

Making Smart Cities Smarter – MBSE Driven IoT

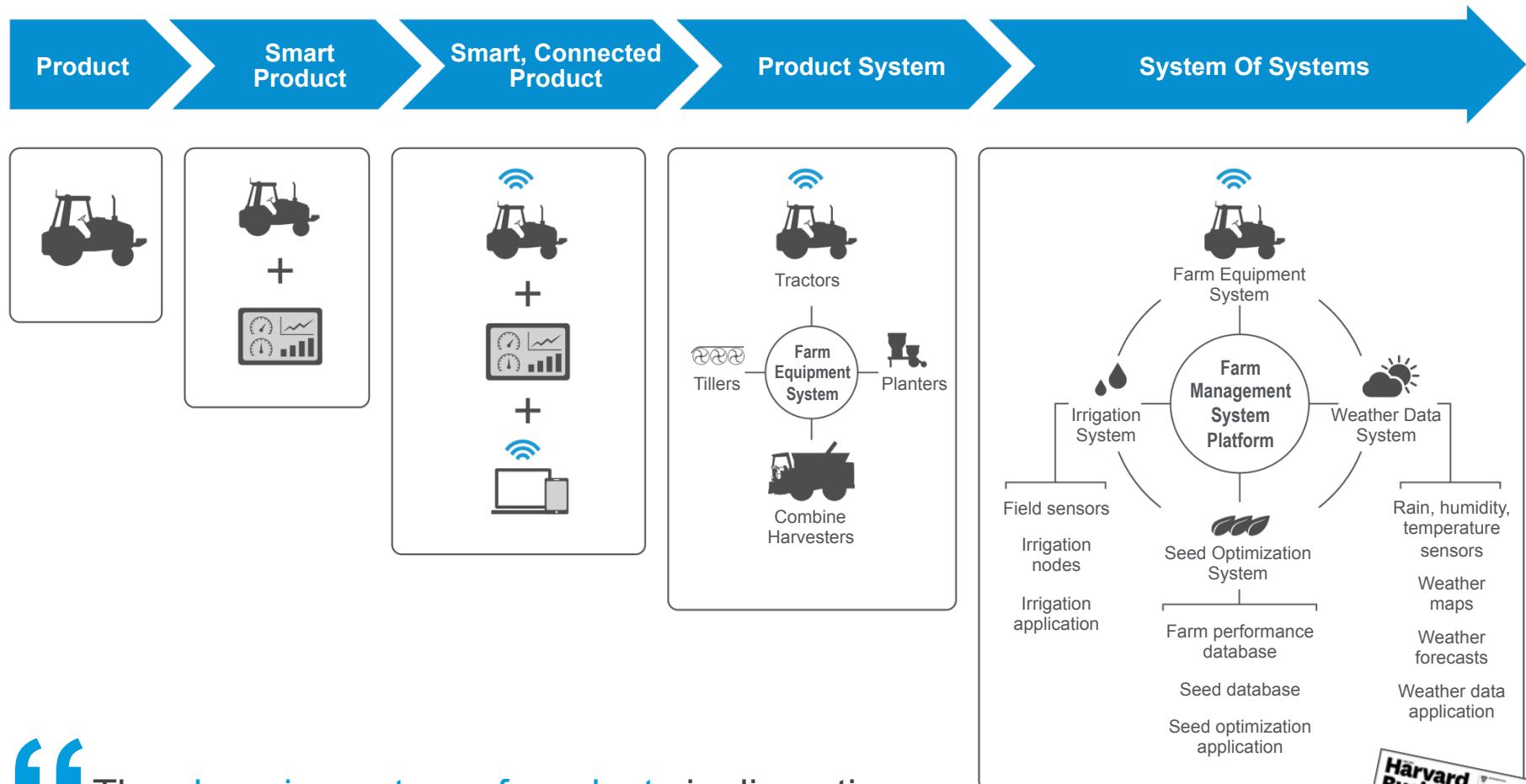
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PTC Engineering Fellow, GTM Technical Specialist

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PTC Principal Solutions Engineer, MBSE





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



- **1. General Background**

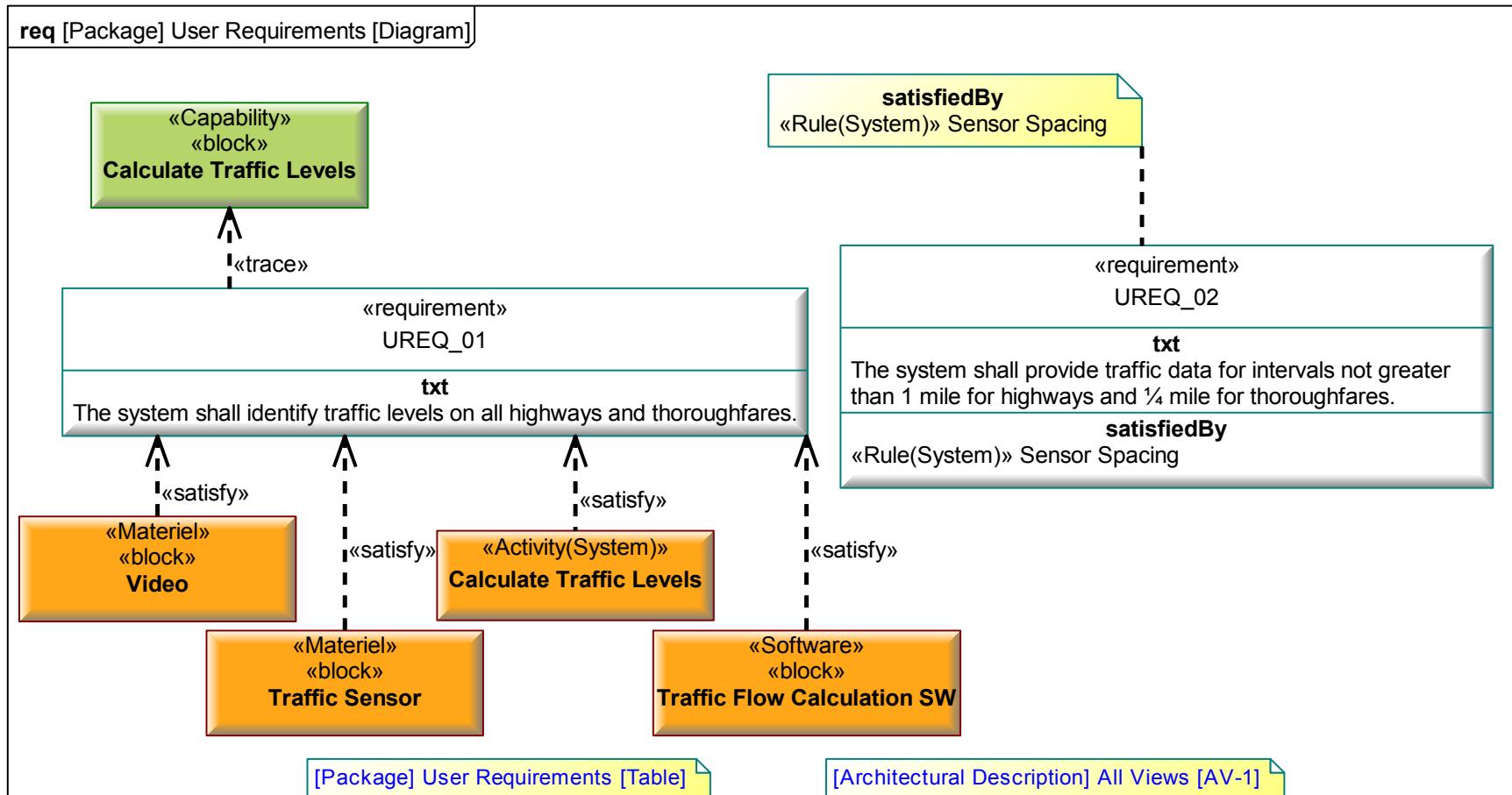
The city of Autoville has just elected a new city council with a mandate to reduce traffic on the highways and thoroughfares.

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.

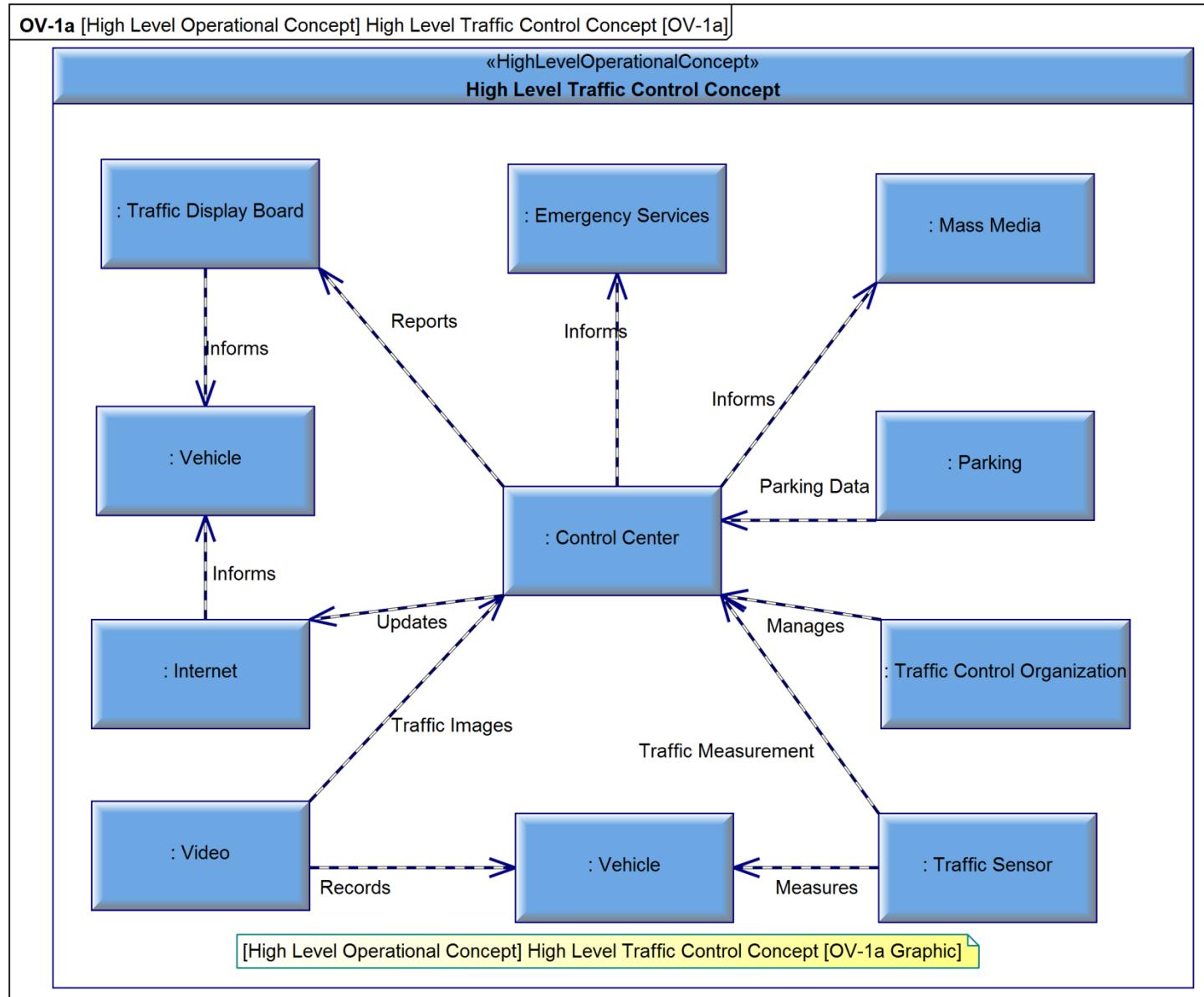
The city of Autoville has 100 miles of highway with 10 interchanges and 300 miles of thoroughfares with 100 major intersections.

Systems will include controlled parking facilities, availability monitoring and dissemination, emergency management, traffic control and prediction, and support for electric vehicles.

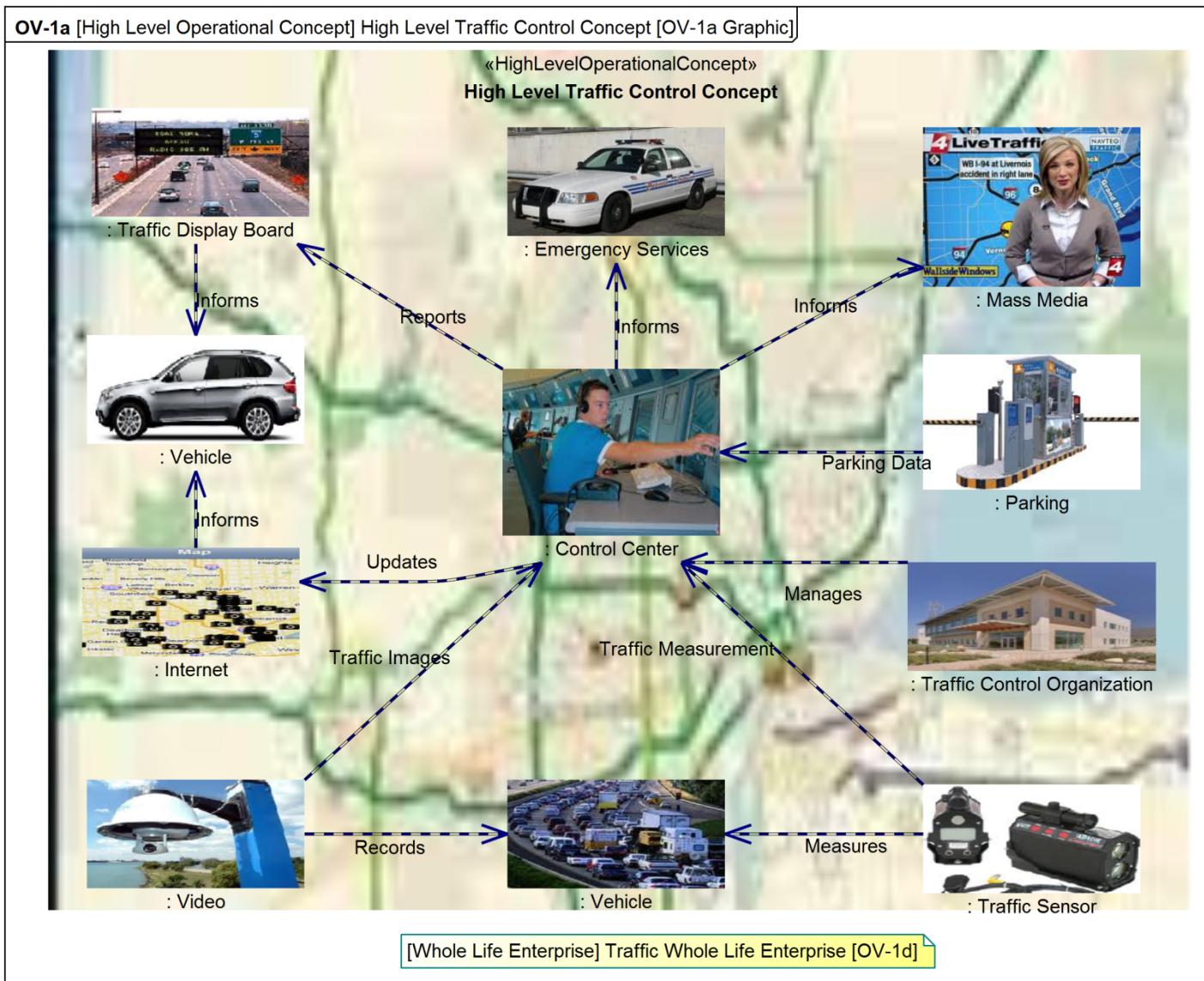
SysML Requirements Diagram



Operational Concept with Boxes

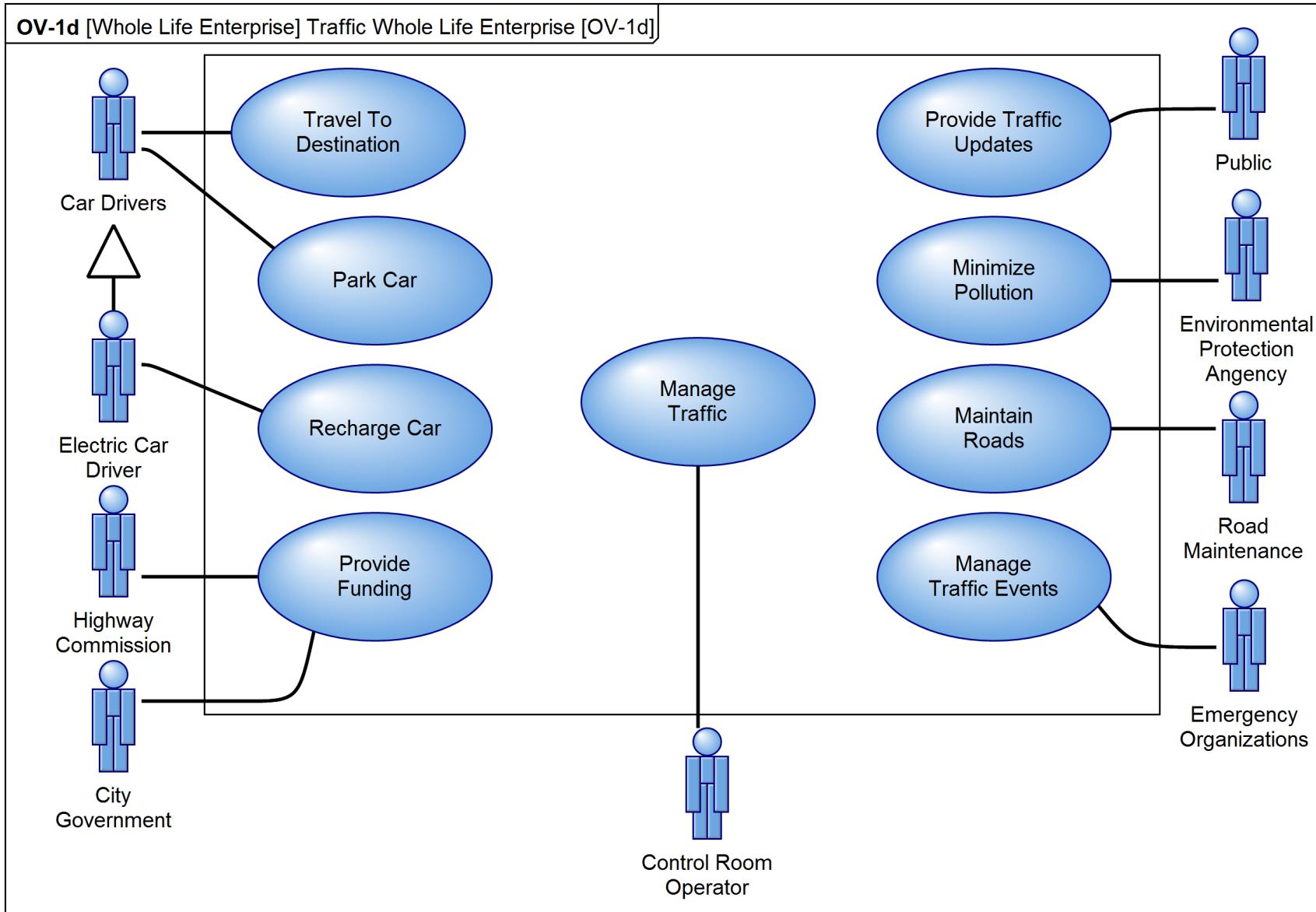


Operational Concept with Graphics



Traffic Management Use Cases and Stakeholders

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Capability Taxonomy with Implementing Resources

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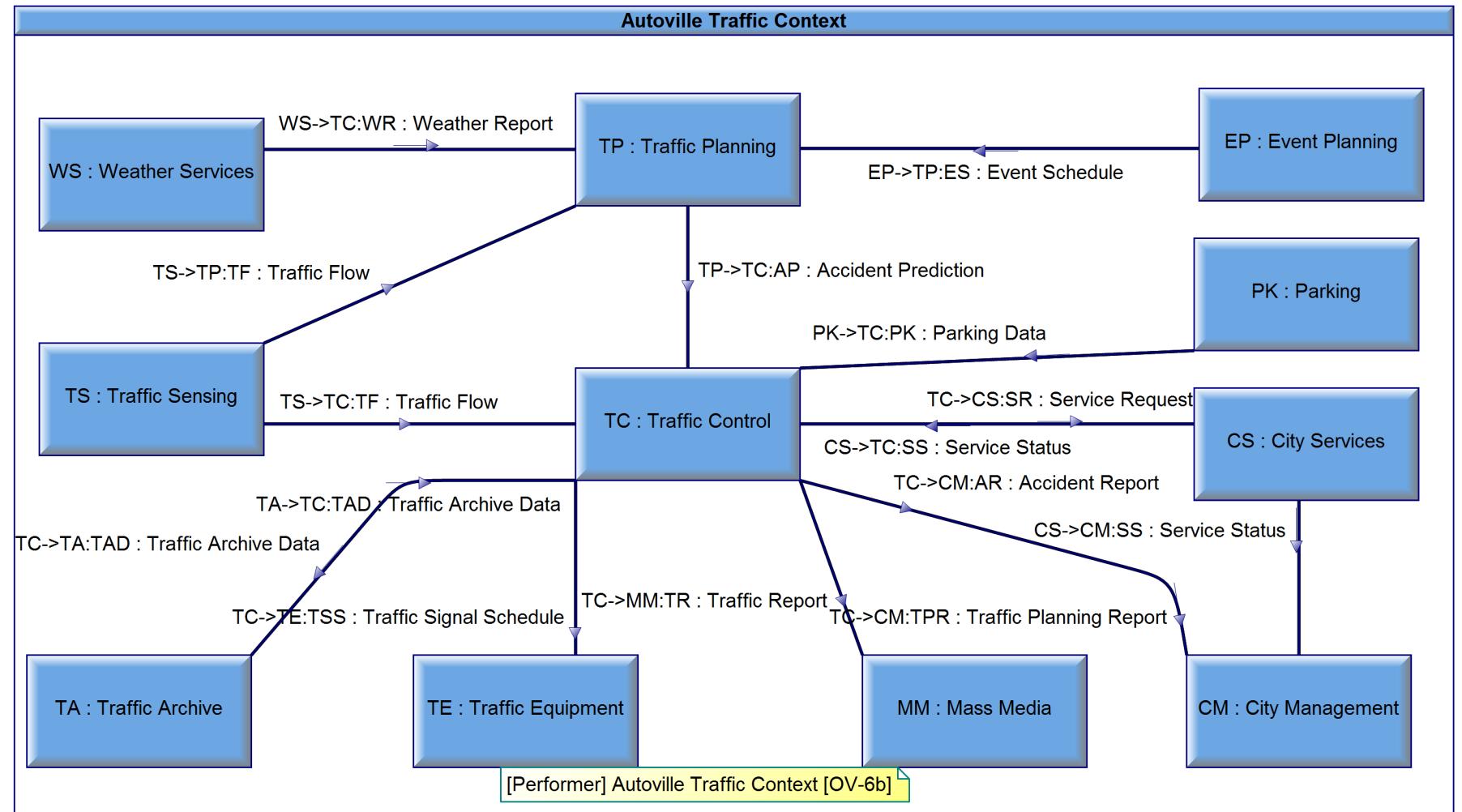
CV-2 [Architectural Description] Capabilities [CV-2 Resources]

<p>«Capability» Calculate Traffic Levels</p> <p>exhibitingElement «EnterprisePhase» Traffic Architecture Phase1 «EnterprisePhase» Traffic Architecture Phase2 «Software» Traffic Flow Calculation SW</p>	<p>«Capability» Traffic Prediction</p> <p>exhibitingElement «EnterprisePhase» Traffic Architecture Phase2 «Software» Traffic Prediction SW</p>	<p>«Capability» Respond to Traffic Event</p> <p>exhibitingElement «Software» Emergency Services SW «EnterprisePhase» Traffic Architecture Phase1 «EnterprisePhase» Traffic Architecture Phase2 «Software» Traffic Event SW</p>
<p>«Capability» Traffic Control</p> <p>exhibitingElement «Performer (System)» Control Center «Performer (System)» Control Room «EnterprisePhase» Traffic Architecture Phase2 «Software» Traffic Control SW «Performer (System)» Traffic Display Board «Software» Traffic Signal SW</p>	<p>«Capability» Coordination</p> <p>exhibitingElement «Software» Emergency Services SW «EnterprisePhase» Traffic Architecture Phase1 «EnterprisePhase» Traffic Architecture Phase2 «Software» Traffic Control SW</p>	<p>«Capability» Traffic Surveillance</p> <p>exhibitingElement «Software» Sensor Processing SW «EnterprisePhase» Traffic Architecture Phase1 «EnterprisePhase» Traffic Architecture Phase2 «Software» Traffic Display SW «System» Traffic Sensor «System» User Interface «System» Video «Software» Video Processing SW</p>
<p>Traffic Context</p>	<p>«Capability» Traffic Reporting</p> <p>exhibitingElement «EnterprisePhase» Traffic Architecture Phase2 «Software» Traffic Report Generation SW</p>	<p>«Capability» Provide Traffic History</p> <p>exhibitingElement «EnterprisePhase» Traffic Architecture Phase2 «Software» Traffic Data Archive SW</p>
<p>«Capability» Communication</p> <p>exhibitingElement «EnterprisePhase» Traffic Architecture Phase1 «EnterprisePhase» Traffic Architecture Phase2</p>	<p>«Capability» Parking Management</p> <p>exhibitingElement «Performer (System)» Internet «Performer (System)» Parking «EnterprisePhase» Traffic Architecture Phase2</p>	

Operational Structure

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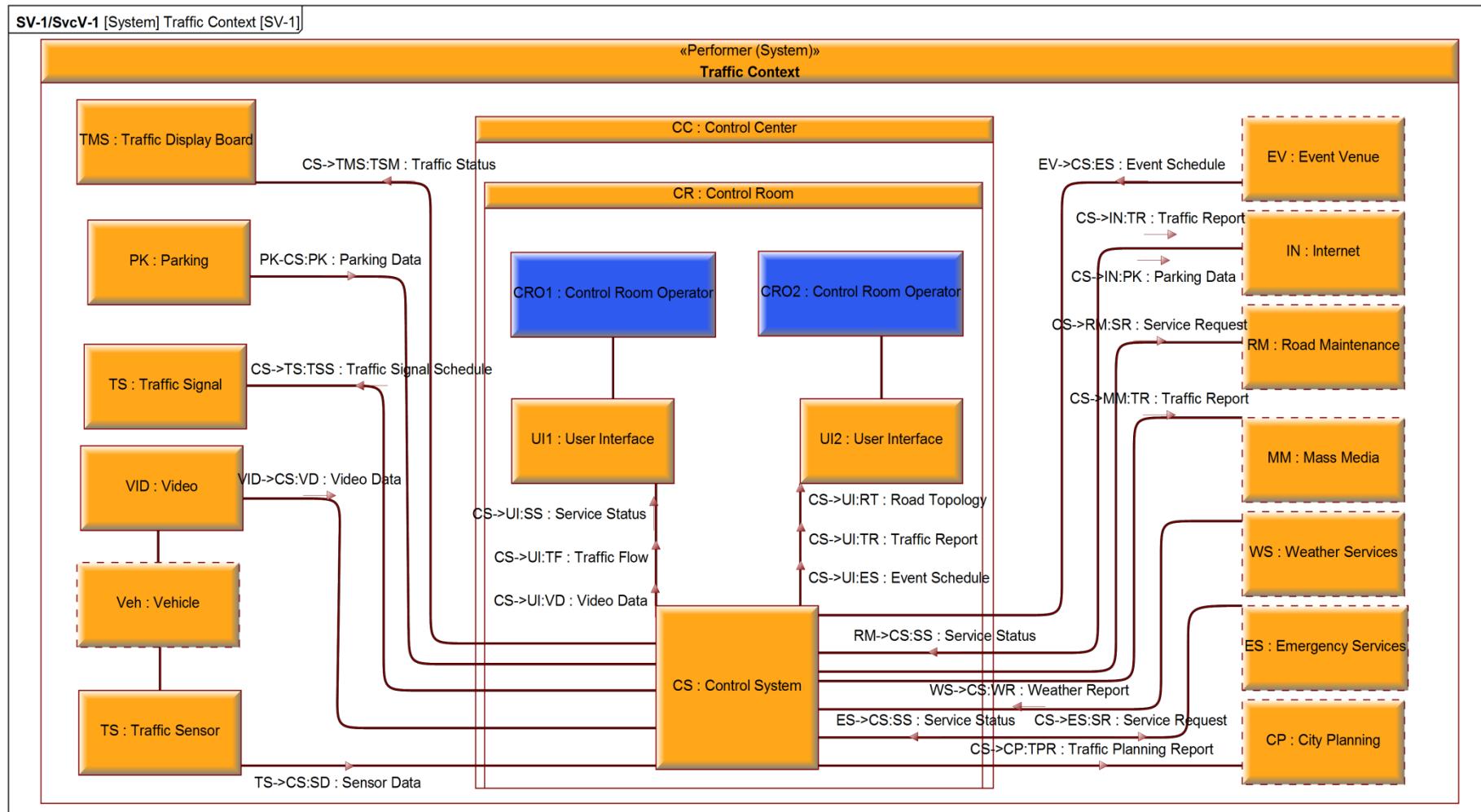
OV-2 [Performer] Autoville Context [OV-2]



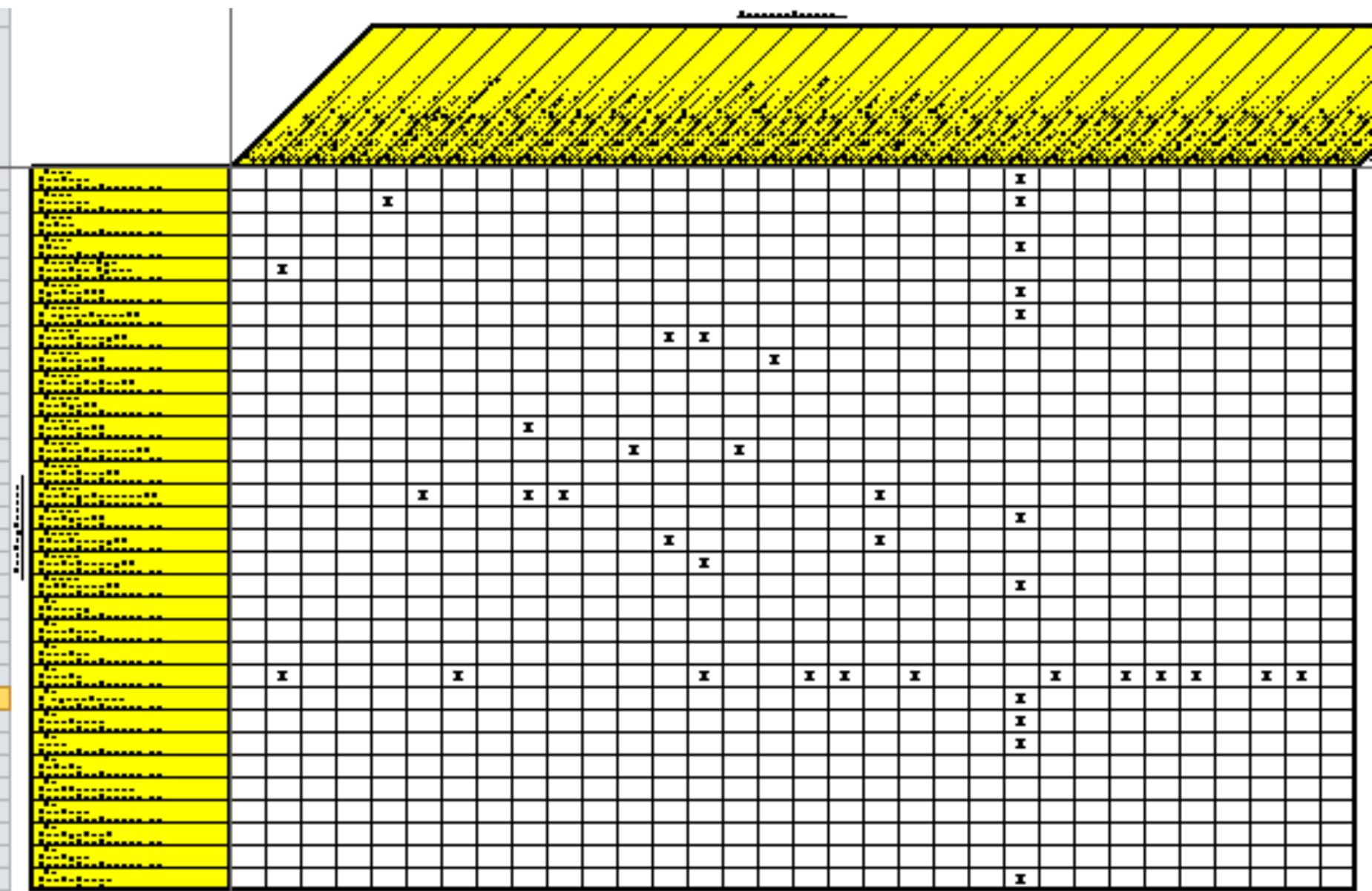
Interaction Summary (ICD)

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	

Traffic Management Systems

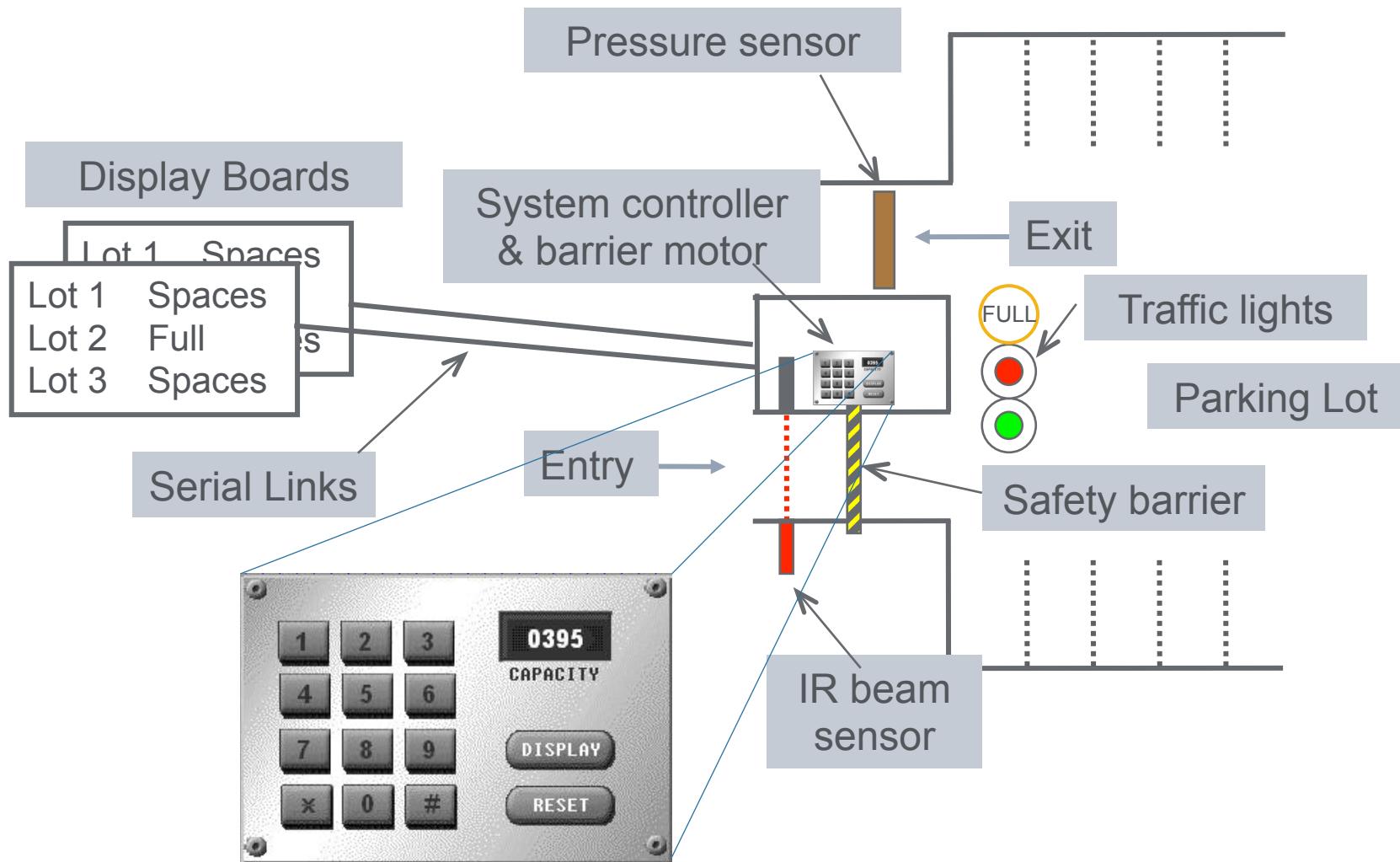


System Connection Matrix – N^2

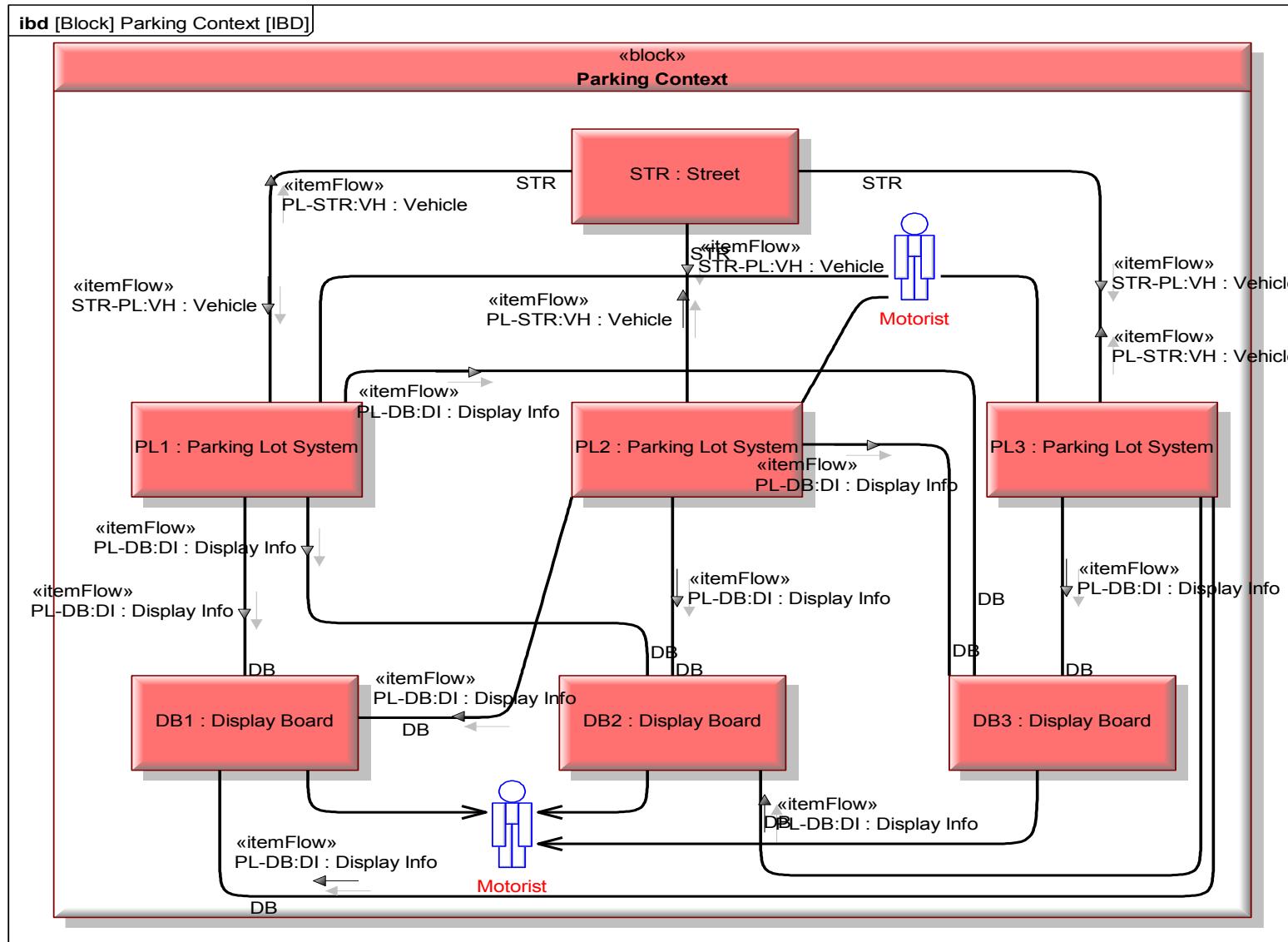


Proposed Parking Lot System

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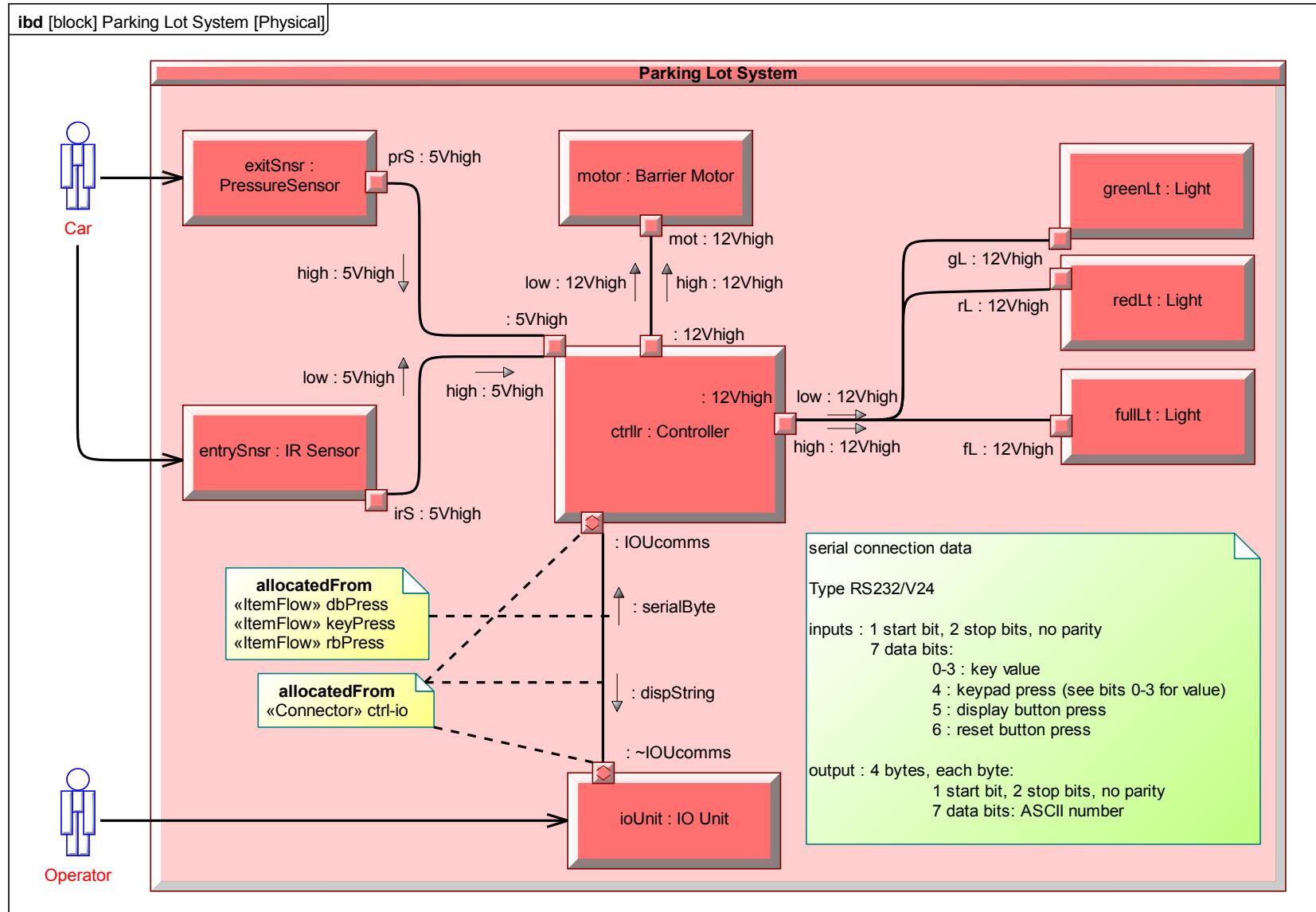


Parking Control Context

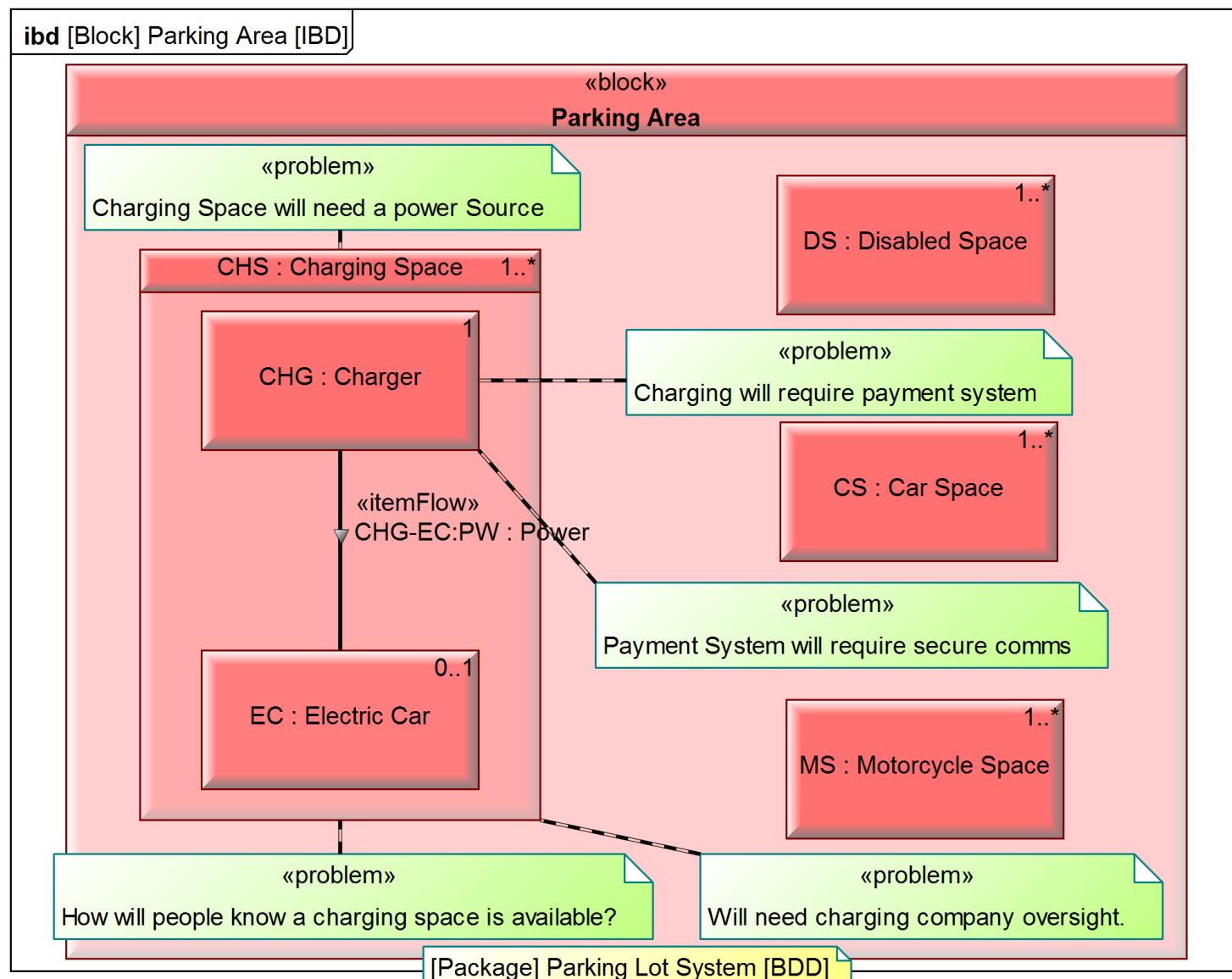


Parking Lot System Model

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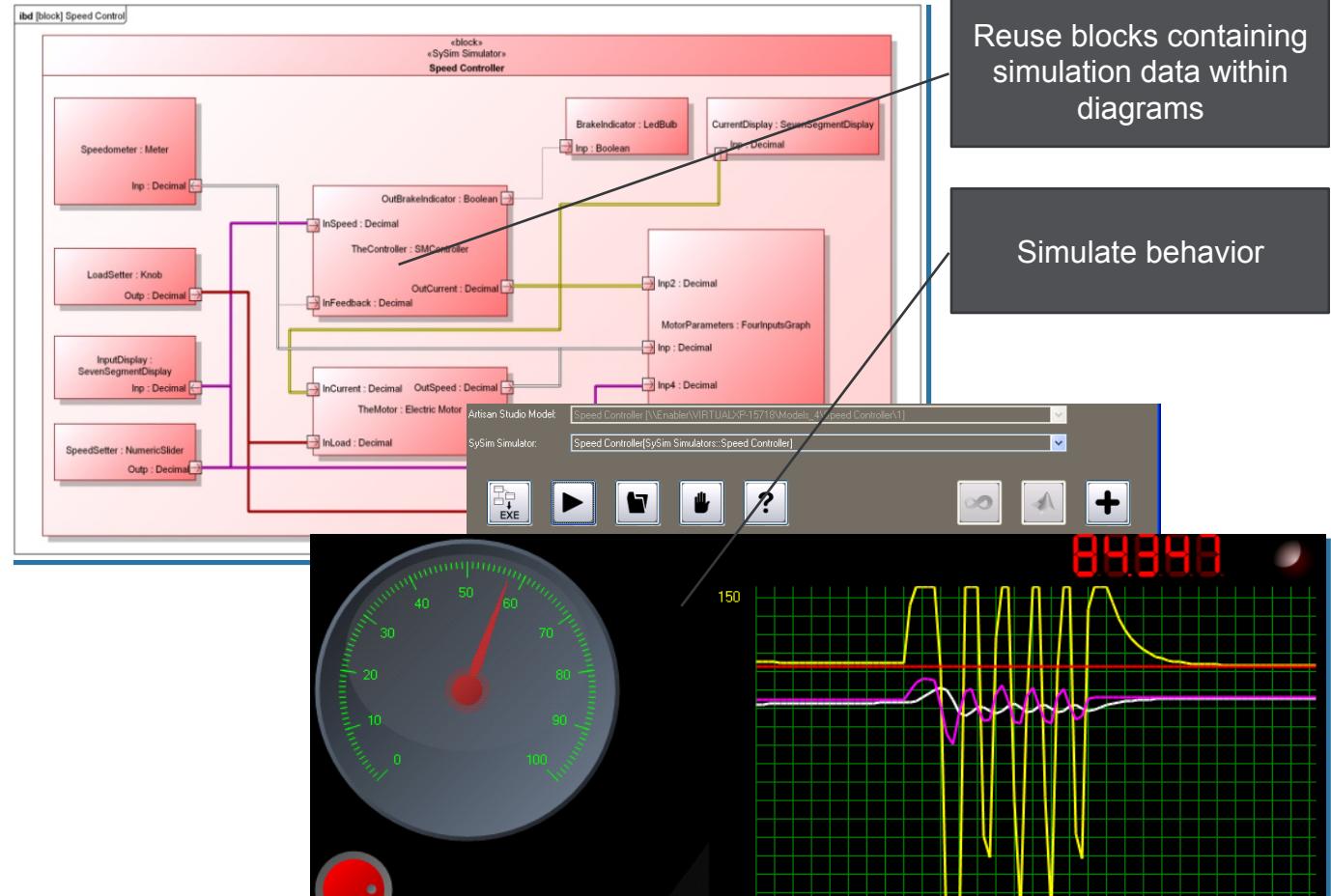
Parking Area with Charging Space



CAPABILITIES

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

PTC Integrity™ Modeler



BENEFITS

Validate complex behavior early

Project cost reduction

Reduce design walkthrough efforts

Reduce design errors



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*



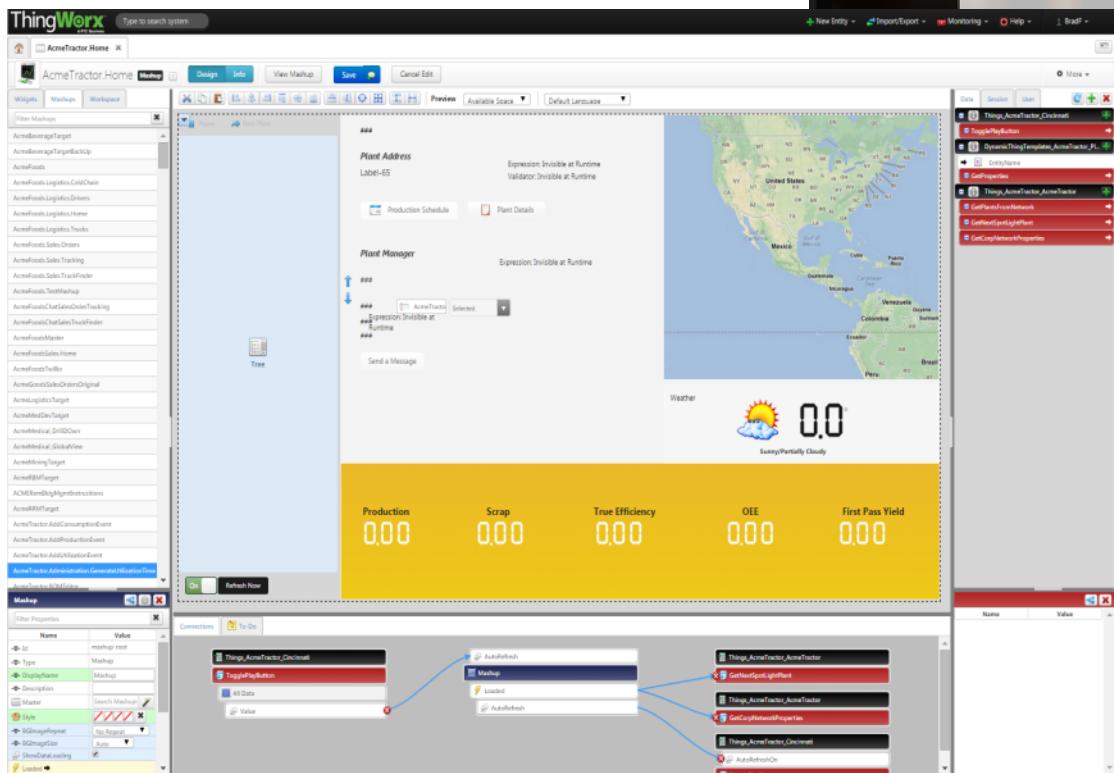
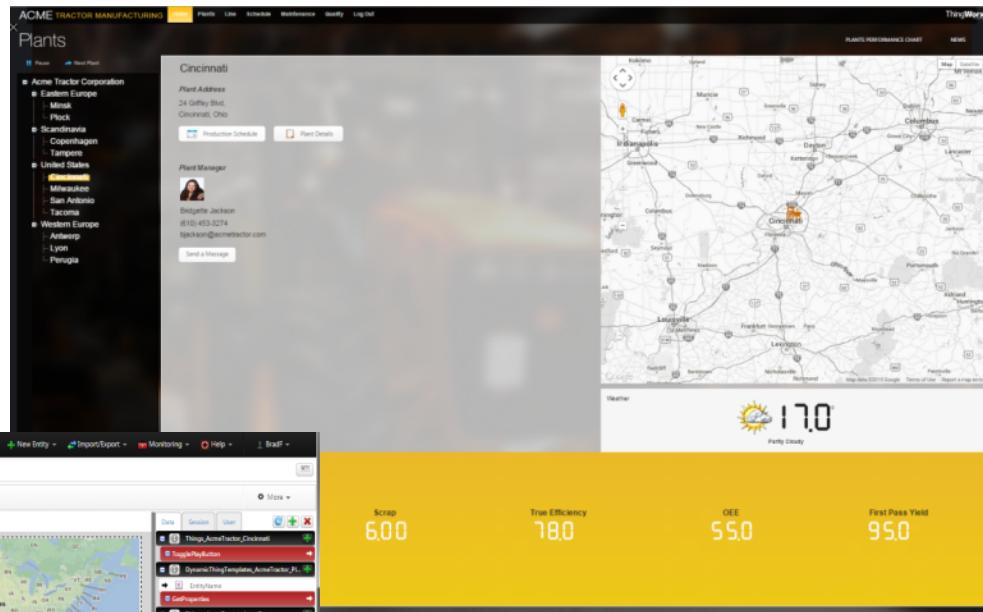
*Beta

Digital Twin*

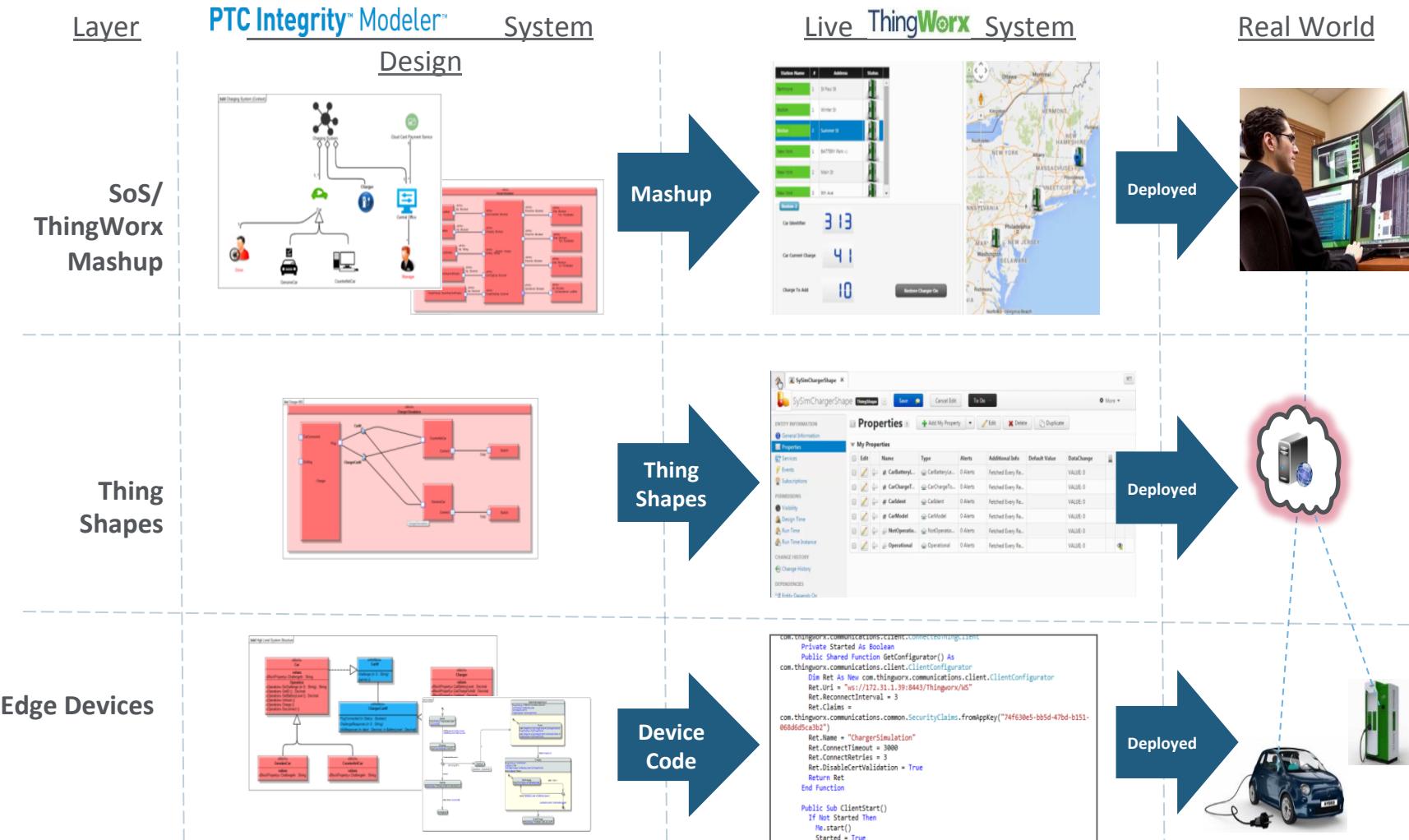


*Beta

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

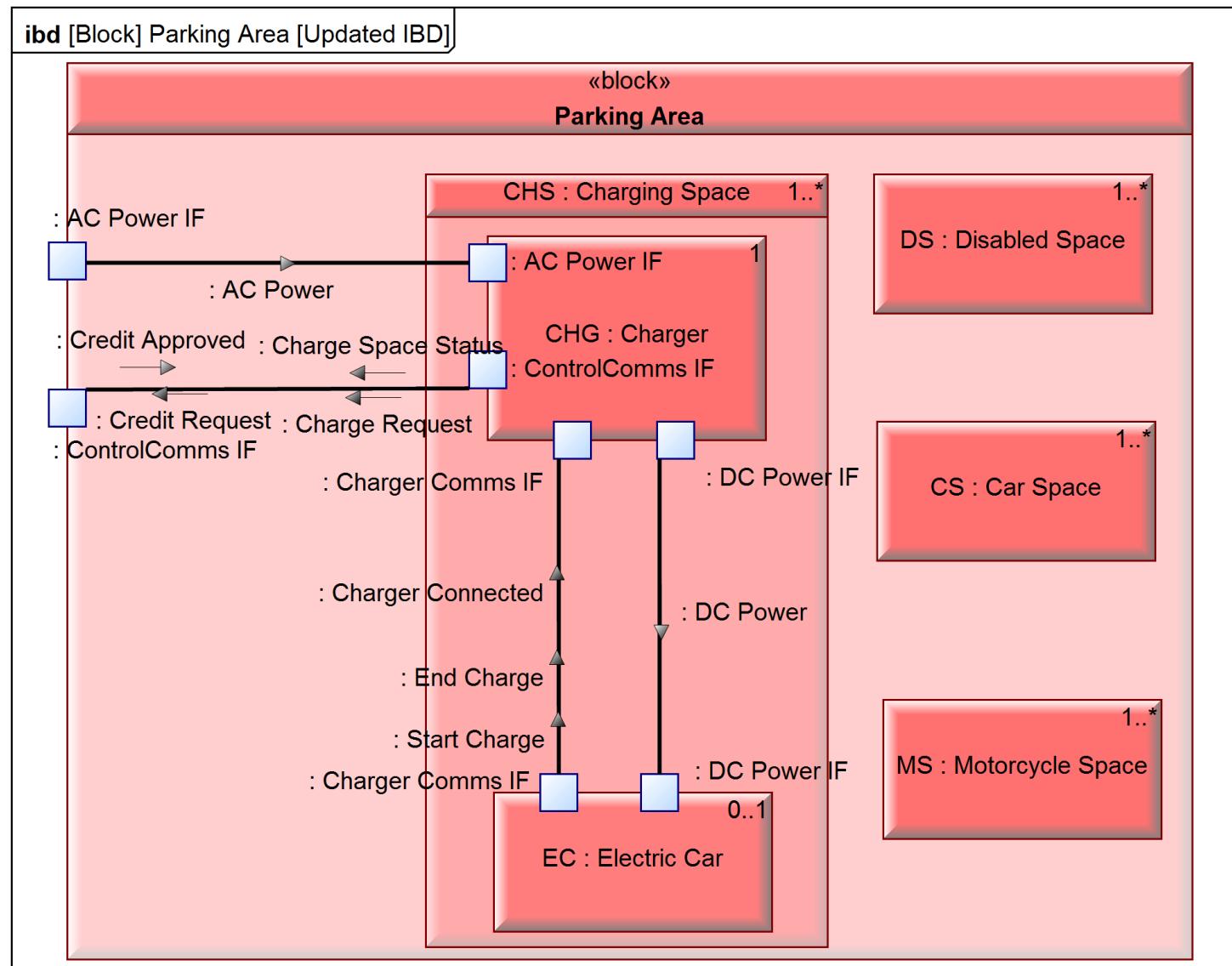


PTC Integrity Modeler – Automated ThingWorx Code Generation



Prototype driving requirements for Integrity Modeler 8.3

Updated Parking Area with Charge Space





Neuron™

Neuron is an advanced learning technology that simplifies and democratizes the once complex and time consuming science of advanced and predictive analytics.



+



Neuron™

ThingWorx

- Explanatory Analysis
- Actionable Insights
- Operationalized Predictions

Predictive Signals

PTC®

Show/Hide Log Show/Hide Debug Info Reload Default Fullscreen

Choose Prediction: Soil Moisture 16in (weather only)
Choose Filter: All Data

NeuronDiscover

Learn Predict

PREDICTIVE SIGNALS

Category View

- Time and Location
- Soil Temperature
- Weather Solar Radiation
- Weather Potential Evapotranspiration
- Weather Air Temperature
- Weather Apparent Temperature
- Weather Wind Chill
- Weather Wind Chill AVG 0 to 1 DAY prior
- Weather Wet Bulb Temperature
- Weather Diffuse Radiation
- Weather Direct Radiation
- Weather Air Pressure

Weather Wind Chill AVG 0 to 1 DAY prior

Range	Value
27.89-32.51	~29.5
32.13-41.76	~34.5
46.39-51.01	~35.5
55.63-60.26	~36.5
64.88-69.51	~37.5
74.13-78.76	~40.5
83.38-88.01	~42.5
92.63-97.26	~42.5

PROFILES

Feature	Value	Avg. Goal	Population	Z Score
Weather Diffuse Radiation AVG 4 to 5 DAY prior	[17.26 - 36.71]	33.66	10,061	33.17
Weather Relative Humidity AVG 8 to 9 DAY prior	[8.75 - 62.76]	31.76	6,170	35.32
Weather Relative Humidity AVG 10 to 11 DAY prior	[8.75 - 73.56]	31.22	5,405	35.49
Weather Wind Direction AVG 0 to 1 DAY prior	[115.37 - 235.3]	30.17	4,365	36.23

Predictive Analyzer

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Show/Hide Log Show/Hide Debug Info Reload Default Fullscreen

NeuronDiscover

PREDICTED PERFORMANCE
Soil Moisture Prediction Next Week @ 16in

ESTIMATED MODEL ACCURACY

94.37%

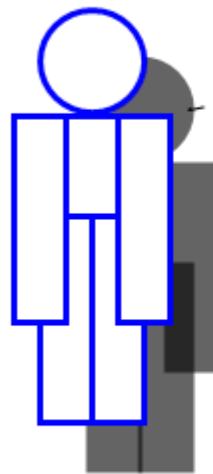
RMSE 0.06 **PEARSON CORRELATION** 0.98 **VALIDATION RECORDS** 14827

FACTORS INFLUENCING PREDICTION FOR +1 DAY

Feature Name	Feature Value	Influence
Location Name	Location 5	High
Weather Wind Chill AVG 0 to 1 DAY prior	69.5	Medium
Weather Apparent Temperature AVG 0 to 1 DAY prior	69.58	Medium
Weather Air Temperature AVG 0 to 1 DAY prior	69.5	Medium
timestamp_month_of_year	4 April	Medium

ENSEMBLE METHODS

Enabled	Learning Technique
✓	BACKPROP
✓	DECISION TREE
✓	LINEAR REGRESSION
✓	GRADIENT BOOST



Speaker

Thanks for your attention!

PTC® PRODUCT & SERVICE
ADVANTAGE®