Technical and Commercial Challenges of V2V and V2I networks

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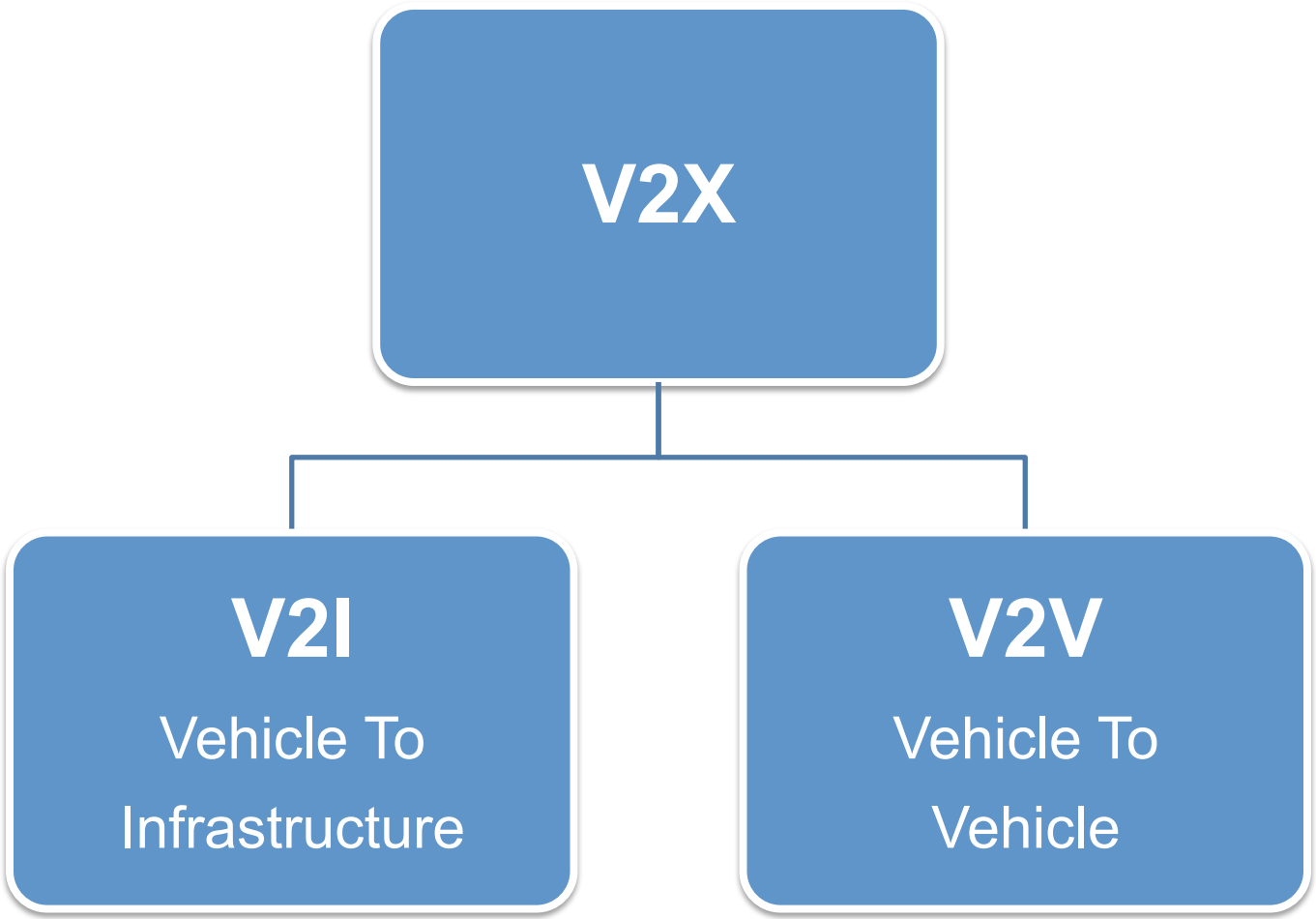
Open Source Meetup
Sept 27th 2012

Savari: V2X Experts

- Savari has developed an automotive grade connected vehicle platform for safety and mobility applications
  - Superb outdoor performance rivals all competition
  - Powered by Qualcomm & Intel chipsets
- Proven in various trials in Arizona, California, Michigan, Minneapolis, New York
- Developing technology simultaneously with eight OEMs
  - Selected for US DOT's largest field operational trial in Ann Arbor, MI

TECHNOLOGY


V2X
V2I
Vehicle To
Infrastructure
V2V
Vehicle To
Vehicle

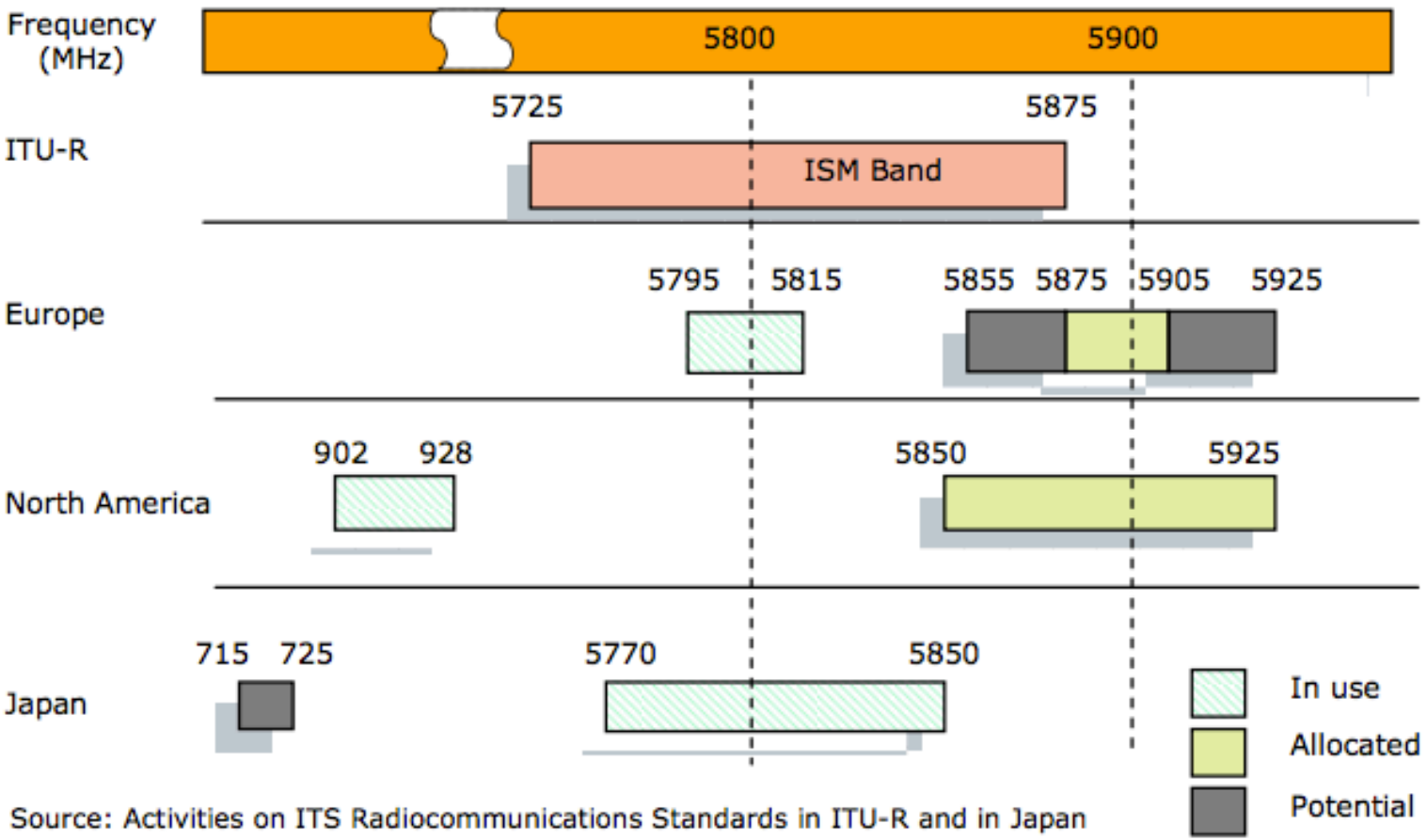
DSRC

- **DSRC – Dedicated Short Range Communications**
- **Advantages**
  - Licensed Band – 75 MHz of spectrum in the 5.9 GHz band
  - Low Latency
  - High Reliability
  - Prioritization – Safety applications given priority over non-safety applications
  - Interoperability
  - Security and Privacy

DSRC .. Contd

- **Intended to provide a foundation for a variety of applications**
  - Vehicle Safety
  - Emergency Vehicle Notification
  - Automated tolling
  - Enhanced Navigation
  - Traffic Management

Worldwide Spectrum Allocation



Source: Activities on ITS Radiocommunications Standards in ITU-R and in Japan

V2X Global Standards

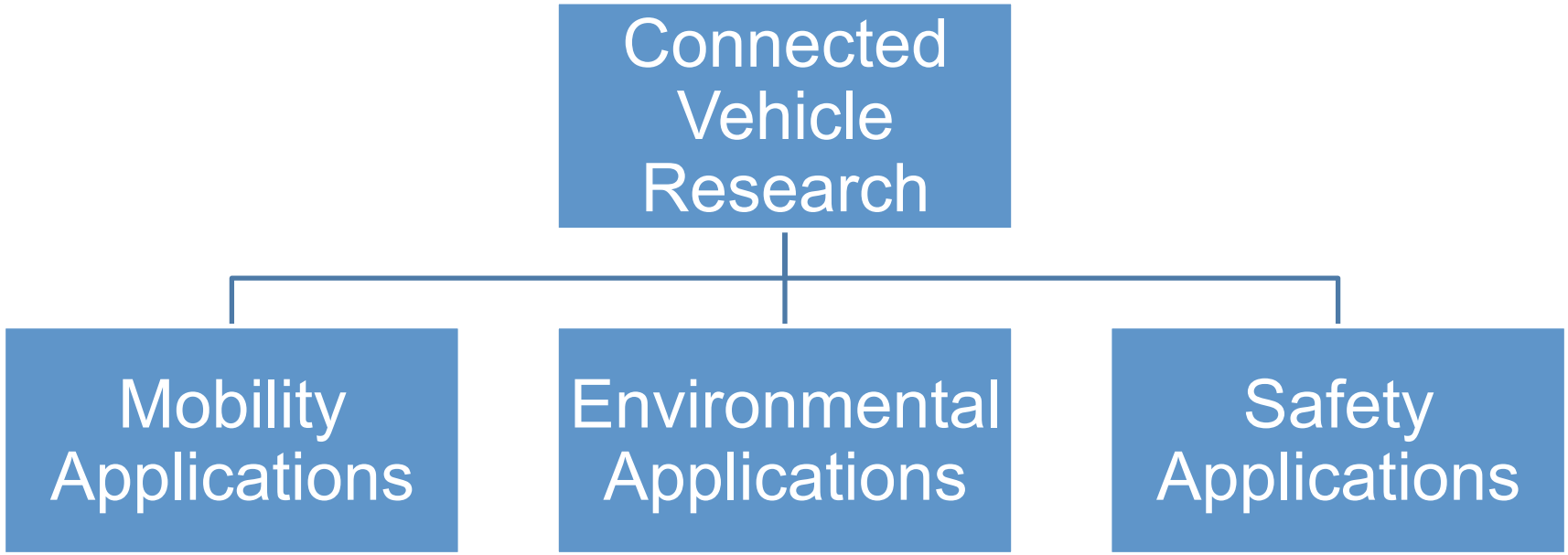
SAE J2735 (U)
CAM, DENM (E)

IEEE1609.1-4 (U)
Geo Networking (E)

IEEE 802.11p (U)
ITS G5 (E)

US/Europe

Connected Vehicle Research



Dynamic Mobility Applications

- Aimed at improving speed and decision making abilities of infrastructure system managers and system users
- Use frequently collected multisource data
- To enhance operations in general.

- Active Traffic and Demand Management

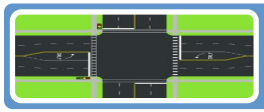
Environmental Applications

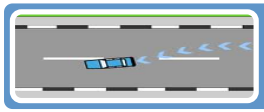
- Generate and capture real-time data to enable environmentally friendly practices
  - Eco-driving
  - Alternate Route Planning
  - Public Transit
  - Road Weather Connected Vehicle Applications
    - Improve safety during adverse weather conditions
    - Reduce weather related delays
    - Optimize use of labor and other equipment

Safety Applications


Emergency brake light warning


Forward collision warning


Intersection movement assist


Blind spot and lane change warning

Do not pass warning


Control loss warning


Weather-related vehicle stabilization activation

V2V Safety using DSRC

V2I using DSRC

- Interaction between Roadside Equipment (RSE) and vehicle's On-Board Unit

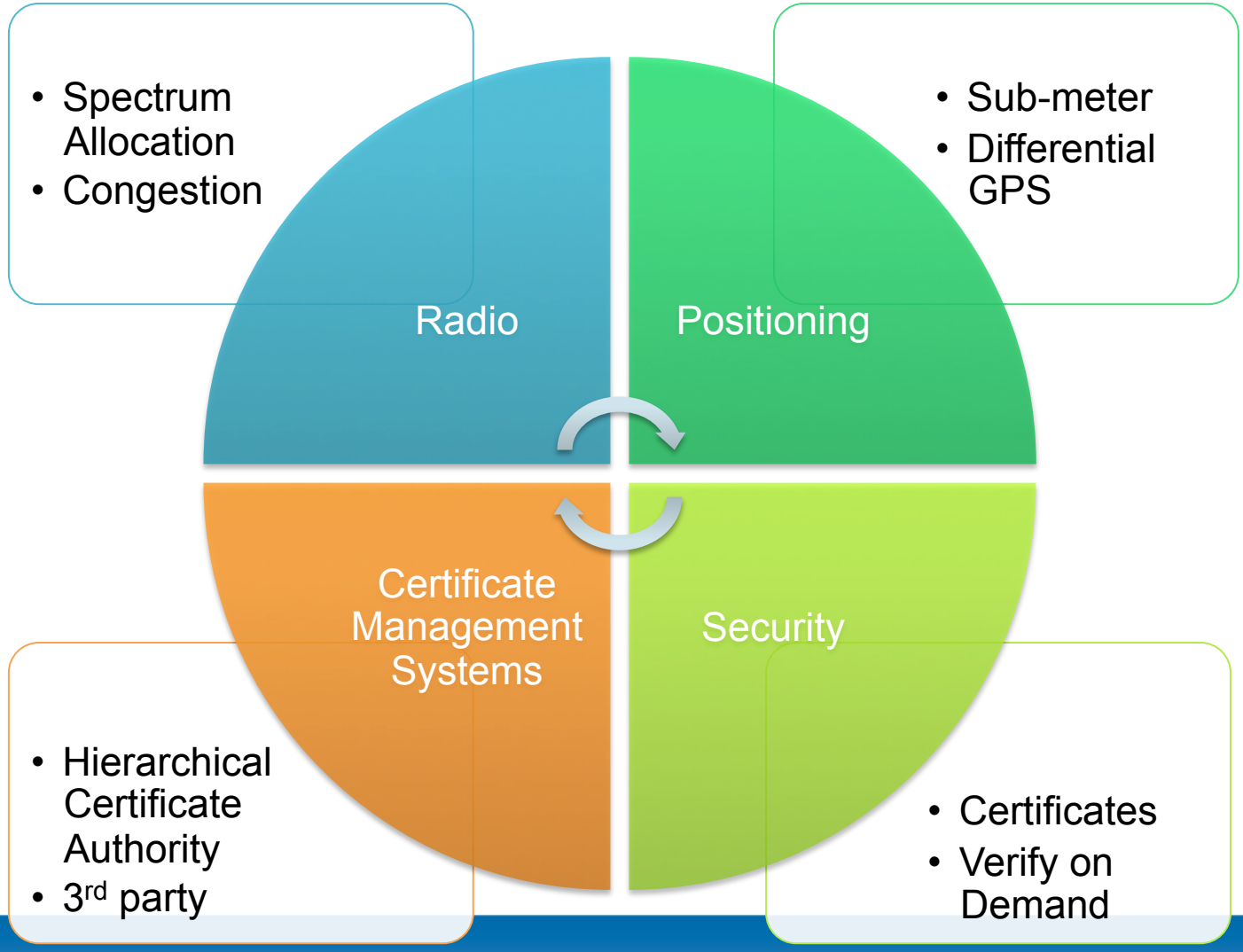
- **RSE**
  - Broadcasts MAP and SPaT messages
  - Receives and tracks BSM's from vehicles
  - Receives Signal Request Messages from Emergency Vehicles and manages signal priority
  - Can be used to collect performance measures

V2I Applications

- Transit Signal Priority
- Emergency Vehicle Preemption
- Work zone alerts
- Real-time Traveler Information Messages
- Pedestrian Assist
- Ramp Metering
- Parking Systems
- Curve Speed Warning
- Dilemma zone
- Freight Signal Priority

TECHNICAL AND COMMERCIAL CHALLENGES

Technical Challenges



Congestion Control

- Algorithms to control transmit power and/or rate or both with probabilistic approach

- Common Metrics
  - Packet Error Rate
  - Inter Packet Gap
  - Channel Busy Percentage

Scalability Testing

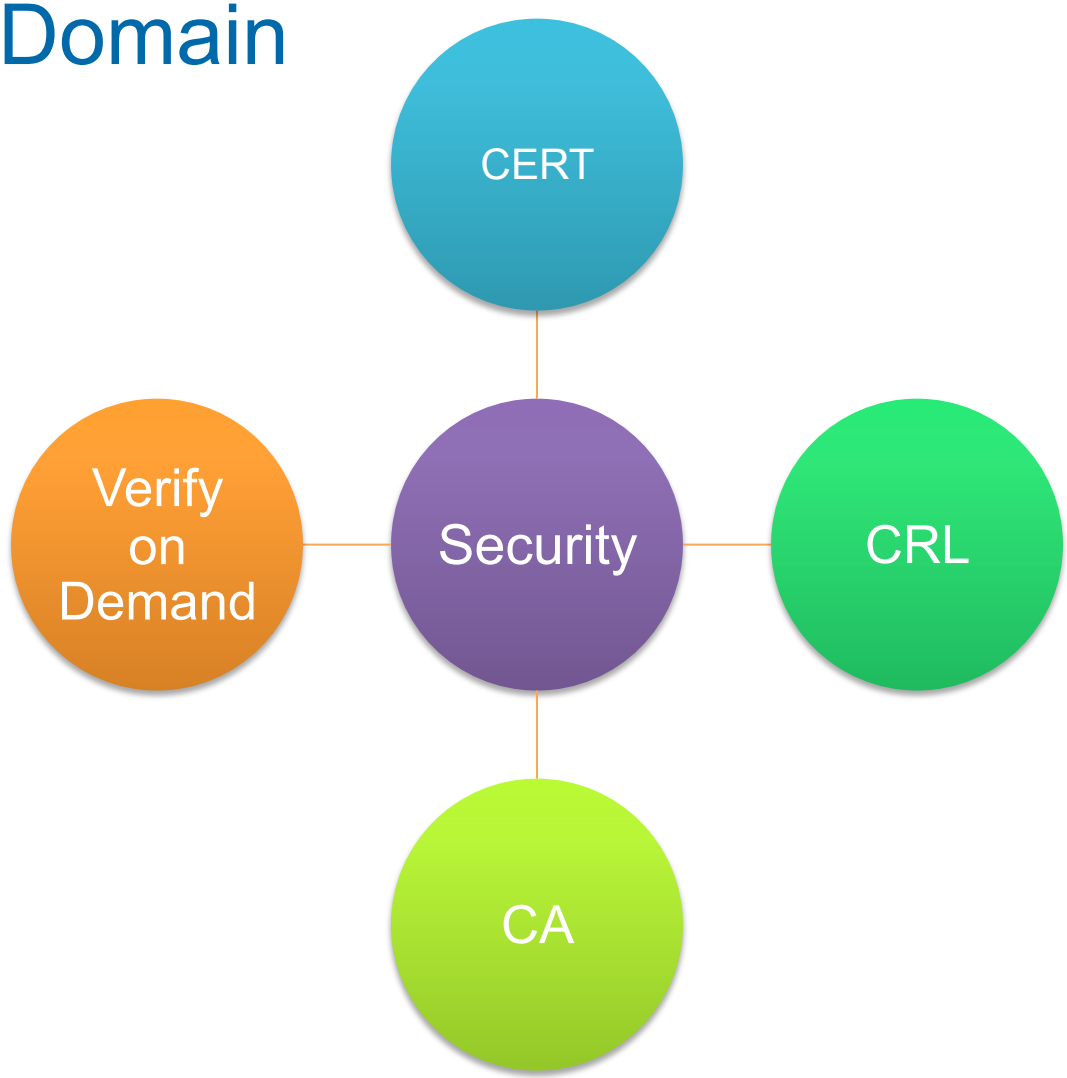
- US
  - 100 car tests in Alameda (California). 200 car tests at TRC in Marysville (Ohio)
  - Model deployment of 2700 cars by UMTRI & US DOT
- Europe
  - SimTD testing of 120 cars in Germany
- Improvements with Congestion algorithms
  - Improves channel utilization by 50% to 75%
  - CPU utilization drops to 50%

Positioning

- Application Requirements
  - WhichRoad (5m, 90% confidence)
  - WhichLane (0.8m, 90% confidence)
  - WhereInLane (0.5m, 90% confidence)

- RTK Servers
  - Differential GPS corrections
  - Corrections via WiFi/3G/LTE/DSRC

Security Domain



Certificates

- OBU
  - All message certificates (short-term and fall-back message certificates) are imprinted with a linked identifier that allows efficient revocation
  - Manages certificate pool and certificate revocation lists
  - Bad actor detection and reporting
- CA
  - Does detection and revocation
  - CA talks to Registration Authority and Local Authority
- Need constant connectivity with CA
  - TCP or UDP
  - How do we handle mobile scenarios?

Verify on Demand

- Certificate Scalability
  - Need the OBUs verify every certificate from every message
- Solution
  - Verify on Demand
- Verify the messages only that results in a warning or an alert or a hint to the driver

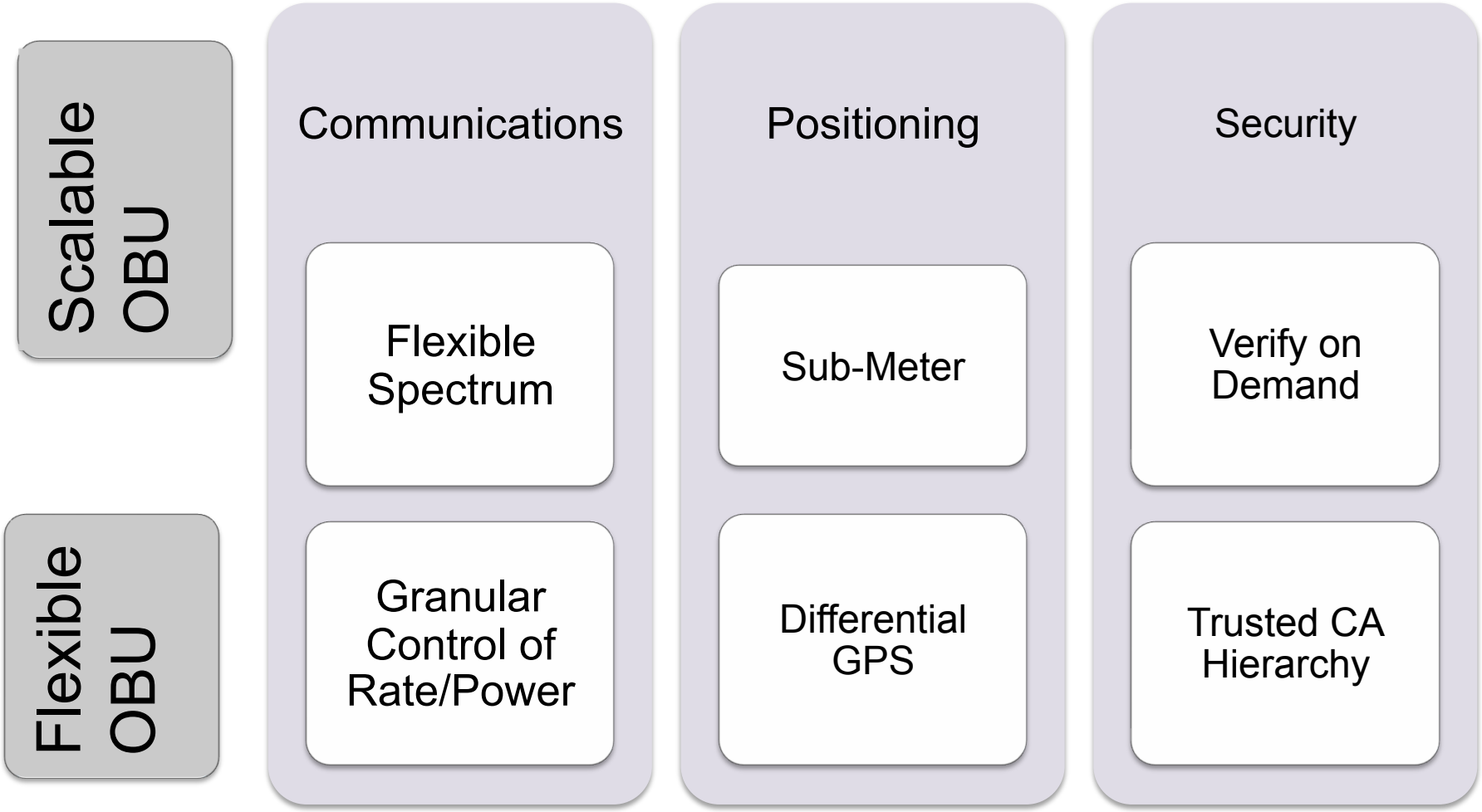
Connectivity with CA

- Security Framework Access Device (SFAD)
- A device that manages connectivity to the CA on behalf of the OBU
  - Supports 3G/LTE/WiFi/DSRC/Ethernet
  - Supports IPV6 router functionality
  - Supports VPN tunnels
  - Supports dynamic mobility and handovers
  - Geocentric Routing

Certificate Management Systems

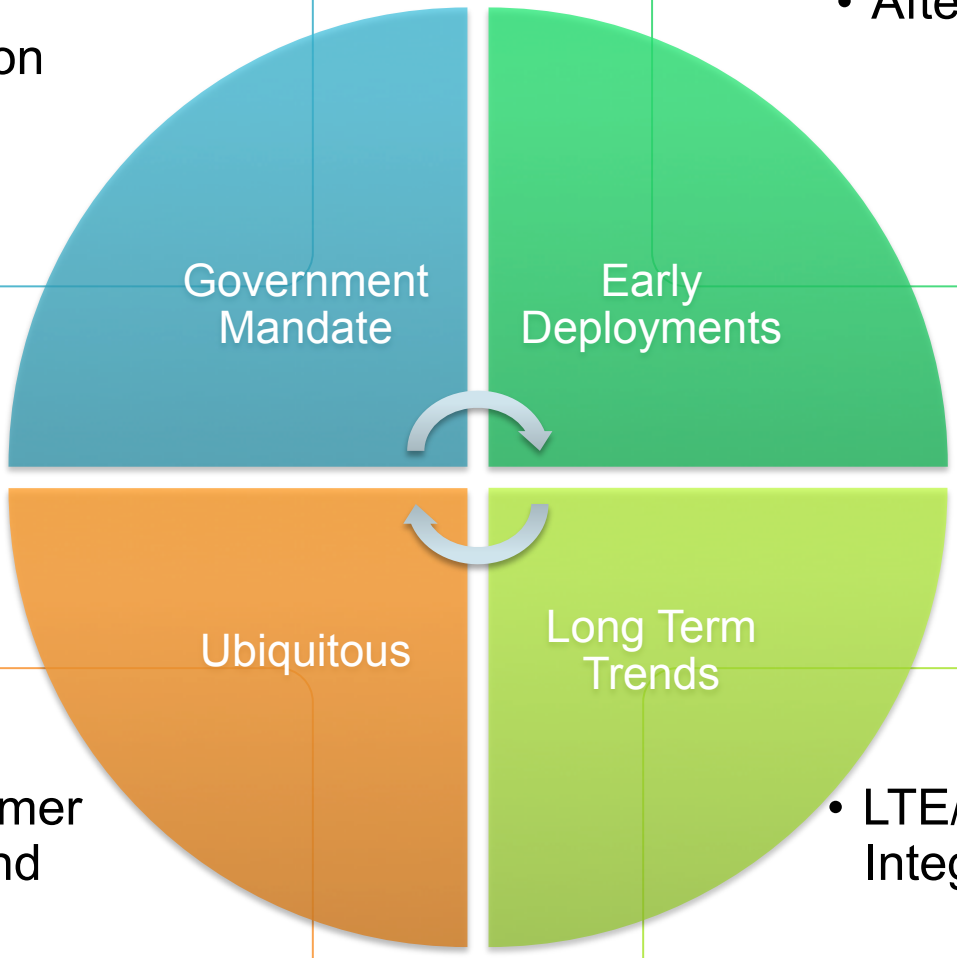
- PKI certificates are cumbersome and expensive
  - Certificates need to be maintained
  - Someone needs to setup and run the Certificate Authority (CA)
- Who pays for all of this?
  - OEMs
  - Vehicle Owners
- Solution
  - Collaboration between OEMs with regional and global hierarchy.
  - No need for federal funding

Technical Solutions: The BIG Picture



Business Challenges

- 2013 Decision
- Aftermarket



- Consumer Demand
- LTE/WiFi Integration

Mandate – Soft or Hard

- Is mandate required? If so, what type? What's the post mandate scenario?

- US
  - Government mandate decision in 2013
  - V2V first

- Europe
  - Start of voluntary deployment by 2015
  - V2V and V2I

Early Deployments for V2V

- Who is going to be the torch bearer?
- What channels?
  - Aftermarket
    - What applications will be the driving force?
- Who is the target customer?
  - Fleet owners
- What target areas?
  - Airports
- What verticals?
  - Insurance Industry

Deployments for V2I

- US
  - RSU
    - 350,000 signalized intersections in US
    - AAHSTO plans for 2020/2030
- Europe
  - RSU
    - Selected areas like big cities
    - No need to cover the entire continent

SafetyPilot

- **SafetyPilot**
  - **Driver Clinics**
    - August 2011 – Early 2012
  - **Model Deployment**
    - Fall 2012 – Fall 2013
- **Research Goals**
  - Support the 2013 NHTSA agency decision by obtaining empirical data on user acceptance and system effectiveness
  - Demonstrate real-world connected vehicle applications in a data-rich environment
  - Establish a real-world operating environment for additional safety, mobility, and environmental applications development
  - Archive data for additional research purposes.

TRIALS AND TESTBEDS

V2X Global Deployment

- V2X Deployment is being planned globally
- Harmonization work is underway, but
  - There are still multiple standards in multiple geographic regions
- Trials are underway, but
  - Standards won't be complete until trial-proven

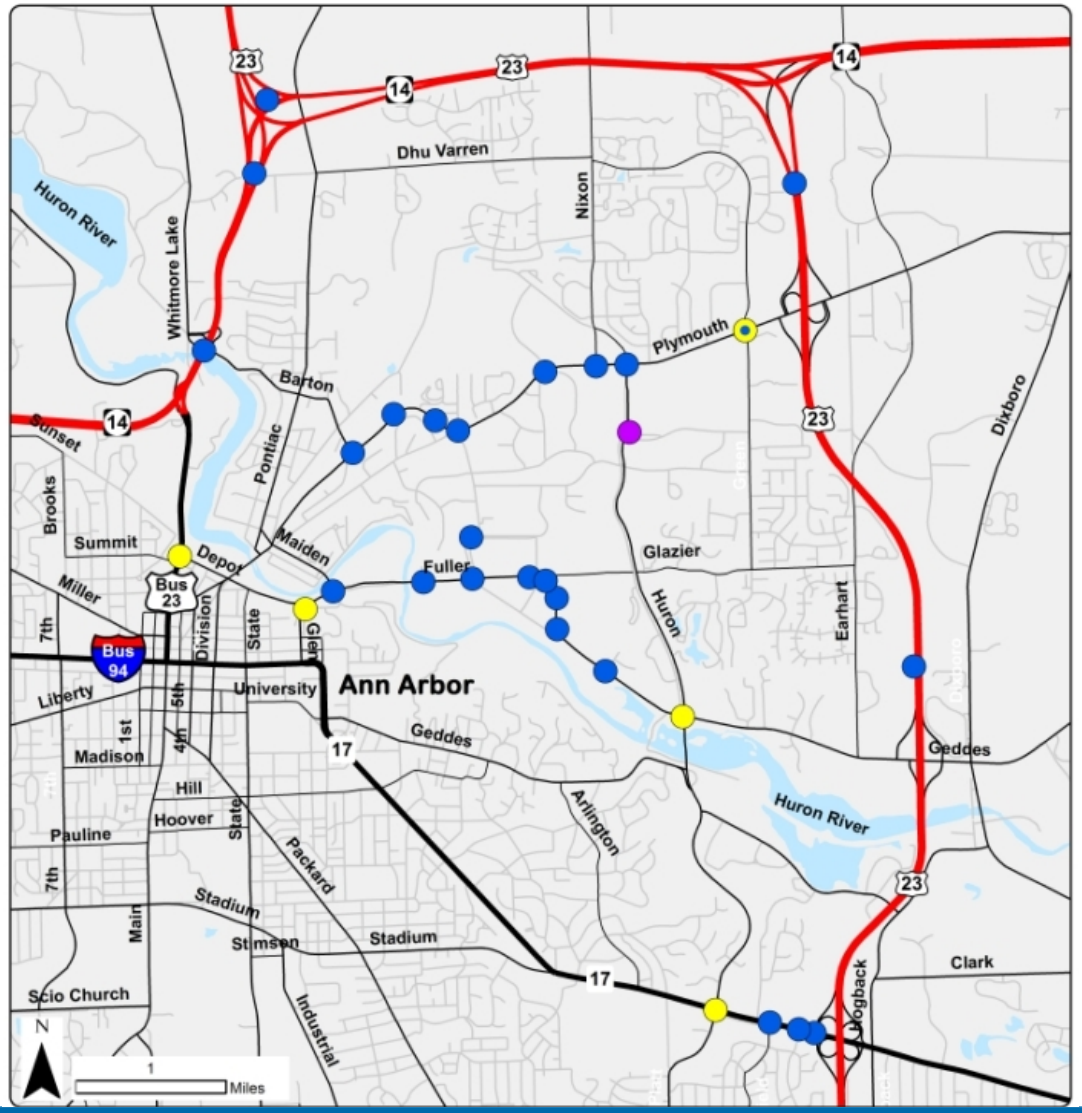
US Safety Pilot Deployment

Key Site Elements:

- 75 miles of instrumented roadway
  - 29 roadside units
- ~3000 vehicles
  - -Cars, trucks, buses
  - Integrated, aftermarket, and retrofit
- -1 year of data collection

Also:

- Exercising security options
- Vetting device certification process



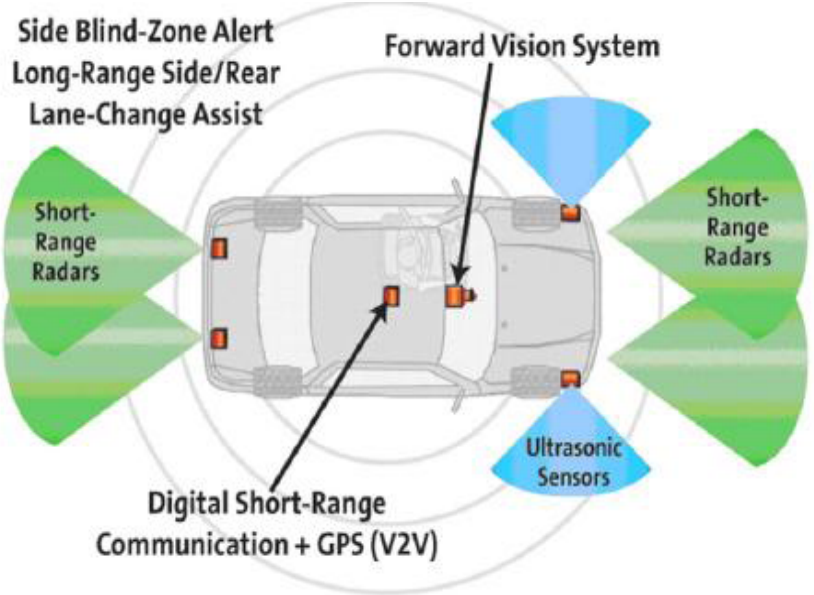
US SafetyPilot - Equipment

- **Vehicle Awareness Device**
  - Capable of only sending the basic safety message (BSM) over a DSRC link with no warnings/alerts
- **Aftermarket Safety Device (ASD)**
  - Capable of sending/receiving the safety messages over a DSRC link. It has driver interface, runs V2V and V2I safety applications, issues audible or visual warnings and/or alerts to the driver of the vehicle
- **Road Side Unit (RSU)**
  - Capable of sending WAVE announcements integrated with V2I messages for road safety

Developments/Trends

- ADAS Integration
  - Integration of co-operative safety with active safety systems like Cameras and Radars
- WiFi/LTE penetration
  - More radios and antennas in cars
- Electric vehicle penetration
  - Mileage Based User Fee… Need to collect road tax
- Current state: Only 2% of vehicles are connected

Coming Tomorrow: Autonomous & Connected



Savari networks

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