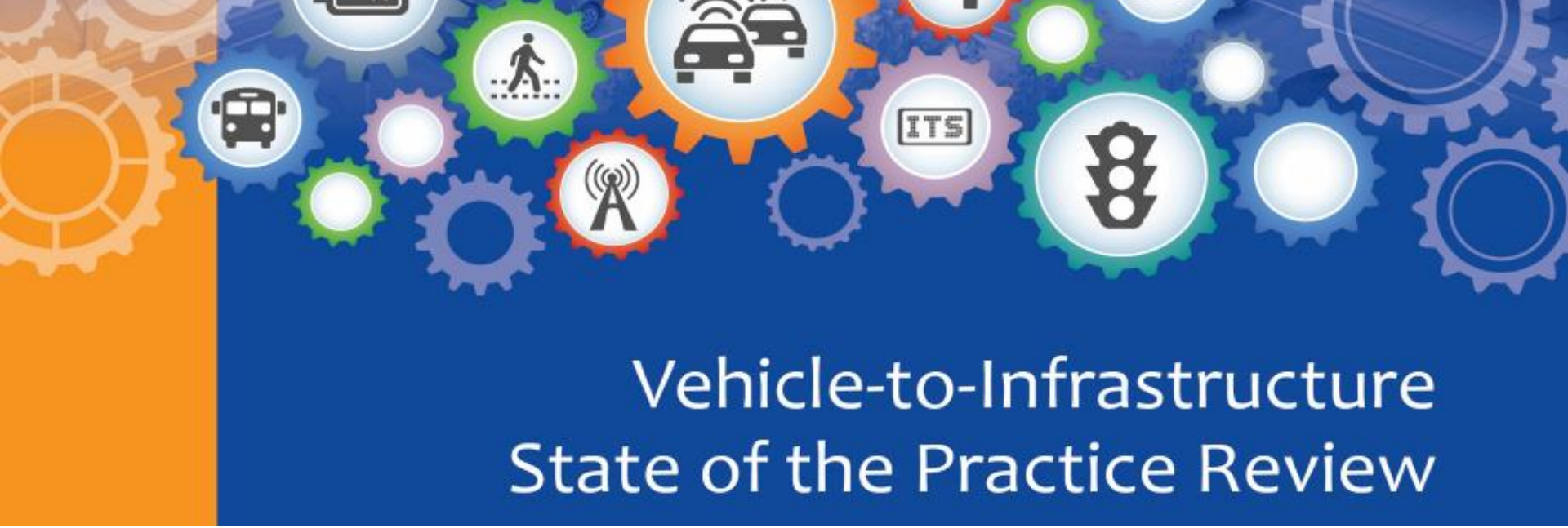


Vehicle-to-Infrastructure State of the Practice Review

Orange County Traffic Engineering Council

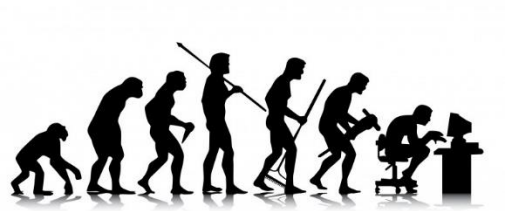
OCTEC – March Luncheon

Shayan Khoshmagham, Iteris

March 22, 2018

Evolution of Traffic Operations

- Operational and Maintenance Standards
    - **From:** Nothing Universal
    - **To:** NTCIP, Society of Automotive Engineers (SAE)
- Signal Controllers
    - **From:** Manual Directions
    - **To:** Modern Traffic Light Control (TLC) Systems
- Data Collection
    - **From:** Tally Sheets, Mechanical Counting Board
    - **To:** Wireless Technologies (e.g. Probe, Bluetooth) and GPS-enabled Devices



Evolution of Traffic Data Collection

- ✓ Manual Counts and Speed Measurements
- ✓ Fixed Location Sensors to log the passage time of the vehicles
  - Loop Detectors, Laser Ranging Profilers, Video Surveillance Cameras
- ✓ Passive matching of vehicles using infrastructure-based data
  - Vehicle Signature Matching with: wireless magnetic sensors, license plate recognition systems, Automatic Vehicle Identification (AVI) tags, MAC addresses of Bluetooth enabled devices, and cellular phones
- ✓ Active matching of GPS-enabled equipped vehicles
  - Fleets of Probe vehicles, taxis, heavy commercial vehicles
- ✓ High Resolution Traffic Signal Controller and Detailed Vehicle Trajectories
  - Eco-system of Smart Vehicles and Advanced Signal Controllers

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Today's ITS Components

Intelligent Infrastructure

- Traffic Signs
- Variable Message Sign (VMS)
- Sensors

Smart Vehicles

- GPS Navigational Systems
- Smart Speed Assist
- Intelligent Cruise Control

Information Services

- Real-time Guidance information
- Smart phone applications

Emergence of Connected Vehicles

- No longer a question of '**if**' but rather of '**when**'
- Internet-of-Things (IoT) Applications:
  - ❑ Intelligent Signal Control (I-SIG)
  - ❑ Queue warnings (Q-WRN)
  - ❑ Eco Driving
  - ❑ Collision Avoidance
  - ❑ Freight Platooning

Connected Vehicle Essentials

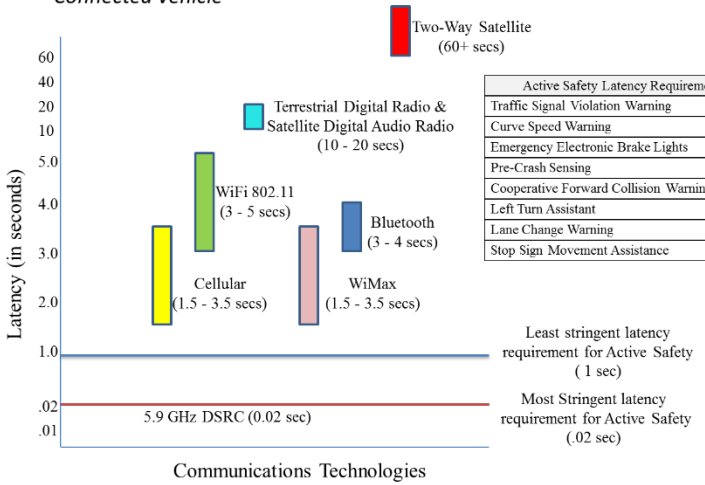
5.9 GHz **DSRC** Communication:
- vehicle-to-vehicle (v2v)
- vehicle-to-infrastructure (v2I)

SAE J2735 Message Set:
- BSM, SPAT, MAP, SRM, PSM…

Applications:
- SAFETY
- MOBILITY
- ENVIRONMENT

Goal:
- A more complete picture of traffic networks, signalized intersections, and travelers

From US DOT Briefings on Connected Vehicle



Active Safety Latency Requirements (secs)	
Traffic Signal Violation Warning	0.1
Curve Speed Warning	1.0
Emergency Electronic Brake Lights	0.1
Pre-Crash Sensing	0.02
Cooperative Forward Collision Warning	0.1
Left Turn Assistant	0.1
Lane Change Warning	0.1
Stop Sign Movement Assistance	0.1

Emerging CV Ecosystem

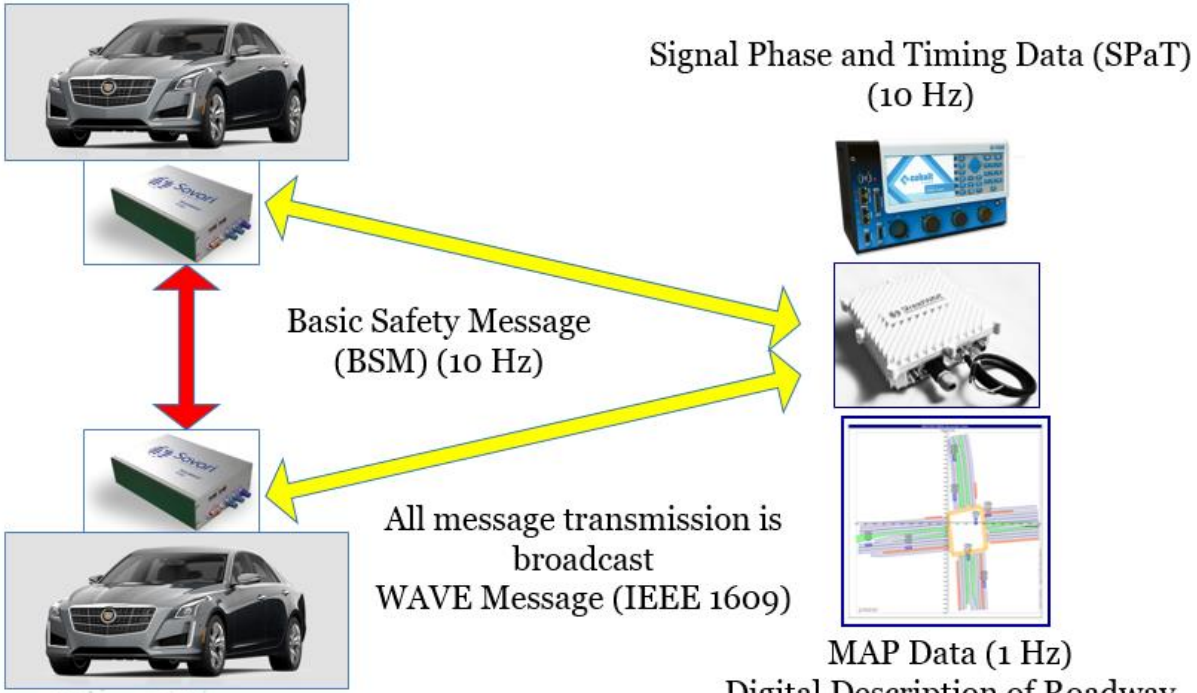
Intelligent Transportation Systems

- *I*nstruments: Sensors, Onboard Unit, Roadside Unit
- *I*nterconnected: V2I, V2V, V2P, V2X
- *I*ntelligence: Smart Applications

Big Data

- *V*olume: Terabytes and Petabytes of Data Objects
- *V*ariety: Internal, External, Structured, Unstructured
- *V*elocity: Low Latency, High Availability

CV Basic Building Blocks



*Courtesy of MMITSS-AZ

CV Basic Building Blocks

Channel 182

Channel 172

NTCIP

SPaT

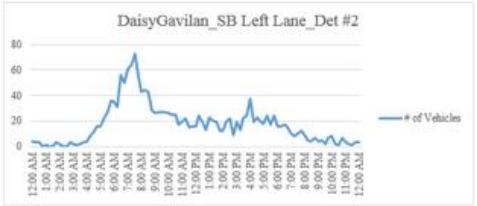
Fiber Optic Backbone Communication System

Full Inductive Loop Detectorization

System Detectors

Stop bar Detectors

Traffic Demand



*Courtesy of MMITSS-AZ

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CV Field Test and Deployment

SPaT deployment underway

SPaT deployment operational

*SPaT Challenge
**National Operations Center of Excellence

CV State-of-the-Practice Review
OCTA

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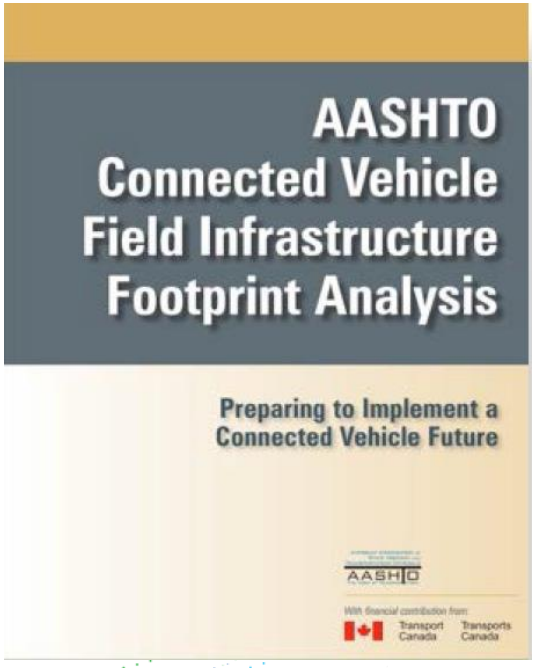
Footprint Analysis



- **National deployment footprint** requires CV capabilities as they might **support multiple applications**
- Benefits of field infrastructure compounded as devices are deployed:
  - Road Side Unit (RSU)
  - Advanced Transportation Controller (ATC)
  - On-board Unit (OBU)
  - After-market Safety Device (ASD)

Orange County Transportation Authority

- Understanding the role that "OCTA" plays in the region:
  - Monitor
  - Shape
  - Lead
  - Implement

- Applications in Categories of:
  - Dynamic Mobility
  - Safety
  - Agency Data
  - Safety V2I/V2V

Shortlist of Applications

APPLICATION GROUP	APPLICATION BUNDLE	APPLICATION
Mobility	Enable ATIS	Advanced Traveler Information System (mobility)
	Multimodal Intelligent Traffic Signal Systems (MMITSS)	Intelligent Traffic Signal System (I-SIG)
		Freight Signal Priority (FSP)
		Transit Signal Priority (TSP)
		Mobile Accessible Pedestrian Signal System (PED-SIG)
		Emergency Vehicle Preemption (PREEMPT)
	Integrated Network Flow Optimization (INFLO)	Dynamic Speed harmonization (SPD-HARM)
		Queue Warning (Q-WARN)
		Cooperative Adaptive Cruise Control (CACC)
	Response, Emergency Staging and Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.)	Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
		Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
		Emergency Communications and Evacuation (EVAC)
Mobility	Integrated Dynamic Transit Operations (IDTO)	Connection Protection (T-CONNECT)
		Dynamic Transit Operations (T-DISP)
		Dynamic Ridesharing (D-RIDE)
	Freight Advanced Traveler Information Systems (FRATIS)	Freight-Specific Dynamic Travel Planning and Performance (FRATIS)
		Drayage Optimization (DR-OPT)

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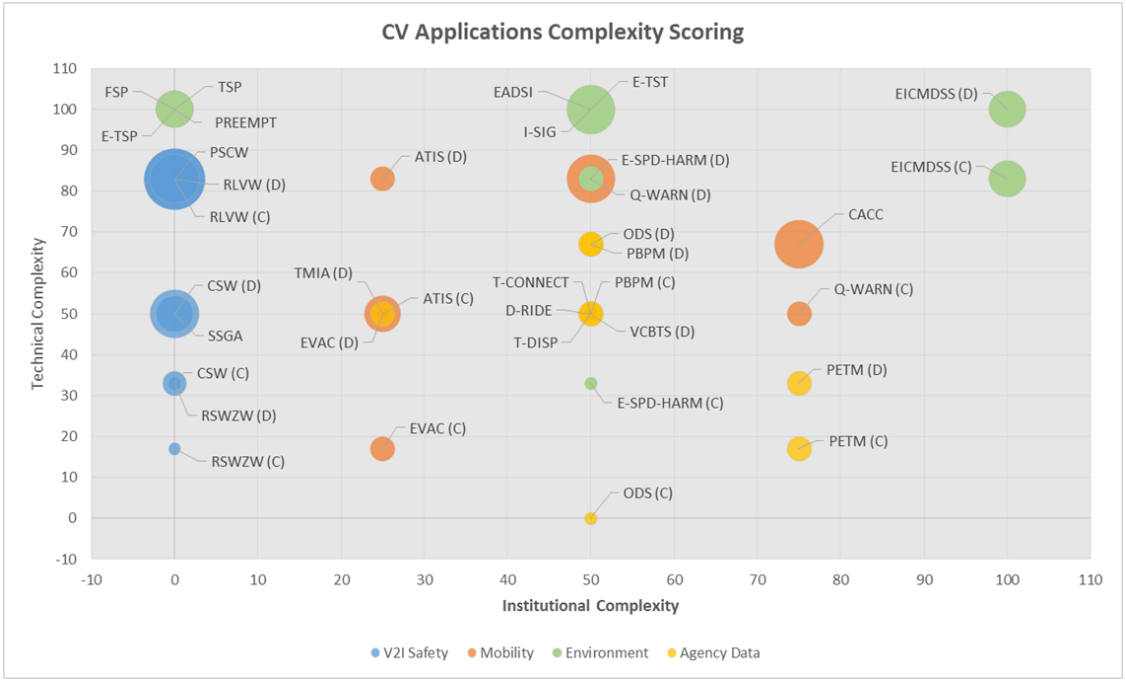
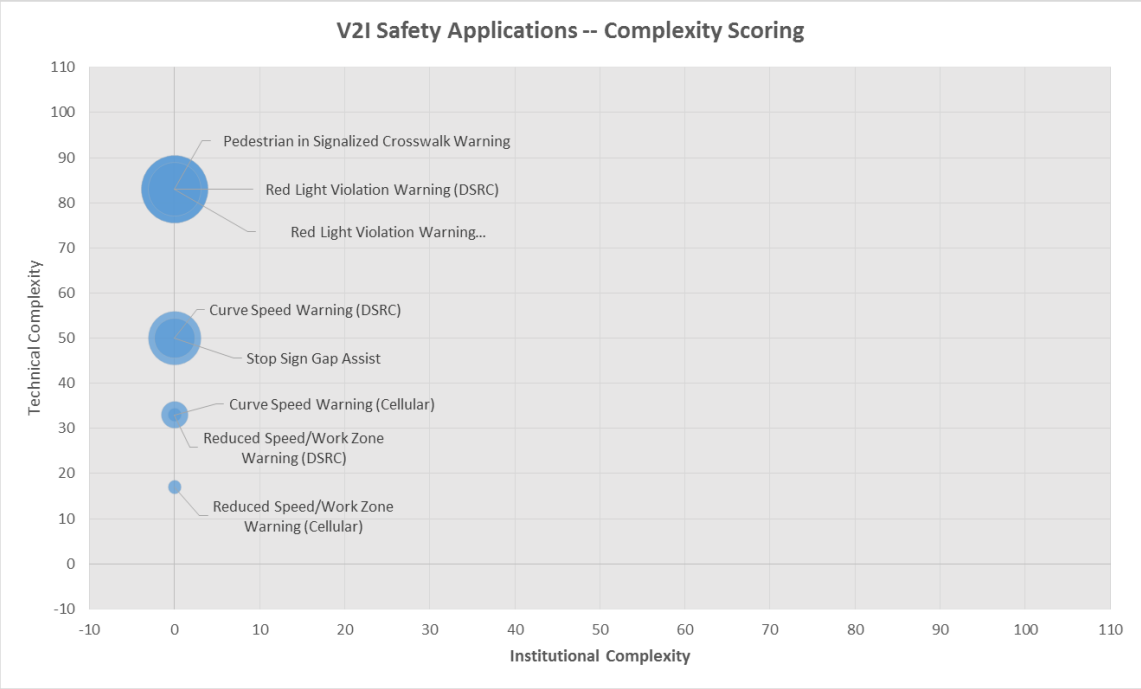
Complexity Score

- Computed for each application
- Data Availability:
  - 2014 AASHTO CV Field Infrastructure Footprint Analysis
  - Open Source Application Development Portal (OSADP)
  - Research Data Exchange (RDE)
- Components:
  - Institutional complexity
  - Technical complexity
  - Risk Level
- Lower score = Easier deployment

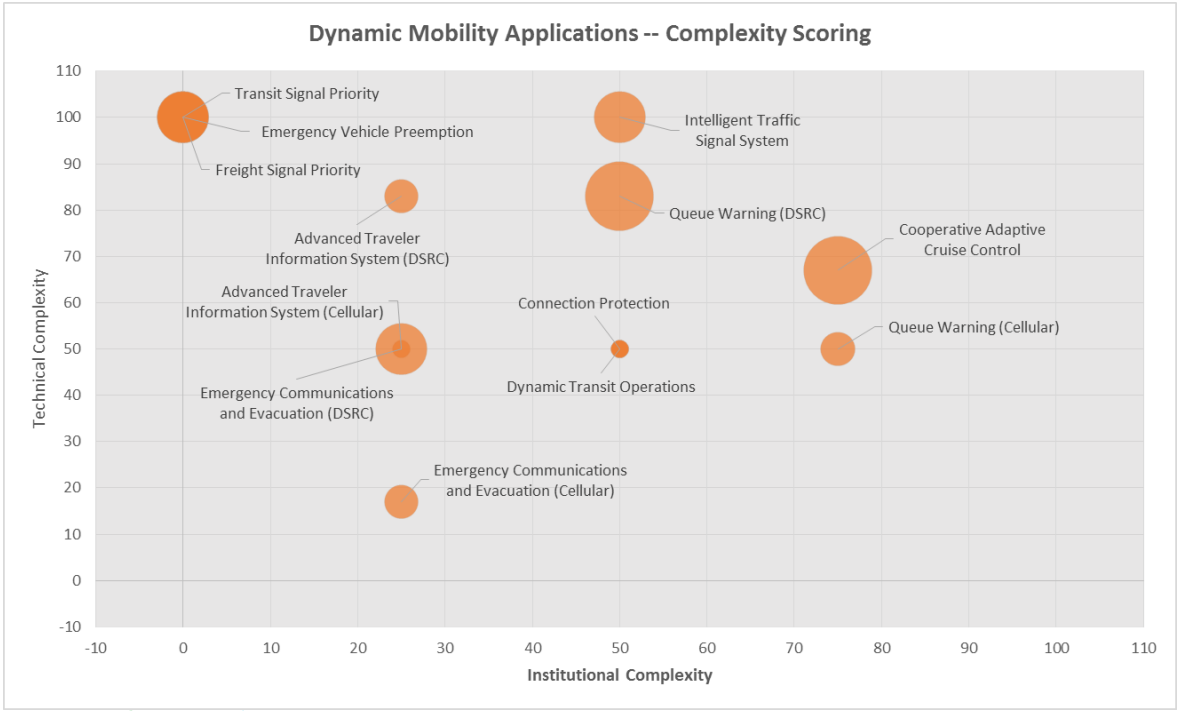
Complexity Score Visualization



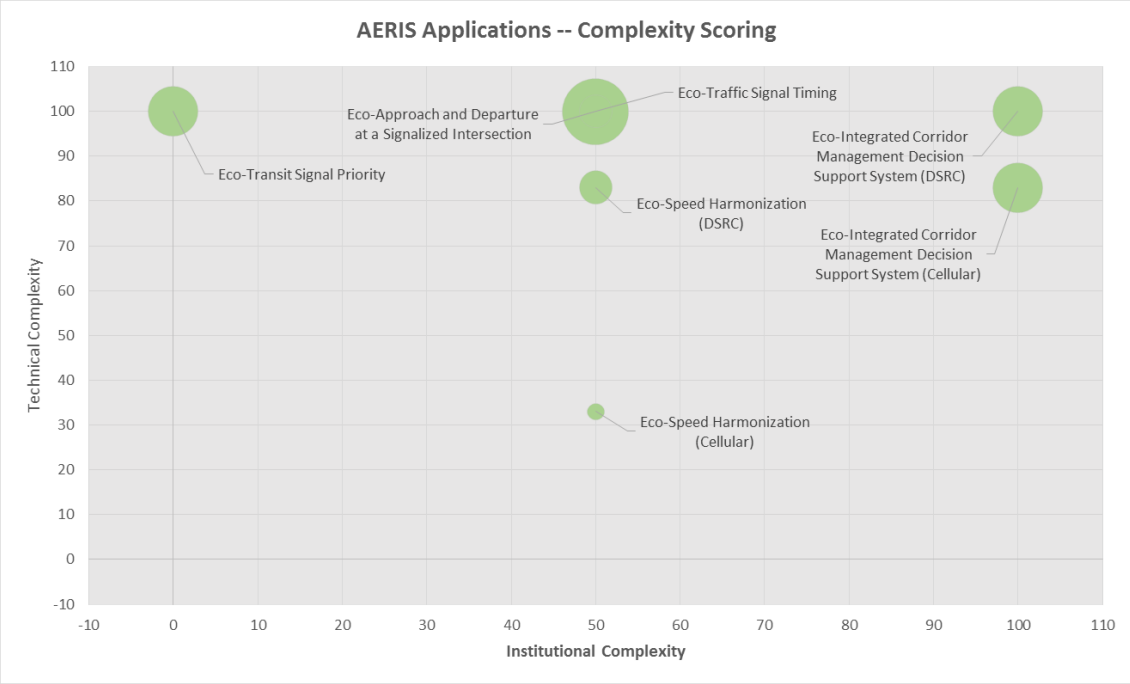
V2I Safety Applications



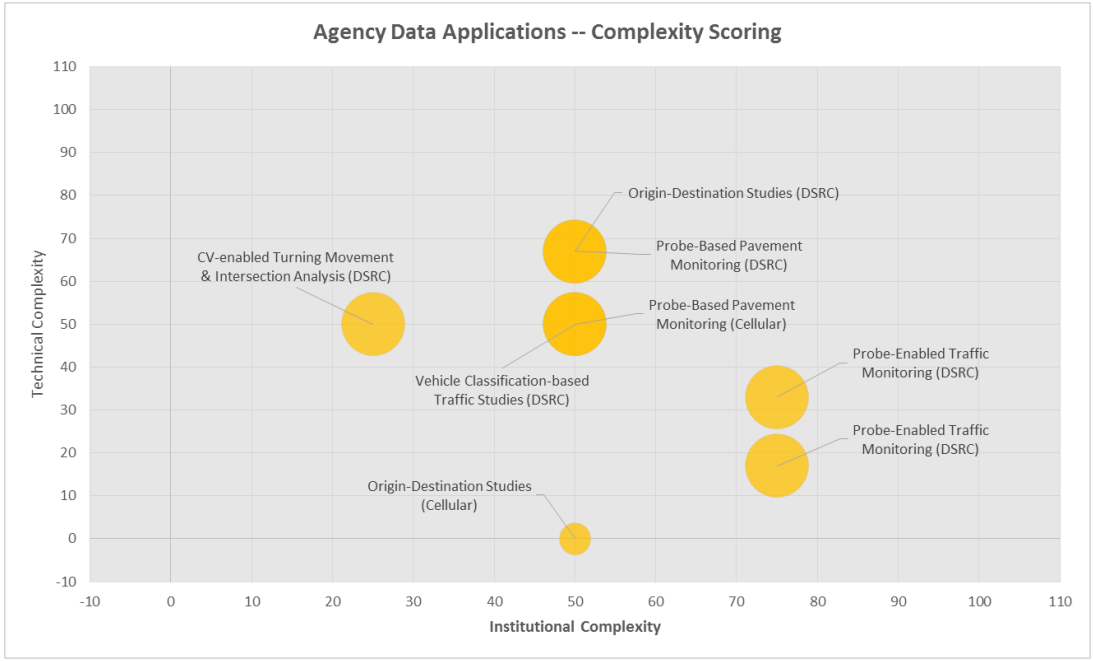
Dynamic Mobility Applications



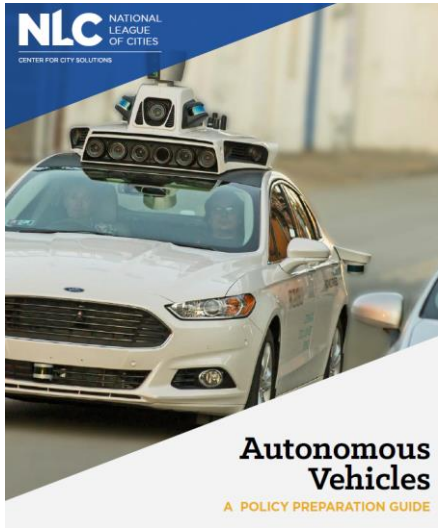
Environmental Applications



Agency Data Applications



Action Items…



- Cities should **encourage** V2I **investment** & become an **active investment partner**.
- Data processing requirements often out of reach; **partnering** with local academic institutions a solution.
- **Wireless broadband needs will grow** exponentially, understand **infrastructure** will need to be **constantly updated**.
- While 5G is important today, it **will be surpassed** in the future.

V2I Deployment Survey

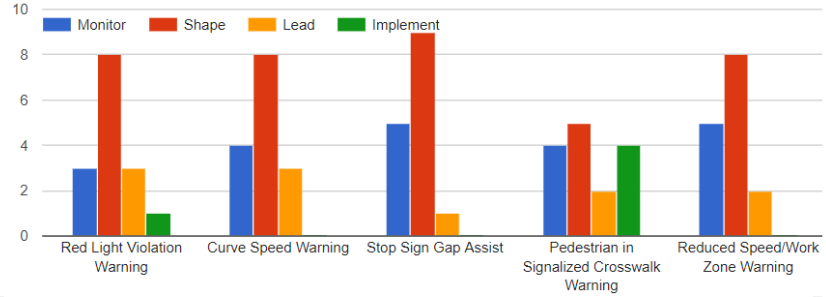
Evaluation matrix

- Responsible parties and respective actions
- Challenges & risks with possible actions & roles
- Benefits with possible actions & roles
- Resources to obtain more information

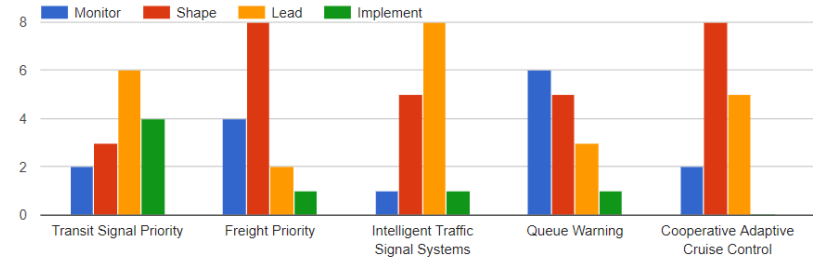
Survey – Participants

- City of Laguna Hills
- City of Lake Forest
- City of Irvine
- Aliso Viejo
- City of Laguna Niguel
- Caltrans
- City of Fullerton
- City of RSM
- City of Newport Beach
- City of Laguna Niguel
- Caltrans District 12
- City of La Habra
- Los Alamitos
- Tustin
- City of Santa Ana

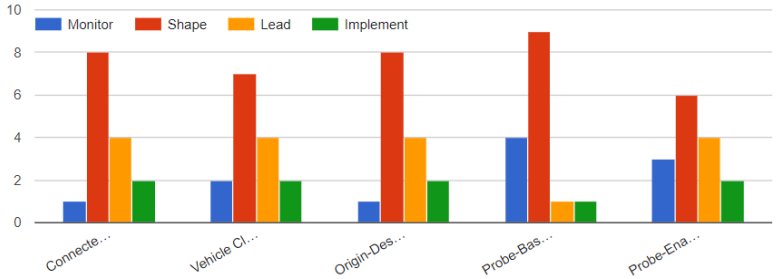
Survey – OCTA Primary Role



Safety

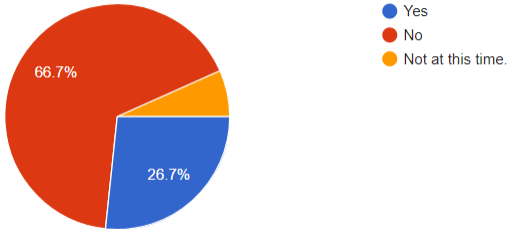


Dynamic Mobility



Agency Data

Survey – Pursuing V2I Initiatives



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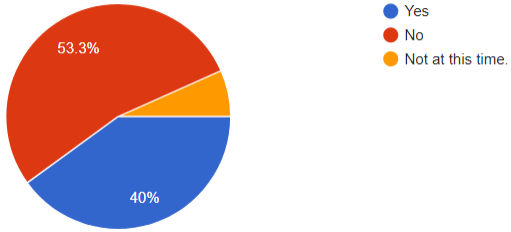
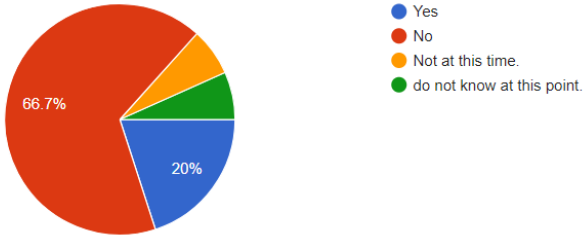
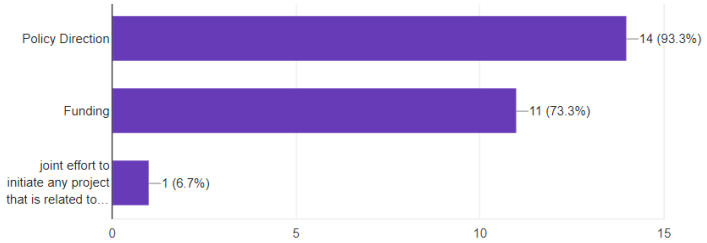


Dynamic Mobility

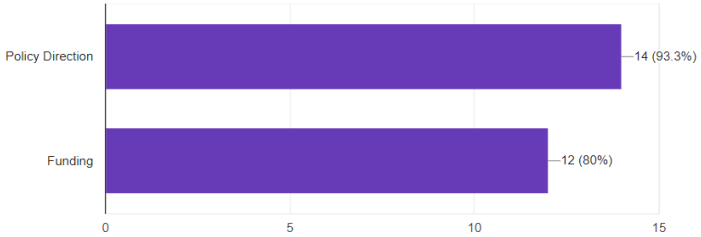


Agency Data

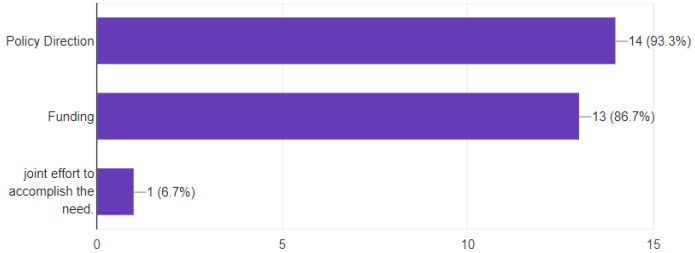
Survey – OCTA Assistance



Safety

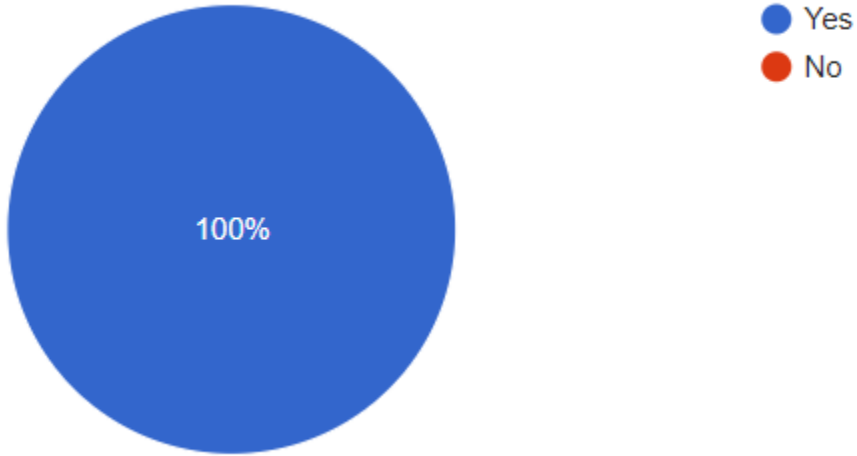


Dynamic Mobility



Agency Data

Survey – Future Participation



Thank You!

Questions?

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