Interoperability White Paper

What is Interoperability?

Connected vehicles, automated vehicles, big data—as the nation's transportation network grows more technical and complex and moves toward integration with smart cities, all elements need to work together in a safe, trusted, interoperable, and efficient manner. The U.S. Department of Transportation (USDOT) and the Intelligent Transportation Systems Joint Program Office (ITS JPO) are working towards ensuring interoperability among vehicles, devices, and infrastructure to support widespread deployment of transportation innovation. The *ITS Strategic Plan 2015-2019* identifies Interoperability as one of six key Program Categories that define the research goals for the JPO.

Interoperability is critical for transforming safety in transportation—ensuring that all makes and models of vehicles and devices can interoperate allows for communications about threats and hazards forming in the roadway. This interoperability further creates new and dynamic data that results in optimizing system operations, which can result in greater opportunities for mobility or improved environmental performance. Interoperability also allows for a common experience from coast to coast, meaning that users from New York to California, from Georgia to Oklahoma through to Washington State, or across borders in North America can continue to benefit from these technologies as they travel across the Nation.

What Does the Interoperability Program Do?

The ITS JPO works on five topics related to Interoperability: Architecture, Standards, Certification Testing, Cybersecurity, and Human Factors. These five topics support interoperability it different ways:

Architecture – Architectures present implementers with an illustrated framework of options to guide planning in a systematic and rigorous manner. These frameworks result in interoperable deployments of ITS systems, technologies, and organizations. In addition to a National ITS Architecture for technology implementation at the State, corridor, or regional levels, the ITS JPO provides a reference architecture for connected vehicle technologies—inclusive of vehicles, mobile devices, infrastructure, operations centers, and backhaul, among other elements. These architectures are designed to evolve with technological innovation. Ongoing deployment support activities include technical assistance to deployers, training programs and workshops, and specialized tools for developing tailored architectures.

Standards – Standards ensure that the interfaces, data flows, and message content allow for the open exchange of communications among technologies; and further ensure a competitive marketplace for the technologies. The ITS architectures illustrate and describe the role for standards. For those interfaces or data flows that are unique to ITS, the ITS JPO provides support to standards development organizations (SDOs) that facilitate consensus-based standards in cooperation with industry, State and local agencies, and other interested stakeholders. For those interfaces which can be satisfied by existing technology standards, ITS JPO works with experts to recommend appropriate

standards choices. Work continues to both broaden standards availability as well as to update standards to keep pace with technological evolution.

Certification Testing – The JPO is working to ensure that all passenger and freight cargo transport has access to safe, interoperable, secure, privacy protected, consistent, and reliable travel. Tests ensure that the transportation technology works and can be counted on to function properly and that specific functions and devices work as described. Granting certification occurs upon presentation of test results that verify that system components are manufactured according to interoperability requirements and are able to perform to appropriate standards. The JPO's certification research effort works in close cooperation with public and private partners to establish appropriate objective test procedures. The JPO will work with industry to facilitate the emergence of an industry-sustained governance and accreditation process, similar to those that exist in other industries.

Cybersecurity – This program seeks to increase the integrity of connected objects by ensuring that personal information and locations are kept private, and that systems, devices, and applications employ the appropriate level of security to provide a trusted environment for all users. Cybersecurity research identifies ongoing risks associated with attacks and explores the options for mitigating risks. The JPO is working to develop a unified approach to cyber security by structuring guidelines, best practices, and self-assessment tools for transportation practitioners. The reference architecture for connected environments illustrates where security is required or recommended, and will provide information on levels of trust and security for implementers and manufacturers.

Human Factors – The Human Factors for Connected Vehicles (HFCV) program is working toward the end-goal of producing Driver Vehicle Interface (DVI) Design Assistance for Advanced Technology Applications. The goal is for technologies and applications to have DVIs that effectively communicate safety information while managing workload and minimizing distraction. The DVI Design Assistance will assist manufacturers in their designs to ensure that interfaces are effective without increasing distraction or creating high workload.

This research in interoperability is being undertaken in collaboration with a wide range of stakeholders, including device manufacturers; application developers; architecture, standards, and certification experts; and implementers and future users at both the domestic and international levels. Domestically, the JPO works closely with the modal administrations to achieve key goals for interoperability in support of their rulemaking activities, guidance efforts, and deployments. The JPO also creates opportunities for technology transfer and training. Through international harmonization efforts, the JPO works to maximize commonality of ITS deployments around the world to enable a global marketplace for these innovative technologies. International collaboration results in leveraging resources for access to the best available expertise in order to facilitate developments in interoperability.

The Interoperability Program uses the systems engineering approach to ensure effective project deployment and inter-connectivity across the transportation network. The systems engineering approach provides a structured and replicable approach for completing ITS projects. According to the Federal Highway Administration (FHWA), the systems engineering process allows for more adaptable

and reliant systems, verified functionality and fewer defects, higher levels of reuse of system components from one project to the next, and better documentation.

The Benefits of Interoperability

The technology revolution of the past 15 years has allowed for the opportunity to create an inter-connected, trusted, and interoperable transportation environment. This transformation further allows transportation to integrate with smart, connected cities and the Internet of Things (IoT) as a rigorous, systematic, secure and trusted partner.

There are significant benefits of transportation interoperability:

- **Safety benefits:** Interoperability is a key enabler of transforming safety—with the ability for all makes and models of vehicles and infrastructure to communicate, data on emerging roadway hazards to be gathered from multiple external sources (i.e., other vehicles that are broadcasting data, infrastructure, or portable devices) and fused with on-board vehicle data. This dynamic exchange allows for real-time crash avoidance alerts and warnings. To achieve these benefits, communications must be seamless (human factors), interoperable (standards, architecture, and certification), trusted and safe (cybersecurity), and reliable (certification).
- **System Optimization benefits:** The surface transportation system in the United States is highly interconnected. Vehicles travel easily from region to region, and incidents in one region can have a significant impact on operations in adjacent regions. Use of standards and application of cybersecurity mitigations ensures that operating agencies can openly exchange information that is trusted and optimizes system performance; and that vehicles can interact with infrastructure systems or mobile devices.
- **New Business Models:** A key feature of these technologies is the new data sets that are available due to the interoperable exchanges enabled by standards and the open architecture nature of the connected vehicle environments. This data will contain greater detail about the conditions of the transportation environment, and will greatly enhance existing data sources. Because the data will be openly available (but privacy protected), application developers and private innovators can create new products.
- **Cost benefits:** Connected vehicle technologies are expected to impact costs in several ways:
    - **Avoidance of premature obsolescence:** Transportation equipment and systems represent a significant investment for both end users and the authorities that manage the transportation system. As such, buyers typically place high importance on the expected lifetime of a purchase. By purchasing equipment that conforms to recognized and supported standards, buyers can ensure that the purchased equipment will remain backward-compatible with new implementations.
    - **Enabling a competitive marketplace**: Similar to other industries, standards provide certainty for the marketplace and incentivize investments. A stable set of robust standards allows multiple vendors to create a range of equipment with different features and characteristics while still ensuring that the equipment will easily interoperate. A

competitive marketplace lowers initial costs, replacement/upgrade costs, and overall life-cycle costs for ITS equipment.

- **Reduction in life-cycle costs:** Equipment maintenance represents a major component of life-cycle system costs. By ensuring that all equipment conforms to the same standards:
  - Consumers and agencies are positioned to have their ITS equipment serviced by a broader range of providers who no longer have to learn a different set of operating parameters for every piece of equipment of the same general type. This reduces training costs for providers and lowers barriers to market entry for new providers.
  - Agencies reduce maintenance costs by finding that parts and repair services can be sourced competitively rather than being limited to those available from the original equipment manufacturer.

- **Consumer Benefits:** Transportation solutions that are able to resolve interoperability issues amongst all various stakeholders will increase transportation efficiencies, reduce costs, support dynamic data exchange, and provide real-time information to all.

What is the USDOT's Role?

JPO takes a leadership role in identifying the technical, economic, institutional, and policy challenges that present barriers to safe, trusted, and reliable interoperability; and in scoping and managing leading-edge national and international research to explore options and innovations. The goal of the interoperability research is to facilitate interoperable deployments that maximize the public benefits of ITS. Through ongoing cooperation with Canada and Mexico, the USDOT is working to advocate North American ITS interoperability.

USDOT cooperates with standards-making bodies and other development organizations, such as the American Association of State Highway and Transportation Officials (AASHTO), the Institute of Transportation Engineers (ITE), the American Public Transportation Association (APTA), and the Institute of Electrical and Electronics Engineers (IEEE), to address interface requirements between different ITS applications. Along with the USDOT, the European Union, Japan, Australia, and Korea are all involved in the research, testing, development, and implementation of ITS and connected vehicle technology; USDOT supports beneficial cooperation with international partners.

What's next?

As connected and automated technologies move towards deployment and greater adoption, and move toward integration with Smart Cities, interoperability will become even more essential. Connected Vehicle Deployment Pilots in Tampa, New York City and Wyoming are basing their deployments on the results from the research in architecture, standards, cybersecurity, certification, and human factors. As these sites move to operational status, they will act as living laboratories and provide the Nation with valuable real-world insights into the value and benefits of these technologies. Using these inputs, the JPO will work with modal partners, stakeholders, and international collaborators to continually evolve

architecture and standards, improve and add to certification test procedures, refine human factors guidelines, and identify cybersecurity best practices that support large-scale ITS deployments.

The nation's transportation network is advancing and innovative technological changes are appearing at a dynamic rate. It is no longer a matter of "if" but rather "when" the next opportunity for transformation appears. Ensuring interoperability is crucial to realizing the benefits in safety, mobility, and environmental sustainability expected from Connected and Automated Vehicles.

For more information please visit the JPO website: http://www.its.dot.gov/

Sources:

- FHWA: Systems Engineering for Intelligent Transportation systems. http://ops.fhwa.dot.gov/publications/seitsguide/section2.htm
- Intelligent Transportation Systems (ITS) Standards Program Strategic Plan for 2011–2014: http://www.its.dot.gov/standards_strategic_plan/index.htm
- JPO Primer Module 1: https://www.pcb.its.dot.gov/eprimer/module1.aspx