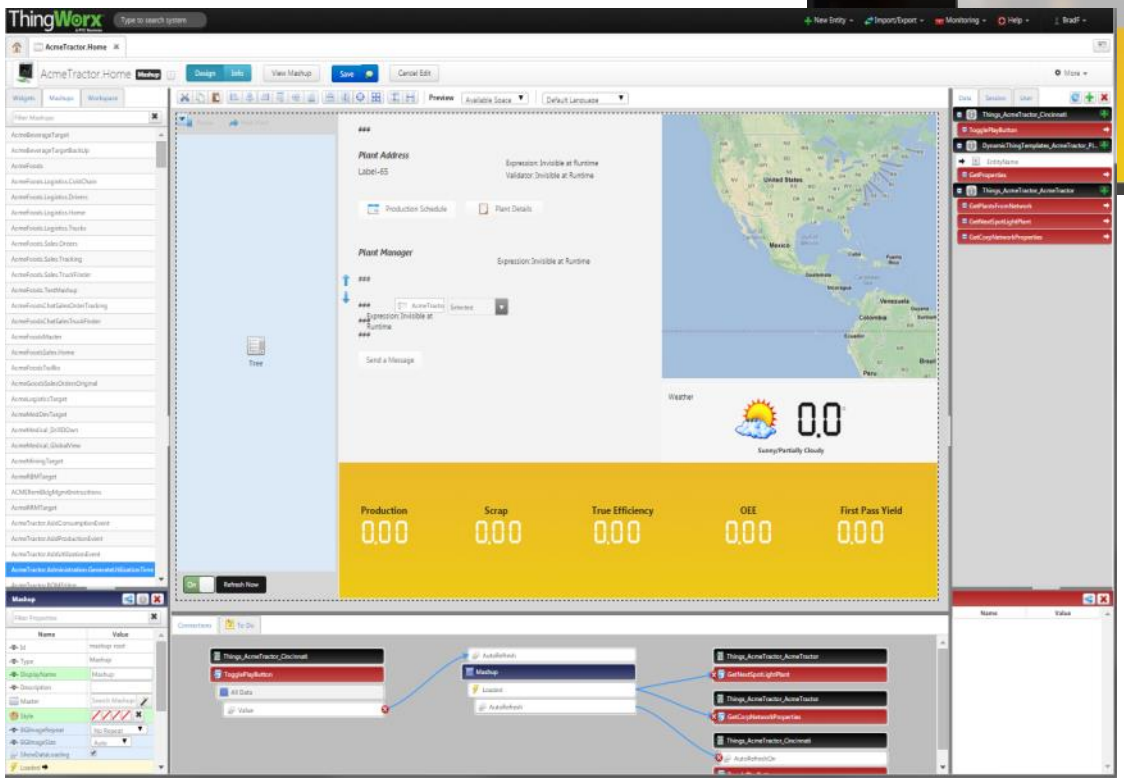
Digital Twin*

*Beta

ThingWorx Composer –Rapid Application Development

- Customer Portals
  - Mashup of Data Sources
- Mobile Applications
  - Smartphone and Tablet Applications to enhance Product Experience
- New Internal Applications
  - Field Service Applications

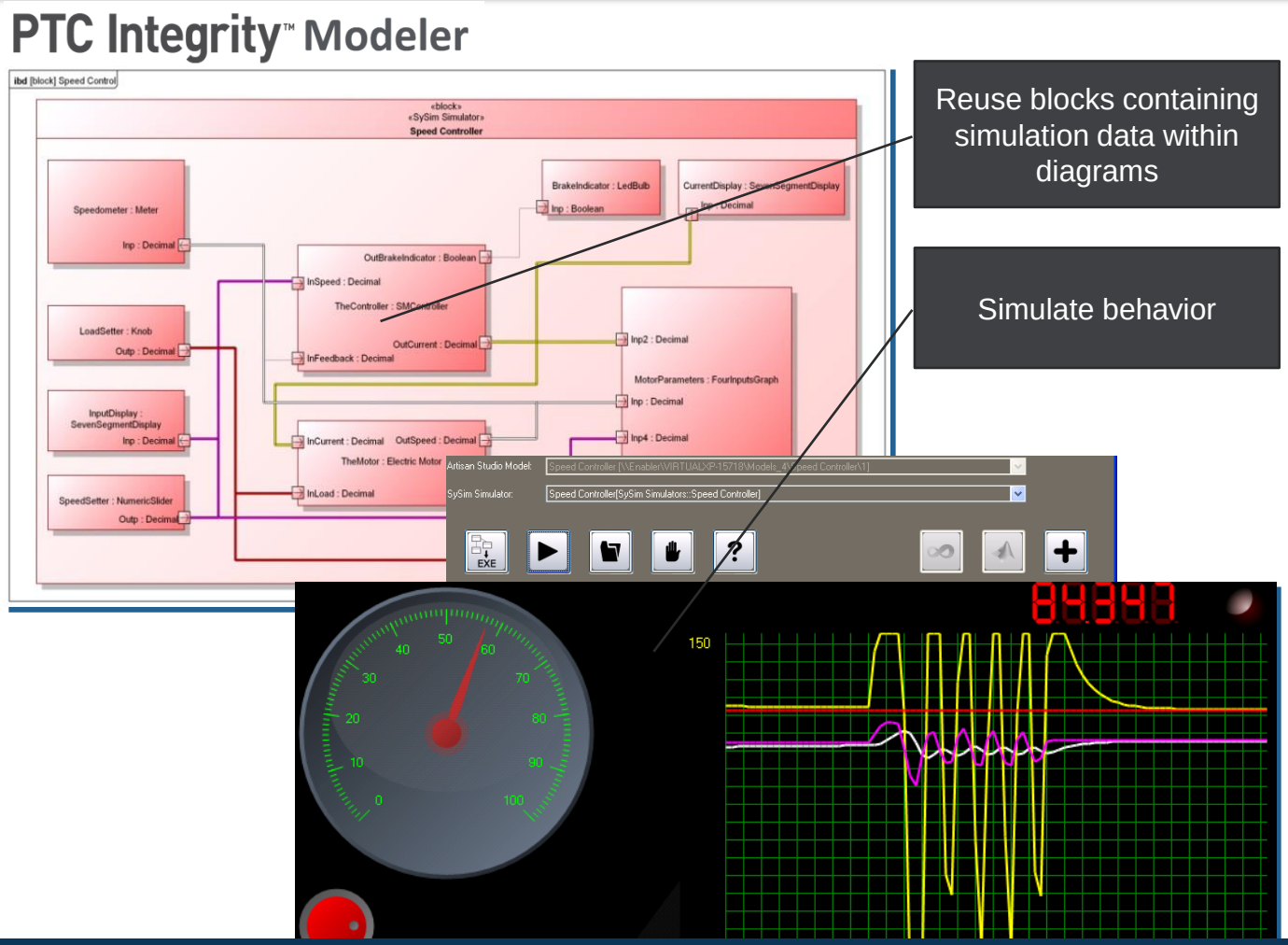




System Model Simulation

CAPABILITIES

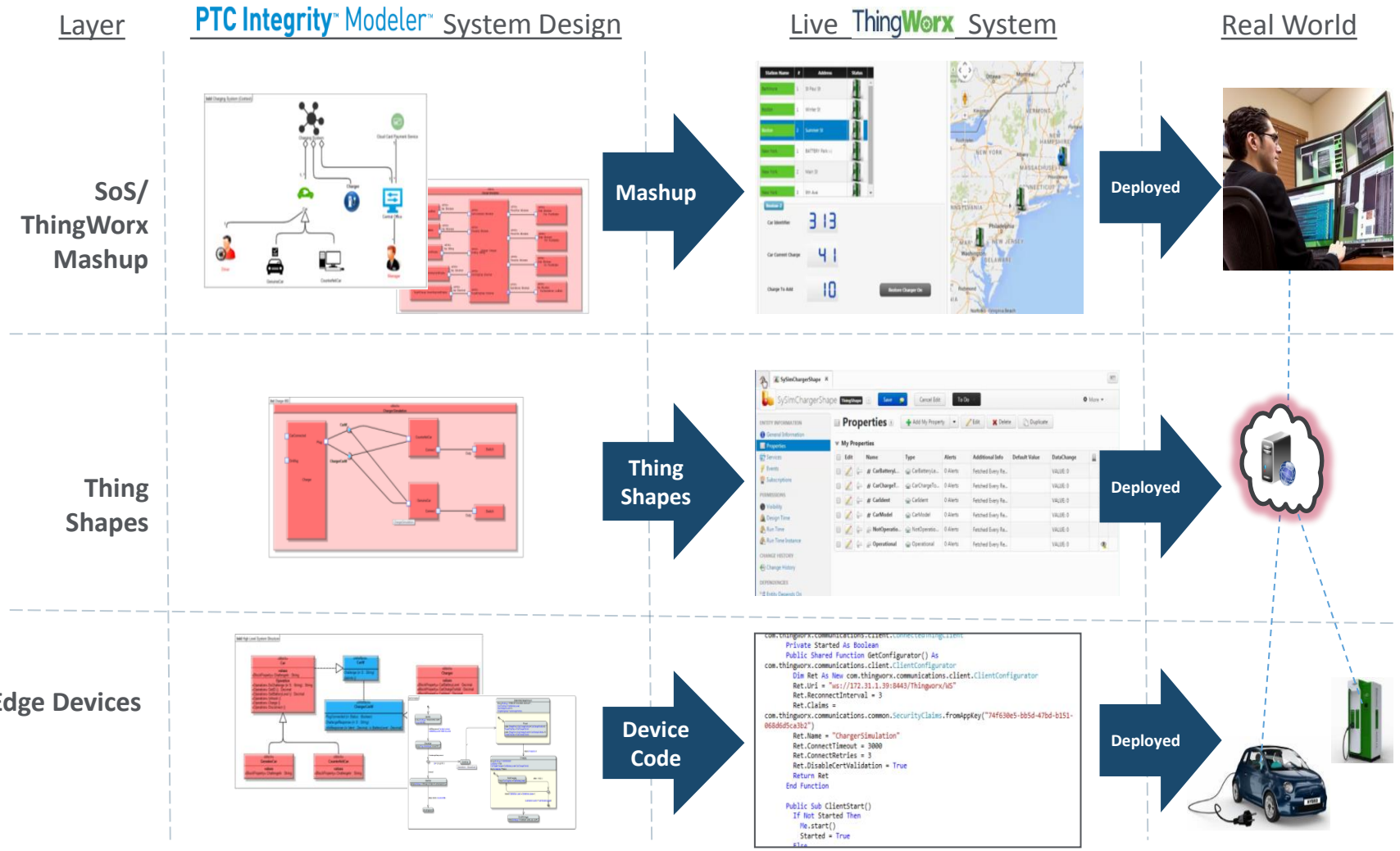
- Simulate SysML model visually
- Store simulation information within system model blocks
- Drag and Play Simulation
- Connect to third-party simulators (MATLAB Simulink™, etc.)



BENEFITS

- Validate complex behavior early
- Project cost reduction
- Reduce design walkthrough efforts
- Reduce design errors

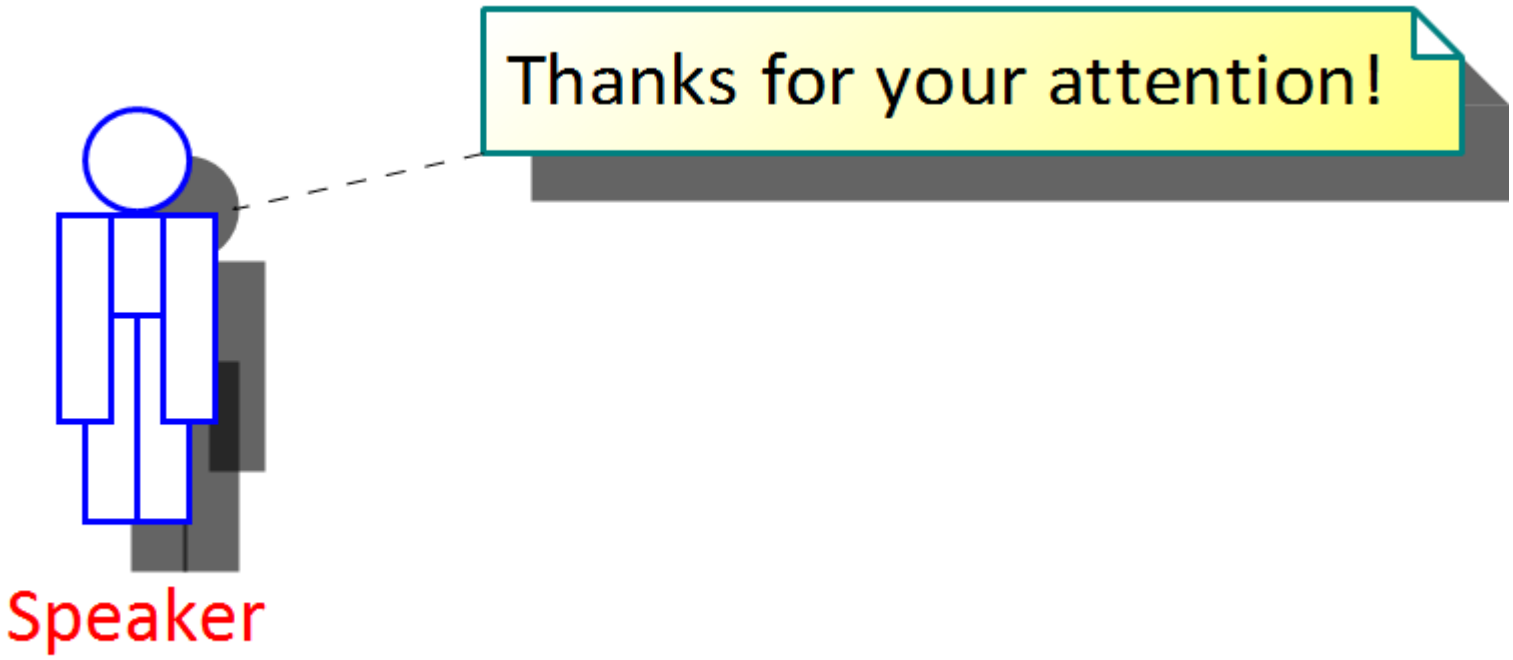
PTC Integrity Modeler – Automated ThingWorx Code Generation



Prototype driving requirements for Integrity Modeler 8.3

Demo

Questions and Answers



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