



Connected Vehicle  
**PlugFest**

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# Southeast Michigan Project Architecture

# Connected Vehicle Project Architecture

- A Design **Tool**,  
not a Design

# Other Engineering Disciplines have Graphical Tools

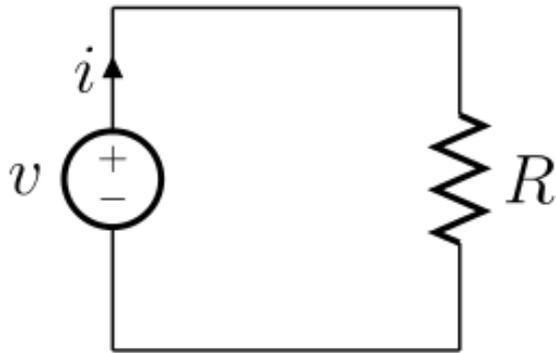


Image Source: Wikipedia

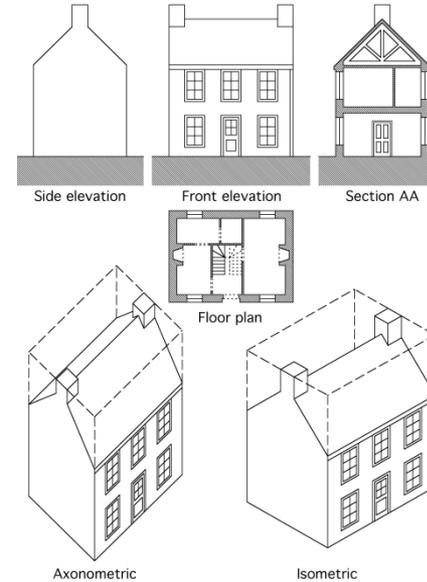


Image Source: Wikipedia

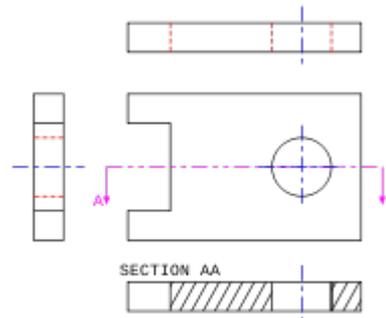


Image Source: Wikipedia



# ITS National Architecture

- <http://www.its.dot.gov/arch/index.htm>

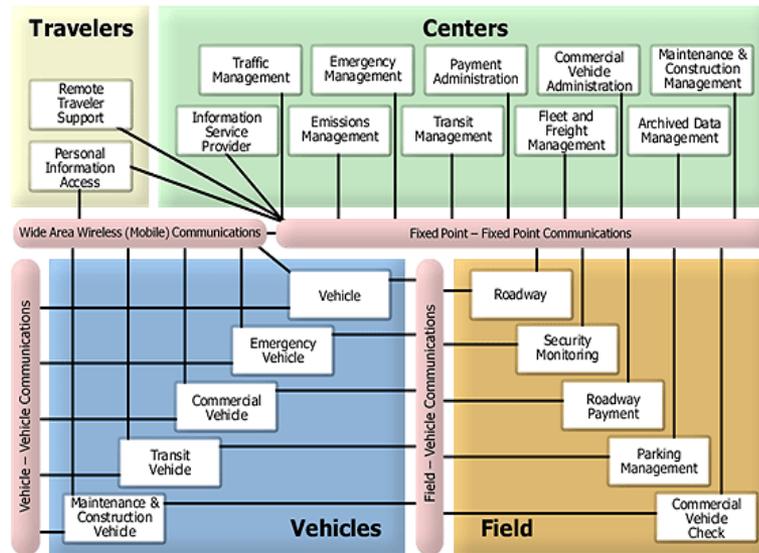


Image Source: USDOT

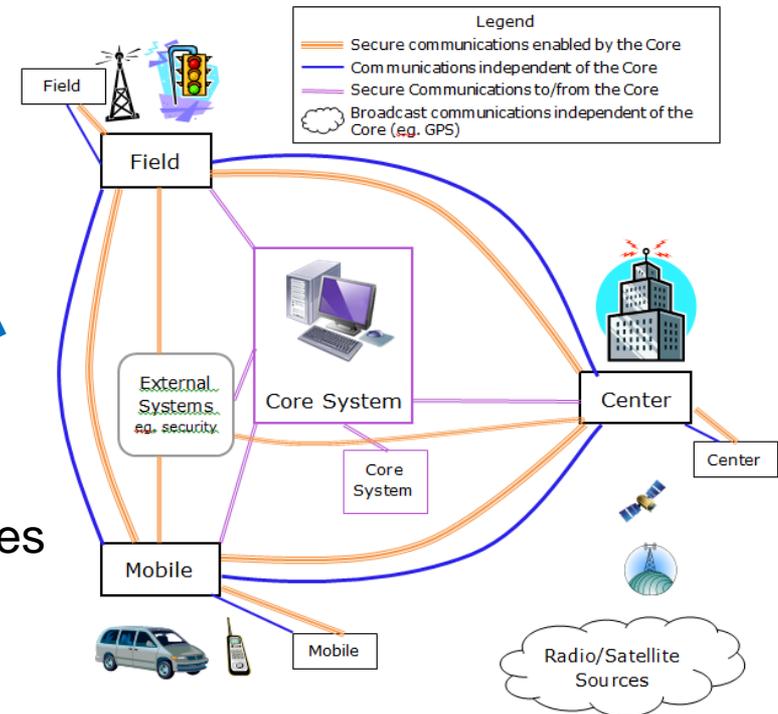


Image Source: USDOT

- Broadcast and Peer-to-Peer data exchanges
- Enable Big Data
- Multiple wireless communication media

# Southeast Michigan Connected Vehicle 2014 Project Architecture

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Complete Architecture shown in a set of views

- Physical view [**THINGS**] – overviews and specifics of objects and the information that flows between them, hierarchically arranged to show varying levels of detail.
- Enterprise view [**PEOPLE**] – includes installation, operations, maintenance and certification diagrams for each physical diagram
- Communication views [**INFORMATION**] – one for each information flow

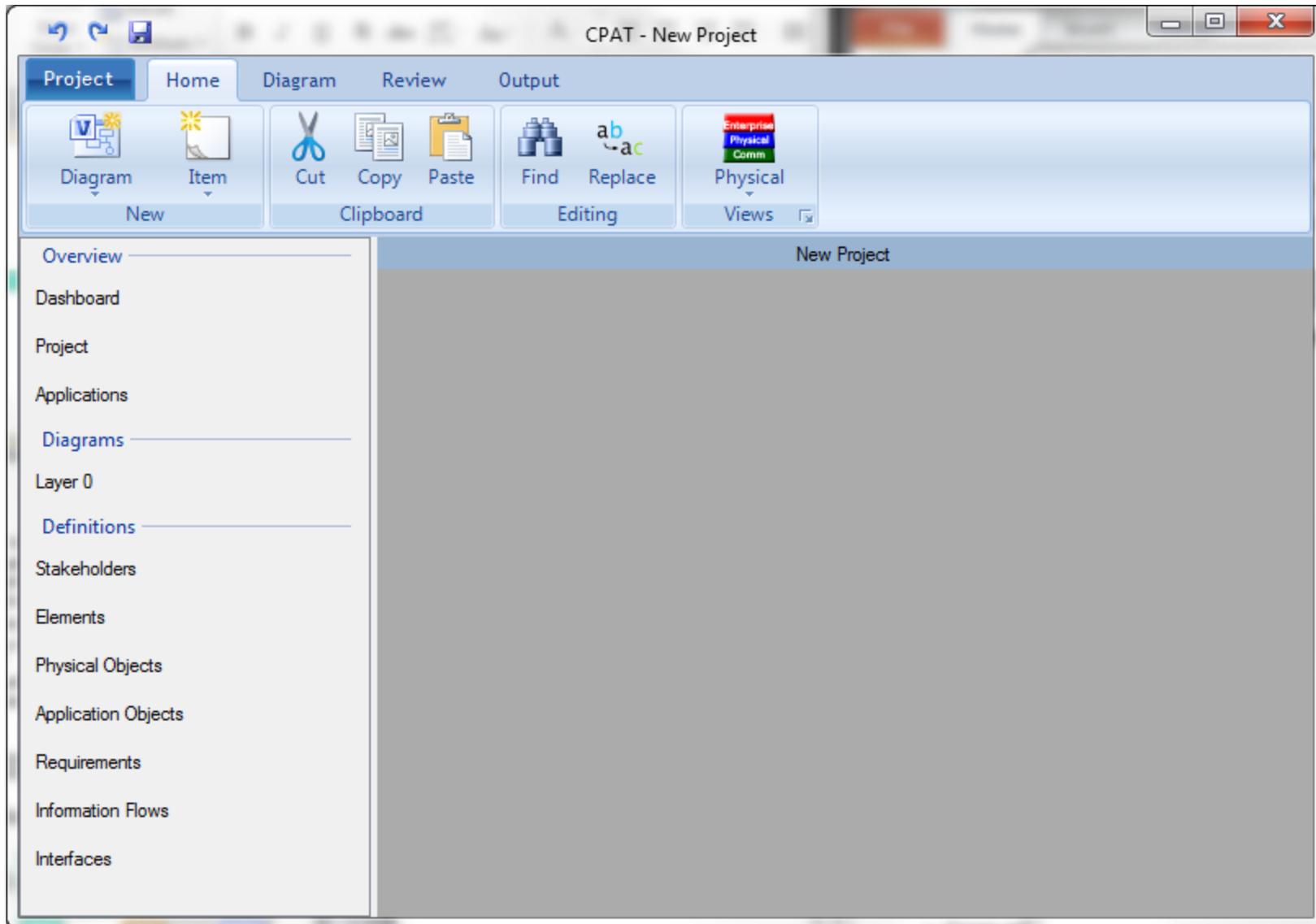


# Architecture Tool - Screenshots

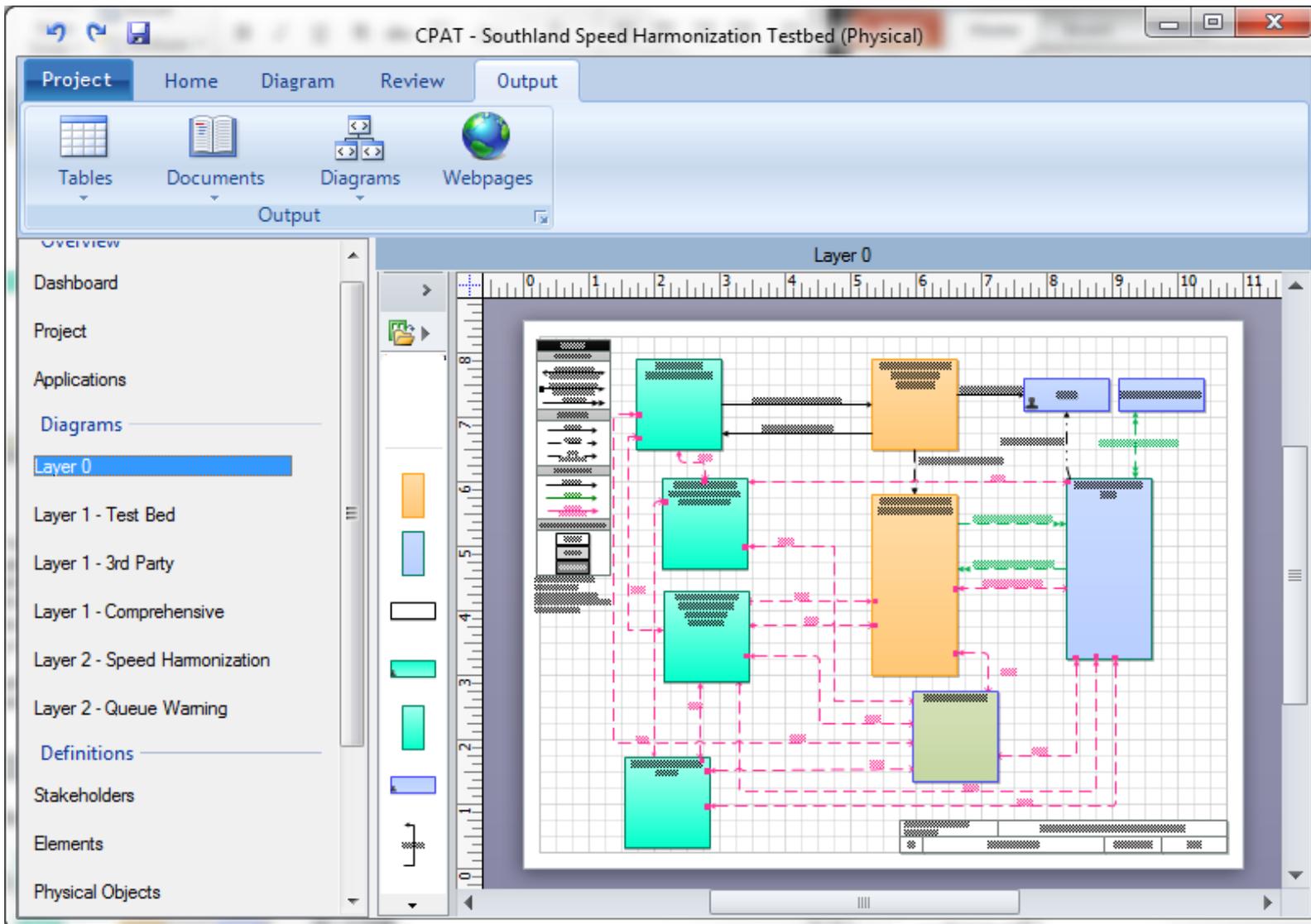
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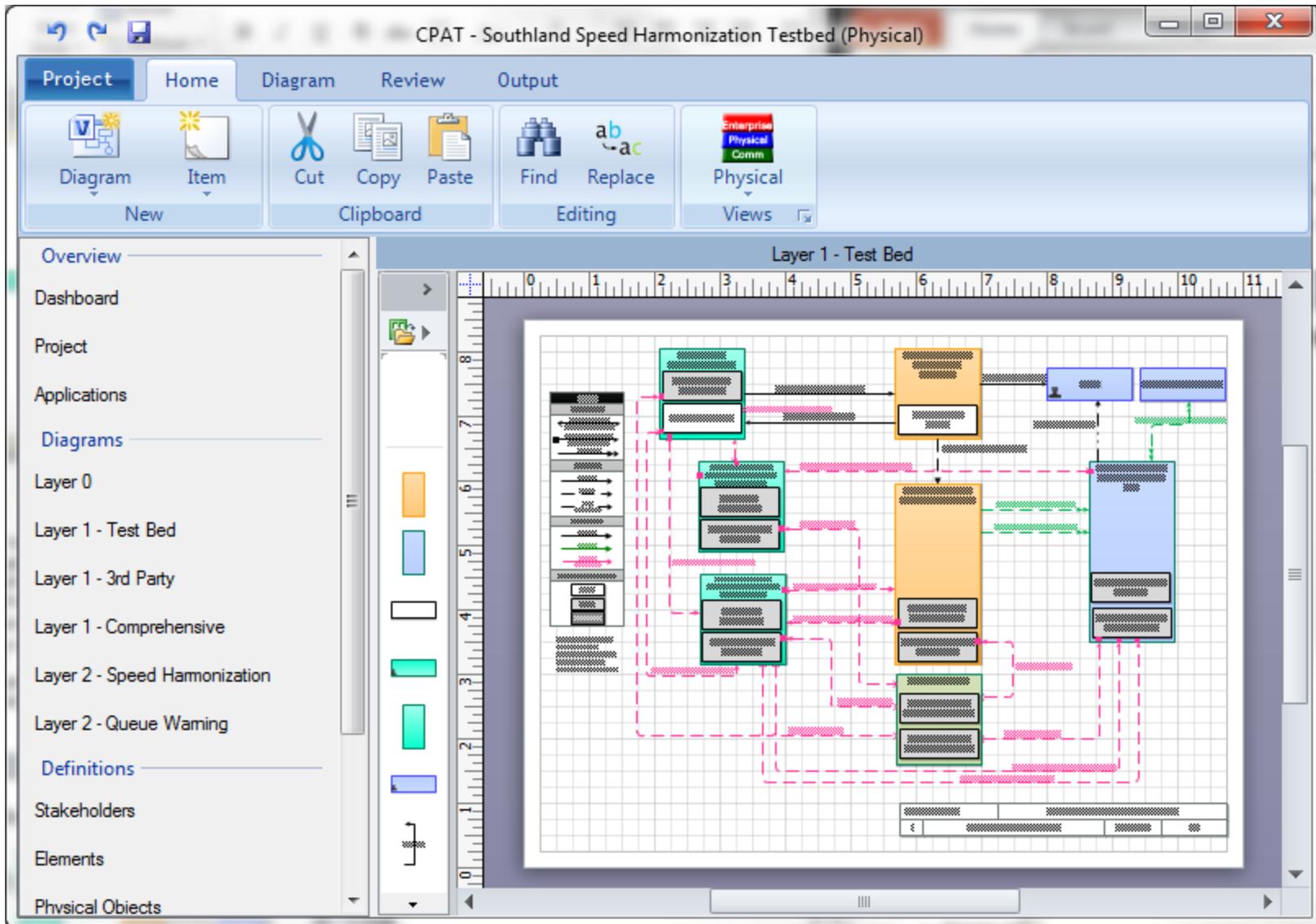
# Blank Project Opening Screen



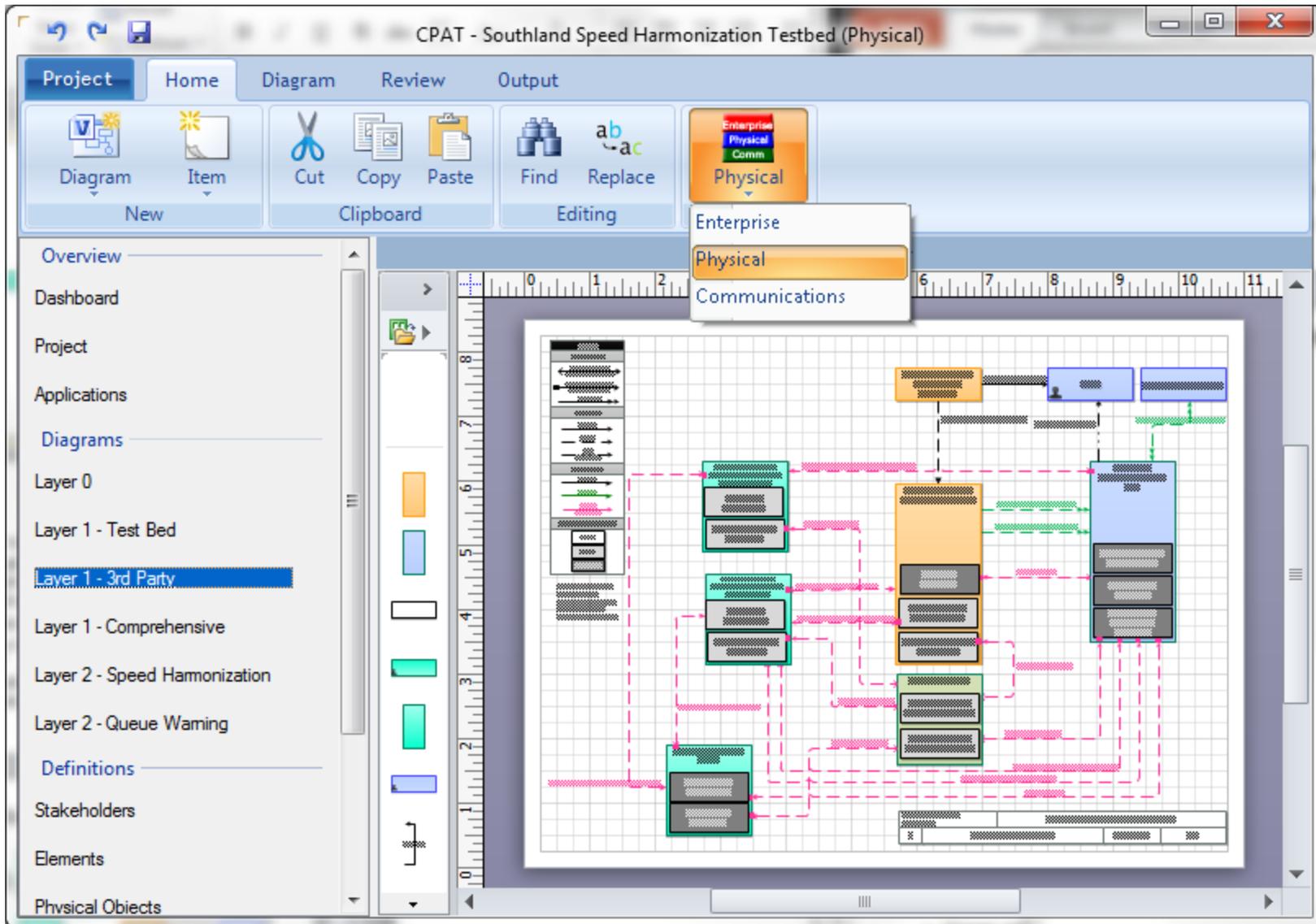
# Physical Layer 0



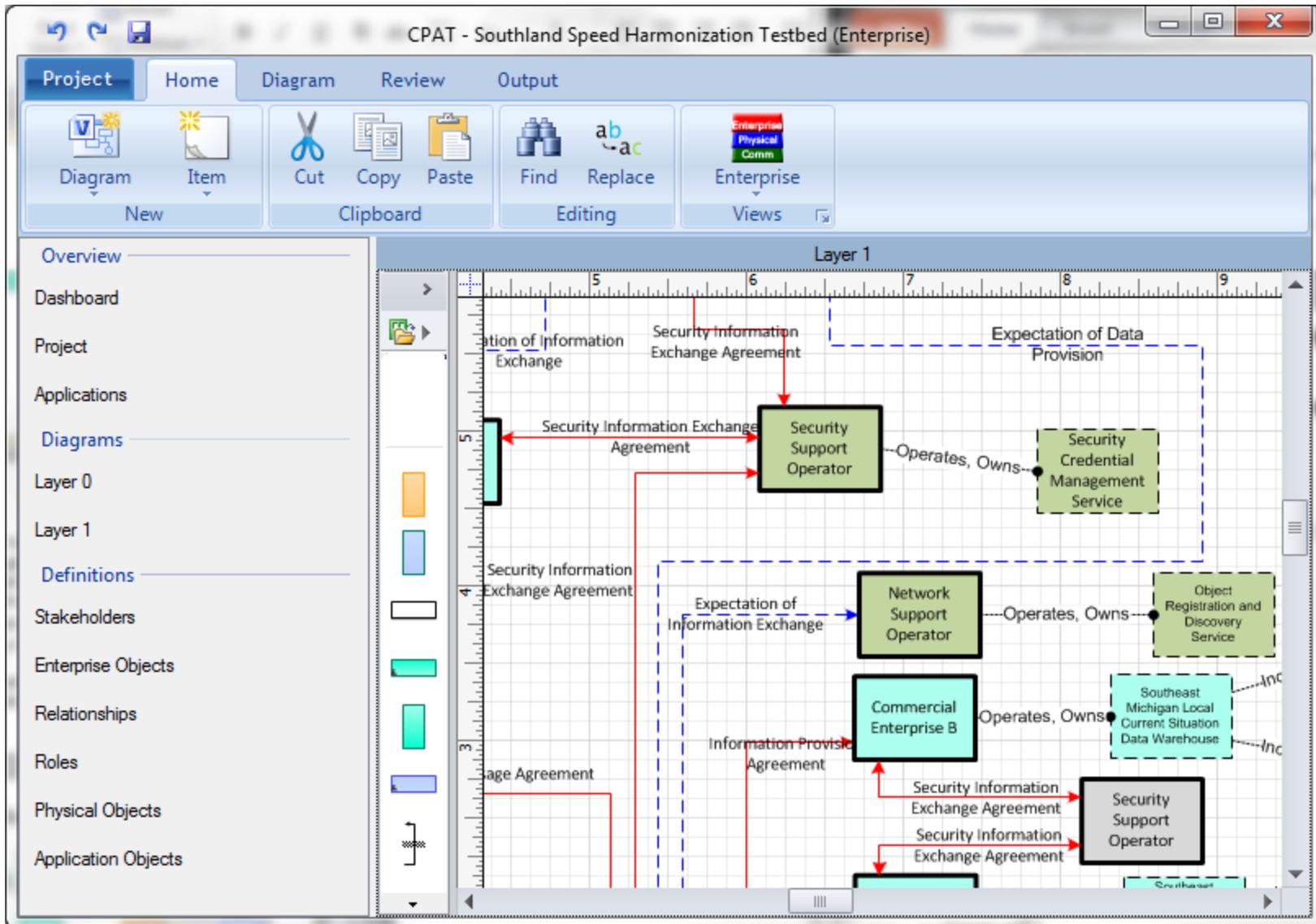
# Physical Layer 1



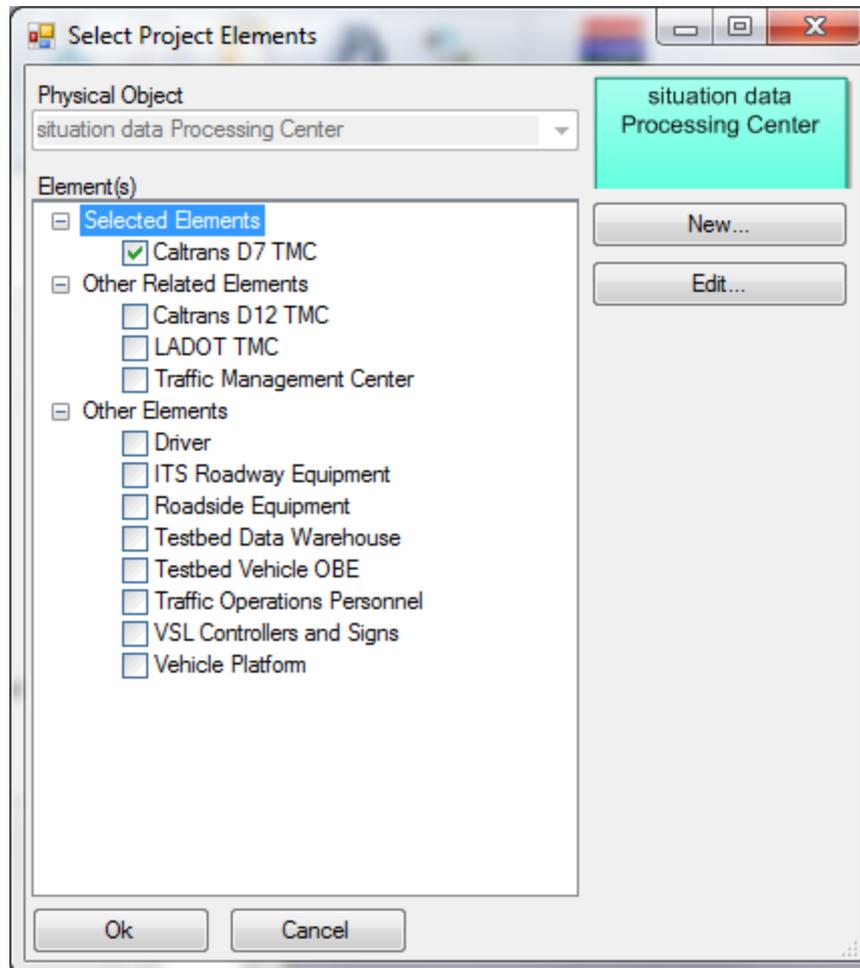
# Alt Physical Layer 1



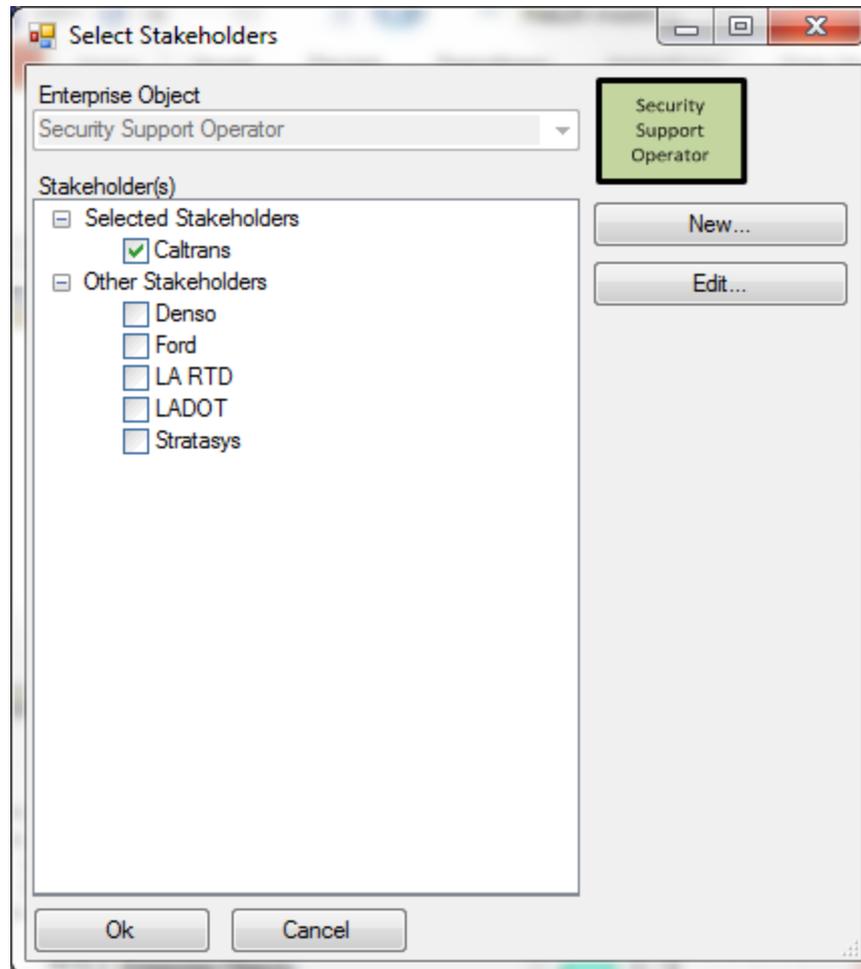
# Enterprise



# P-Object Edit (Physical)



# Stakeholder Assignment (Enterprise)



# CVRIA Application Browsing

CPAT - Southland Speed Harmonization Testbed (Physical)

Project Home Diagram Review Output

Diagram Item Cut Copy Paste Find Replace Physical

Overview

- Dashboard
- Project
- Applications
- Diagrams
- Layer 0
- Layer 1 - Test Bed
- Layer 1 - 3rd Party
- Layer 1 - Comprehensive
- Layer 2 - Speed Harmonization
- Layer 2 - Queue Warning
- Definitions
- Stakeholders
- Elements
- Physical Objects

| Type          | Group             |
|---------------|-------------------|
| Environmental | Road Weather      |
| Mobility      | Border            |
| Mobility      | Commercial Vehic  |
| Mobility      | Misc              |
| Mobility      | Planning and Perf |
| Mobility      | Public Safety     |
| Mobility      | Traffic Network   |

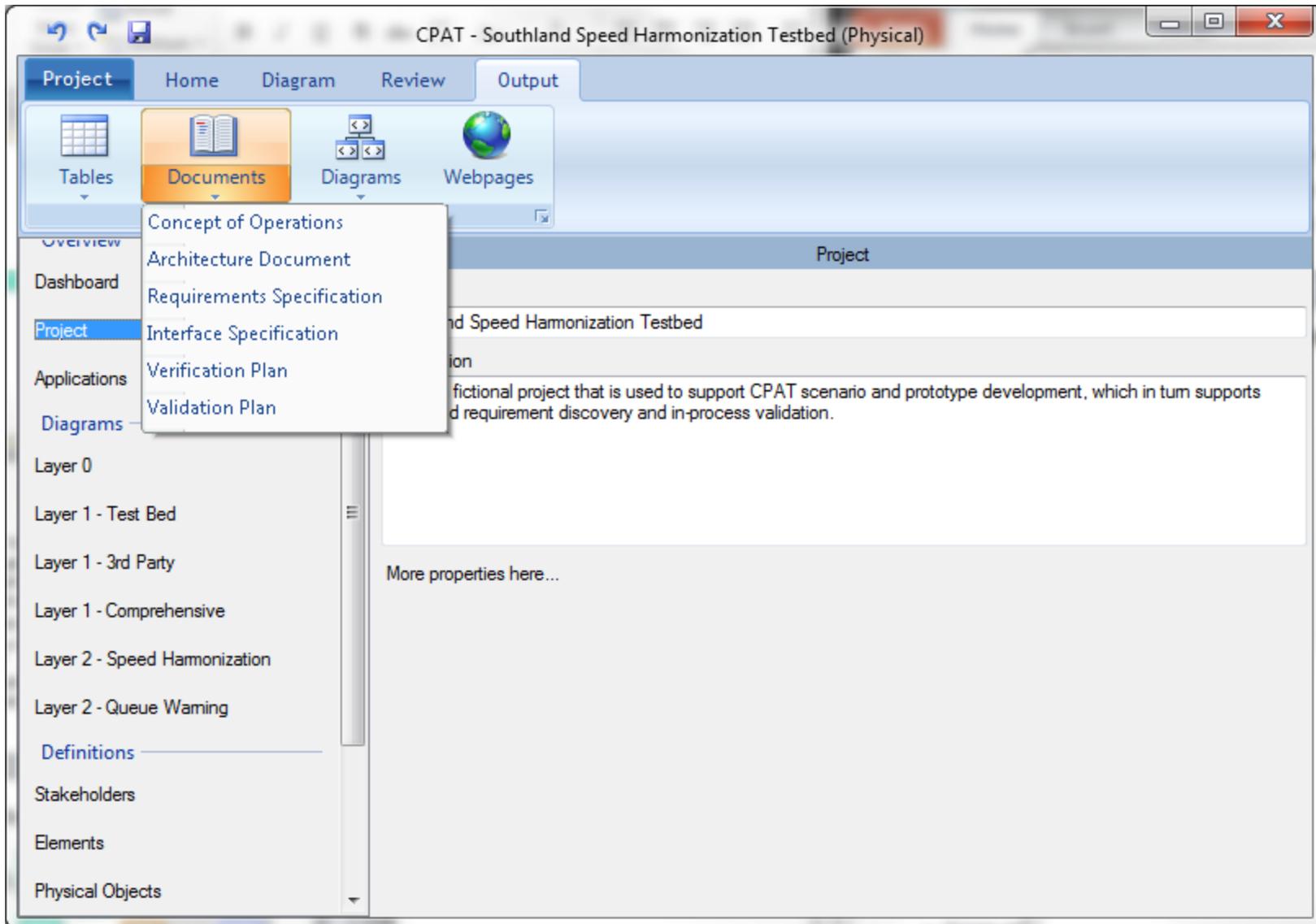
Applications

The Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE) application employs communications technologies to provide warnings and alerts relating to incident zone operations. One aspect of the application is an in-vehicle messaging system that provides drivers with merging and speed guidance around an incident. Another aspect is providing in-vehicle incident scene alerts to drivers, both for the protection of the drivers as well as incident zone personnel. A third aspect is an infrastructure based warning system for on-scene workers when a vehicle approaching or in the incident zone is being operated outside of safe parameters for the conditions. Additional information such as arriving and staging of additional responders would also be provided to assist in staging decisions and response to the incident.

Ok Cancel

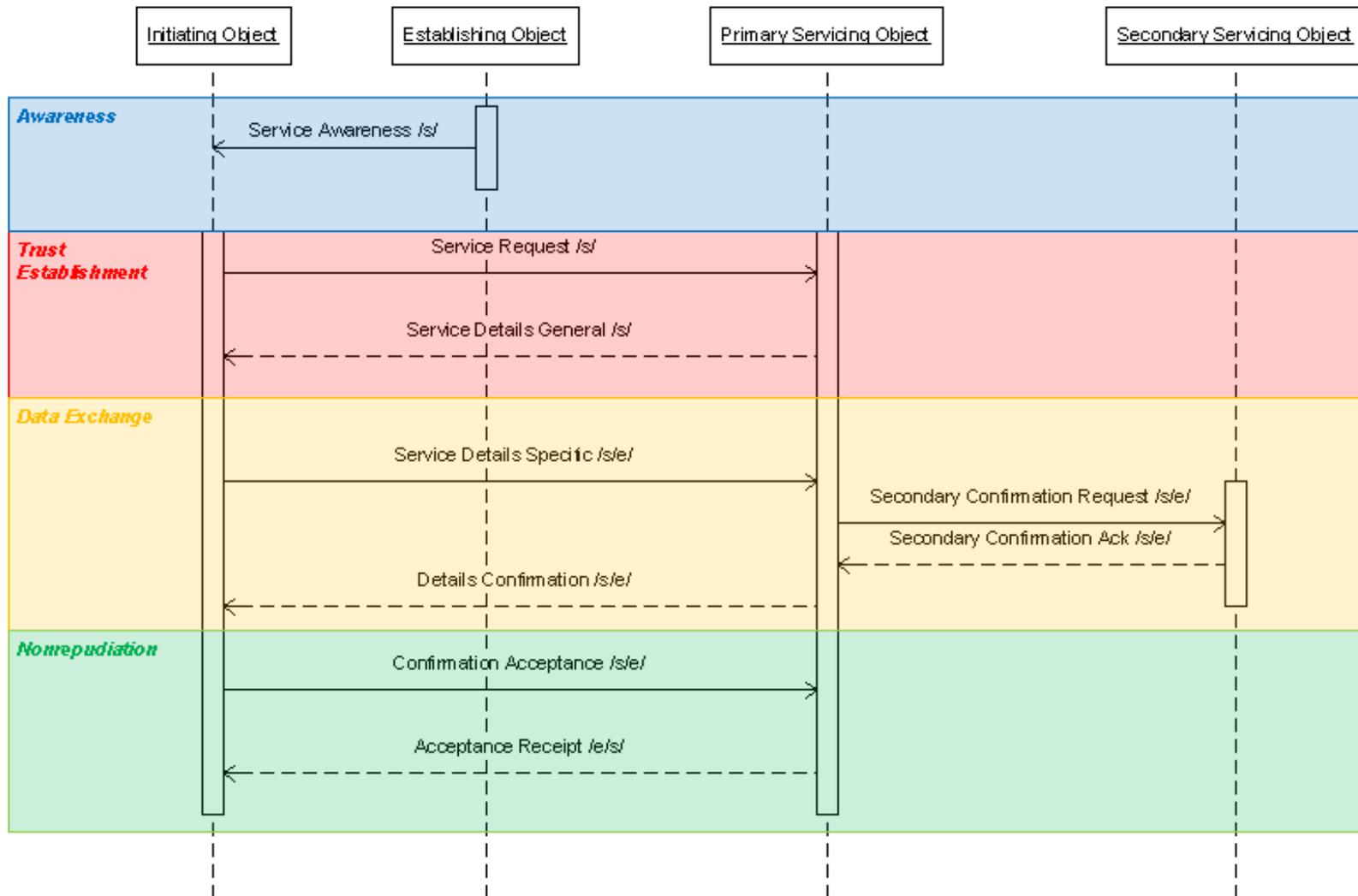
Transportation 14

# Output



# Message Sequences

Phases of a Peer-to-Peer Data Exchange Message Sequence



# Message Payloads

DSRC RSU Messaging

File About

**INFLO** THE SIMULATOR

Battelle  
The Business of Innovation

Connect Send Predefined Send Clear

RSA Type Mobile Situation

**Message**

Main Code 257 Stopped traffic

|      |                                  |    |      |        |
|------|----------------------------------|----|------|--------|
| 560  | truck stuck under bridge         | Up | Down | Delete |
| 7427 | use right lane                   | Up | Down | Delete |
| 7723 | and                              | Up | Down | Delete |
| 7438 | allow emergency vehicles to pass | Up | Down | Delete |

**Preview**



Traffic Conditions

Stopped traffic truck stuck under bridge use right lane and allow emergency vehicles to pass

**Road Side Alert Message**

|      |                                      |             |     |
|------|--------------------------------------|-------------|-----|
| 2049 | abnormal load                        | Set as Main | Add |
| 2051 | long load                            | Set as Main | Add |
| 2052 | slow vehicle                         | Set as Main | Add |
| 2053 | farm equipment                       | Set as Main | Add |
| 2054 | horse drawn vehicles                 | Set as Main | Add |
| 2055 | overheight load                      | Set as Main | Add |
| 2056 | overweight load                      | Set as Main | Add |
| 2057 | Tracked vehicle                      | Set as Main | Add |
| 2058 | vehicle carrying hazardous materials | Set as Main | Add |
| 2059 | slow moving maintenance vehicle      | Set as Main | Add |
| 2060 | Convoy                               | Set as Main | Add |
| 2061 | Military convoy                      | Set as Main | Add |
| 2062 | Refugee convoy                       | Set as Main | Add |
| 2063 | motorcade                            | Set as Main | Add |
| 2064 | mobile situation repositioning       | Set as Main | Add |
| 2065 | winter maintenance vehicles          | Set as Main | Add |
| 2066 | snowplows                            | Set as Main | Add |
| 2172 | slow moving maintenance vehicle      | Set as Main | Add |
| 2173 | exceptional load warning cleared     | Set as Main | Add |
| 2174 | hazardous load warning cleared       | Set as Main | Add |
| 2175 | Convoy cleared                       | Set as Main | Add |

# Project Architecture Scope

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- An Implementation, not THE Implementation
- Finite, well-defined scope that is part of the implementation process

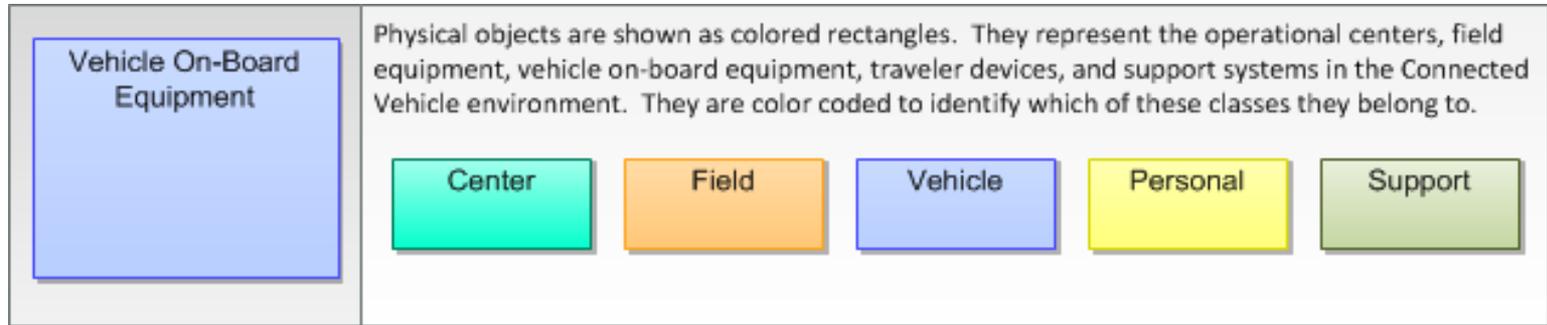


# Southeast Michigan Project Architecture

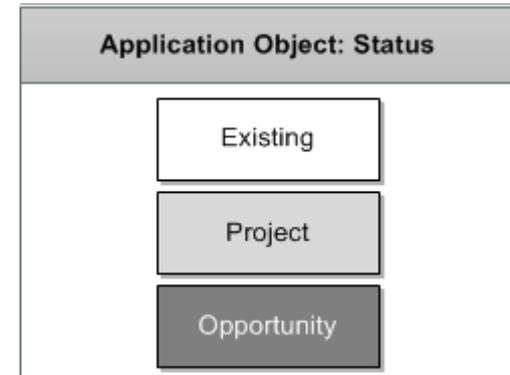
- Physical View
  - Layer 0: The physical objects that participate, the interconnects between them
  - Layer 1: The project-specific functions performed by each physical object, and the data exchanged between them
  - Layer 2: Application-specific; shows only those objects that are part of the application, with more detail on the flow of data
- Enterprise View
  - Layer 0: The people and agencies that own and operate physical objects
  - Layer 1: The people and agencies that own and operate physical objects and application objects
- Communications View
  - For each information flow in the Physical View, the layered communications protocols necessary to implement the information flow



# Physical View Architecture Constructs: Objects

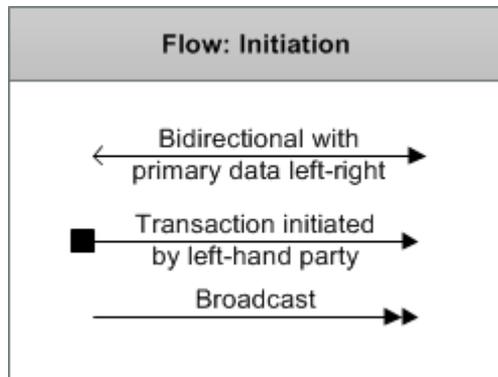


Application objects are also categorized according to their implementation within the project.

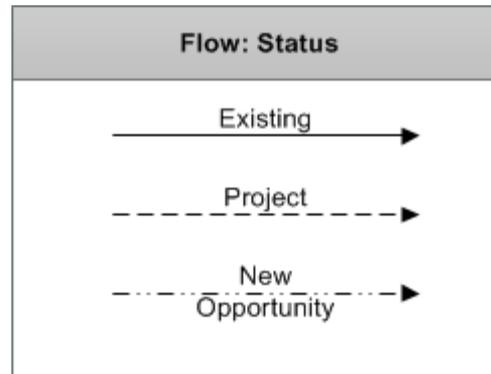


# Physical View Architecture Constructs: Flows

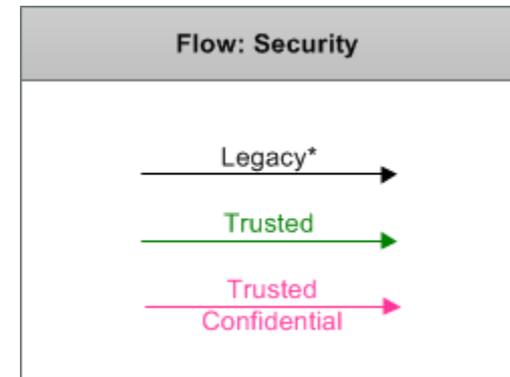
- Which device initiates the flow?
- What is the communication pattern?



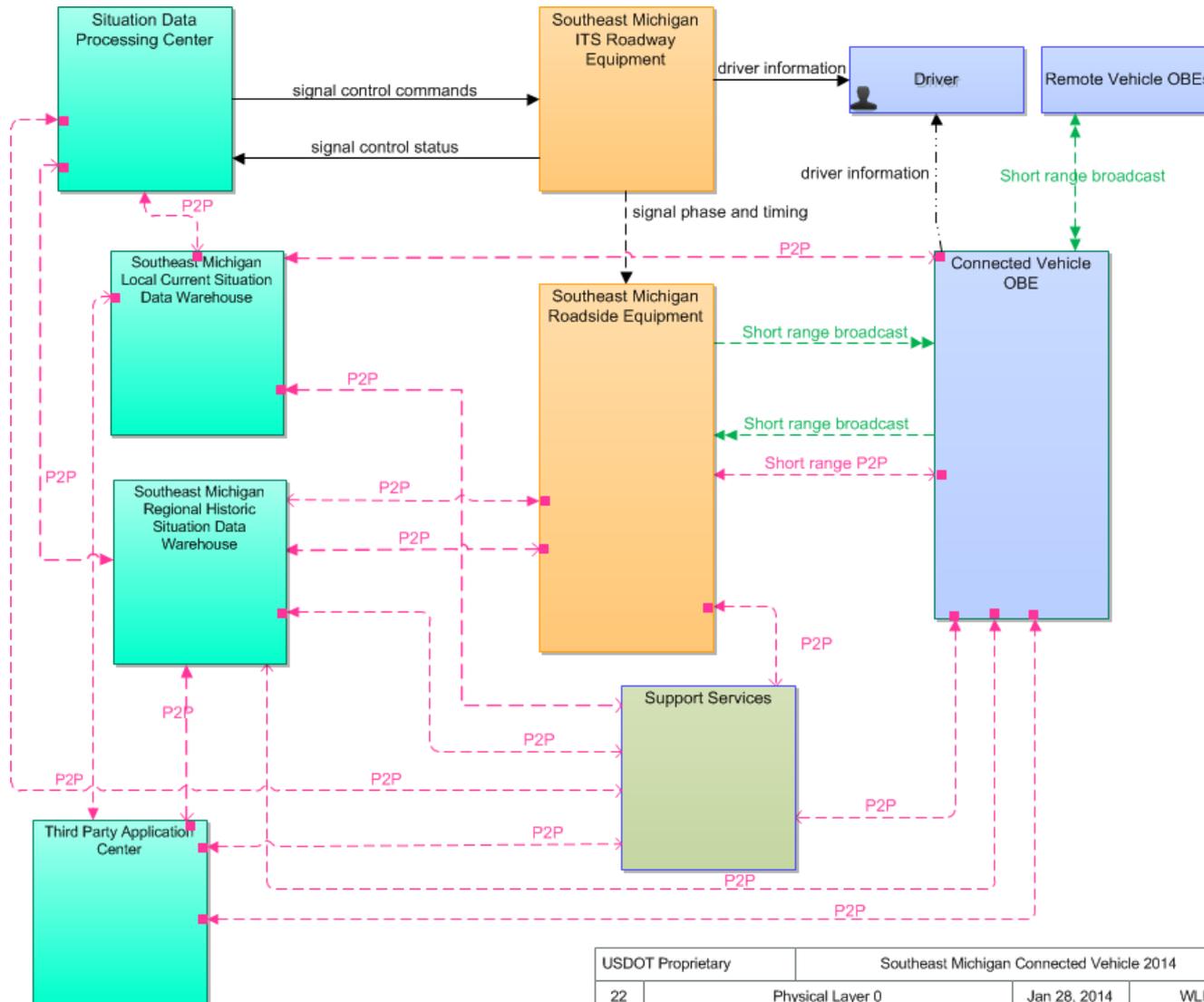
- Does the flow exist?



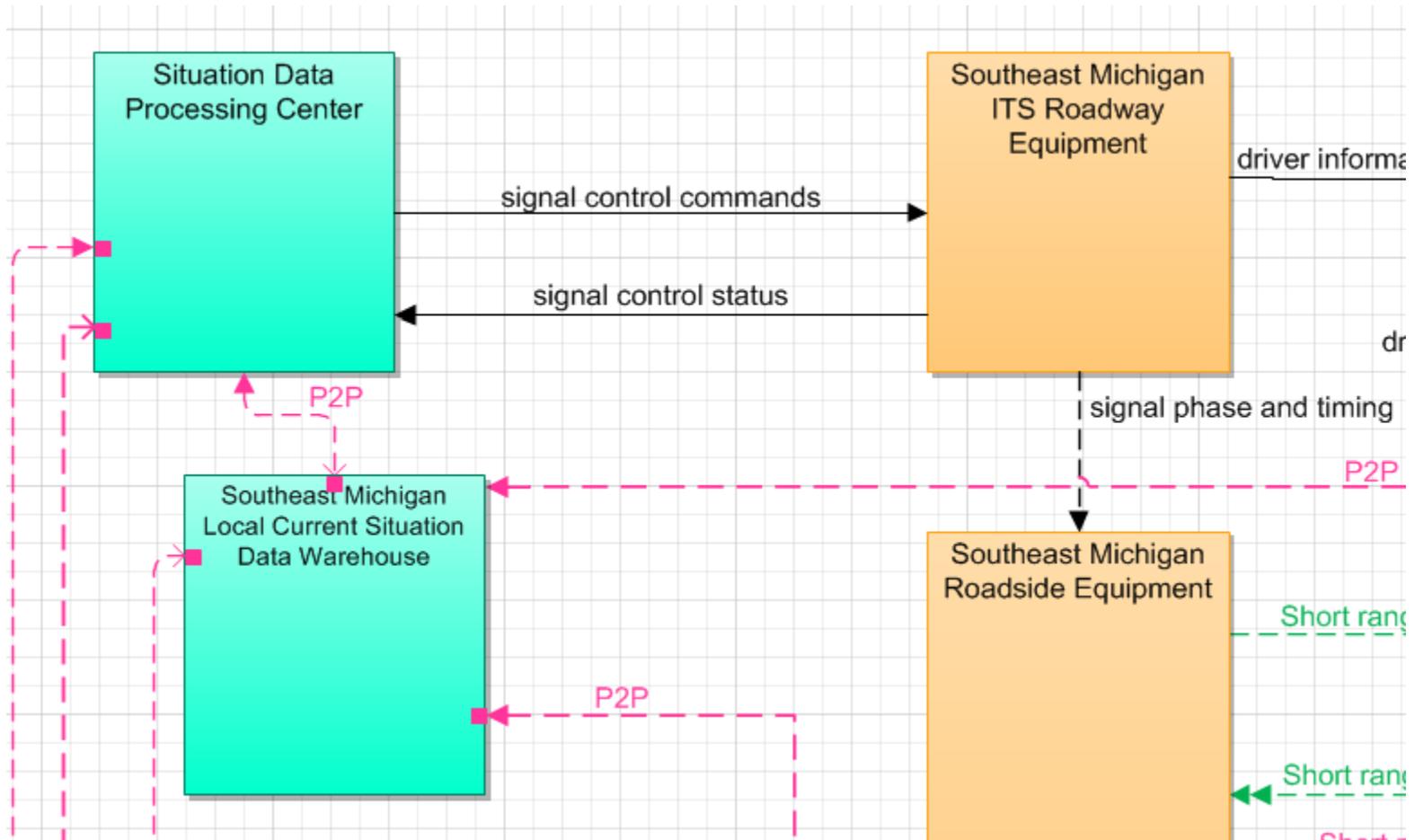
- What type of security does the flow require?



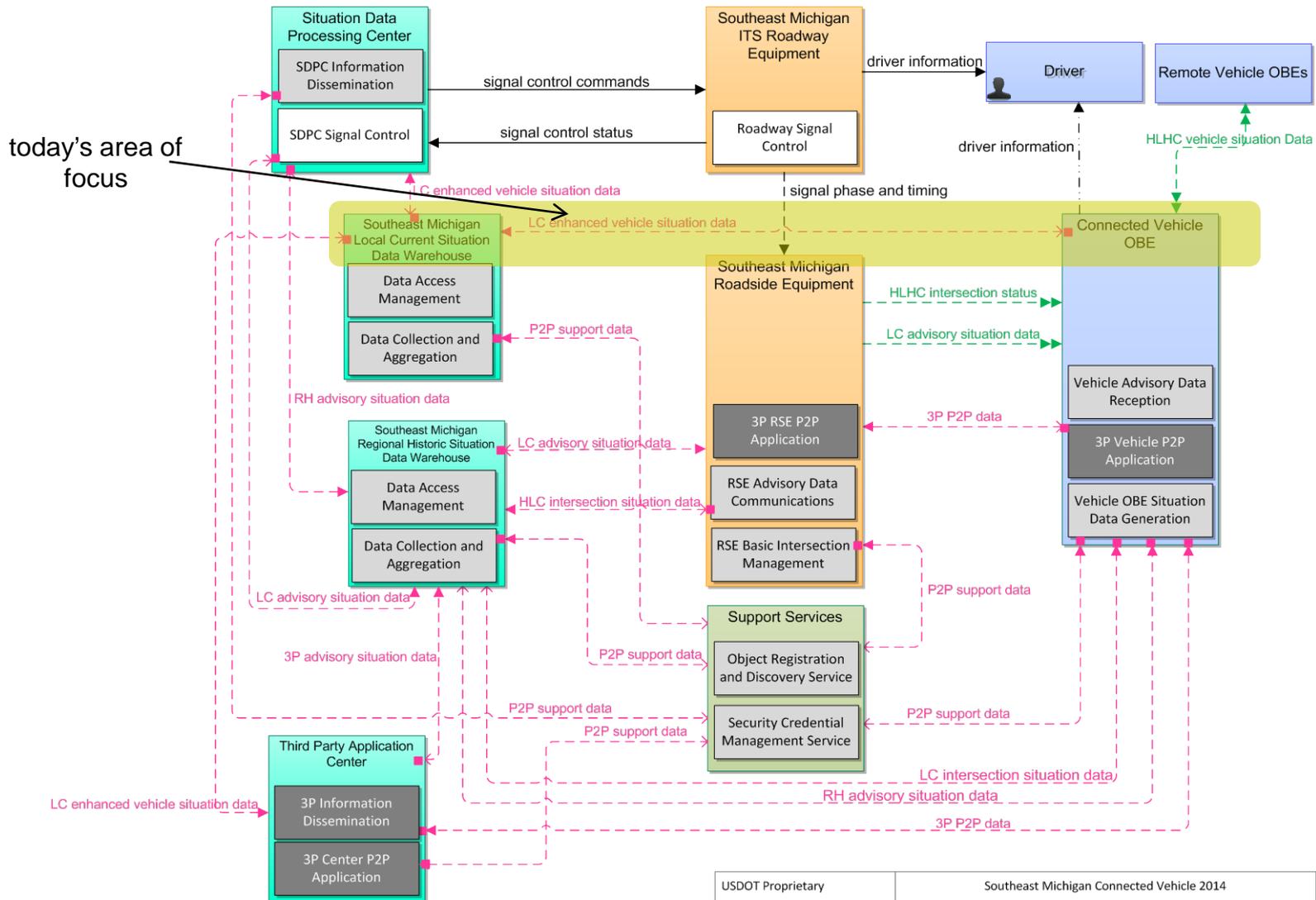
# Physical View – Southeast Michigan 2014 Layer 0



# Physical View Layer 0 Example



# Physical View – Southeast Michigan 2014 Layer 1



|                   |                                  |   |     |
|-------------------|----------------------------------|---|-----|
| USDOT Proprietary |                                  | Southeast Michigan Connected Vehicle 2014 |     |
| 19                | Physical Layer 1 - Comprehensive | Jan 28, 2014                              | WLF |

# Physical View – LC Enhanced Situation Data



From this snippet we can see that the LC enhanced vehicle situation data flow has the following characteristics:

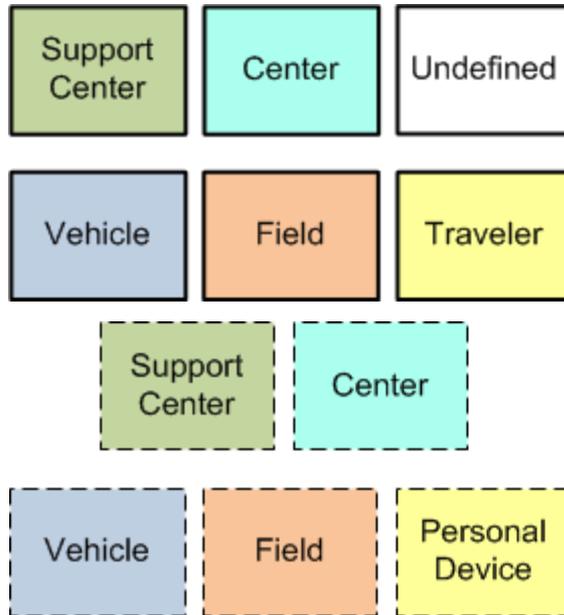
- The Connected Vehicle OBE initiates this data exchange
- This flow is encrypted and signed
- This flow is part of the testbed development

# Communications View – LC Enhanced Situation Data

| Vehicle-Center (RSE)  |  |                                    |                           |  |
|---|--|------------------------------------|---------------------------|--|
| LC Enhanced Vehicle Situation Data ->   |  |                                    |                           |  |
| Southeast Michigan Connected Vehicle OBE<br>Vehicle OBE Situation Data Generation |  | Roadside Equipment                 |                           | Southeast Michigan Local Current Situation Data Warehouse<br>Data Collection and Aggregation |
| SAE J2735 (2009) – Sequence Design  |  |                                    |                           | SAE J2735 (2009) – Sequence Design   |
| ASN.1 BER   |  |                                    |                           | ASN.1 BER  |
| (session layer unused)  |  |                                    |                           | (session layer unused)   |
| UDP   |  |                                    |                           | UDP  |
| IPv6  |  | IPv6                               | IPv6                      | IPv6   |
| 1609.3, 802.2, 802.11p  |  | 1609.3, 802.2, 802.11p             | IEEE 802.2                | IEEE 802.2   |
| 5.9 Ghz wireless (802.11p) / 1609.4   |  | 5.9 GHz wireless (802.11p), 1609.4 | Backhaul PHY <sup>2</sup> | Backhaul PHY <sup>2</sup>  |
|   |  | IEEE 1609.2                        | IEEE 1609.2               |  |

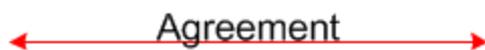
2: An Internet connection or private network connection that is routable between the RSE and the Southeast Michigan Local Current Situation Data Warehouse

# Enterprise View Architecture Constructs



Enterprise objects (people, organizations) are shown as boxes with thick black borders, color coded by their relationship to the transportation environment

Physical objects are color coded the same as in physical view diagrams, but shown as rectangles with dashed lines.



Formal coordination between people and/or organizations, documented in some contract or other form of written agreement that both parties acknowledge.



Information coordination between people and/or organizations, usually undocumented.



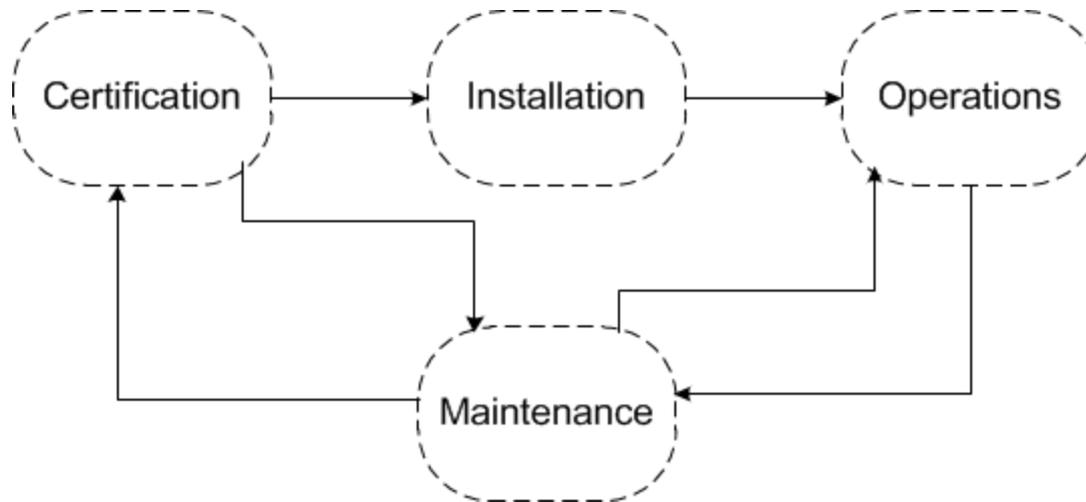
Relationship between people and/or organizations (e.g., member of) or between people/organizations and physical objects (owns, operates, maintains, installs, certifies etc.)



Relationship between physical objects that is relevant to people and/or organizations: includes, extends

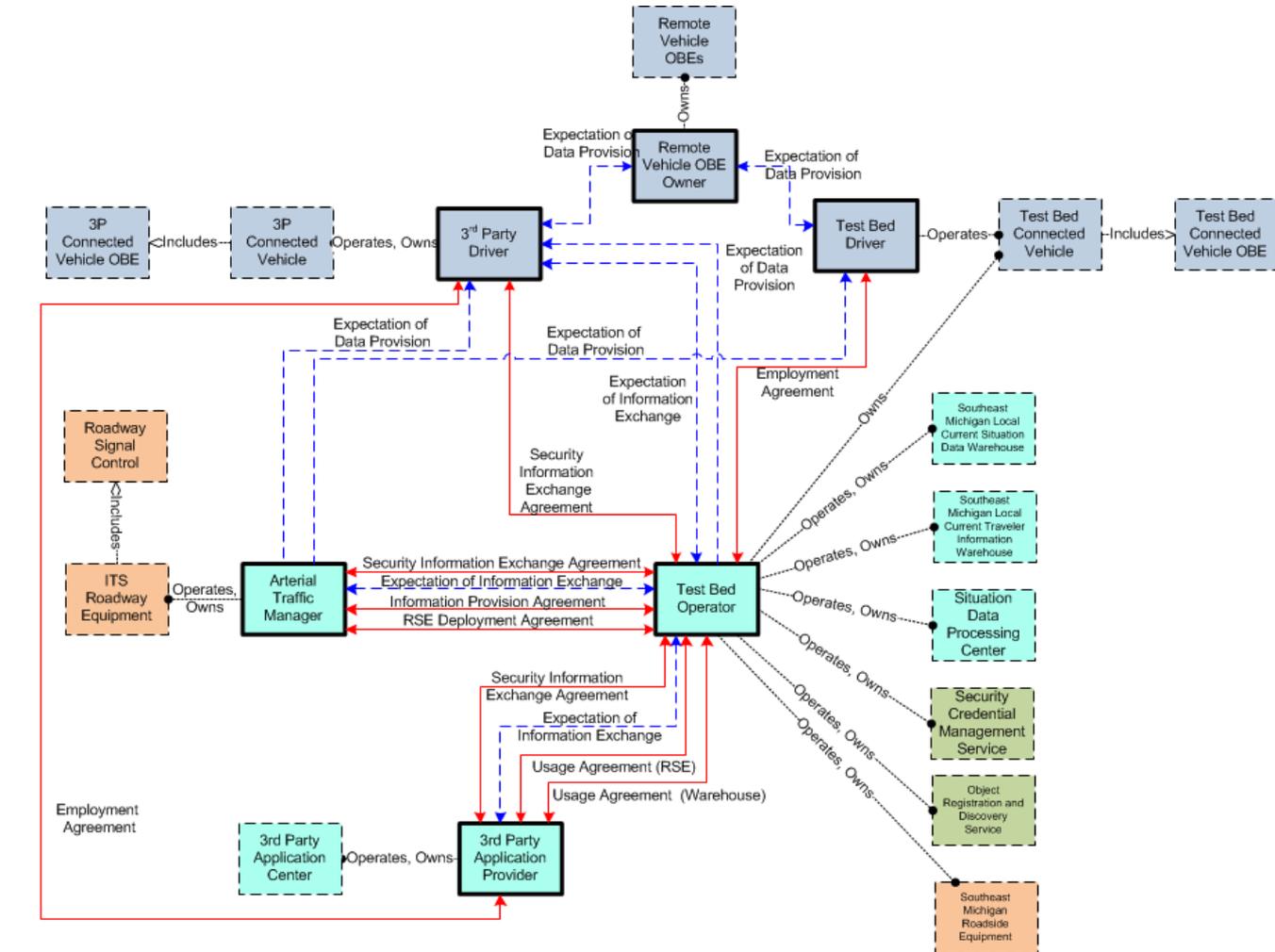
# Enterprise View – Life Cycle

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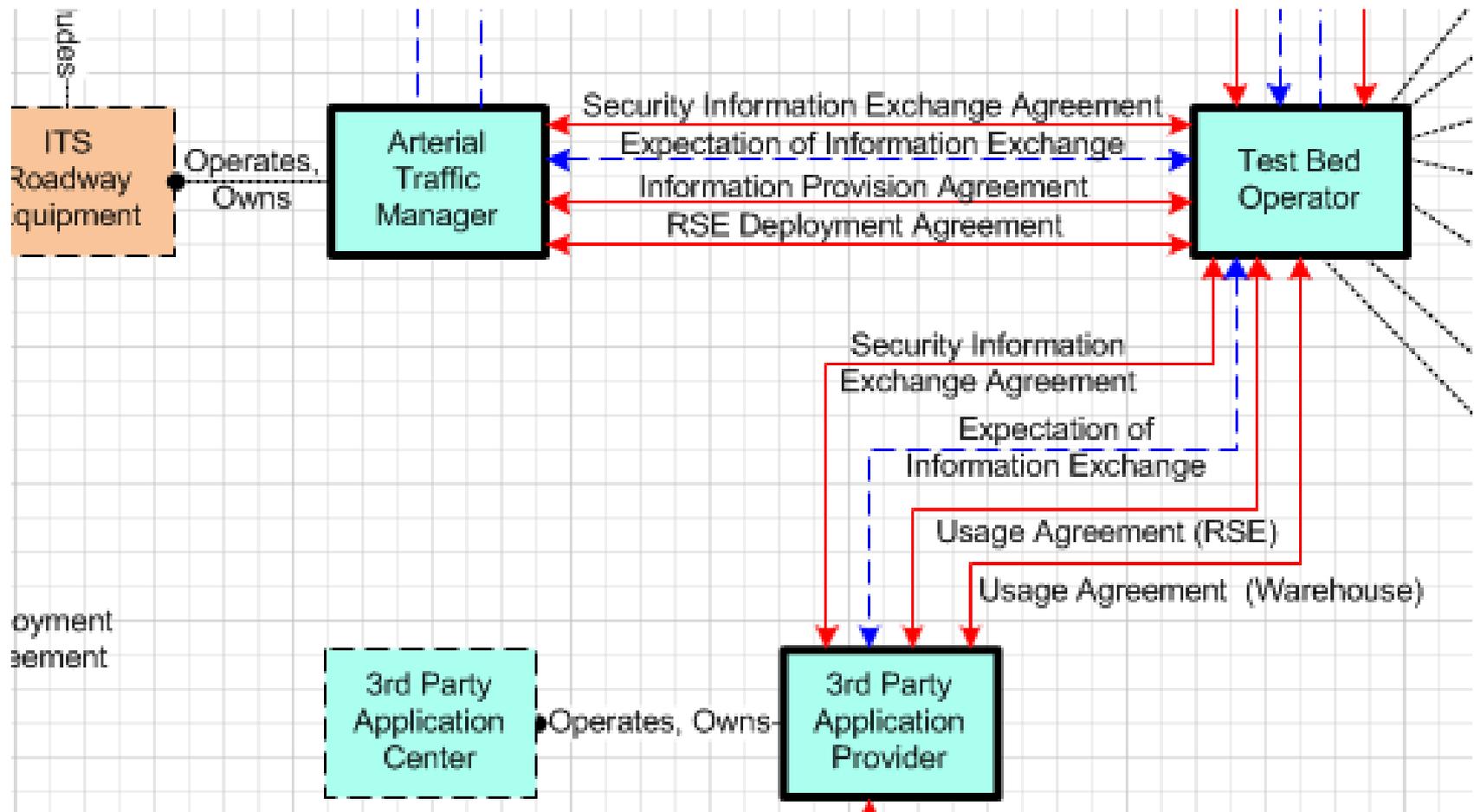
- Certification Phase: application and device approval, adherence to standards
- Installation Phase: deployment of applications and devices
- Operations Phase: operation of applications to provide benefits to end users
- Maintenance Phase: maintenance of applications and devices, and feedback of performance

# Enterprise View – Southeast Michigan 2014



| Southeast Michigan Connected Vehicle 2014 |                    |              |     |
|---|--------------------|--------------|-----|
| 7   | Layer 0 Enterprise | Jan 24, 2014 | JLM |

# Enterprise View Layer 0 Example



# Project Architecture Tool Support

- All Southeast Michigan project architecture diagrams were drawn using the CVRIA Mini-Tool
- Short-term use method for drawing CVRIA-like diagrams, using the viewpoint specifications defined in the CVRIA
- Enables a common language
- Enables information exchange and re-use
- Provides a rich backdrop of work that has already been done to define the 85+ applications USDOT has already considered in some fashion



# Contact Information

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- Tom Lusco
- [ctl@iteris.com](mailto:ctl@iteris.com)
- Project Architecture CVRIA Mini-Tool:  
<http://www.iteris.com/cvria/html/resources/tools.html>
- CVRIA: <http://www.iteris.com/cvria>

