Connected Vehicle Dynamic Mobility Applications for Intelligent Network Flow Optimization (INFLO)

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Presentation Overview

• Connected Vehicle Background
• Overview of Dynamic Mobility Applications
• Intelligent Network Flow Optimization (INFLO)
• INFLO DMA Status
Connected Vehicle Overview

Research Initiative lead by ITS Joint Program Office

- About wireless communications between vehicles and other vehicles (V2V) as well as between vehicles and the surrounding infrastructure (V2I) such as traffic signals, work zones, etc.

- Research to Improve;
  - **Safety**
  - **Mobility**
  - **Environment**
ITS Research: Multimodal and Connected

Research of technologies and applications that use wireless communications to provide connectivity:

- Among vehicles of all types
- Between vehicles and roadway infrastructure
- Among vehicles, infrastructure and wireless consumer devices

FCC Allocated 5.9 GHz Spectrum (DSRC) for Transportation Safety
Up to 80% of non-impaired crash types may be impacted by connected vehicle technology

Source: NHTSA
## Connected Vehicle Structure

### Applications
- **Safety**
  - V2V
  - V2I
  - Safety Pilot
- **Mobility**
  - Real Time Data Capture & Management
  - Dynamic Mobility Applications
- **Environment**
  - AERIS
  - Road Weather Applications

### Technology
- Harmonization of International Standards & Architecture
- Human Factors
- Systems Engineering
- Certification
- Test Environments

### Policy
- Deployment Scenarios
- Financing & Investment Models
- Operations & Governance
- Institutional Issues
DMA Program

- The *Dynamic Mobility Applications (DMA) Program* seeks to create applications that fully leverage frequently collected and rapidly disseminated multi-source data gathered from connected travelers, vehicles and infrastructure, and that increase efficiency and improve individual mobility while reducing negative environmental impacts and safety risks.
USDOT Dynamic Mobility Applications (DMA) Program

Vision
- Expedite development, testing, commercialization, and deployment of innovative mobility application
  ▪ maximize system productivity
  ▪ enhance mobility of individuals within the system

Transformative Mobility Applications
(May have more impact when BUNDLED together)

Objectives
- Create applications using frequently collected and rapidly disseminated multi-source data from connected travelers, vehicles (automobiles, transit, freight) and infrastructure
- Develop and assess applications showing potential to improve nature, accuracy, precision and/or speed of dynamic decision
- Demonstrate promising applications predicted to significantly improve capability of transportation system
- Determine required infrastructure for transformative applications implementation, along with associated costs and benefits

Project Partners
- Strong internal and external participation
  ▪ ITS JPO, FTA, FHWA R&D, FHWA Office of Operations, FMCSA, NHTSA, FHWA Office of Safety
DMA Program Overview

93 ideas ➔ 30 applications ➔ 7 bundles

**LEGEND**
- Green: DMA PROGRAM FUNDED
- Yellow: DMA SUPPORTED (NOT FUNDED), OPEN TO OTHER PROGRAMS AND RESEARCHERS

*JOINTLY FUNDED BY DMA AND PUBLIC SAFETY PROGRAMS*

U.S. Department of Transportation
Intelligent Network Flow Optimization (INFLO)

- Three applications compose the INFLO bundle
  1. Queue Warning (Q-WARN);
  2. Speed Harmonization (SPD-HARM); and
  3. Cooperative Adaptive Cruise Control (CACC)

- They will enhance freeway and arterials operations by exchanging data with these respective environments and implementing applications that will improve their operations.
Dynamic Speed Harmonization (SPD-HARM) aims to dynamically adjust and coordinate vehicle speeds in response to congestion, incidents, and road conditions to maximize throughput and reduce crashes.

- Reducing speed variability among vehicles improves traffic flow and minimizes or delays flow breakdown formation
- Utilize V2V and V2I communication to coordinate vehicle speeds
- Provide recommendations directly to drivers in-vehicle
- Recommend speeds by lane, by vehicle weight and size, by pavement traction
SPD-HARM Illustrative

1. Vehicles slowing down at recurrent bottleneck broadcast speed, location, etc.

2. TMC identifies impending congestion and initiates speed harmonization plan for upstream vehicles

3. TMC relays appropriate speed recommendations to upstream vehicles

4. Upstream vehicles implement (or alert drivers to) the recommended speed
Queue warning (Q-WARN) aims to provide drivers timely warnings and alerts of impending queue backup.

- To reduce shockwaves and prevent collisions and other secondary crashes
- Predict location, duration and length of queue propagation
- Utilize V2V and I2V communication for rapid dissemination and sharing of vehicle information
  - E.g., position, velocity, heading, and acceleration of vehicles in the vicinity
- Allows drivers to take alternate routes or change lanes
- Applicable to freeways, arterials, and rural roads
Q-WARN Illustrative

1. Queue condition forms

2. Vehicles broadcast their rapid changes in speed, acceleration, position, etc.

3. Host Vehicle receives data and provides driver with imminent queue warning

4. Driver provided sufficient time to brake safely, change lanes, or even modify route
Cooperative Adaptive Cruise Control (CACC)

CACC aims to dynamically adjust and coordinate cruise control speeds among platooning vehicles to improve traffic flow stability and increase throughput.

Three possible implementations:

1. **Vehicle-to-vehicle (V2V) CACC**, where the lead vehicle communicates with the following vehicle and informs it of the location, speed, and the speed of the vehicle in front of it.

2. **Infrastructure-to-vehicle (V2I) application**, where the traffic manager sets a gap policy to maintain traffic flow at or below the roadway capacity to prevent congestion.

3. **Ad hoc Platooning** concept, where several vehicles form a platoon that behaves as a single unit.
CACC Illustrative

Without CACC:

- Irregular braking and acceleration
- Longer headways
- Lower throughput
- Risk of rear-end collisions

CACC Enabled:

- Coordinated speeds
- Minimized headways
- Higher throughput
- Reduced rear-end collisions

1. Lead Vehicle broadcasts location, heading, and speed
2. CACC-enabled following vehicles automatically adjust speed, acceleration, and following distance
3. Any speed or acceleration perturbations by Lead Vehicle can be instantly accounted for by following vehicles utilizing V2V communication
4. TMC observes traffic flow and adjusts gap policy to manage road capacity

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INFLO Deployment Vision

Near-Term (Today – 2020)
- Subset of DOT fleets, taxi fleets, etc.

Mid-Term (2020 – 2030)
- 5% annual growth in fleet penetration

Ultimate (2030+)
- 100% vehicle penetration
Project Tasks and Stakeholder Involvement

Task 1 — Project Management & Systems Engineering Management

Task 2 — Concept of Operations Development
- Task 2.1 — Assess Relevant Prior and Ongoing Research
- Task 2.2 — Solicit Stakeholder Input on Goals, Measures, & Needs
- Task 2.3 — Develop Concept of Operations

Task 3 — Requirements Development
- Develop Functional Requirements
- Develop Qualitative and Quantitative Performance Targets
- Develop High-Level Data and Communication Needs

Task 4 — INFLO Test-Readiness Assessment
- Identify and Assess Key INFLO Issues

Major Deliverables
- PMP
- INFLO Concept of Operations
- Requirements and Needs Report
- Test-Readiness Assessment Summary
DMA Design/Development Status

- Assessment of Relevant Prior and Ongoing Research (Complete – March 2012)
- INFLO Concept of Operations (Complete - June 2012)
- Functional and Performance Requirements, and High-Level Data and Communication Needs (Complete - September 2012)
- Test Readiness Assessment (October 2012)

- Next Steps – Pilot Development and Testing
For more information

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Questions