Connected & Automated Vehicles: Current Situation

Richard Bishop
Alabama Transportation Conference
February 2015
Connectivity & Automation: Powerful New Waves
V2X COMMUNICATIONS: THE “INTERNET OF THINGS” COMES TO THE ROAD
Why should cars communicate with each other and the road?

• We can’t see everything we need to see
  – nor can on-board sensors
• V2X extends the “information horizon”
• When cars share information with their neighbors
  – safety improves
  – traffic flow improves
  – environmental impacts lessen
• USDOT working with auto industry, AASHTO, others
V2X for Safety: A Vital Role

• V2X “sees” where sensors are blind
  – around blind curve
  – several vehicles ahead
  – Do Not Pass warning
  – Intersection Movement Assist
  – Left Turn Assist
  – Slick Road Warning

• Intersections
  – fewer crashes
  – …but more severe
V2X: Technical Basis

- Spectrum allocated at 5.9 GHz
- IEEE 802.11 protocol adapted for vehicle environment to create 802.11p
- Basic vehicle operating data is broadcast at 10 Hz
- Transmissions occur in 20 msec
- Message sets are standardized
- Privacy / Security:
  - no personal information transmitted
  - layers of communications security built in
Safety Pilot: Major Field Test Successful

- Ann Arbor, Michigan
- 3000 vehicles over 1 year
- Vehicles successfully exchanged thousands of V2V messages
V2V: NHTSA Regulatory Process

- **February 2014:**
  - USDOT announces intent to begin regulatory process to require V2V on new automobiles

- **July 2014:**
  - Advance Notice of Proposed Rulemaking

- **August 2014:**
  - Research Report - Readiness of V2V Technology
Safety Benefits: If All Cars Equipped

• Analysis for:
  – Intersection Movement Assist
  – Left Turn Assist
• Reduction of crashes: 25,000 to 592,000
• Lives saved: 49 to 1,083
• Injuries (MAIS 1-5) avoided: 11,000 – 270,000
• Reduction in property damage crashes: 31,000 – 728,000
Vehicle-to-Infrastructure Communications (V2I)

- Roadside transceivers
- Sending
  - traffic signal phase and timing
  - weather (RWIS) information
- Receiving
  - “probe data” of vehicle parameters
  - helpful for traffic management, weather, more
- AASHTO analyses completed
- FHWA gearing up
USDOT: Connected Vehicle Pilots

• Field tests in a handful of U.S. cities
• Applications beyond safety:
  – traffic flow, eco-driving, automation
• RFP released January 2015
• Several “waves” of awards expected
  – $2-$20M each
AUTOMATED DRIVING: REAL OR ALL HYPE?
Why Automate Driving?

• It fixes the major design flaw in automobiles: human operation.
• We insist on being productive everywhere… or at least having the choice
• Choice and productive time reduces stress and enhances quality of life
• Driving is the last bastion.
Crash Avoidance is the Starting Point

- Electronic Stability Control
- Lane Centering
- Automatic Braking
  - front
  - rear
- Blind spot Monitoring
- Pedestrian Detection
- Fatigue Alert
- Night Vision
- Speed Sign Recognition
Doing Things Right!

• Crash avoidance is different from automated driving.
• Crash avoidance technology intervenes when things go wrong
  – … and our human capabilities are not up to the task.
• Automated driving technology automates the things we do RIGHT.
Automated Driving: Enabling Technology

**Multi Mode Radar**
- 80 m range / opening angle 16°
- 30 m range / opening angle 80°

**Stereo Multi Purpose Camera**
- 500 m range, with 3D capability over a range of 50 m / opening angle 45°

**Long Range Radar with Mid-Range Scan**
- 200 m range / opening angle 18°
- 60 m range / opening angle 60°

**Ultrasonic Sensors**
- 1.2 m / 4.5 m range

**Short Range Radar**
- 0.2 m–30 m range / opening angle 80°
Automated Driving: Enabling Technology

MULTI MODE RADAR
80 m range / opening angle 16° and
30 m range / opening angle 80°

STEREO MULTI PURPOSE CAMERA
500 m range, with 3D capability over a
range of 50 m / opening angle 45°

LONG RANGE RADAR
WITH MID-RANGE SCAN
200 m range / opening angle 18°
60 m range / opening angle 60°

ULTRASONIC SENSORS
1.2 m / 4.5 m range

SHORT RANGE RADAR
0.2 m–30 m range / opening angle 80°

V2V?
Automated Driving: Enabling Technology

V2V?

...on a separate and parallel path
... not required to automate driving.
Levels of Automation (NHTSA)

- Level 0: hands and feet ON
- Level 1: hands or feet OFF
- Level 2: hands and feet OFF, eyes ON
- Level 3: hands, feet, eyes OFF, brain on
- Level 4: hands, feet, eyes, brain OFF

Aim: safer than current human drivers
Automated Driving Starts on the Highway: Early Systems are Here

- Traffic Jam Assist (low speed)
- Mercedes, BMW launched 2013
- 2016: GM
- 2016: Nissan
Automated Driving Starts on the Highway

- Highway Pilot (full speed, co-pilot)
  - Infiniti Q50 2013
  - Mercedes S, E Class launched 2013
  - Hyundai Genesis launched last year
  - Acura 2015

“Full-up” Highway Driving

Highway Pilot (Level 2 Automation)
- Now: prototypes covering full speed range & lane changing
- 2016: GM (with driver monitoring)
- 2016: Audi “piloted driving” << CES
- “mid-decade”: Toyota (Automated Highway Driving Assist)
- 2018: Nissan (with lane changing)
ROAD TO AUTOMATED DRIVING

- Today’s Driver Assist Package
- "SuperCruise" Concept
- Emergency Intervention (Limited Control)
- Limited On-Demand Automation (Monitored Control)
- Complex On-Demand Automation (Transferred Control)
- Autonomous Driving (Chauffeured Driving)

TECHNOLOGY ENABLERS:
- Perception & Algorithms
- Integrated Sensing with Maps, GPS, V2X
- Driver State Knowledge

Today → Future
Streets?

• 2013: Mercedes research vehicle drives route of 1888 with the first automobile
• 104 kilometers
  – three major cities, 23 small towns
  – traffic lights, roundabouts
• Use of close-to-market sensors
  – vision (mono, stereo) and radar
• Digital maps used as reference
  – localization and maneuver planning
Mercedes Berta Benz drive
What About Google?

- Google awarded 25 of the first 29 permits issued by the state of California to test driverless cars on public roads.
- Major steps by Google will stimulate the market…
- …. but the big volumes will stay with car-makers.

- Low speed robotic taxi service starting soon
- Limited geographic region
Trucks!

- Daimler
  - Automated Truck 2025
- Automated “drafting” with two-truck platoons
  - FHWA currently funding two research projects
    - Caltrans/UC-Berkeley
    - Auburn University
  - Fuel savings on both trucks
- American Trucking Association
  - Automated Driving and Platooning Task Force
AERODYNAMIC DRAG: ~65% OF FUEL USE AT 65MPH

Improve Safety
12% Hwy Fuel Savings

Increased Fleet Profits
Early Opportunity: Driver Assistive Truck Platooning (DATP)

• DATP extends Adaptive Cruise Control with V2V communications
  – allows closer following while maintaining safety
  – significant fuel economy increases
  – use of DSRC within large fleets need not wait on regulatory process

• Longitudinal control is the key to benefits
  – drivers still steer
Driver Assistive Truck Platooning

- Fuel savings at 60 mph, 11m gap:
  - lead truck: 4.5%
  - following truck: 10.0%
Driver-Assistive Truck Platooning: Technical Development and Business Case Evaluation

GPS and Vehicle Dynamics Lab
Auburn University
Schedule

• **Phase One (2013-2014)**
  - Concept of Operations
  - Examine Business Case
  - Technology Performance Evaluation
  - Develop System Requirements
  - Conduct Traffic Simulations

• **Phase Two (2014-2015)**
  - Implement Prototype System
  - Evaluate on Test Track and (ideally) Public Highway
  - Assess Technical Performance
  - Assess Benefits (fuel economy, traffic flow)
  - Assess User Acceptance
    - drivers
    - fleets

• **Phase Three (2015-2016)**
  - dissemination of results
State Level Regulations for AV Use

• States regulate how vehicles are operated
  – NHTSA only regulates equipment on new vehicles
• California, Florida, Nevada, D.C. have acted
  – Florida: “does not regulate or prohibit use of AV’s”
• A regulation may not be required for AV use to be legal
• Typical content:
  – $1M or more bond
  – evidence of insurance
  – incident reporting
How Can State DOT’s Prepare for AV?

• Market-driven automotive product
  – car-makers ensure system works on roads “as-is”

• Basic infrastructure support desired
  – high quality lane markings, signage
  – information on work zones, etc.
  – (long term) traffic signal phase/timing
    – *Upload to Cloud!*

• Driving Code may need to be adjusted
  – following distance for platooning
  – hands on-wheel
  – texting
WILL AUTOMATED DRIVING BE A SUCCESS IN THE MARKETPLACE?
J.D. Power:
Consumer Interest Continues to Grow

• $4000 automated driving feature
  – current high end “tech package” cost: ~$3000

• 24% of drivers interested in autonomous driving
  – 21% in 2013

• By age group:
  – 41% Generation Y
  – 25% Generation X
  – 13% Later Boomers
  – 13% Early Boomers
How Fast Will AV Happen?
Diffusion Modeling (Marconi-Pacific)

• **New territory:** No other technology ever offered in cars allows drivers to do something else with their brain.

• **2025:**
  – 48% of light vehicles sold with crash avoidance / automation
  – 18% of overall fleet equipped

• **2035:**
  – 85% of light vehicles sold with crash avoidance / automation
  – 53% of overall fleet equipped

• **Resulting in 25% crash reductions mid-term**
  – eventually extending to 98% in the long term
WHAT STANDS IN THE WAY?
What stands in the way?

- Test / Evaluation / Certification?
- Government regulations?
- Cybersecurity?
- Privacy?
- Liability?
- Insurance?
What stands in the way?

- Test / Evaluation / Certification?
- Government regulations?
- Cybersecurity?
- Privacy?
- Liability?
- Insurance?
What stands in the way?

- Test / Evaluation / Certification?
- Government regulations?
- Cybersecurity?
- Privacy?
- Liability?
- Insurance?
What stands in the way?

• Test / Evaluation / Certification?
• Government regulations?
• Cybersecurity?
• Privacy?
• Liability?
• Insurance?

typically lags industry
What stands in the way?

- Test / Evaluation / Certification?
- Government regulations?
- Cybersecurity?
- Privacy?
- Liability?
- Insurance?

*typically lags industry*
What stands in the way?

- Test / Evaluation / Certification?
- Government regulations?
- Cybersecurity?
- Privacy?
- Liability?
- Insurance?
What stands in the way?

- Test / Evaluation / Certification?
- Government regulations?
- Cybersecurity?
- Privacy?
- Liability?
- Insurance?

*typically lags industry*
What stands in the way?

- Test / Evaluation / Certification?
- Government regulations?
- Cybersecurity?
- Privacy?
- Liability?
- Insurance?

typically lags industry
THE FUTURE OF PERSONAL MOBILITY
What Does Mobility Look Like in 20 Years?

• V2X
  – improvements in safety, traffic flow, emissions
  – passenger cars
  – truck platoons
• Only incremental benefits as long as human needed in the loop
  – next 10-15 years for mass market sales
• When cars can drive without a human – Game Changer!
  – driverless taxi’s
  – elderly, disabled, children get chauffeured
• Car sharing / auto-taxi takes hold in urban areas
What Does Mobility Look Like in 20 Years?

- Who still owns a vehicle and who shares?
  - Gen Y’ers concentrate in megacities.
  - Older generation stays active and independent.
- Affluent commuters move farther out.
- Cities evolve as parking lessens and goes to the periphery.
What Does Mobility 2035 Mean to You?

- You’re always dropped at the doorstep. You walk when you want to, rather than being compelled by parking situations.
- Two-car households in urban and near-urban areas shrink to one or none.
- Your choices about where to live open up.
- Your kids have a chauffeur.
- Your parents have a chauffeur.
- YOU have a chauffeur.
Thank You

Richard Bishop
Bishop Consulting
richardbishop@mindspring.com