

Dynamic Mobility Applications Policy Analysis

Policy and Institutional Issues for Intelligent Network Flow Optimization (INFLO)

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16. Abstract <p>The report documents policy considerations for the Intelligent Network Flow Optimization (INFLO) connected vehicle applications "bundle." INFLO aims to optimize network flow on freeways and arterials by informing motorists of existing and impending queues and bottlenecks; providing target speeds by location and lane; and allowing capability to form ad hoc platoons of uniform speed.</p> <p>The policy team documented the following potential issues for INFLO:</p> <ul style="list-style-type: none"> • <u>Compliance with Speed Harmonization.</u> Relying on voluntary compliance with SPD-HARM notices is likely to produce greatly varying results, at least initially. • <u>Planning for Mixed-Mode Traffic.</u> It could take a decade or more before INFLO achieves significant fleet penetration to produce realizable benefits. In the transition period, it may be necessary to plan for operations and maintenance of parallel systems (such as the use of changeable message signs) that must be operated consistently as well as to take other steps to ensure the safe and efficient operation of connected vehicle-equipped and non-equipped vehicles on the same roads. • <u>Liability.</u> Liability is a concern in all connected vehicle applications. For INFLO, liability concerns stem from three possible sources: the potential for missed messages because of equipment malfunction in individual vehicles; the driver's reliance on data provided from multiple sources; and (with CACC) the proper functioning of automated vehicle controls. While the first and the third issue are likely addressable by the existing legal system (there is precedence for both), the second issue of parsing the multiple sources of data that have been fused together to form the INFLO message in order to understand the chain of liability, is still an emerging area in tort law. Research suggests that tort law will address INFLO liability issues in the future. • <u>Public Acceptance and Use of Geo-Location Data.</u> INFLO applications will use vehicle location data to send targeted messages to vehicles in specific areas. Although the geo-location data will not include any identifying information about the driver or vehicle, their use could raise privacy concerns among the public – including concerns about vehicle tracking – that might threaten acceptance of the applications. This issue is germane to the entire set of Connected Vehicle applications. Data privacy policies and best practices exist at the State and local levels and are available to address this issue. • <u>In-Vehicle vs. Roadside Signage.</u> INFLO's use of in-vehicle messages raises a broad legal question of whether in-vehicle messages could take precedence over standard road signs (either static or changeable), or whether in-vehicle messages will always be considered "advisory" from a legal standpoint. It will be particularly important to resolve this issue in the case of SPD-HRM, where in-vehicle speed advisories may differ from posted (roadside) speed limits. 		

- Technology Obsolescence. As with other connected vehicle applications, the various hardware and software components of INFLO will “age in place.” There is a risk that they will lose interoperability unless formal update and policies are established, including requirements for backward compatibility. Jurisdictions implementing INFLO would benefit from guidance and standards to ensure ongoing backward compatibility and interoperability.
- Potential Driver Distraction. Visual devices displaying connected vehicle messaging have the potential to distract drivers and compromise safety. Some INFLO messages, due to their role in helping avoid congestion, may be especially alluring to drivers making decisions about route selection while traveling at high speeds. The National Highway Traffic Safety Administration (NHTSA) has issued guidelines for developing visual, in-vehicle displays that reduce distraction.
- Equipment Interoperability and Certification. For INFLO to be fully and ubiquitously functional, standards may be required so that local infrastructure is fully interoperable with infrastructure on interstate highways and major state roads.
- Messaging Standards and Priority. Under INFLO, new technology will provide in-vehicle messages about congestion and speed advisories. The role of INFLO in providing this type of information raises potential policy issues about the need for message standards, to insure that INFLO messages comply with all applicable MUTCD standards.

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Executive Summary

Dynamic Mobility Applications Program

The Dynamic Mobility Applications (DMA) Program is prototyping applications that are anticipated to transform public sector transportation system management and modal integration. This technical research is a part of the U.S. Department of Transportation's (USDOT) research into new technologies supporting the emergence of an intelligent and connected vehicle (CV) environment.

The objective of the DMA research is to foster the release of high-value, open-source applications that use synthesized, multisource Intelligent Transportation Systems (ITS) data to transform surface transportation management and information. The DMA Program research is also focused on developing tools (for instance, an open source portal), metrics, and concepts to support additional application development.

The Intelligent Transportation Systems Program's role within the USDOT is to facilitate high-risk/high-reward research in cooperation with industry and academia to meet transportation needs. Investments in new research are based on policy analysis that determines that the technology concepts meet the following threshold criteria:

- They advance the state-of-the-practice and, if successful, will deliver transformational transportation benefits to the nation.
- They are unlikely to be pursued in industry given the nature of the risks compared to the required investment.
- The advancements are desired by stakeholders, who will champion the transfer of results into use.
- The advancements are significant enough to take precedence over other investment choices.

A decision to pursue research is followed by the development of prototypes and demonstration and testing under real-world conditions. Successful results advance the process of transferring new technologies into market adoption and use. They set the stage for planning and preparing for technology implementation, operations and maintenance, and, eventually, upgrades and evolution. Throughout this technology life cycle, policy and institutional issues can often become the major stumbling blocks to realizing success.

Thus, identification of, and research into, the policy issues and practical options and solutions is an important step that raises the assurance that the Federal investment will result in adoption and use by agencies, organizations, the private sector, and travelers. It is an iterative process with the technical research teams—identification of policy challenges early in the development stage can change the nature of technical decisions; envisioning and addressing policy challenges throughout the life cycle supports preparation for robust technology transfer to the market.

Purpose of this Report: Document INFLO Policy Issues

The Connected Vehicle Mobility Policy team (herein, policy team) developed this report to document policy considerations for the Intelligent Network Flow Optimization (INFLO). INFLO comprises a “bundle” of mobility applications that use existing and new connected vehicle data sets to optimize network flow on freeways and arterials by informing motorists of existing and impending queues and bottlenecks; providing safer target speeds by location and lane¹; and enabling the capability to form ad hoc vehicle platoons of uniform speed.

The analysis is based on the policy team’s review of a wide range of materials that include:

- The INFLO Concept of Operations (ConOps)
- Report on High Level Concept Development and Needs Identification for INFLO
- Report on Detailed Requirements for the INFLO Prototype
- Report on Architecture Description for the INFLO Prototype
- The Connected Vehicle Reference Implementation Architecture (CVRIA) diagrams for INFLO²
- Discussions with the technical team overseeing development of the prototype applications within the INFLO bundle and a review of the prototype documents
- Industry best practices and standards in information technology, security and privacy, and data exchange
- Existing applicable regulatory, legal, and insurance regimes

As policy or institutional issues emerged during the review, they were categorized as being unique to INFLO or as having elements in common with other DMAs. They were then placed into one of four categories (not every bundle had issues in all four categories) and were further paired with recommended actions for resolution, if options were available. Where they were not available, additional research is recommended. The four issue categories are:

- *High priority* issues need immediate attention and resolution as they may challenge deployment.
- *Medium priority* issues have potentially serious consequences but clear, if challenging, paths to resolution; which should be accomplished prior to technology transfer.
- *Low priority issues* have policy implications but also have solutions underway or represent current best practices that can be implemented before INFLO applications are introduced to the marketplace.
- *Emerging* issues have some probability of challenging deployment over time, as INFLO implementations grow in complexity or geographic coverage.

¹ Lane level information is very challenging at this time, but might be available in the future with availability of higher resolution/accuracy positioning systems.

² <http://www.iteris.com/cvria/html/applications/applications.html> accessed March – April 2014.

The policy issues are summarized below, and described in more detail, along with potential mitigations, in Chapter 4.

Policy Issues Common to INFLO and Other Mobility Applications

The following policy issues are shared by INFLO and applications in other DMA bundles.

High Priority Common Issues

- **Liability.** Nearly all connected vehicle applications have some form of potential liability issues. In the case of INFLO, there are three: the potential for missed messages because of equipment malfunction in individual vehicles; the use of multi-source data; and (with cooperative adaptive cruise control) the proper functioning of a vehicle with the addition of automated vehicle control.

INFLO sets up a complex set of conditions that will make it challenging to determine crash liability among the many parties involved—e.g., the driver, the automobile manufacturer, and the various entities involved in developing, installing, and deploying in-vehicle and roadside INFLO components. Furthermore, it is unclear whether case law exists to establish liability in cases of automated interventions or system-generated recommendations to drivers; like other DMAs, INFLO may present heretofore unexplored issues for the legal system.

Recommendations for addressing liability include verifying whether “application usage agreements” in the connected vehicle system architecture are meant to include liability disclaimers; researching the applicability of “opt-in” approaches; and understanding the effectiveness of various in-vehicle alert functions at warning vehicle operators about system malfunctions or degraded performance.

- **Public Acceptance and Use of Geo-Location Data.** The Queue Warning application (Q-WARN) and SPD-HRM will use vehicle location data to send targeted messages to vehicles in specific areas. Only those vehicles affected by a given incident (e.g., vehicles approaching a congested highway segment) will receive notices about the incident. Although the location data will not include any identifying information about the driver or vehicle, their use could raise privacy concerns among the public – including concerns about vehicle tracking – that might threaten acceptance of the applications. Privacy impact analyses are being conducted for all mobility applications, including INFLO. Additionally, USDOT is pursuing further research to identify the likelihood of tracking and to identify best practices for connected vehicle environments as a whole. The proposed security framework for all connected vehicle applications will present very high barriers to tracking and other privacy breaches. Nevertheless, gaining public trust in the system will remain critically important.
- **In-Vehicle vs. Roadside Signage.** INFLO’s use of in-vehicle messages raises a broad legal question of whether in-vehicle messages will always be considered “advisory” from a legal standpoint³, or whether such messages could, potentially, take precedence over standard

³ As currently envisioned, INFLO messages will be advisory only.

road signs (either static or changeable). It will be particularly important to resolve this issue in the case of SPD-HRM, where in-vehicle speed advisory notices could differ from posted (roadside) speed limits. From a policy perspective, this issue is complex because individual states may, potentially, have to determine the legal standing and enforceability of in-vehicle messages. Guidance from the USDOT could assist states in making these determinations.

Medium Priority Common Issues

- **Technology Obsolescence.** As with other connected vehicle applications, the various hardware and software components of INFLO will “age in place.” There is a risk that they will lose interoperability unless formal update policies are established. This issue has two aspects. First, roadside infrastructure will need to be updated (e.g., firmware updates) and upgraded as necessary to maintain compatibility with the evolving capabilities of Connected Vehicle applications. Second, in-vehicle software will also require periodic updates. A related issue is that in-vehicle hardware will generally renew only at the rate of fleet turnover, so that there will eventually be millions of vehicles in operation with “legacy” systems that may not be capable of running the latest versions of software. Roadside units will need to maintain backward compatibility with prior versions of in-vehicle systems (hardware, software, OS).

From a policy perspective, the in-vehicle software and hardware update issues mean that jurisdictions deploying INFLO will need to specify backward compatibility in contracts for the installation and maintenance of roadside equipment, and be able to confirm such compatibility in the installed units. Guidance on crafting appropriate language for RFPs and contracts would assist state and local implementers.

- **Potential Driver Distraction.** Visual devices displaying connected vehicle messaging have the potential to distract drivers and compromise safety. Q-WARN and SPD-HRM messages, due to their role in helping avoid congestion, may be especially alluring to drivers making decisions about route selection while traveling at high speeds.

USDOT and its partners will continue to address the challenges of distracted driving. NHTSA’s research on distracted driving⁴ will continue to inform the DMA program and any INFLO applications that are developed in the marketplace. As new technologies emerge offering in-vehicle services, USDOT is working to ensure that driver distractions do not increase.

- **Equipment Interoperability and Certification.** As noted previously, like many connected vehicle applications INFLO will require vehicle-to-infrastructure (V2I) communication. For INFLO to be fully and ubiquitously functional, standards may be required so that local, state, and interstate highway infrastructure are all fully interoperable with equipped vehicles. Interoperability of infrastructure-based components and in-vehicle components will need to be tested at a much higher level than is currently done under today’s OEM self-certification process. In addition, certification may be needed to ensure that infrastructure at all levels is appropriately configured.

⁴ Guidelines and other studies can be accessed at this link:
<http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+DOT+Releases+Guidelines+to+Minimize+In-Vehicle+Distractions>.

USDOT is in the process of developing policy guidance on certification and requirements for standards for Connected Vehicle applications and equipment. Adoption of these standards and certification processes will be part of each jurisdiction's process of deploying INFLO. Coordination of research activities across DMA bundles regarding maintaining the performance of roadside equipment will help ensure that the standards, certification processes, and guidance produced are suitable for all DMA applications.

Low Priority Common Issue

- Messaging Standards and Priority. Under INFLO, new technology will provide in-vehicle messages about congestion and speed advisories. The role of INFLO in providing this type of information raises two potential policy issues⁵.

The first issue is whether the in-vehicle icons and formatting of INFLO messages should be standardized across all vehicles, so that all drivers receive identical messages. Should standardization of INFLO messages be needed, current processes for developing standardized in-vehicle symbols (such as those currently in-use on vehicle instrument panels) will be appropriate for this.

Second, with in-vehicle displays increasingly used to disseminate traffic-related messages, there is a question about whether the Manual of Uniform Traffic Control Devices (MUTCD) will need to be updated to provide guidance on in-vehicle messaging and ensure that in-vehicle messages do not contradict MUTCD definitions. The MUTCD has a well-established process for implementing updates. It is unclear at this time if in-vehicle messaging will be left solely to auto manufacturers or if the USDOT will issue guidance.

Policy Issues Unique to INFLO

The policy team documented two issues unique to INFLO.

High Priority Unique Issue

- Compliance with Speed Harmonization. The success of dynamic speed harmonization will depend on drivers' compliance with in-vehicle, speed advisory messages. Relying on voluntary compliance may produce uncertain results, because some proportion of drivers will disregard in-vehicle reduced speed advisories, especially in situations where those notices are being issued to slow traffic upstream because of conditions not yet apparent to drivers.

Without effective compliance, the dynamic speed harmonization (SPD-HARM) application will not produce the congestion-reduction benefits it is capable of and, therefore, drivers will see no obvious reason to embrace and use it. This could lead to situation in which SPD-HARM never reaches the tipping point of adoption necessary for success.

Published research from FHWA and others on similar technologies since the 1970's have provided a basis of information that can be drawn upon in establishing connected vehicle

⁵ These issues are also common to the INC-ZONE application within the INFLO DMA bundle INC-ZONE will provide speed reduction warnings to vehicles approaching incident zones.

environments⁶. Existing speed-harmonization programs provide useful findings on the success factors for improving voluntary compliance. These include standardized messages and icons, and ensuring that speed advisories provide drivers with information about the reason for the reduced speed (e.g., “accident ahead”). Thus, while this is a high priority issue, strategies and practices exist to support State and local DOT implementation. Further policy analysis for compliance with speed harmonization may be needed.

Medium Priority Unique Issue

- Planning for Mixed-Fleet Traffic. It could take a decade or more before INFLO achieves significant fleet penetration. To accommodate vehicles of varying levels of INFLO in mixed traffic that includes many non-equipped vehicles, a combination of approaches can help. These include increased use of changeable message signs for the foreseeable future to communicate speed harmonization notices independently from INFLO. In addition, studies are being conducted as part of the new automation research to look at the benefit-cost of segregated lanes. Such studies may support adoption of these applications if like vehicles with similar automated capabilities and in-vehicle communications could be traveling together. Failure to take such steps to support INFLO could hamper its adoption and long-term success.

Conclusions and Next Steps

Based on the results of this analysis, only two potential issues – liability, and use of geo-location data – could complicate successful market adoption and use by industry. Ultimately, guidance on installation, integration, operations, and maintenance will be produced by the technical teams when completing their technology transfer to the marketplace.

The mobility application development process is responsive to numerous considerations; some of these are purely technical in nature, while others are policy-related. This report documents the decisions made throughout the application development process so that stakeholders will understand how and why particular choices were made regarding application functionality, data sources, and other important factors.

With the documentation of policy issues and decisions that have been made throughout USDOT’s INFLO application development process, stakeholders have the ability to comment on whether:

- There are additional policy or institutional issues that may present challenges to the successful market adoption and use of INFLO and that are not documented but for which new or additional research and analysis is recommended.
- The policy options identified for resolution of the issues are appropriate.

Finally, it should be noted that data privacy and security have been raised as key policy concerns for all of the dynamic mobility applications. Research is ongoing in this area to develop options to address these new applications as well as to standardize security for future applications that have yet

⁶ More information on existing systems in the United States and Europe can be found at <http://ops.fhwa.dot.gov/publications/fhwahop10031/sec3.htm>.

to emerge. To develop optional approaches for security and privacy, analysis using National Institute of Standards and Technology (NIST) standards (Special Publication 800-53⁷ Rev 4) is underway to assess any policy or institutional challenges⁸. This analysis explores the minimal data set that is necessary for INFLO functionality, and to assess any public concerns or policy challenges associated with the data set. Notably, INFLO applications will be transferred to market adopters and the private sector is expected to play a major role in setting privacy and data access policies. However, if INFLO is used by Federal agencies, there will likely be additional reviews of practices for data collection, access, and storage; handling of any personally-identifiable information (PII); and/or security practices.

⁷ <http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-53r4.pdf>

⁸ USDOT research and analysis results are made available through the ITS Joint Programs Office website at www.its.dot.gov.

Chapter 1 Introduction

This report documents policy considerations for Intelligent Network Flow Optimization (INFLO). INFLO provides warnings of queues ahead, provides speed advisories to improve safety and reduce the formation, size, and duration of queues, and provides for coordinated, closely spaced platoons of vehicles to improve fuel efficiency, increase throughput, and reduce delays.

INFLO is one of several connected vehicle applications that the Intelligent Transportation Systems Joint Program Office (ITS JPO) of the United States Department of Transportation (USDOT) and its partners are prototyping as part of its Connected Vehicle Program, and the ITS JPO is advancing new connected vehicle technologies through innovative research and field testing.

Dynamic Mobility Applications

In the future, cars, trucks, buses, roads, and smartphones will talk to each other. They will share valuable safety, mobility, and environmental information over a wireless communications network that is already transforming our transportation system as we know it. This system of connected vehicles, mobile devices, and roads will provide a wealth of transportation data, from which innovative applications will be built. These applications will make travel not only safer, but more efficient and greener.

The USDOT's Dynamic Mobility Applications program is exploring these possibilities, specifically focusing on reducing delays and congestion and thus significantly improving mobility. The following six mobility application bundles are being prototyped to make this possible:

- *Enabling Advanced Traveler Information Systems (EnableATIS)* provides a framework to develop multisource, multimodal data into new advanced traveler information applications and strategies.
- *Freight Advanced Traveler Information System (FRATIS)* provides freight-specific route guidance and optimizes drayage operations so that load movements are coordinated between freight facilities to reduce empty-load trips.
- *Integrated Dynamic Transit Operations (IDTO)* facilitates passenger connection protection, provides dynamic scheduling, dispatching, and routing of transit vehicles, and promotes dynamic ridesharing.
- *Intelligent Network Flow Optimization (INFLO)* aims to optimize network flow on freeway and arterials by: informing motorists of existing and impending queues and bottlenecks; providing target speeds by location and lane; and allowing the capability to form ad hoc vehicle platoons of uniform speed.
- *Multi-Modal Intelligent Traffic Signal Systems (MMITSS)* is a comprehensive traffic signal system for use on complex arterial networks that include passenger vehicles, transit, freight, and emergency vehicles, as well as pedestrians.

- *Response, Emergency Staging and Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.)* involves advanced vehicle-to-vehicle safety messaging over dedicated short-range communications (DSRC) to improve the safety of emergency responders and travelers.

The USDOT's Connected Vehicle Mobility Policy team is performing the analysis needed to document policy and institutional issues and recommend options for resolution for each of these bundles in separate reports.

Policy Considerations for New Connected Vehicle Technologies

Throughout the process of developing new connected vehicle technology, various policy or institutional issues can become stumbling blocks. Examples include changes brought about by the application and its operations that could possibly affect established norms for liability; governance interoperability of hardware, software, and data; and other issues that may preclude adoption and use by industry.

Policy analysis is an iterative process that proceeds in concert with research and development. Hence, identification of important policy challenges early in the development stage can change the nature of technical decisions. Envisioning policy challenges throughout the lifecycle enables smooth technology transfer and system deployment.

The remainder of this report is structured as follows:

- Chapter 2 Description of INFLO
- Chapter 3 Policy Analysis Approach for Analyzing New Connected Vehicle Applications
- Chapter 4 Policy Analysis Results on INFLO Applications
- Chapter 5 Considerations for Stakeholders Deploying or Using INFLO
- Chapter 6 Conclusion
- Appendix A Source Materials
- Appendix B List of Acronyms

Chapter 2 Description of INFLO

The INFLO bundle comprises three applications:

SPD-HARM: Dynamic Speed Harmonization

This application uses V2I-derived traffic conditions and weather information to determine optimal speed recommendations for a given section of highway. In the event of bad weather or congestion, broadcasts from connected vehicles alert a traffic management center (TMC) of impending congestion. The TMC initiates a speed harmonization plan and relays speed recommendations to vehicles upstream of the problem area. Those vehicles adjust to the new, recommended speed, maintaining flow, reducing unnecessary stops and starts, and maintaining consistent speeds. Speed recommendations can be provided in-vehicle for connected vehicles or through roadside signage for non-connected vehicles.

Q-WARN: Queue Warning

The Queue Warning application uses vehicle to vehicle (V2V) and V2I status broadcasts (e.g., rapid deceleration, disabled status, lane location) to alert nearby upstream vehicles and TMCs to queues caused by various situations, such as by geometric bottlenecks, accident sites, construction sites, among others. Q-WARN allows vehicles to brake safely, change lanes, or modify their route. Q-WARN is not intended to be a crash-avoidance system. Its purpose is to provide warning well in advance of any potential crash situation, providing messages and information to drivers in order to minimize the likelihood of their needing to take crash avoidance or mitigation actions later.

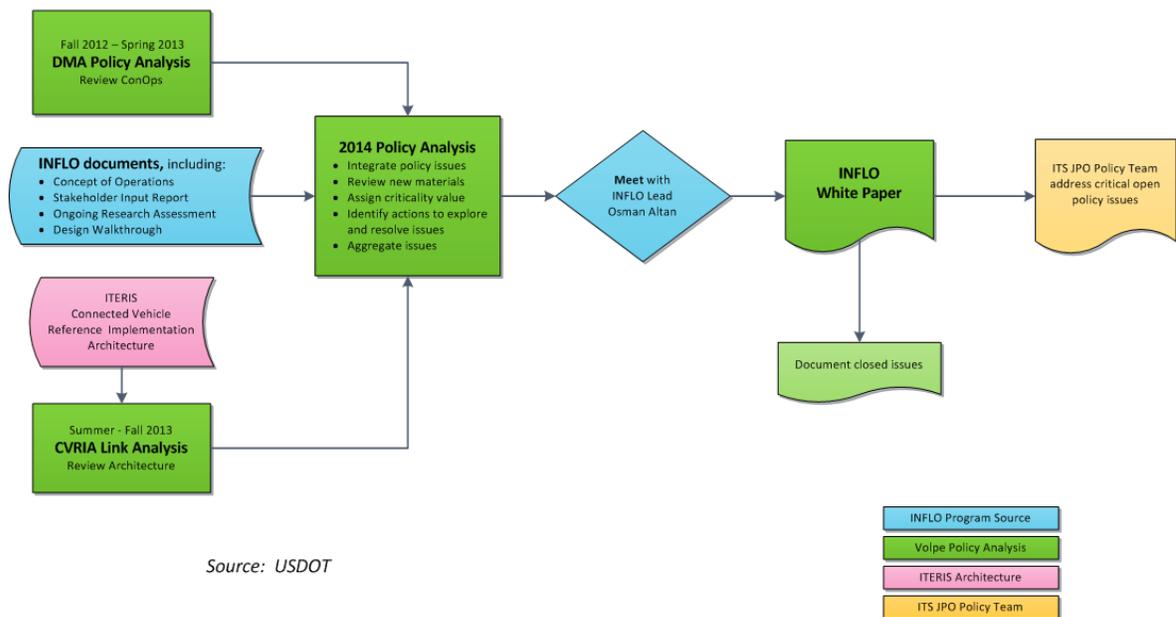
CACC: Cooperative Adaptive Cruise Control

This application uses V2V communication to automatically synchronize the movements of many vehicles within a platoon. A lead vehicle broadcasts its location, heading, and speed, and other vehicles automatically adjust to follow at a given distance. V2V communications allows following vehicles to detect and adjust to any speed or acceleration perturbations in the lead vehicle. A TMC observing the flow can send recommendations which will adjust gaps to manage road capacity.

Chapter 3 Policy Analysis Approach for Analyzing New Connected Vehicle Applications

The policy analysis for this report was conducted in several steps, illustrated in Figure 3-1, and described in this section.

Figure 3-1. INFLO Policy Analysis Process



1. **Review Operations Concept:** The Volpe Center policy team reviewed the original Concept of Operations for INFLO⁹. The team documented potential policy issues at each stage of the development and deployment process, identified known policy options and solutions, and recommended areas for further investigation. The final Operations Concept was also reviewed to see if new policy issues had emerged, and to see if identified issues were still present or had been resolved.

⁹ Concept of Operations. June 14, 2012.

2. Review Connected Vehicle Reference Implementation Architecture: The policy team conducted a detailed analysis of the Connected Vehicle Reference Implementation Architecture¹⁰. The CVRIA provides a set of system architecture viewpoints that describe the functional, physical, and logical interfaces; enterprise relationships; and communications dependencies for each technology and application within the connected vehicle environment. These viewpoints serve as a common reference to help identify and prioritize standards development and to support policy considerations for the connected vehicle environment.

The policy team used the CVRIA viewpoints to identify both the entities sharing data in each application, and the specific data elements being transmitted. By doing so, the team was able to identify potential issues for INFLO.

3. Integrate Results: Having completed the Operational Concepts analysis and the CVRIA analysis, the policy team undertook a process of integrating the results of those two efforts. This was important because the Operational Concepts analysis tended to focus on broader issues, while the CVRIA analysis in many cases identified issues that related to specific types of data being exchanged between specific entities within a given application. Integrating the results from both analyses enabled the policy team to develop a complete picture of all the potential issues for the INFLO bundle.
4. Review New Materials: Additional materials for INFLO were reviewed and assessed against the results of the first level analysis. An updated Operational Concept was reviewed, along with a Market Readiness Assessment and the proceedings from a Strategy Assessment meeting¹¹.
5. Eliminate Non-Policy Challenges: After integrating the results of the two efforts, the policy team identified and eliminated any issue that was purely technical or logistical in nature and therefore did not have direct policy impacts. For example, the issue of malicious hacking of hardware or software is not included in the analysis as it is currently being addressed through technical development and will apply, overall, to connected vehicle environments. Separate technical working groups are identifying the security policies that will be needed in support of the technical solutions; this policy team will, in the future, identify whether INFLO may require any further tailoring of those policies to support operations.
6. Prioritize Policy Issues: The team assigned a priority to each of the remaining issues on the following basis:
 - a. *High priority* issues need immediate attention and resolution as they may obstruct deployment.
 - b. *Medium priority* issues have potentially serious consequences but clear, if challenging, paths to resolution; which should be accomplished prior to technology transfer.
 - c. *Low priority issues* have policy implications but also have solutions underway or represent current best practices that can be implemented before INFLO applications are introduced to the marketplace.

¹⁰ <http://www.standards.its.dot.gov/DevelopmentActivities/CVReference>.

¹¹ Report on Stakeholder Input on Transformative Goals, Performance Measures and High-Level User Needs for INFLO, April 10, 2012.

- d. *Emerging* issues have some probability of obstructing deployment over time, as INFLO implementations grow in complexity or geographic coverage.
7. Identify Issues Common to Other DMA Bundles: The team differentiated between policy issues that are unique to a single DMA bundle and issues common to multiple DMA bundles. Applications common to multiple DMA bundles may need to be resolved at the level of the DMA program, rather than within the individual bundle development efforts. Thus, the final set of issues includes a mix of unique and common issues of several priority levels.
8. Meet with Technical Team: After completing the preceding steps, the policy team summarized the policy issues in table form and discussed them with the INFLO technical lead which provided the opportunity to agree or disagree about the veracity and priority of each issue, and to provide more information on each issue—information the policy team used to refine the policy analysis and conclusions.
9. Stakeholder Outreach: Once the results were discussed with the technical team, the draft report was shared with external stakeholders for validation. All comments were incorporated into this final draft.
10. Document Results: This report includes the results of that analysis and identifies issues that have been resolved and concerns that are recommended for additional USDOT research.

Chapter 4 Policy Analysis Results on INFLO Applications

This chapter describes the policy issues the INFLO policy analysis identified. Policy issues are characterized as high priority if they could impede the development, implementation, or market adoption of the INFLO mobility bundle if left unresolved and also if there do not, at present, appear to be clear paths to resolving them.

Table 4-1 provides an inventory of the INFLO policy issues. In the text following the table, the high-priority and medium-priority issues that are *unique to INFLO* are discussed first, followed by the high-priority and medium-priority issues that are *common to INFLO and other DMAs*. Low priority issues, whether unique or common, are discussed last.

Table 4-1. INFLO Policy Issues

Issue	Priority	Common to Other DMA Bundles?
Liability	High	Yes
Public Acceptance and Use of Geo-Location Data	High	Yes
In-Vehicle vs. Roadside Signage	High	Yes
Compliance with Speed Harmonization	High	No
Technology Obsolescence	Medium	Yes
Potential Driver Distraction	Medium	Yes
Equipment Interoperability and Certification	Medium	Yes
Planning for Mixed-Fleet Traffic	Medium	No
Messaging Standards and Priority	Low	Yes

Policy Issues Common to INFLO and Other Mobility Applications

Several policy issues are relevant to INFLO and other mobility applications as described in this section.

High Priority Issues Common to DMA Bundles

The analysis identified three potential high priority policy issues that are common to many dynamic mobility application bundles, including INFLO.

- **Liability.** Liability is a concern across all connected vehicle applications at this point in time. For INFLO there are three potential liability concerns: the potential for missed messages because of equipment malfunction in individual vehicles; the driver's reliance upon data from multiple sources, potentially obscuring the source of a critical error; and (with CACC) the proper functioning when adding a small amount of automated vehicle control.

Liability resulting from the malfunction of in-vehicle systems is not new; it is something OEMs potentially face regularly in today's vehicle industry. With INFLO, the issue becomes more complex, because malfunction in this context means failure to work in a cooperative, connected vehicle environment.

Multi-source data are not unique to INFLO or connected vehicles generally. Numerous applications use data from multiple sources simultaneously. With the exception of CACC, INFLO applications are using the data to send messages to the driver, who retains ultimate decision-making authority. The issue, therefore, becomes whether the driver has an implied "right" to expect those messages (and, therefore, the data upon which they are based) to be error free all the time.

As for automation, the CACC application in INFLO would utilize data from surrounding vehicles to dynamically adjust vehicle speed, and permit platooning. Although the driver would remain "in-the-loop" and would retain overall control of the vehicle, the potential exists for system automation errors to lead to safety problems. In these circumstances it would be difficult to determine whether human error, machine error, or both caused the problem. Adding to the complexity would be the challenge of determining which vehicle(s) in a platoon were malfunctioning. Here again, similarities exist between potential INFLO-related issues, and present-day vehicles, although the situation in the case of INFLO is demonstrably more complex. Present day systems like dynamic stability control, adaptive cruise control, and anti-lock brakes have a high degree of automation; they take corrective actions automatically, and often (as in the case of stability control) without the driver's knowledge. These systems have proven themselves to be extremely robust and reliable, but there is still the potential for failure. In all cases, the "default" situation in a system failure is for the driver to retain control of the vehicle.

Potential liability related to the vehicle automation functions in INFLO is uncharted territory. It could be argued that, from a liability standpoint, CACC is no different than adaptive cruise control systems currently available on certain model cars. With respect to those systems, OEMs face potential liability for system malfunctions, just as they do when other vehicles malfunction. Current systems operate independently: each vehicle uses its own sensors to determine the position of the vehicle in front of it, and changes its own speed accordingly, while the driver retains ultimate control of the vehicle. In the case of INFLO, the driver still retains ultimate control of the vehicle, but an important difference exists, because CACC is intended to exchange data with other vehicles and with the infrastructure, and to work cooperatively with the vehicles around it.

In a situation where the failure of an INFLO application (software or associated hardware or automation functions) lead to a crash, it would be difficult to determine and/or allocate liability among the driver, the automobile manufacturer, and the various entities involved in developing, installing and deploying the in-vehicle and roadside INFLO components¹². Furthermore, it is unclear whether case law exists establishing liability in cases of automated interventions or system-generated recommendations to drivers; like other DMAs, INFLO may present heretofore unexplored issues for the legal system.

Given the uncertainty about assessing liability, automotive OEMs may be reluctant to install CACC in their vehicles, for fear that liability will fall on them by default, even in cases where mishaps occur due to externally generated, erroneous information such as faulty data broadcast from a roadside unit.

Several recommendations emerged from the INFLO research to help address potential liability issues. First, the CVRIA indicates that “application usage agreements” will exist between entities. Verifying whether these agreements are meant to include liability disclaimers or protections will be an important initial step in developing a liability framework for INFLO and other DMAs. If the “application usage agreements” are intended to include liability protections, then the underlying architecture of INFLO will need to be designed to enable verification and acceptance of such agreements by participating entities. This is an institutional challenge rather than a technical one.

Also important will be an understanding of existing “opt-in” approaches for addressing liability, such as the “accept” buttons that are ubiquitous on in-vehicle navigation screens and portable GPS units. Of particular value will be research to determine whether existing case law contains precedent establishing that such opt-in approaches mitigate device maker and OEM liability, particularly in instances of crashes stemming from inaccurate mapping data.

Another important area of research will be to gain an understanding of the effectiveness of various in-vehicle alert functions at warning vehicle operators about system malfunctions or degraded performance. Such alerts already exist in automobiles, of course (e.g., engine warning lights), but for INFLO they would need to warn the driver of system status in addition to vehicle status, and would therefore need to convey a broader range of warnings than they currently do. OEMs are expected to regain control over the design of in-vehicle displays, but some standardization of the alerts to drivers may be warranted. Human factors research from the rail and aviation industries will be particularly informative in this regards, and will help guide research in this area.

Finally, further research into the complexity of these legal issues may be warranted, to understand fully whether institutional changes undertaken at the federal level are necessary for national deployment of DSRC-based systems in support of safety, mobility, and environmental goals.

¹² This scenario could be complicated in cases where a roadway is being managed/operated by a private entity, under a public-private partnership.

- Public Acceptance and Use of Geo-Location Data. Q-WARN and SPD-HRM will use vehicle location data to send targeted messages to vehicles in specific areas. Only those vehicles affected by a given incident (e.g., vehicles approaching a congested highway segment) will receive notices about the incident. Although the location data will not include any identifying information about the driver or vehicle, their use could raise concerns among the public, including concerns that the identity of individual drivers could be deduced through “triangulation” using multiple data sources (e.g., address records combined with trip origin-destination data).

Managing PII linked to connected vehicle apps is a challenge to the entire DMA (and connected vehicle) program. Although basic safety messages (BSM) do not use PII, they do use GPS, the telemetry from which may be employed (using expensive and sophisticated equipment and algorithms) to re-identify a driver and/or the vehicle used and its specific routes. The proposed security solution for connected vehicle environments presents a very high barrier to such an activity (a high level of financial investment, time, and computing capabilities). This security solution is independent of communications media but analysis acknowledges that use of today’s cellular or Wi-Fi data may carry additional PII such as media access control (MAC) addresses (unique, device-specific identifiers assigned to network interfaces for communications) or cell phone numbers, allowing for more direct identification (DSRC communications do not require such identifiers).

Privacy impact analyses are being conducted for all mobility applications. Additionally, NHTSA is pursuing further research to identify the likelihood of tracking and to identify solutions for connected vehicle environments, as a whole.

Exploration of alternatives to mandatory use of applications that use vehicle location data is warranted for two reasons. First, even with thoroughly anonymized data, concerns among the public about government surveillance may be difficult to assuage; voluntary models – either opt-in or opt-out – may be necessary to mitigate public resistance. Second, from a broader institutional perspective, voluntary models would help insulate state DOTs and municipalities and other stakeholders that deploy INFLO from a range of potentially burdensome, time-consuming, and costly issues related to privacy and factors. As described in the INFLO ConOps documentation,

An opt-in approach, as opposed to a mandatory program, would mitigate the inherent regulatory, enforcement, privacy, and liability related burdens on system implementers, transportation agencies, and industry partners¹³.

From a policy perspective, the key challenge with regard a voluntary approach is, of course, that if significant numbers of connected vehicle owners “opt out” (or fail to “opt in”) and thereby prohibit the use of their vehicles’ location data, the effectiveness of INFLO applications may be reduced for everyone, even drivers who have “opted in.” Therefore, public outreach and education to alleviate concerns about privacy and surveillance as much as possible and maximize opt-in will be essential to the success of INFLO. The widespread success of transponder-based toll payment systems suggests

¹³ INFLO Concept of Operations, June 14, 2012

that such systems may provide worthwhile best practices for how to overcome public concerns about privacy and “tracking.”

- In-Vehicle vs. Roadside Signage. INFLO’s use of in-vehicle messages raises a broad legal question of whether in-vehicle messages will always be considered “advisory” from a legal standpoint, or whether (and under what circumstances) in-vehicle messages could take precedence over standard road signs (either static or changeable). It will be particularly important to resolve this issue in the case of SPD-HRM, where in-vehicle speed advisories may frequently differ from posted (roadside) speed limits. From a policy perspective, this issue is complex because individual states may have to determine the legal standing and enforceability of in-vehicle messages. Guidance from the USDOT could assist states in making these determinations.

Medium Priority Issues Common to DMA Bundles

The analysis identified three potential medium priority policy issues that are common to many dynamic mobility application bundles, including INFLO. These policy issues, while important, appear to have more straightforward paths to resolution than do the high priority issues.

- Technology Obsolescence. As with other connected vehicle applications, the various hardware and software components of INFLO will “age in place.” There is a risk that they will lose interoperability unless formal update policies are established. This issue has two aspects. First, roadside infrastructure will need to be updated (e.g., firmware updates) and upgraded as necessary to maintain compatibility with the evolving capabilities of connected vehicle applications. While not particularly challenging technically (i.e., most software updates to RSE could be implemented remotely from TMCs), such updates will need to be scheduled, and monitored to ensure that they are happening on time. Jurisdictions implementing INFLO may benefit from guidance in this area to suggest appropriate update schedules and monitoring protocols, as well as guidance on including such protocols as requirements in contracts they sign with the companies hired to provide, install and maintain the roadside equipment. Jurisdictions with prior experience maintaining modern traffic signal control systems and other ITS infrastructure will be good sources for such guidance, and the USDOT may wish to pursue peer exchanges and other mechanisms to facilitate this information sharing.

The second aspect to the technology obsolescence issue is that in-vehicle software will also require periodic updates. It may be feasible for some of these updates to occur automatically, without the vehicle owners taking any action or even being aware the updates are taking place. Other updates may need to be performed by trained vehicle service technicians. Regardless, since there will be no way to guarantee that every connected vehicle’s software is always up to date (even if such updates are mandated), external systems communicating with vehicles (e.g., roadside units) will need to maintain backward compatibility with previous versions of in-vehicle systems. The USDOT and the OEMs are currently considering different options for ensuring updates.

A related issue is that in-vehicle hardware will generally renew only at the rate of fleet turnover, so that there will eventually be millions of vehicles in operation with “legacy” systems that may not be capable of running the latest versions of software. This is analogous to the millions of older computers in use today that cannot run the newest

versions of operating systems and other software; it will require roadside units to maintain backward compatibility with prior versions of in-vehicle systems (hardware, software, OS).

From a policy perspective, the in-vehicle software and hardware update issues mean that jurisdictions deploying INFLO will need to specify backward compatibility in contracts for the installation and maintenance of roadside equipment, and be able to confirm such compatibility in the installed units. State and local agencies deploying INFLO might benefit from guidelines they can use when writing contracts for installation and maintenance of roadside infrastructure, to specify that all hardware and software must be interoperable over time – including backwards compatibility.

Updating roadside equipment and/or applications (particularly if safety applications are involved) also raises a policy question regarding how and when such changes would impact the "certification" of the roadside equipment or applications and at what point would recertification be needed. Maintaining "certified" performance is part of the overall trust needed in a cooperative connected environment. This also has potential implications for the operation of security systems if security credentials are no longer valid or new certificates are needed.

- Potential Driver Distraction. In-vehicle visual displays of connected vehicle messaging have the potential to distract drivers and compromise safety. Q-WARN and SPD-HRM messages, due to their role in helping avoid congestion, may be especially alluring to drivers making decisions about route selection while traveling at high speeds.

This challenge is not unique to INFLO and, in fact, already exists as automobiles are increasingly using touchscreen driver interfaces both to manage vehicle systems (such as sound system and temperature controls) and to provide information regarding engine function and vehicle location. At this time, NHTSA guidelines on distracted driving are the primary source of information and guidance on in-vehicle systems. NHTSA in collaboration with the auto industry both continue to promote safe driving practices, and collect data on driver distraction-related crashes to better inform decision making in this area.

In addition to these known concerns, the probable near-term rapid expansion of connected vehicle communications technologies will bring additional data—and associated potentially-distracting information—into vehicles. The market will likely continue to introduce these technologies at a rapid pace, potentially exacerbating a serious public safety hazard.

USDOT and its partners will continue to address the challenges of distracted driving. NHTSA's research on distracted driving¹⁴ will continue to inform the DMA program and any INFLO applications that are developed in the marketplace. As new technologies emerge offering in-vehicle services, USDOT is working to ensure that driver distractions do not increase.

¹⁴ Guidelines and other studies can be accessed at this link:
<http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+DOT+Releases+Guidelines+to+Minimize+In-Vehicle+Distractions>.

- **Equipment Interoperability and Certification.** As noted previously, like many connected vehicle applications, INFLO will require vehicle-to-infrastructure communication. For INFLO to be fully and ubiquitously functional, local infrastructure may in certain cases need to be upgraded or re-calibrated. Standards may be required so that local, state, and interstate highway infrastructure are all fully interoperable with equipped vehicles. Interoperability of infrastructure-based components and in-vehicle components will need to be tested at a much higher level than is currently done under today's OEM self-certification process. FHWA is in the process of developing policy guidance on certification for connected vehicle applications. A recent Request for Applications was offered on June 18, 2014 to industry to research certification processes for equipment and applications¹⁵. Adoption of these standards and certification processes will be part of each jurisdiction's process of deploying INFLO. Coordination of research activities across DMA bundles regarding maintaining the performance of roadside equipment will help ensure that the standards, certification processes, and guidance produced are suitable for all DMA applications.

State and local agencies may choose to contract out the operation and maintenance of roadside equipment, just as many of them do today with certain infrastructure. This will obviate the need for agency staff to be certified [to modify and maintain roadside infrastructure], although it will not lessen the need for standards and personnel certification processes. Although the federal government will drive development of standards and certification, state and local agencies must be involved from the beginning in developing the standards and protocols. Public private partnerships for managed lanes may introduce additional policy issues and add complexity and liability issues that will need to be addressed. Early involvement will reduce the uncertainty state and local agencies will face in trying to participate in INFLO, and will also help build a partnership with the DOT.

Low Priority Issue Common to DMA Bundles

- **Messaging Standards and Priority.** Under INFLO, new technology will provide in-vehicle messages about congestion and recommended driving speeds. The role of INFLO in providing this type of information raises two potential policy issues¹⁶. The first issue is whether the in-vehicle icons and formatting of INFLO messages should be standardized across all vehicles, so that all drivers receive identical messages – as they do when viewing a static road sign, for example. The development of national standards for INFLO messages may be warranted.

Standards are an important aspect of all connected vehicle applications, and are a major focus the Joint Program Office.

The ITS Standards Program is teaming with standards development organizations (SDOs) to accelerate the development and testing of nearly 100, consensus-based,

¹⁵ http://www.its.dot.gov/procurements/wireless_comm.htm.

¹⁶ These issues are shared by the INC-ZONE application within the R.E.S.C.U.M.E. DMA bundle – that application will provide speed reduction warnings to vehicles approaching incident zones.

*ITS standards while working with state and local highway and transit agencies on standards-based ITS implementation strategies*¹⁷.

To date, 86 ITS standards, including at least one relating to message signs, have been published and are ready to use in ITS deployments¹⁸. As the DMA bundles move forward, they will be the focus of additional standards development where necessary. Further research may be warranted to understand the need for standardized over-the-air datasets.

Second, with in-vehicle displays increasingly used to disseminate traffic-related messages, there is a question about whether the Manual of Uniform Traffic Control Devices (MUTCD) will need to be updated to provide guidance on in-vehicle messaging. The MUTCD does not currently address in-vehicle messages, but there is an established update process for the MUTCD, which could be used to add such content and ensure in-vehicle messaging do not contradict MUTCD definitions. It is unclear at this time if in-vehicle messaging will be left solely to auto manufacturers or if the USDOT will issue guidance.

Policy Issues Unique to INFLO

The analysis has identified two potential policy issues that are unique to the INFLO bundle – one deemed high priority and one deemed medium priority.

High Priority Issue Unique to INFLO

- Compliance with Speed Harmonization. The success of dynamic speed harmonization will depend on drivers' compliance with in-vehicle speed advisory messages. From a public policy perspective, this raises a dilemma. As currently envisioned, INFLO will disseminate speed advisory messages, which are by definition non-mandatory. Yet relying on voluntary compliance would produce uncertain results, because some percentage of drivers will disregard reduced speed notices, at least initially, especially in situations where those notices are being issued to slow traffic upstream of a congestion zone that is not yet visible to drivers.

Compliance with speed harmonization notices may increase over time, as drivers come to trust the accuracy of the applications (e.g., speed reduction notices do, in fact, precede actual congestion) and experience the benefits of compliance (reduced congestion and delay). But this will only occur if an initial "tipping point" of compliance occurs, and SPD-HARM is able to produce the congestion-reduction benefits it is capable of, thereby giving additional driver incentives to comply. Without this initial compliance, SPD-HARM could fail to flourish.

Identification of models and best practices to maximize voluntary compliance with speed harmonization will be useful for states and metropolitan areas that are considering implementing INFLO. Of particular use will be documentation of the content and

¹⁷ <http://www.standards.its.dot.gov/About/AboutITSStandardsProgram>

¹⁸ <http://www.standards.its.dot.gov/DevelopmentActivities/PublishedStandards>

structure of successful speed harmonization messages. FHWA has been proactive in researching speed harmonization and other active congestion management strategies, many of which have been in use internationally for years, particularly in Europe. FHWA has conducted extensive research on these approaches, including a scanning study of Greece, Germany, Denmark, The Netherlands, and England¹⁹. One of findings from this research is that clearly communicating to drivers the reason for each speed reduction (e.g., congestion, accident, lane closure) helps improve compliance and therefore system effectiveness. From a policy perspective, this suggests that national messaging standards for SPD-HRM and Q-WARN would be beneficial; such standards would help ensure that drivers receive the same messages and/or incident icons regardless of where they are.

Medium Priority Issue Unique to INFLO

- **Planning for Mixed-Fleet Traffic.** As is the case with any new technology, it will take time for INFLO to permeate throughout the vehicle fleet (as newer, INFLO-equipped vehicles replace older non-equipped ones). Consequently, there will be a period of time (10 years or more) in which vehicle capabilities will be highly heterogeneous across the fleet with respect to V2V communications, speed harmonization, CACC, and other capabilities. Active safety systems on the market today include a degree of automation, but, as noted earlier, these systems do not act cooperatively, and therefore can operate in mixed traffic situations without any negative effects. Ironically, in the case of cooperative applications like INFLO, the potential exists for this heterogeneity to exacerbate speed variability. Some vehicles would act cooperatively while others sharing the same roads would not, and some drivers would receive instantaneous queue warnings while others would not. Once the vehicle fleet is more homogeneously INFLO-equipped, significant reductions in speed variability could be achieved, assuming good driver compliance²⁰. Thus, without proper planning and initiatives to support INFLO during the transition to a connected vehicle-equipped fleet, INFLO could increase traffic problems and therefore risk generating public opposition.

To accommodate vehicles with varying levels of INFLO capabilities – in mixed traffic that includes many non-equipped vehicles – a combination of institutional, educational approaches can help. From an institutional perspective, the continued use of variable message signs will be needed for the longer-term. These currently communicate to everyone within a specific region so that all drivers in that region are acting from the same information. From an educational standpoint, the in-vehicle communications may need to be introduced into driver’s education programs. From a system operations perspective, new studies are being done as part of the new automation research to look at the benefit-cost of segregated lanes, which may support adoption of these applications if like-vehicles with similar automated capabilities and in-vehicle communications could be traveling together.

From a broader public policy perspective, new guidelines may be warranted regarding dedicated lanes, variable speed advisories, and other factors to help mitigate mixed-fleet conflicts. Several steps can be taken to help inform the development of such guidelines:

¹⁹ <http://international.fhwa.dot.gov/pubs/pl07012/index.cfm>.

²⁰ The discussed issues may be more problematic in SPD-HRM and CACC rather than Q-WARN, the latter being very similar to widespread services like WAZE and Google Traffic.

- Review published studies on safety impacts of present-day adaptive cruise control, as an analog for SPD-HRM and CACC. Determine if research results indicate any factors that should be included in planning guidelines for these applications.
- Review studies on segregated lanes and other INFLO-like active congestion management programs applications such as those in Europe (and also, potentially, those in the US), to develop best practice guidelines²¹.
- Review research and forecasts of market penetration for INFLO applications on “nomadic devices” (i.e., smartphones). This would not be relevant to CACC, but could hasten fleet penetration of SPD-HARM and Q-WARN and consequently diminish the mixed-mode traffic issue.

²¹ The effectiveness of segregated lanes would be limited to those sections of roadway where congestion is known and not due to random events. Connected vehicle applications seem better suited for advisory of random traffic disruption events.

Chapter 5 Conclusions

Based on the results of this analysis, the policy team does not foresee a need for any new policies to be enacted or any major issues that will stand in the way of successful INFLO market adoption and use by industry. Ultimately, guidance on installation, integration, operations, and maintenance will be produced by the technical teams when completing their technology transfer to the marketplace. And, appropriate standards are expected to emerge to support interoperability, as needed.

Recommended Actions

High Priority Policy Issues

- Liability: Review application usage agreements in the CVRIA to understand whether they are intended to include liability disclaimers, and document institutional requirements for INFLO. Research applicability to INFLO of existing voluntary “opt-in” and “opt-out” models for addressing liability, comparing pros and cons of both approaches. In particular, understand whether existing tort law contains precedent establishing that such approaches mitigate device maker and OEM liability in cases of faulty data. Review human factors research from other industries (rail, aviation) on in-vehicle warning functions. Determine applicability connected vehicle applications like INFLO where warnings about system status as well as vehicle status will be needed.
- Public Acceptance and Use of Geo-Location Data: Conduct privacy impact analyses of INFLO and other connected vehicle applications. Continue ongoing research on data de-identification. Research applicability of opt-in models to address privacy concerns.
- In-Vehicle vs. Roadside Signage: Conduct legal research to determine whether in-vehicle messages could take precedence over standard road signs (either static or changeable), or whether in-vehicle messages will always be considered “advisory” from a legal standpoint.
- Compliance with Speed Harmonization: Review published research on speed-harmonization initiatives in the US and Europe and document lessons learned and best practices, including message standardization.

Medium Priority Policy Issues

- Technology Obsolescence: Develop guidance for implementing jurisdictions to suggest appropriate update schedules and monitoring protocols, as well as guidance on including such protocols as requirements in contracts they sign with the companies hired to provide, install and maintain the roadside equipment. Continue ongoing research on updates to in-vehicle software.
- Potential Driver Distraction: Provide stakeholders with NHTSA guidelines on distracted driving as a basis for equipment vendors and application developers.

- **Equipment Interoperability and Certification:** Complete ongoing FHWA development of policy guidance on certification for connected vehicle applications. Involve state and local agencies in the process to reduce uncertainty and build strong partnerships that will drive INFLO deployment.
- **Planning for Mixed-Fleet Traffic:** Plan for continued/expanded use of Changeable Messages Signs to ensure ubiquitous speed harmonization and queue warning messages. Continue studies on the benefits and costs of segregated lanes for connected vehicle applications like SPD-HARM. Explore development of guidelines on dedicated lanes, variable speed advisories, and other factors to help mitigate mixed-fleet conflicts. Review published studies on safety impacts of present-day adaptive cruise control, as an analog for SPD-HRM and CACC. Determine if research results indicate any factors that should be included in planning guidelines for these applications.

Low Priority Policy Issues

- **Messaging Standards and Priority:** Explore development of national standards for INFLO messages. If warranted, use existing MUTCD update process to add content on in-vehicle messages such as variable speed advisories and ensure in-vehicle messages do not contradict MUTCD definitions.

Next Steps

The policy issues identified in this report as having been resolved or having identified solutions will not be pursued further. They are documented herein in case stakeholders raise them in the future and need to know how the DMA program has addressed them.

The remaining, open, issues are also documented in this report. These issues will be the focus of additional policy research, outreach, and other steps, including detailed privacy and security analyses.

It is expected that this report will support a dialogue with stakeholders. Stakeholders may comment on:

- Any additional policy or institutional issues that may present challenges to successful emergence of INFLO technology and practice, which are not documented but for which new or additional research and analysis is recommended.
- Whether policy options identified for resolution of the issues are appropriate.

APPENDIX A. Source Materials

In conducting this analysis, the policy team used the following documents and information sources about INFLO:

1. *Concept Development and Needs Identification for Intelligent Network Flow Optimization (INFLO): Assessment of Relevant Prior and Ongoing Research. Final Report. April 10, 2012.*

Prepared for the United States Department of Transportation, Research and Innovative Technology Administration, Intelligent Transportation Systems Joint Program Office. Prepared by Science Applications International Corporation (SAIC).

2. *Concept Development and Needs Identification for Intelligent Network Flow Optimization (INFLO): Report on Stakeholder Input on Transformative Goals, Performance Measures and High Level User Needs for INFLO. Final Report. April 10, 2012.*

Prepared for the United States Department of Transportation, Research and Innovative Technology Administration, Intelligent Transportation Systems Joint Program Office. Prepared by Science Applications International Corporation (SAIC).

3. *Concept Development and Needs Identification for Intelligent Network Flow Optimization (INFLO). Version 3.0. June 14, 2012.*

Prepared for the United States Department of Transportation, Research and Innovative Technology Administration, Intelligent Transportation Systems Joint Program Office. Prepared by Science Applications International Corporation (SAIC).

4. *Report on Architecture Description for the INFLOW Prototype. Final Report. January 10, 2013.*

Prepared for the United States Department of Transportation, Research and Innovative Technology Administration, Federal Highway Administration. Prepared by Battelle Memorial Institute/ Texas A&M Transportation Institute.

5. *INFLO Prototype – Design Walkthrough December 18, 2013*

Prepared for the United States Department of Transportation, Research and Innovative Technology Administration, Intelligent Transportation Systems Joint Program Office. Prepared by Texas A&M Transportation Institute and Batelle.

6. *Report on Detailed Requirements for the INFLO Prototype. Final Report. December 27, 2013.*

Prepared for the United States Department of Transportation, Research and Innovative Technology Administration, Federal Highway Administration. Prepared by Battelle Memorial Institute/ Texas A&M Transportation Institute.

7. *Policy Analysis for the Connected Vehicle Dynamic Mobility Applications. Draft Report. April 12, 2013.*

Prepared for the United States Department of Transportation, Research and Innovative Technology Administration, Intelligent Transportation Systems Joint Program Office. Prepared by Volpe National Transportation Systems Center.

APPENDIX B. List of Acronyms

BSM	Basic Safety Message
CACC	Cooperative Adaptive Cruise Control
ConOps	Concept of Operations
CV	Connected Vehicles
CVRIA	Connected Vehicle Reference Implementation Architecture
DMA	Dynamic Mobility Applications
DOT	Department of Transportation
DSRC	Dedicated Short-Range Communications
EnableATIS	Enabling Advanced Traveler Information Systems
FHWA	Federal Highway Administration
FRATIS	Freight Advanced Traveler Information System
GPS	Global Positioning System
IDTO	Integrated Dynamic Transit Operations
INC-ZONE	Incident Scene Work Zone Alerts for Drivers and Workers
INFLO	Intelligent Network Flow Optimization
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
MAC	Media Access Control
MMITSS	Multi-Modal Intelligent Traffic Signal Systems
MUTCD	Manual of Uniform Traffic Control Devices
NIST	National Institute of Standards and Technology
NHTSA	National Highway Traffic Safety Administration
OEM	Original Equipment Manufacturer
OS	Operating System
PIA	Privacy Impact Assessment
PII	Personally Identifiable Information

Q-WARN	Queue Warning
R.E.S.C.U.M.E.	Response, Emergency Staging and Communications, Uniform Management, and Evacuation
RSE	Road Side Equipment
SDO	Standards Development Organization
SPD-HARM	Speed Harmonization
TMC	Traffic Management Center
USDOT	United States Department of Transportation
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle

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