



UNITED STATES
DEPARTMENT OF TRANSPORTATION

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

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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

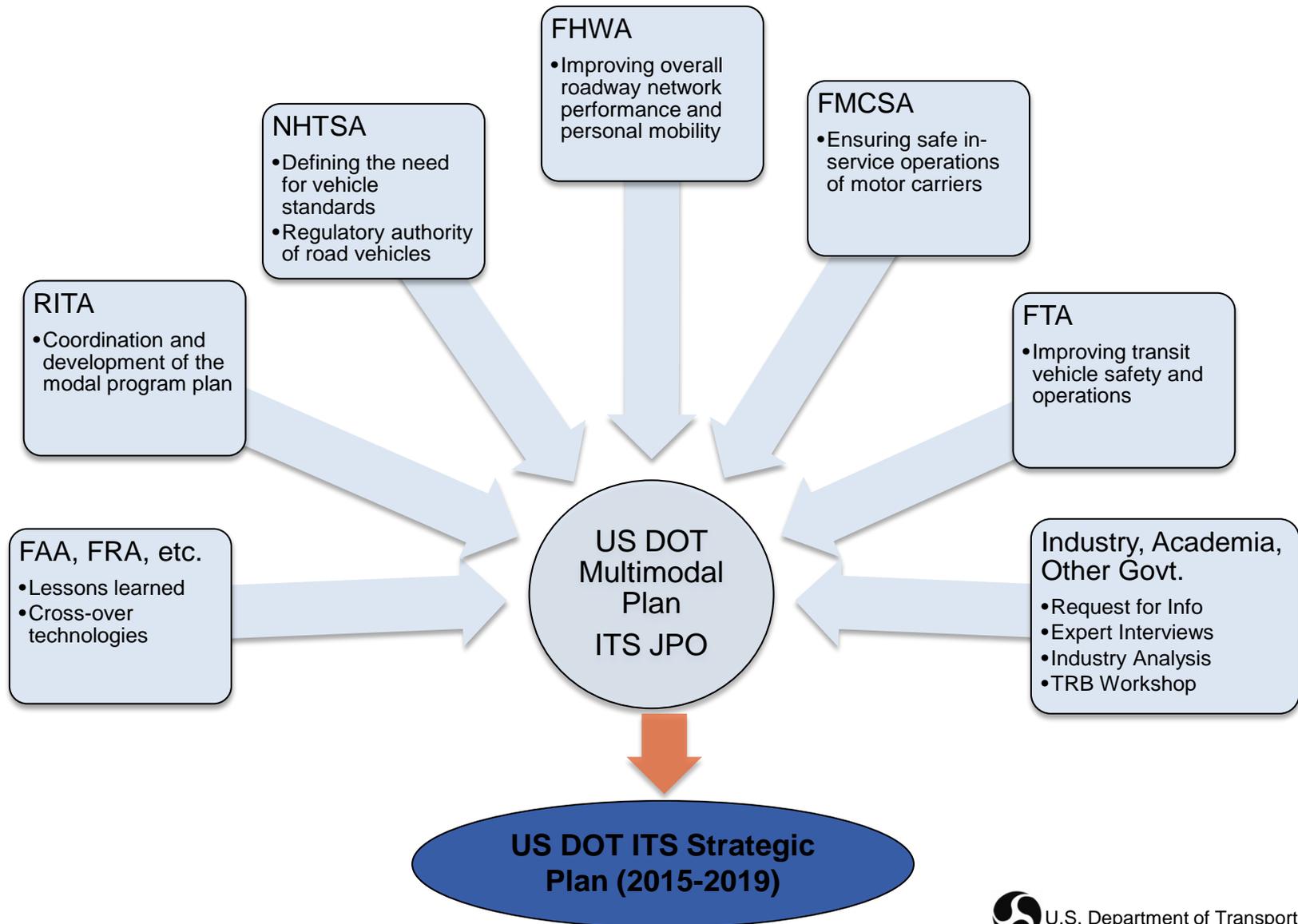
- Define key road vehicle automation research challenges
 - ◻ Focus on areas appropriate for US DOT investment
 - ◻ Prioritize research challenges

- 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



Modal Research Interests in Automation

Agency	Research Interests
RITA	Provide coordination and outreach for vehicle automation program <ul style="list-style-type: none"> • Multimodal R&D program plan • Stakeholder outreach
NHTSA	Conduct research to support regulatory process and to determine the need for vehicle automation standards <ul style="list-style-type: none"> • Human factors • Electronic control systems (safe reliability and cyber security) • System performance requirements
FHWA	Improving overall roadway network performance <ul style="list-style-type: none"> • Application research (CACC, Platooning, Speed Harmonization) • Infrastructure requirements to support automation • Personal mobility
FTA	Improving transit vehicle safety and operations <ul style="list-style-type: none"> • Application research (Precision Docking, Bus Lane Assist, Platooning) • Commercialization of automation technology
FMCSA	Ensuring safe in-service operations of motor carriers <ul style="list-style-type: none"> • Enabling technology (truck / trailer coupling)
All Modes	Evaluation of safety, mobility and environmental benefits

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

Organization	Noteworthy Developments & Announcements
	Conducting demonstrations of Traffic Jam Assist at locations around the US in 2013
Mercedes-Benz	MY 2014 – Steering Assist (Lane Keeping + Adaptive Cruise Control) in U.S. production vehicles; Self-driving vehicle for sale by 2020.
	MY 2015 – Traffic Jam Assist (Lane Keeping + Adaptive Cruise Control) in U.S. production vehicles
	MY 2016 – Traffic Jam Assist (Lane Keeping + Adaptive Cruise Control) in U.S. production vehicles
	Traffic Jam Assist technology will be ready in 2014 for use by OEMs
	Plans to release a fully self-driving vehicle by 2020
	Plans to release nearly self-driving vehicle by 2020
	Partnered with Google and IBM to develop autonomous driving systems
	Researching a semi-autonomous vehicle designed to keep the driver in the control loop and takeover in case of an imminent accident

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 Automated Vehicle

- Leverages autonomous automated and connected vehicles



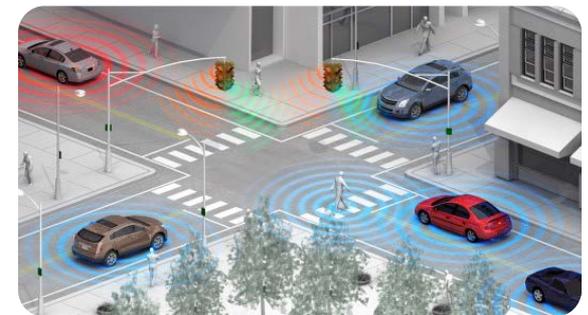
Connected Vehicle

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



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

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