Intelligent Transportation, Smart Infrastructure and Connected Vehicle

Technology and Market Themes in Smart Cities

Steven H. Bayless
Vice President Public Policy and Regulatory Affairs

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Intelligent Transportation Society of America
ITS America’s unique asset is a membership that spans

- **Infrastructure Planners and Operators** (public and private road, transit, and other transportation infrastructure operators),
- **Industries** (auto, telecom, IT and emerging tech, consumer apps and electronics, industrial electronics, shared-use mobility, and freight/logistics), and
- **Research Centers** (across disciplines)

...organizations that are bringing new technology from our nation’s test tracks and labs to our roads, cars, trucks, motorcycles, and public transit systems.
ITS America Priorities

- Accelerate New Technology Deployment
- Remove Technology Roadblocks
- Finance Intelligent Infrastructure
Safe Driving Behaviors are too Shallow
- Driver is the only component that can perceive, decide, and initiate driving response for a vehicle
- Total reliability always at or below the weakest link
  - Driving task demands can exceed driver capabilities
  - Driver error accounts for +90% of roadway crashes

Technology can increase system reliability by arranging components in parallel to driver functions
- Both driver and vehicle sensors can perceive threats
- Both driver and algorithms can decide responses

By 2030, we could be as good at crash prevention as we are with occupant protection and crash-worthiness?

Source: Greg Fitch, Virginia Tech – ITSA Safety Forum (adapted)
Vehicle Performance

- **Driver Assistance/ Automation Systems** – Vehicle performance is improving
  - Travel advisory systems to improve driver expectation
    - Route selection, road and weather conditions
  - Indirect viewing systems to improve spatial awareness
  - Collision warning systems to direct attention to crash threat
  - Collision avoidance systems to initiate avoidance maneuver if driver fails to do so
  - Driving Automation (SAE levels 4 to 5) and Cooperative Driving Automation

- **Driver-Optimized Interfaces are Coming**
  - Needed to safely deliver information and mitigate driver distraction

- **Workload Management may need to be Implemented**
  - Needed to adjust or deactivate technological components when driving task demands are high

- **Combination of efforts will improve safety**
  - Help to uphold driver reliability
  - Increase total system reliability by adding redundancy from Assistance Systems

Source: Greg Fitch, Virginia Tech – ITSA Safety Forum (adapted)
Technology can improve the Infrastructure, but slowly

- Public decisions to invest in new infrastructure are driven by benefit cost analyses based upon large and growing ITS “data ecosystem”
- The transportation system will transmit quality-of-service information and pricing signals to all users.
- Traffic is intelligently mitigated or re-routed around disturbances and peaks
- Security and credentialing is automated; freight flows more predictably
- ITS travel demand management help push some transportation related environmental emissions back to safe levels

Congestion growing: US land use will still be suburban, requiring travel by greater distances feeding congestion, which is spreading to more of the system

Travel Patterns Shifting: Road network fits traffic patterns of 1950's, not the 2020's

Investment Waning: Local authorities will not keep up with the demand for infrastructure investment, focusing resources mostly on preservation and maintenance.
Technology Revolution is here: Technological revolutions are defined by a powerful cluster of new and dynamic technologies, industries and products that drive productivity

- Those clusters seem to be forming around…
  - **Vehicle** (connected/automated)
  - **Infrastructure** (smart cities/internet-of-things)
  - **Transportation Users** (mobile apps/cloud)

Integration of technologies, such as within a “smart city,” suggests investment where productivity gains could be greater than the sum of its parts

**But there are lots of moving parts…..**
Moving Parts

- Mobility
- Safety
- Security
- Privacy
- Sustainability
- Accessibility

Assurance? - Reliable, Robust or Resilient
Urban Growth Drives Innovation: Growing urbanization requires better management of traffic operations, parking, EV charging, transit & share use mobility

Urban Planning back in Style: Integrated “smart growth” programs that result in community design similar to what developed in the US prior to 1950

- Smart Growth, New Urbanism and Transit Oriented development are influencing real estate investment in growing urban centers (e.g. DC Southwest/Navy Yard)
- Strategies can reduce vehicle ownership and travel 20-40%
- Can significantly increase walking, cycling and public transit, with even larger impacts if integrated with increased investments in alternatives to car-only

Cannot build way out of Congestion – too many chokepoints – Need to operate and integrate freeways, arterials and transit rail
Adoption Phases

Innovation Adoption Lifecycle

- Innovators: 2.5%
- Early Adopters: 13.5%
- Early Majority: 34%
- Late Majority: 34%
- Laggards: 16%

Emblematic Cases –
Smart Infrastructure/Cities

**Smart Parking**

Adoption Phases:
Cycle- Early Majority/
Late Majority

Simple

(Non-V2X)

**Vehicle-to-
Vehicle/Infrastructure/Communications**

Adoption Phases:
Innovators Early Adaptors

Complex but Standardized

(V2X Standards)
Smart City Illustration

Smart Parking

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Parking is a $24-25 billion industry - highly fragmented but experiencing consolidation and outsourcing of operations.

Low growth in construction starts and new facilities Number of existing facilities may be well over 10,000. Number of spots is uncertain – Far above 300 million.

Zoning and Bundling – In US parking minimums, in Europe and elsewhere parking maximums - Most parking is “bundled” free (ie subsidized) –

Payment Drives Data Ecosystem: Minimum of 10% of all parking is for-charge. Growing percentage use cashless payment.

Diverse, but may Consolidate: Very wide variety of Facility Owners and Operators

Growth Opportunity is in Services – Little focus on customer experience

Smart Parking is telling example of complexity of deploying Internet of Things in Smart City Context
Parking Models must link diverse Customers, Operators, and Partners

- Diversity of Operators – Municipalities, Large Institutions (eg. Universities), Transportation Facilities (Airports, transit stations), Commercial and Retail (REIT)
- Diversity of Configurations – On-street/Off-street, brownfield/green deployment
- Diversity of Customers and Customer Needs
  - Transient/discretionary vs Non-discretionary trips (shopping vs. commuting)
  - Degree of synchronization with trip generating activities (e.g. appointments)

Fragmentation applies to most “smart city” deployments, not just parking

- There are thousands of municipalities, and multiple departments within them
- Public procurement processes make it no easier; right-of-way access troublesome
- Private infrastructure have low operating margins, requiring short paybacks
- Very difficult to find easily scalable solutions and growth – Challenging for startups
Service Model: – Provides mobile payment service for parking with minimal infrastructure footprint (essentially signage, very scalable)

Data Model: Indirect Parking Occupancy
- Historical occupancy data collected to do prediction where sensors unavailable
- Crowdsourcing - Operator Dashboard lets parking operators establish profiles

Hardware Oriented Service/Data Model - Direct Parking Occupancy/Permitting:
- Install ground sensors into parking spots in select areas to provide parking occupancy data (No V2X per se)
- Camera based parking occupancy, but adds permitting (ANPR) and traffic incident detection and maybe public safety

Summary - All these models have 1) Service revenue that subsides hardware or 2) data model where data licensed to navigation services or 3) sell analytics
**Smart Parking is Asset Management**  Smart Parking is a great example of how technology changes can potentially change traffic patterns and land use incentives

* Parking is the single biggest land use in any city
* Smart Parking matches idle parking assets to consumers’ unmet needs.
* Smart Parking measures or predicts parking availability and simplify payments
* Navigation gets turn-by-turn to the block, parking NAV gets you to the spot

**Smart Parking improves land use by increasing productivity**

* Transportation: Cities want to use smart parking to improve mobility – 30% of congestion caused by searching/cruising for parking
* Real Estate: Parking is a major class of real estate investment in most cities – growing parking receipts through smart parking apps appreciates underlying asset
**Key Challenge:** Government Agencies typically don’t do operational data well.

**Procurement:** One approach is to eschew traditional arms-length inflexible model of public procurements and focus on public/private partnerships – Examples:

**Open Data:** Encourage every effort by public sector infrastructure entities to make data available to third parties for application development, research or performance measures

- Reduce barriers for its data reuse and consumption
- Address security, privacy, and accessibility
- Build data ecosystems- allow data to be shared in a secure manner across any app
- Standards have been major challenge in the past
Smart City Illustration

Vehicle-to-Vehicle/Infrastructure
Need for Adaptive Traffic Management (ATM)

- Delays at traffic signals contribute an estimated 5-10% of all delay
- Traffic incidents contribute 40% of delay – un-harmonized traffic flow
- Signal/Ramp coordination needed to enhance throughput (~20%)
- Signal timing plans may not meet traffic demands during all periods of weekdays and weekends, holidays, special events, and incident conditions.
- Signal Automation - responsive (several cycles) or real-time – is complex
- Traditional systems using detection are expensive and difficult to maintain (examples are LAACTS, SCATS, SCOOT)

Public Safety and Crash Avoidance Needs

- Intersection Signal Priority (Emergency Vehicle, Transit, Freight, or other)
- Adaptive Intersection Safety (braking “dilemma zone,” left turn warning etc.)
- Corridor Safety (Dynamic Speed Limits/Speed Harmonization)

Next potential enhancement is ATM/Vehicle-to-Infrastructure Communications, and future support for fully driverless vehicles (SAE Automation Level 5)
Why V2X? Standards!

- V2X establishes an Intelligent Transportation Systems Architecture that includes not just Infrastructure, but also Vehicles and Pedestrians
  - One standard for all vehicles and all traffic control systems enables industry to focus on new application development without worrying about interoperability.
  - One standard drives economies of scale and scope, and lowers the cost of Intelligent Transportation Systems.
- Assessed value of all traffic signal assets at $82.7B (2012-NTOC)
**V2I Core Standards**

* The Dedicated Short Range Communications/Wireless Access For Vehicular Environments (DSRC-WAVE) stack addresses applications, interoperability, privacy, security, media access (SAE2735, IEEE 802.11p/1609.x standards)

* **Short Range Peer-to-Peer model:** V2X equipped vehicles pass messages to only neighboring cars/traffic signals (<300 ft to support “highly local/highly current” apps)

* **Robust Interference Mitigation:** licensed spectrum dedicated for V2X DSRC provides assurance for mission/safety critical operations

* **Privacy Assurance:** Messages are anonymized alerts—no driver, vehicle, or other identity information provided
  * Anonymity efforts assures drivers with V2V cannot be subject to surveillance

* **Security Assurance:**—operational design that addresses potential threats major part of “connected vehicle” effort
V2I App Standards

- SAE J2735 V2X Messaging Standards that Support V2I
  - Basic Safety Message (V2V, V2I Broadcast)
  - Personal Safety Message (Vulnerable Road Users)
  - Traffic Signal Phase and Timing (SPAT)
  - Signal Request Message (I2V)
  - Signal Status Message
  - Basic Infrastructure Message
  - Map Data
  - Roadside Alert
Vehicle Safety Communications (V2V) Rule at NHTSA under consideration – Major issues to address:

- **Interoperability** – standard is IEEE 802.11p, 1609.x, but 3GPP and 5GAA suggest they can hit performance requirements using DSRC band (5.9GHz)
- **Safety/Security/Operational Assurance** – suitability for IOT crash avoidance, driving automation, or intelligent signal control, not broadband/infotainment
- **Equipage Path** – Voluntary adoption vs. Mandate (or similar accelerated adoption model) – utility of V2X is a function of number of nodes equipped
- **Vehicle Aftermarket** – will accelerate adoption far more than OEM alone
- **V2X App Ecosystem** – More app development and ongoing commitment to security, privacy and other foundational assurance elements
- **Intelligent Infrastructure** – Road Infrastructure operators needs are different from autos/aftermarket, so much more attention for Vehicle-to-Infrastructure apps
Percentage of Road Users (All Light and Heavy Vehicles) Equipped with DSRC over Time

V2I Prospect: V2V Penetration will likely determine rate of V2I deployment, absent concerted effort of to deploy infrastructure separately.
* **The Challenge:** Very small percentage of traffic signal controllers have an API, but does not mean interface is impossible

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Source: AASHTO Infrastructure Footprint Analysis

- **The Opportunity:** Legacy controller equipment, when upgraded, will likely include V2I support when recapitalization of infrastructure occur
NYC DOT will install Vehicle to Vehicle (V2V) technology in up to 8,000 vehicles, as well as Vehicle to Infrastructure (V2I) portion.

Michigan Ann Arbor Pilot included 3,000 vehicle. There are V2I installations in 26 states; other large scale deployments in Tampa Bay, Florida and Cheyenne, Wyoming.

Some challenges to scaling V2I deployment:

- **Cost**: Backhaul highest cost - Of the 300K intersections, only ~40% are backhauled. Of which ~80% in urban areas ~20% elsewhere.

- **Sustainability**: Transportation planning/budgets favor CAPEX over operations and maintenance.
V2I or only I2V?

- **Some Automakers focus on Infrastructure-to-Vehicle only** – OEM see benefit in getting signal countdowns to drivers (e.g. Audi/TTS Traffic Light Assist)
- **Vehicle-to-Infrastructure Adaptive Traffic/Intersection Safety will probably still require DSRC**
  - Current road user crowdsourced Data-as-a-Service (e.g. INRIX, WAZE etc..) supports road user centric traffic information now. (Vehicle-to-Cloud)
  - DAAS Traffic Data is not granular to support adaptive road operations or to control traffic signals (e.g. no lane-level movements)
  - But DAAS Traffic Data combined with data V2V equipped vehicles (at low penetration rates) could likely be an ATM gap filler
- **First challenge is access to signal controller – V2I or I2V** requires partnerships with hundreds road agencies if focus nationwide
  - State DOT’s & large cities may take leadership here

Source: INRIX
* Casting a wide net for Smart Cities Transportation
  * Not just parking and active traffic management – these are bookends
  * Must examine all infrastructure assets – lighting, utilities, telecom, right-of-way
  * …and All vehicle assets – car/ride sharing, transit and microtransit.
  
* Infrastructure data is likely under-leverage
  
* Leadership and culture needs to change to encourage innovation
Other Notable Smart Infrastructure

- **Shared Use Mobility Integration**
  - First Mile/Last Mile Connections - incentives for passengers to use transit
  - Service integration of ride hailing to improve para-transit, or use vouchers by transit agencies to supplement their lower-frequency/higher-cost off-peak services
  - The Future: Sharing/Micro-Transit operations using Highly Automated Vehicles

- **Electric Vehicle Infrastructure**
  - Infrastructure models for providing parking/charging services.
  - More charging nodes per square mile are possible than for fuel stations
  - The Future: EVs establish collective spinning or frequency-response reserves for utilities that could counteract generation disruptions or spikes in demand

- **Lighting/Telecom IOT**
  - Push to deploy smart cities apps when cities upgrade street lighting or wireless small cell infrastructure along transportation right-of-way
Traffic Management Systems (and the data in them), with a few exceptions, are largely unleveraged

- *Integrated Corridor Management Deployments* - Leverage data by adding interagency/jurisdictional coordination and “integrated” operations (e.g. integrate highway, transit and parking data etc)

- *Regional Integrated Transportation Information System (RITIS)* – University of Maryland CATT Lab

Public Agencies have lots of leverage-able Assets

- Encourage road right-of-way access to third parties to encourage Internet-of-Things tech and wireless deployment (eg. Street sensors, small cells etc..)

- Next Steps: Ease burdens through standards and easy to translate requirements, addressing procurement, security, privacy, liability and other components collectively

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How do you encourage entrepreneurship at the local level?

**Culture:** You need to create a culture that is open to innovation – with public agencies this is difficult for a number of reasons

- Takes leadership to unify disparate agencies – often at the very top (Mayors)
- No resources, lack of technical expertise, lack of supporting infrastructure, and lack of standards/architecture
- But most importantly, it takes leadership to take risks on new technologies

**Cluster:** Universities and the research community can help establish relationships with their local governments and states and provide support for new concepts
Thank You!

Steve H. Bayless, VP Policy
sbayless@itsa.org
202-721-4229