Developing a U.S. DOT Multimodal R&D Program Plan for Road Vehicle Automation

Mike Schagrin
Program Manager, Connected Vehicle Safety & Automation
ITS Joint Program Office

Kevin Gay
Vehicle Automation Team Lead
Volpe Center
Research and Innovative Technology Administration

September 25, 2013
Purpose of the R&D Program Plan

- Address the Department and agency strategic priorities (safety, mobility, environment)
- Clarify the government role vs. industry role
- Identify key research areas for the modes involved in vehicle automation:
  - NHTSA, FMCSA, FTA, FHWA, RITA
- Identify lessons learned & cross-over technology from other agencies:
  - FAA, FRA, MARAD, PHMSA, DoD, DoE, NASA, etc.
- Establish the ITS road vehicle automation research agenda for the 2015 – 2019 ITS Strategic Plan
R & D Justification

- **Safety**
  - 5.3 million crashes, including over 32,000 fatalities (2011)
  - Over 90% of crashes ($500 billion per year) attributed to driver error

- **Mobility**
  - $120 billion annual cost of congestion (wasted time and fuel)
  - Potential to double lane capacity (CACC trials)
  - 54 million Americans (20%) have some form of disability
  - $5.7 billion in total operating costs for 190 million paratransit (demand-response) trips.

- **Environment**
  - 25% of US greenhouse gas emissions ($30 billion per year) in societal costs
  - Field trials showed 8%-16% reduction in fuel consumption from semi-automated ‘road trains’ (SARTRE, Energy ITS)

- **Analysis of Benefits**
  - Double counting of benefits across technologies
  - Establish credible basis for benefits
Development of a US DOT Multimodal R&D Plan Project

- Define key road vehicle automation research challenges
  - Focus on areas appropriate for US DOT investment
  - Prioritize research challenges

- Produce a multimodal R&D program plan for safe and connected vehicle automation
  - Define roadmap for execution of slated research
  - Focus on efforts associated with the next ITS Strategic Plan 2015-2019

- Complement, leverage, and enhance what industry activities
  - Avoid duplication of industry efforts
  - Keep pace with industry progress
Input to the USDOT Multimodal R&D Program Plan

- **US DOT ITS Multimodal Plan ITS JPO**

  - **FHWA**
    - Improving overall roadway network performance and personal mobility
  - **FMCSA**
    - Ensuring safe in-service operations of motor carriers
  - **NHTSA**
    - Defining the need for vehicle standards
    - Regulatory authority of road vehicles
  - **RITA**
    - Coordination and development of the modal program plan
  - **FAA, FRA, etc.**
    - Lessons learned
    - Cross-over technologies
  - **FTA**
    - Improving transit vehicle safety and operations
  - **Industry, Academia, Other Govt.**
    - Request for Info
    - Expert Interviews
    - Industry Analysis
    - TRB Workshop

# Modal Research Interests in Automation

<table>
<thead>
<tr>
<th>Agency</th>
<th>Research Interests</th>
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| RITA     | Provide coordination and outreach for vehicle automation program  
|          | • Multimodal R&D program plan  
|          | • Stakeholder outreach                                                                                                                                 |
| NHTSA    | Conduct research to support regulatory process and to determine the need for vehicle automation standards  
|          | • Human factors  
|          | • Electronic control systems (safe reliability and cyber security)  
|          | • System performance requirements                                                                                                                                 |
| FHWA     | Improving overall roadway network performance  
|          | • Application research (CACC, Platooning, Speed Harmonization)  
|          | • Infrastructure requirements to support automation  
|          | • Personal mobility                                                                                                                                 |
| FTA      | Improving transit vehicle safety and operations  
|          | • Application research (Precision Docking, Bus Lane Assist, Platooning)  
|          | • Commercialization of automation technology                                                                                                                                 |
| FMCSA    | Ensuring safe in-service operations of motor carriers  
|          | • Enabling technology (truck / trailer coupling)                                                                                                                                 |
| All Modes| Evaluation of safety, mobility and environmental benefits |

U.S. Department of Transportation
Coordination with Other Agencies

- **White House**
  - Coordination of research across government agencies

- **FAA**
  - Human factors issues for pilots using autopilot systems
  - Testing of “fly-by-wire” systems
  - Privacy & data issues with UAVs

- **FRA**
  - Positive Train Control regulations

- **MARAD**
  - Technology used in underwater, unmanned vehicles for mapping harbors

- **DoD/ TARDEC**
  - Convoy safety and fuel efficiency
  - Personal mobility for soldiers around the base

- **DOE**
  - Vehicle design, ownership models, and urban planning impacted by automated vehicles
  - Significant reduction in energy consumption

- **NASA**
  - Integrated Vehicle Health Management Systems
  - Technology development

- **NSF**
  - Cognitive and Autonomous Test vehicle research
  - Cyber Physical Systems Research

- **DHS / NSA**
  - Cyber security and cyber warfare

- **Veterans Affairs**
  - Personal mobility
International Activity on Vehicle Automation

- Significant planning/investments being made in Japan and Europe
- Japan and Europe are also developing formal technology and policy roadmaps on vehicle automation
- Recently established Tri-lateral Working Group on Automation in Road Transportation.
  - Japan (Ministry of Land Infrastructure, Transport, and Tourism)
  - Europe (European Commission)
  - United States (ITS JPO)
# Industry Developments in Automated Vehicles

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<tr>
<th>Organization</th>
<th>Noteworthy Developments &amp; Announcements</th>
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<tbody>
<tr>
<td><strong>HONDA</strong></td>
<td>Conducting demonstrations of Traffic Jam Assist at locations around the US in 2013</td>
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<tr>
<td><strong>Mercedes-Benz</strong></td>
<td>MY 2014 – Steering Assist (Lane Keeping + Adaptive Cruise Control) in U.S. production vehicles; Self-driving vehicle for sale by 2020.</td>
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<tr>
<td><strong>VOLVO</strong></td>
<td>MY 2015 – Traffic Jam Assist (Lane Keeping + Adaptive Cruise Control) in U.S. production vehicles</td>
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<tr>
<td><strong>Audi</strong></td>
<td>MY 2016 – Traffic Jam Assist (Lane Keeping + Adaptive Cruise Control) in U.S. production vehicles</td>
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<tr>
<td><strong>BOSCH</strong></td>
<td>Traffic Jam Assist technology will be ready in 2014 for use by OEMs</td>
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<tr>
<td><strong>NISSAN</strong></td>
<td>Plans to release a fully self-driving vehicle by 2020</td>
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<tr>
<td><strong>General Motors</strong></td>
<td>Plans to release nearly self-driving vehicle by 2020</td>
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<tr>
<td><strong>Continental</strong></td>
<td>Partnered with Google and IBM to develop autonomous driving systems</td>
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<tr>
<td><strong>TOYOTA</strong></td>
<td>Researching a semi-autonomous vehicle designed to keep the driver in the control loop and takeover in case of an imminent accident</td>
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Key Technical and Policy Challenges

- **Technical Challenges**
  - Sensor fusion and electronic architecture
  - User acceptance of technology
  - Engagement of human in driving (driver assist vs. self driving)
  - Electronic system safety (safe reliability/cyber security)
  - Testing and certification of automated vehicles

- **Policy Challenges**
  - Varying state regulatory frameworks
  - Liability of stakeholders
  - Data ownership and privacy
Highlights of Plan

- Main theme → Safe & Connected Vehicle Automation
- Currently, a technology roadmap; policy elements need to be further developed
- Leverage current successes of the ITS Connected Vehicle Program
- Address areas industry is not currently focusing on (connectivity vs autonomy)
- Collaborate with international interests
- Major objectives of plan include:
  - Ensuring safe operation of deployed automated vehicles, especially in mixed traffic period
  - Understanding and demonstrating application & operational benefits of “connected automation”
  - Engaging relevant stakeholders to identify non-technical areas for future federal research
Safe and Connected Automation

- **Safe**
  - Meets requirements for functional safety, cybersecurity, and system performance
- **Connectivity**
  - Includes all types of communication with vehicles and infrastructure (Wi-Fi, DSRC, Cellular, etc.)

**Autonomous Automated Vehicle**
- Operates in isolation from other vehicles using internal sensors

**Connected Vehicle**
- Communicates with nearby vehicles and infrastructure
- Not automated (level 0)

**Connected Automated Vehicle**
- Leverages autonomous automated and connected vehicles
Benefits of Safe & Connected Automation

- Full benefits of vehicle automation achieved only through safety assurance and connectivity

- Vehicle-to-vehicle communications can enhance and enable system performance among locally connected vehicles

- Vehicle-to-infrastructure communications can optimize overall road network performance, safety, and reliability
Draft Multimodal Program Plan – Structure

- **Research Tracks**
  - Enabling Technologies
  - Safety Assurance
  - Applications
  - Testing & Evaluation
  - Policy & Planning Research
  - Stakeholder Events

- **Major Milestones**
  - Proof of Concepts & Field Tests
    - Individual applications
    - Application bundles
  - Capability Demonstrations
  - Requirements & Guidance
  - **Strategic Plan Milestone: Automated Integrated Corridor Pilot**
Enabling Technologies

- Agencies – NHTSA, FHWA, ITS JPO
- Track Objective
  - *Develop technologies necessary to enable connected automated vehicle applications*
- Key Research Areas
  - *Digital Maps & Positioning Technologies*
  - *Heavy Vehicle Technology (Trailer attributes, Steer/Brake-by-wire)*
  - *Transit Vehicle Technology (Connectivity supporting applications)*
  - *Communications and Data Messages (“BSM” for automation applications)*
  - *Incorporation of Connected, Automated Vehicles into the CVRIA*
  - *Augmenting of Existing and Development of New Standards*
- Research Outcomes
  - *Performance Requirements for Technologies*
  - *Prototype Technologies*
  - *Minimum Performance Requirements for Communications/Messages*
  - *Standards*
Safety Assurance – Electronic System Safety

- Agency – NHTSA (lead)

- Track Objective
  - Develop computing (hardware, software, architecture) requirements and standards for vehicle.
  - Develop functional reliability requirements and standards for safety-critical control systems.

- Key Research Areas
  - Identify electronic control systems gaps and questions, e.g. performance needs, technology capabilities, performance requirements.
  - Specify requirements for the safety of electronic components, HW/SW, lifecycle performance.
  - Safe Reliability – Functional analyses, health management, failure response.
  - Cybersecurity – Technical & operational requirements.

- Research Outcomes
  - Functional safety requirements and standards
  - Reliability requirements and standards for diagnostics, prognostics, and failure response
  - Baseline requirements and standards for cybersecurity
Safety Assurance – Human Factors

- Agencies – NHTSA (lead), FHWA

- Track Objective
  - Develop human factors design and system operability recommendations and guidelines to ensure safe interactions between driver and automated vehicle systems.

- Key Research Areas
  - Address human factors gaps and questions, e.g. driver engagement-re-engagement.
  - Develop DVI guidelines for Level 2 and Level 3 systems (e.g. current project - ends 2014)
  - Assess training requirements for drivers of automated vehicles.
  - Assess driver acceptance of emerging vehicle automation systems and concepts.
  - Develop test and evaluation tools that can be used to support human factors research.

- Research Outcomes
  - DVI requirements for Level 2 and Level 3 systems
  - Results from driver acceptance
  - Recommendations for driver training requirements
  - Simulation tools, test vehicles, and other evaluation tools
Safety Assurance – System Performance Requirements Research

- Agencies – NHTSA (lead), FHWA, FMCSA

- Track Objective
  - Develop system performance requirements and standards for automated vehicle systems.

- Key Research Areas
  - Identify system performance gaps and questions, e.g. automated system performance requirements.
  - Conduct objective testing and evaluation of automated vehicle functions, constraints, and operability.
  - Identify and analyze vehicle automation system performance issues from governments, regulators, suppliers, OEM’s.
  - Acquire and/or develop test and evaluation equipment for performance evaluations

- Research Outcomes
  - System performance requirements
  - Objective test procedures
  - Test and evaluation equipment
Applications

- Agencies – FHWA, FTA, NHTSA
- Track Objectives
  - Develop near term applications to realize highway safety, mobility and environmental benefits of automated vehicles
  - Develop transit applications that utilize technology with a path towards commercialization
- Key Research Areas
  - Speed Harmonization, Cooperative Adaptive Cruise Control, Platooning (Truck / Bus)
  - Lane Change, Merge & Demerge and Intersection Management
  - First Mile / Last Mile, Automated Para-transit
  - Lane Assist, Precision Docking, Automated Yard Operations
- Research Outcomes
  - Proof of concepts and field tests for applications to gather data for evaluation
  - Business cases for applications that demonstrate system benefits to transit agencies and technology developers
Testing & Evaluation

- **Agency** – NHTSA, ITS JPO, FHWA, FMCSA, FTA
- **Track Objective**
  - Develop testing and evaluation methods for automated vehicle systems
- **Key Research Areas**
  - Development of test methods, simulation approaches, and objective test procedures for automated vehicle systems
  - Evaluation of the safety, mobility, and environmental impacts of automated vehicles on the transportation system
  - Analysis of the impacts of connected automation on the transportation system
  - Analysis of the impacts of automated vehicles on infrastructure including highway maintenance and design
- **Research Outcomes**
  - Methods for testing automated vehicle systems
  - Benefits results of automated vehicles in the areas of safety, mobility, and environment
  - Benefits results of adding connectivity to automated vehicle systems
Policy & Planning Research

- Agencies – ITS JPO, NHTSA, FMCSA, FTA, FHWA

- Track Objective
  - Conduct research into policy foundational policy issues that may impact the development and deployment of automated vehicles

- Key Research Areas
  - Conduct a scoping analysis to identify the specific policy issues to be researched by the U.S. DOT
  - Conduct in-depth research into identified policy issues and evaluate Federal role
  - Provide implementation support to state and local agencies regarding the planning and deployment guidance of necessary infrastructure to support automated vehicle operations

- Research Outcomes
  - Policy research plan
  - Results from in-depth policy research
  - Guidance for state and local agencies
Stakeholder Events

- Agency – ITS JPO (lead)

- Track Objective
  - Conduct major stakeholder events in order to raise awareness of the impacts of automated vehicles to industry, media, and other research organizations

- Key Events
  - Review multimodal program plan with industry stakeholders
  - Annual workshops and meetings
    - TRB Workshop on Road Vehicle Automation
    - TRB Annual Meeting
    - Connected Vehicle Public Meeting
  - Application-specific demonstrations
    - Automated Integrated Corridor Pilot
      - Demonstrates impacts of combined vehicle automation applications at a system level
Current USDOT Road Vehicle Automation Activities

- **NHTSA**
  - Vehicle Cybersecurity Research
  - Functional Safety of Automated Lane Centering Controls
  - Human Factors Evaluation of Level 2 and Level 3 Automated Driving Concepts
  - Development of Functional Descriptions and Test Methods for Emerging Automated Vehicle Applications
  - NHTSA Policy Statement

- **FHWA**
  - Partial Automation for Truck Platooning
  - High Performance Vehicle Streams
  - Hardware-in-the-Loop Testing Methods
  - Human Factors Research for Vehicle Automation

- **ITS JPO / All Modes**
  - Vehicle Automation Program Management and Planning
  - Policy Scoping Research
  - Transportation System Benefits Study of Highly Automated Vehicles
Questions & Follow-up Contacts

- Mike Schagrin – ITS JPO
  - Program Manager for Connected Vehicle Safety and Automation
  - Mike.Schagrin@dot.gov

- Kevin Gay – RITA / Volpe Center
  - Vehicle Automation Team Lead
  - Kevin.Gay@dot.gov