

*Automation in Transportation*

# Connected Vehicles

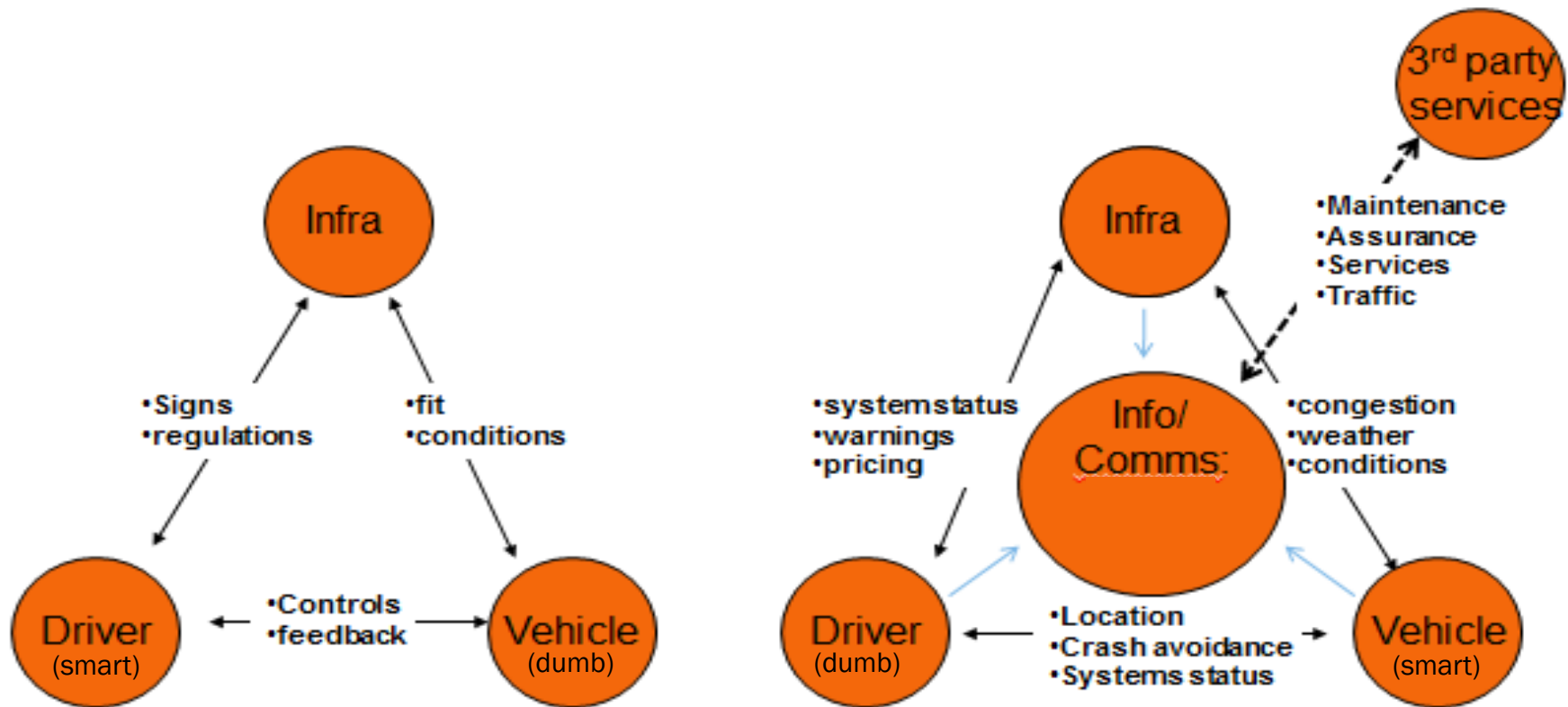
*"The future has already arrived;  
It's just not evenly distributed"*



# This Presentation

- ∞ **Which:** Deconfuse terminology -Connected Vehicles (CV) context
- ∞ **How:** Systems and technology
- ∞ **What:** Functions/Services – public and commercial
- ∞ **Who:** Key players in value creation
- ∞ **When:** Timing
- ∞ **Planning Response:** State/metro/local

# Adding Intelligence



20<sup>th</sup> C -- Loose Fit

21<sup>st</sup> C -- Integration

# Who Does What?

## ∞ “Intelligent Transportation Systems” (exists)

- Based on embedded systems deployed by state/local DOTs
  - sensors/cameras/fiber optics
  - dynamic message signs/ramp meters

## ∞ “Autonomous Vehicles” (in early phases)

- Self-contained: rolled out incrementally in new vehicles – brand by brand

## ∞ “Connected Vehicles: – on-board and roadside equipment (

- Commercial – via cellular – exists today and incremental
- Public interest – via special hi-speed comms. – awaits gov’t mandate or voluntary automaker agreement

# What is “Connected”

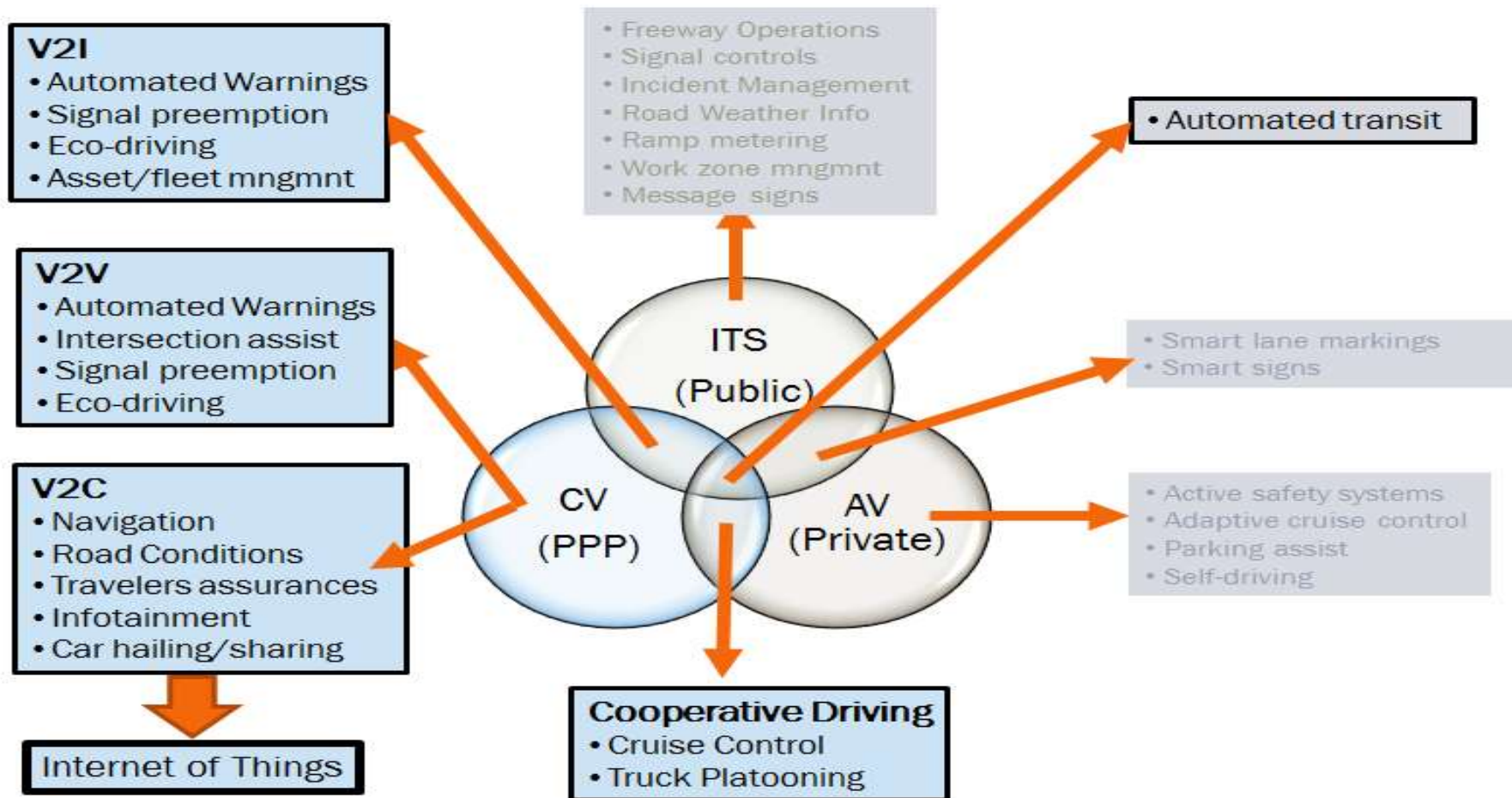
## ∞ For public purposes

- ✓ V2I (“Infrastructure”) – Connects to traffic management centers
- ✓ V2D (“Device”) – Connects to traffic signals and signs
- ✓ V2V -- Extends autonomous vehicle “vision” beyond line of sight for safety

## ∞ For commercial purposes

- ✓ V2C (“cloud”) -- Connects to Internet, OEMs and other service providers

# Synergistic Functions



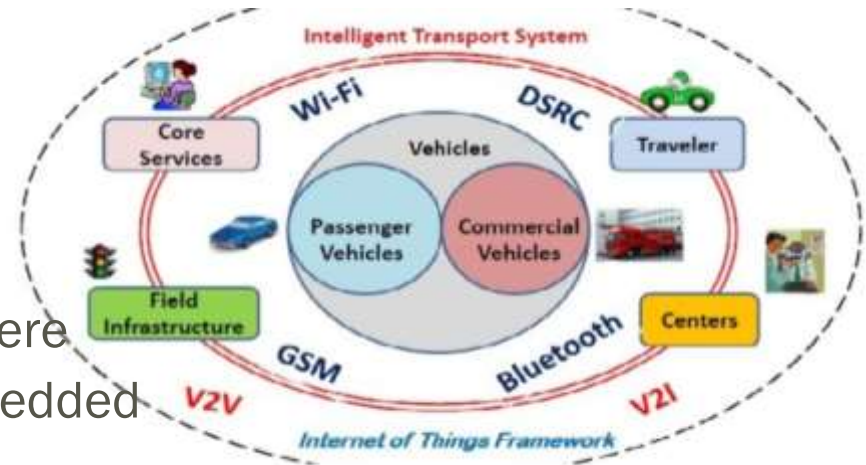
# Current Connectedness -- Levels/Types

## Low speed communication

- ✓ Satellite for crash response –anywhere
- ✓ Cellular –mobile (Bluetooth) or embedded
- ✓ Commercial sponsorship

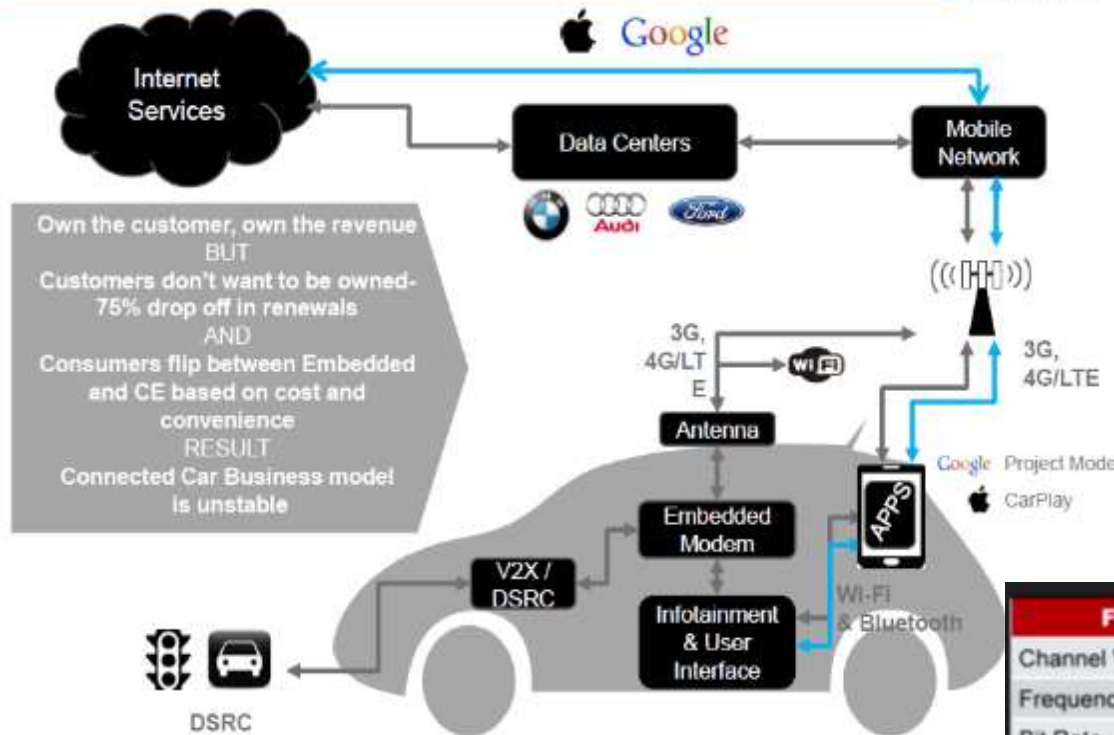
## High speed communications

- ✓ Dedicated radio system - Short range/instantaneous
- ✓ For crash avoidance/cruise control
- ✓ Public program
- ✓ (Note: high speed cellular in development)





# Connected Vehicle (CV) Systems



Own the customer, own the revenue  
BUT  
Customers don't want to be owned-  
75% drop off in renewals  
AND  
Consumers flip between Embedded  
and CE based on cost and  
convenience  
RESULT  
Connected Car Business model  
is unstable

## Competing Technologies – DSRC VS Cellular

Feature	DSRC	LTE-A
Channel Width	10 MHz	Up to 100 MHz
Frequency Band	5.86–5.92 GHz	450 MHz–4.99 GHz
Bit Rate	3–27 Mbit/s	Up to 1 Gbit/s
Range	Up to 1 km	Up to 30 km
Capacity	Medium	Very High
Coverage	Intermittent	Ubiquitous
Mobility Support	Medium	Very High
Market Penetration	Low	Potentially High

<https://smallcells.3g4g.co.uk/2014/05/small-cells-for-connected-car.html>



# Public Interest Applications (1, 2): CV Contributions to Safety & Mobility

V2D (today) – V2I and V2V (Future)



<https://enterpriseiotinsights.com/20170614/internet-of-things/20170613internet-of-thingsv2x-technology-gaining-traction-smart-mobility-tag23>

# Public Interest Applications (3): CV Contributions to DOT Efficiency

## V2I –Today and Future

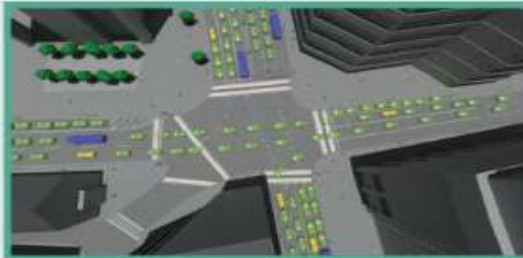
- ∞ CV-based travel/traffic data
- ∞ Plow truck operations
- ∞ Tolling/road pricing
- ∞ Pavement condition data
- ∞ Elimination of selected signage, markings

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[illegible]

# Impact on Transit?

BOSTON TODAY<sup>1</sup>



Primary transport mode	% of trips
• Public transit	56
• Traditional personal vehicle	33
• Traditional taxi and ride hailing	11



Public transit



Traditional personal vehicle



Autonomous taxi  
(shared or single passenger)

SCENARIO A: Gradual shift from private to shared and from human-driven to AV



Primary transport mode	% of trips <sup>2</sup>
• Public transit	50
• Shared autonomous taxi	22
• Autonomous personal vehicle	11
• Traditional personal vehicle	11
• Traditional taxi and ride hailing	6



Traditional taxi and ride hailing

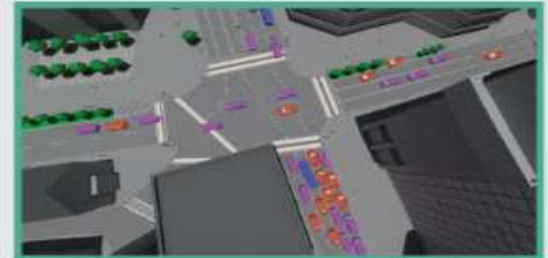


Autonomous personal vehicle



Autonomous shuttle bus

SCENARIO B: Disruptive shift from private and human-driven to shared and AV



Primary transport mode	% of trips
• Public transit	34
• Autonomous shuttle bus	28
• Autonomous taxi	24
• Shared autonomous taxi	14

Sources: World Economic Forum; BCG analysis.

<sup>1</sup>This mix of transportation modes is representative of the study area only. Most trips into and out of the study area are work commutes. The model assumes a simplified modal mix without walking and cycling.

# Commercial Freight Applications (1)

## Connected Trucking: V2V and V2I



### Connected Contribution to Improved trucking

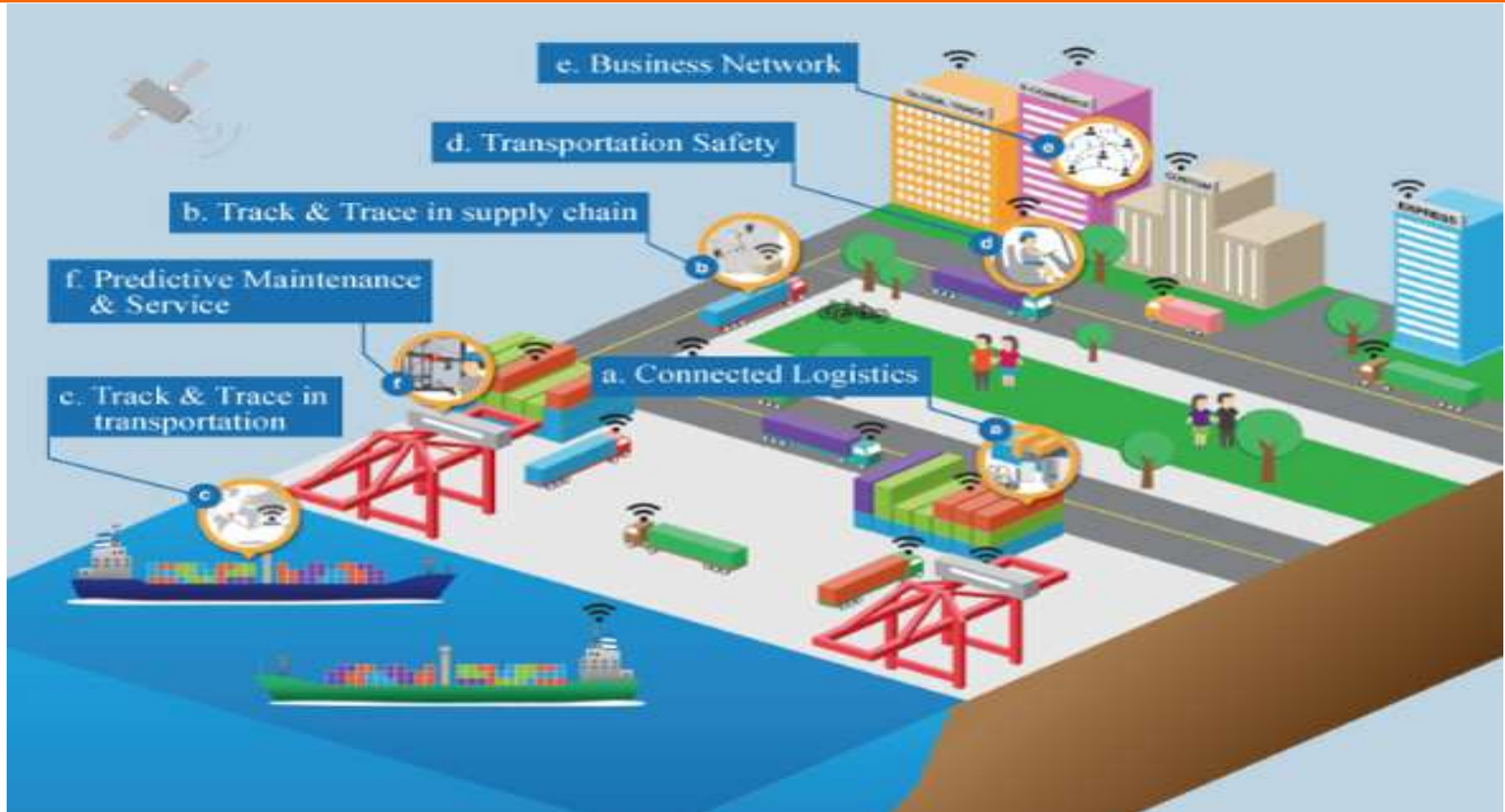
- ✓ Links braking to allow drafting spacing
- ✓ Connects with Operations Center
- ✓ Remote diagnostics
- ✓ Potential roadside connections



<https://favsummit.com/pdfs/richard-bishop.pdf>

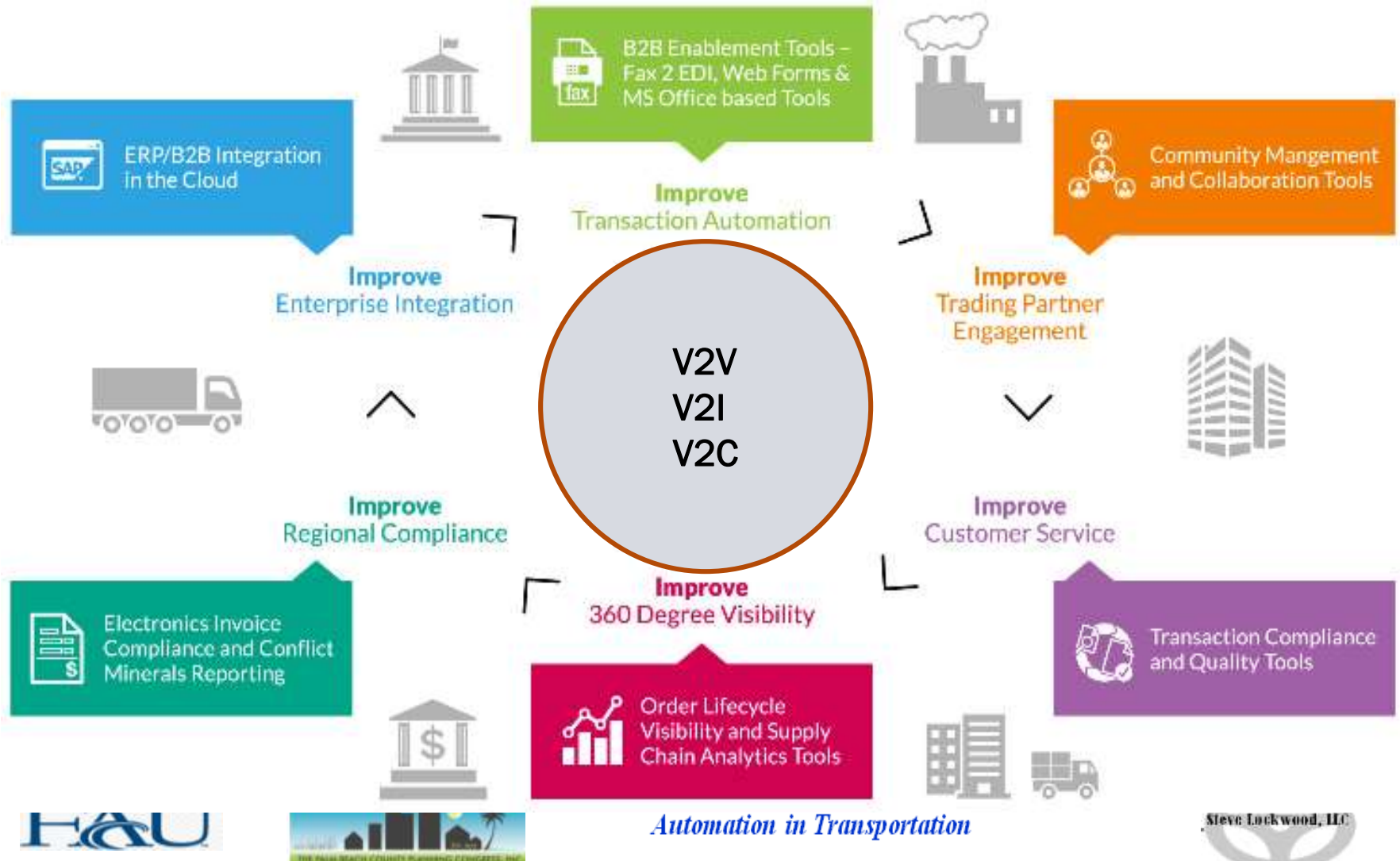


# Commercial Freight Applications (2): Connected Port Activities



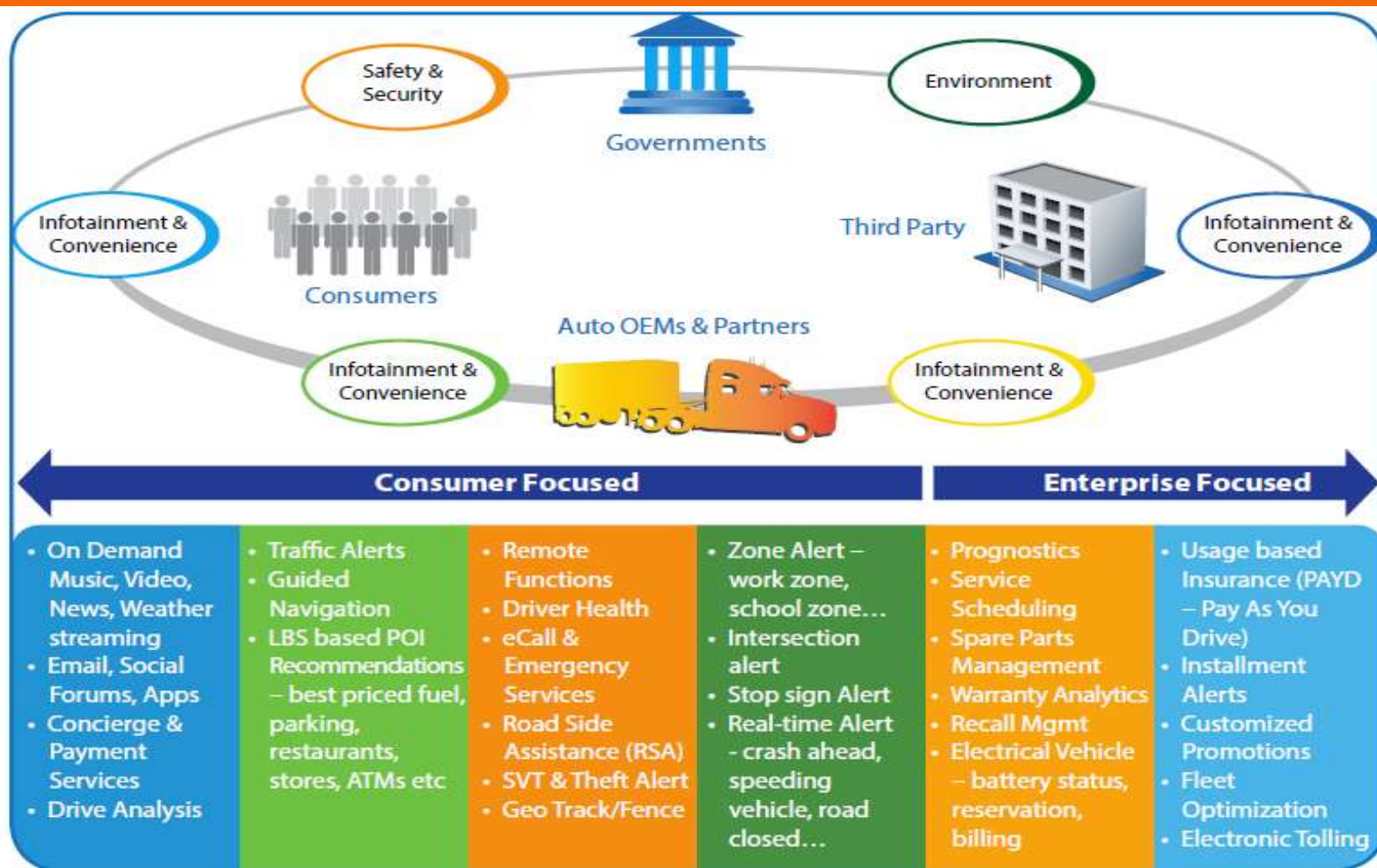
[http://e.huawei.com/it/publications/global/ict\\_insights/201711060837/solutions/201712121546](http://e.huawei.com/it/publications/global/ict_insights/201711060837/solutions/201712121546)

# Commercial Freight Applications (3): Connected Vehicles and Logistics





# Connected Vehicle Context



# CV Payoffs/Veh/Yr

## Internet of Cars: Unlocking \$1,400 in Benefits per Vehicle, per Year

### Internet of Cars Service Providers

- Traffic guidance, navigation, emergency services
- "Google on wheels," PAYD insurance, location-based services

### Auto OEM/OES

- Lower service/warranty costs
- New profit pools
- Architectural savings

### Vehicle User

- Lower insurance
- Lower operation cost
- Less time stuck in traffic, more productivity

### Society

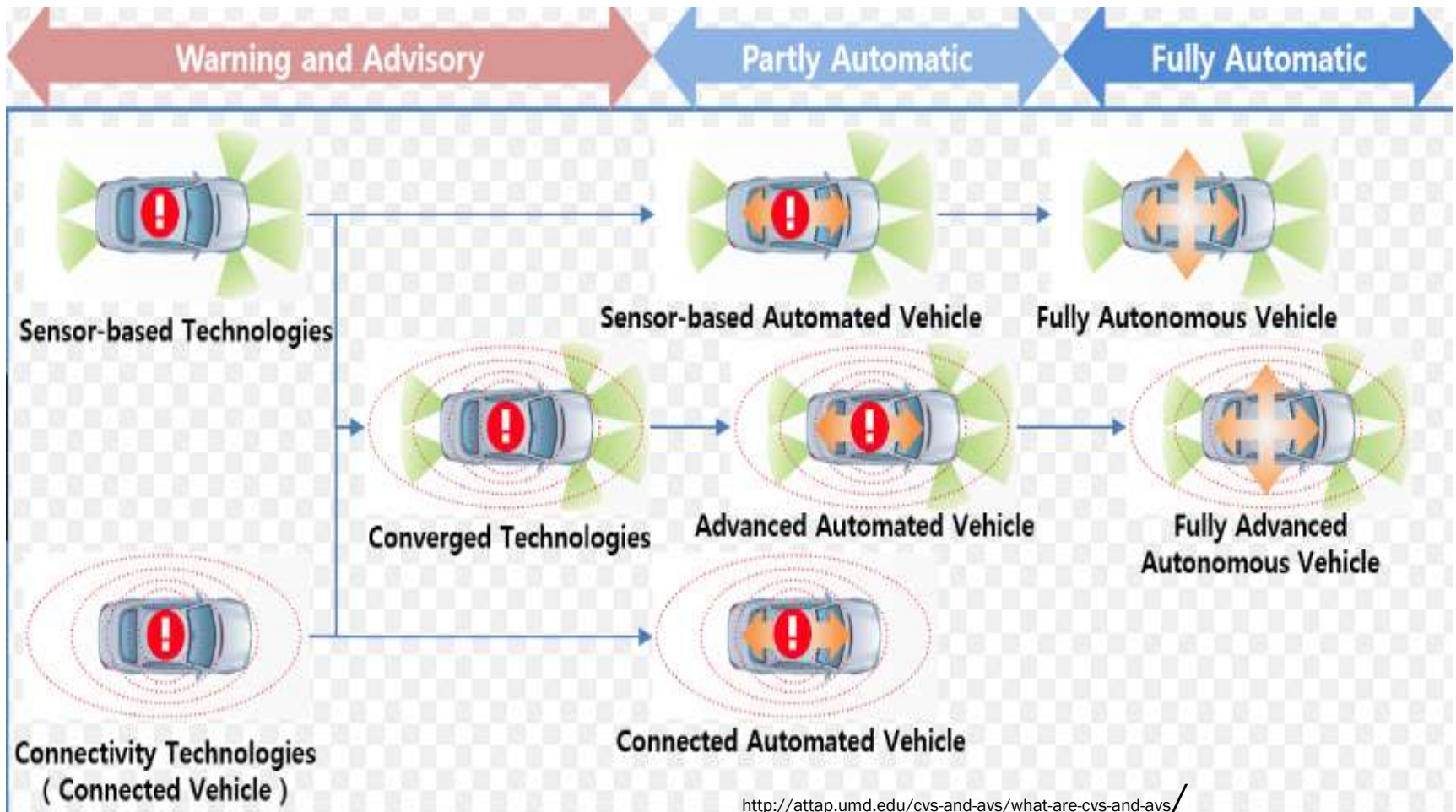
- Fewer crashes
- Lower traffic/road/toll operation costs
- CO<sub>2</sub> reduction



Benefits per vehicle, per year

Source: Cisco IBSG Automotive and Economics Practices, 2011

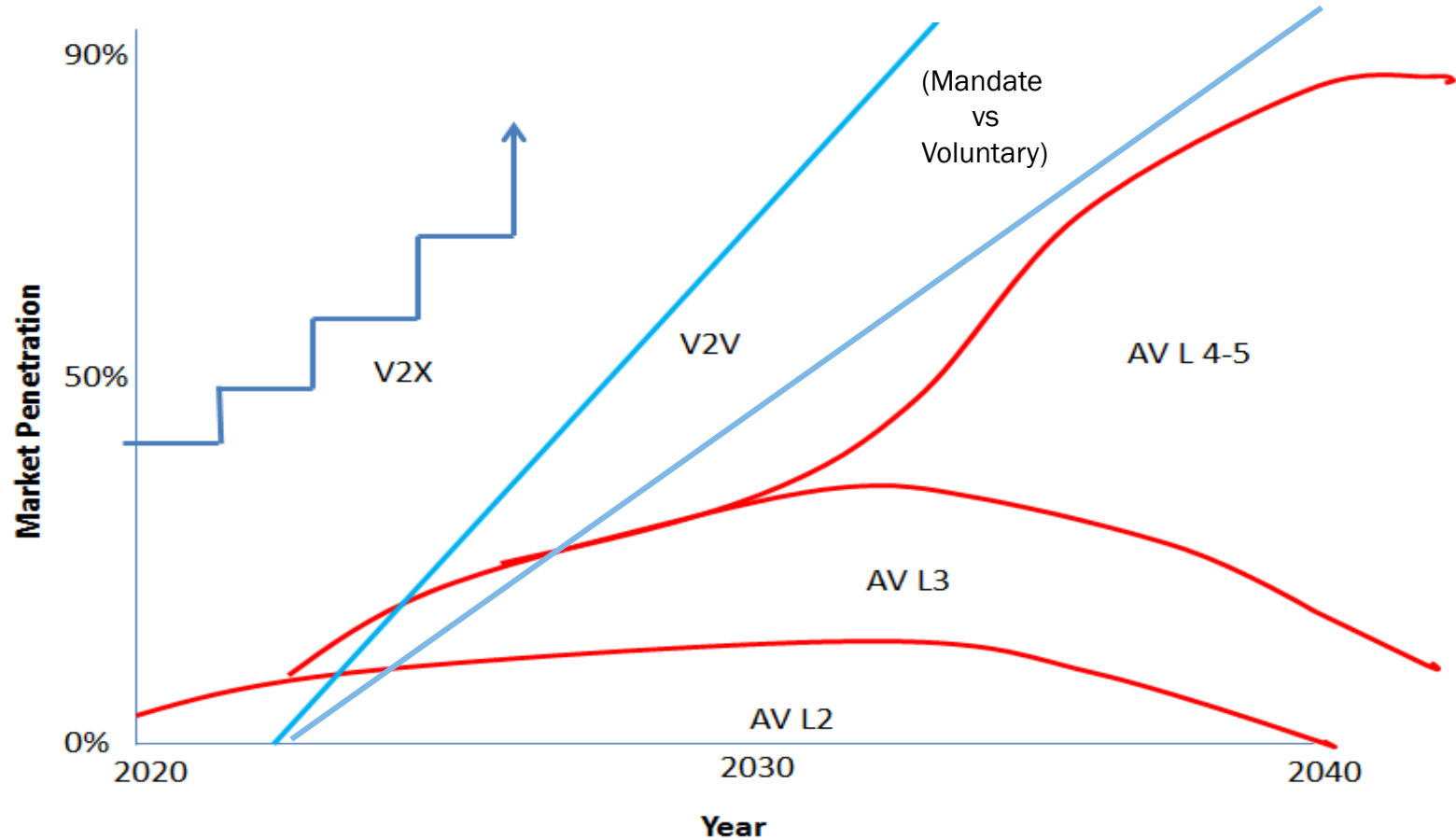
# AV/CV Convergence Incremental



<http://attap.umd.edu/cvs-and-avs/what-are-cvs-and-avs/>



# CV and AV Timing?



# Connected Vehicles Ecosystem

## ROLE OF PUBLIC SECTOR

- ❖ Regulate
- ❖ Cooperate
- ❖ Accelerate



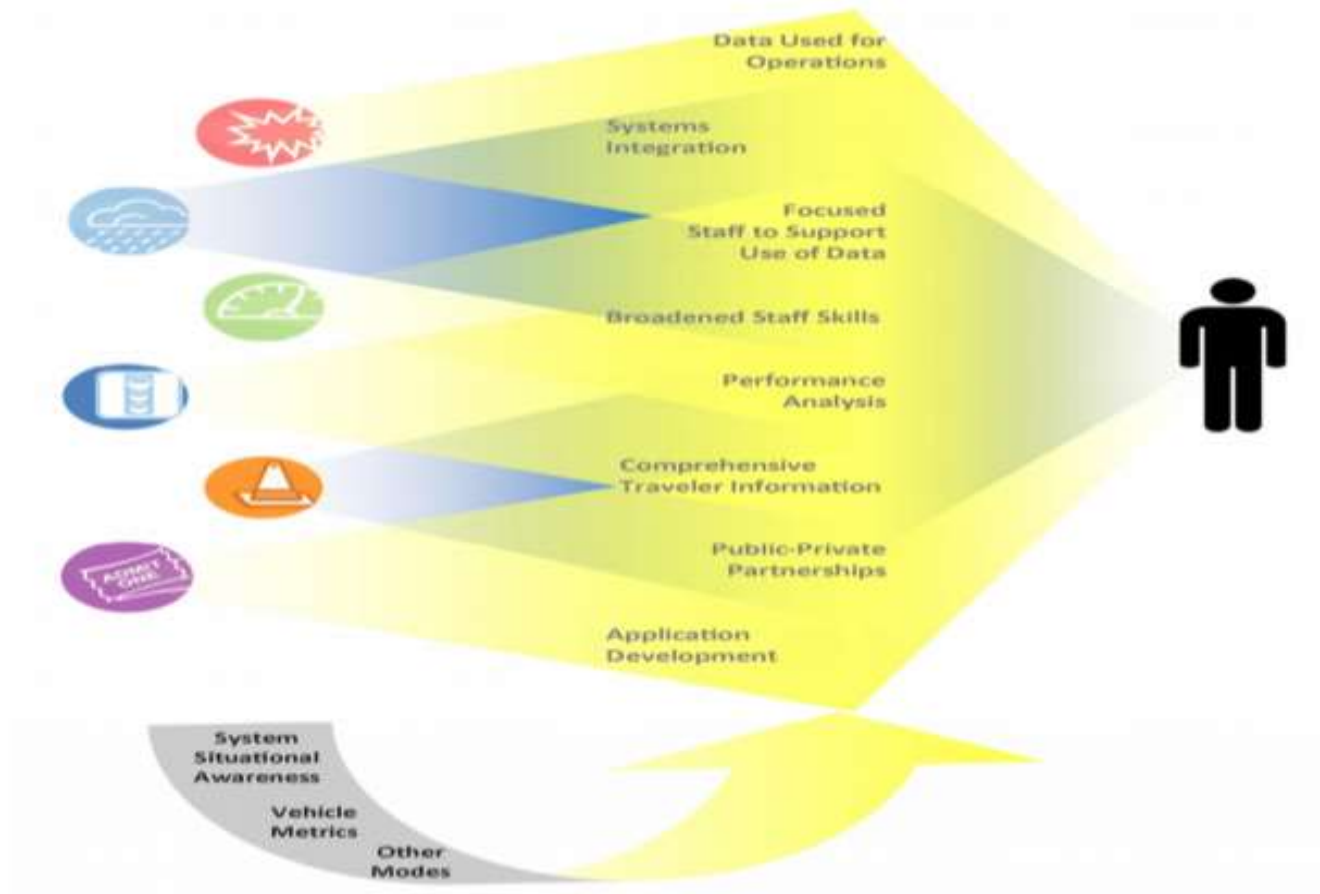
<https://www.automotiveworld.com/analysis/manufacturing-gets-connected-smart/>

# Planing for Connected Vehicles



Proposed Applications	Proposed Applications	
	<ul style="list-style-type: none"> <li>• Dynamic Transit Operations</li> <li>• Connection Protection</li> <li>• Dynamic Ridesharing</li> <li>• Integrated Multi-Modal Electronic Payment</li> <li>• Transit Signal Priority</li> </ul>	<ul style="list-style-type: none"> <li>• Transit Stop Pedestrian Warnings</li> <li>• Pedestrian in Signalized Crosswalk Warnings</li> <li>• Vehicle Turning Right in Front of Bus Warnings</li> <li>• Forward Collision Warning</li> <li>• Emergency Brake Light Warning</li> <li>• Eco-Approach and Departure</li> </ul>

# What CV Brings/Needs



[http://www.cts.virginia.edu/wp-content/uploads/2014/05/Task3\\_Future\\_TMC\\_12232013\\_-\\_FINAL.pdf](http://www.cts.virginia.edu/wp-content/uploads/2014/05/Task3_Future_TMC_12232013_-_FINAL.pdf)



# Planning for Connected Vehicles -- State

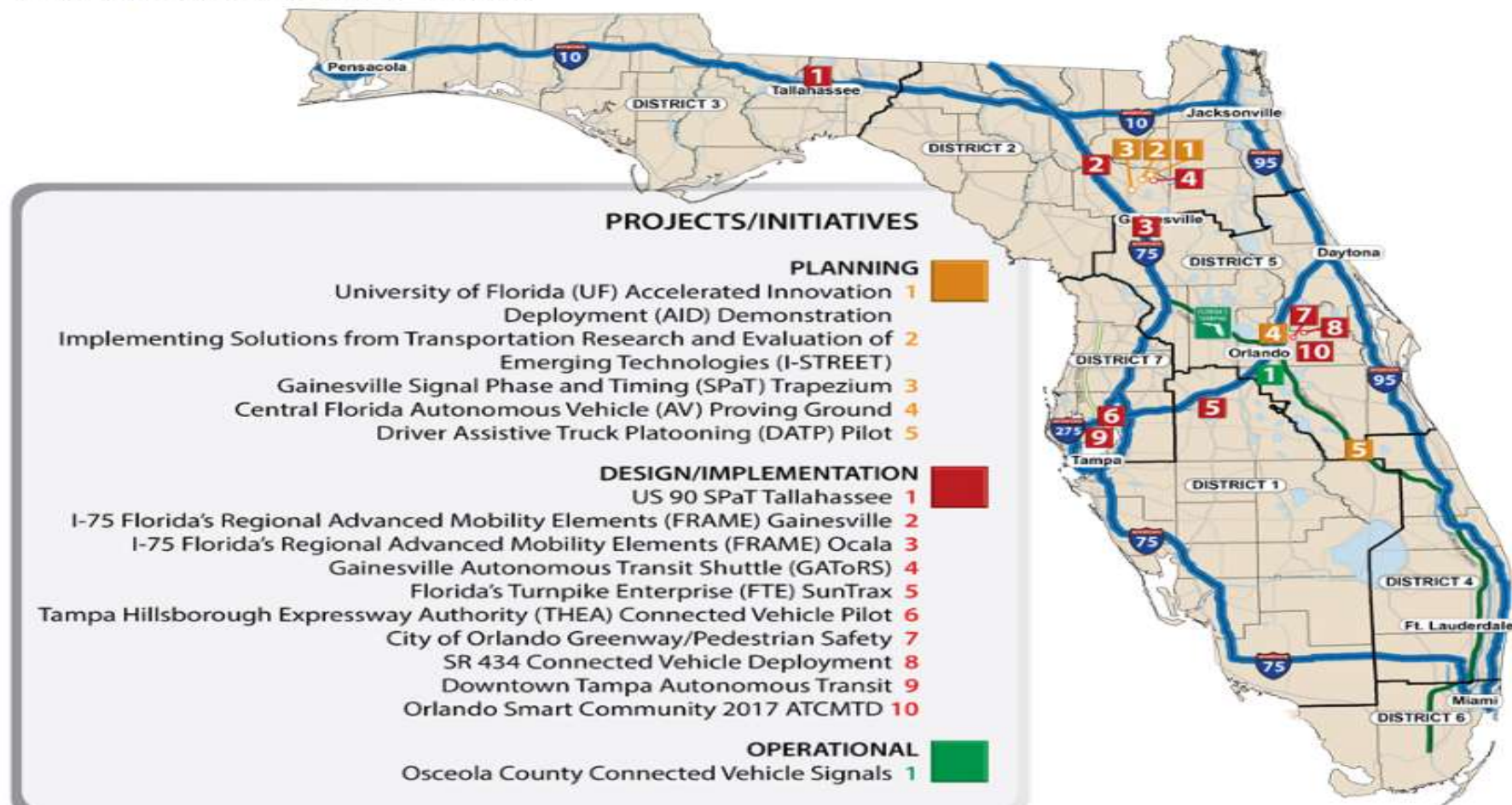
## ∞ Transformational – Not trends extended

- ✓ Shift from Construction focus to Operations (ITS.CV/AV)
- ✓ Uncertainty regarding CV timing (OBUs)
- ✓ Infrastructure (RSUs) provision – public vs private
- ✓ Pilot testing, learning, and no regrets early deployment
- ✓ Business Case vs DOT resources/capabilities

## ∞ State regulatory focus

- ✓ Technology Choice/Spectrum Allocation
- ✓ Information Security/privacy/liability
- ✓ Data Ownership

# Connected Vehicle Program in FL



[https://mydigitalpublication.com/publication/?i=440783&article\\_id=2890264&view=articleBrowser&ver=html5#{"issue\\_id":440783,"view":"articleBrowser","article\\_id":"2890264"}](https://mydigitalpublication.com/publication/?i=440783&article_id=2890264&view=articleBrowser&ver=html5#{)

# Planning for Connected Vehicles -- Metro

- ☞ **Impact on travel demand, trip length and VMT**
  - ✓ Ride hailing/car sharing
  - ✓ Demand vs (reallocated) capacity impacts: congestion?
- ☞ **New transit modes/MaaS – Impact on traffic/transit?**
- ☞ **Land-use /urban design**
  - ✓ Impact of trip length on suburbs
  - ✓ Central area urban design – parking, shared sts., curb space, MaaS
- ☞ **New data sources - Track and update**
- ☞ **Analytics, models and staff capability development**



**Steve Lockwood, LLC**

