Testing Connected Vehicle Technologies in a Real-World Environment

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U.S. Department of Transportation
Leidos
California Department of Transportation
Florida Department of Transportation
Maricopa County Department of Transportation
Michigan Department of Transportation
New York State Department of Transportation
Road Commission for Oakland County
Vehicle Infrastructure Integration Consortium

For more information about Connected Vehicle Test Bed, visit us online at
http://www.its.dot.gov/testbed.htm
What Are Connected Vehicles?

Connected vehicle technology leverages the potentially transformative capabilities of wireless communication to make surface transportation safer, reduce congestion, and mitigate the environmental impacts of travel. Society continues to benefit from the advancement of wireless technology and connected devices such as smartphones. Connected vehicles are the new wave of intelligent transportation technology to address up to 80 percent of unimpaired driver crashes while potentially reducing the estimated 4.8 billion hours Americans spend in traffic each year.

Connected vehicle technology enables two categories of applications – vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I). The U.S. Department of Transportation (USDOT), academic research institutions, vehicle manufacturers, and suppliers have made significant investments in both V2V and V2I connected vehicle technology. The private and public sectors are working toward the goal of a national connected vehicle network – wireless communications among all vehicles, types, passenger and commercial. The transportation community is committed to the development and eventual deployment of solutions for new and existing vehicles to work cooperatively, as needed, with each other and with roadside infrastructure.


The Connected Vehicle Test Bed is a Federally-funded resource available to developers, at no cost, to test how connected vehicle technologies will perform under real-world operating conditions.

It provides an end-to-end ecosystem to permit the plug-and-play testing of devices, systems, and applications. The Test Bed has been established to provide a real environment where intersections, roadways, and vehicles are able to communicate through wireless connectivity.

The Test Bed consists of a network of 50 roadside units (RSUs) installed along various segments of live interstate roadways, arterials, and signalized and unsignalized intersections, in Novi, Michigan – just 30 miles outside of Detroit. These RSUs communicate messages over 5.9 GHz Dedicated Short Range Communication (DSRC).

The Mission: Provide a facility where users can test new hardware and software for the advancement of connected vehicle technology.

Developers and manufacturers are actively being sought by the connected vehicle research community to develop, test and demonstrate advances in the technology. The Connected Vehicle Test Bed will help fill in the missing pieces required to run a fully operable and stable connected vehicle environment. Developers are encouraged to advance and refine the technologies to make them function better and make them easier to implement.

Why Is the Connected Vehicle Test Bed Right for You?

The Connected Vehicle Test Bed provides cutting-edge technology for users to conduct a variety of tests, including Signal Phase and Timing (SPaT) communications, security system operations; and other connected vehicle applications, concepts, and equipment. In addition, the Test Bed offers:

- Connected vehicle infrastructure and equipment to perform tests at no cost to the user
- Preexisting agreements with local agencies eliminating the need for complex testing arrangements with roadway operators
- Highly skilled staff who can help users test a variety of complex scenarios

The USDOT has organized an affiliation of 5.9GHz DSRC infrastructure device makers, operators of vehicle-to-infrastructure (V2I) installations, and developers of applications that use V2I communications. The affiliation facilitates information exchange, shares USDOT tools and resources, and encourages the consistent development and deployment of connected vehicle infrastructure components. Affiliation will help ensure that all future connected vehicle applications are based on common implementations of the communications technology, while harnessing the collective abilities of the membership.

How Do I Get Connected?

**Step 1**
ARRANGE a site visit or tour of the Southeast Michigan Test Bed by contacting the Novi Connected Vehicle Director of Operations, Jeremy Durst.
Telephone: 248.374.5098
Email: jeremy.s.durst@leidos.com

**Step 2**
OBTAIN test plan requirements and usage forms by contacting the Connected Vehicle Test Bed User Services Manager, Gary Golembiewski.
Telephone: 703.318.4718
Email: gary.a.golembiewski@leidos.com

**Step 3**
PREPARE a test plan and complete usage forms.

**Step 4**
SUBMIT the usage forms and test plan to the Connected Vehicle Test Bed User Services Manager, Gary Golembiewski.

**Step 5**
SCHEDULE testing.

**Step 6**
TEST!
How Can You Use the Connected Vehicle Test Bed?

The Connected Vehicle Test Bed is available to customers interested in:

- Testing equipment such as vehicle awareness devices (VADs), aftermarket safety devices (ASDs), in-vehicle safety devices (ISDs), radars, and RSUs.
- Developing and testing DSRC standards.
- Establishing connected vehicle security certificate credential management.
- Developing and testing applications using SpAT and Geometric Intersection Description (GID) data.

The Test Bed’s functionality also allows users to test a number of scenarios, including:

- **SpAT:** Developers can test their system’s ability to receive and process SpAT data in a real-world environment, which is integral to the success of any Connected Vehicle system. The Test Bed offers free access to both a collection of sample SpAT messages and a series of signalized intersections equipped to broadcast SpAT data.
- **Security Management:** Test Bed users can be confident that their system communicates successfully with a Security Certificate Management System (SCMS) by using the SCMS emulator. This provides developers with the assurance that their system can obtain properly formatted 1609 Certificates.
- **Operations:** The Test Bed saves users the high infrastructure costs associated with testing and demonstrating their systems. Developers and researchers can explore the full potential of connected vehicle technology through the versatile array of equipment the Test Bed provides, including networked RSUs, RSUs integrated with signal controllers and broadcasting SpAT data, DSRC Protocol Analyzers, and server enclaves.
- **New Equipment, Standards, Applications, and Research:** Test Bed staff have unparalleled expertise in testing connected vehicle equipment. They can equip users with the knowledge they need to set up their testing and confidently navigate the new DSRC standards for which well-established testing protocols have not yet been established and testing support tools may not be available.

Who Has Used the Connected Vehicle Test Bed?

Any technology developer or researcher interested in the connected vehicle space can test at the Test Bed. Key users in the past include the likes of:

- Denso
- Delphi
- Eaton
- Hirschmann
- NextEnergy
- Argelia
- MIR Labs
- Ricardo
- University of North Texas
- Wayne State University

Auto manufacturers, suppliers, technology developers, and even those that are interested in engineering as a hobby are all encouraged to use the Test Bed to advance connected vehicle technology.

The Southeast Michigan Test Bed Architecture

The USDOT has developed an architecture to depict the systems and interfaces that are being developed for the Southeast Michigan Test Bed. The diagram to the right represents a high-level overview of the architecture, illustrating the key vehicular, road, center, support, and traveler components that make up the Test Bed.

Updated Standards, Open Architecture, New Services and Applications

Thanks to the feedback of the Connected Vehicle Test Bed user community, the Test Bed is undergoing upgrades and enhancements to support the evolving needs of our users. It will be the only testing environment of its kind to advance with the state of the practice, providing developers with a cutting-edge operating environment. These upgrades will provide a better level of service and offer additional functionalities, including:

- Local Certificate Distribution System (LCDS).
- Improved IPv6 functionality and capabilities.
- RSU data-logging.
- New RSUs supporting improved messaging, logging, and IPv6 gateway functionality.
- Vehicles equipped with a universal connected vehicle device mounting system.
- Future upgrades to support mobility applications, other wireless data communications including WiFi and/or cellular.

The implementation of the Southeast Michigan 2014 Test Bed system is an ongoing process. Through this process, all of the existing Test Bed resources are still available to those conducting testing and development activities in the Test Bed environment. These resources include:

- 50 locations broadcasting SpAT and MAP information as well as customizable Traveler Information Messages (TIM).
- 3 portable RSUs and trailers that allow for private testing or testing in atypical locations, such as a parking lot.
- Data Center running 24-7 and on 99% uptime.
- Test vehicles and drivers, upon request.
- On-site experts with years of experience in intelligent transportation systems and connected vehicle systems.

Our goal for the Southeast Michigan 2014 Test Bed system is to provide real-world conditions, state-of-the-art infrastructure, interference-free and continuous wireless connectivity, variable road environments, and much, much more – all part of a system that can be tailored to meet the specific needs of today’s users.
The Test Bed Operations Team is creating and implementing technical solutions to keep up with changing technological trends while meeting users’ diverse performance needs. Our goal is to create and maintain a testing environment that is customizable to each unique user’s requirements, which includes:

- Establishing partnerships with other affiliated test beds, closed-loop testing environments, and proving grounds.
- Coordinating with the simulation and prototyping capabilities of laboratories such as the Saxton Lab at the Turner-Fairbank Highway Research Center.
- Modifying our network of RSUs and installing tester-specific software for easier access to the network and data.

**Test Bed Progression:**

- Test Bed opens as a Proof of Concept
- Primary user: VIIC
- Centralized core (SDN)
- RSU network across a large area

**Test Bed Transitions to New Management**

- Expansion to Telegraph Road
- Centralized core (SDN)
- Larger RSU network across a wider area

**Test Bed Upgrades to 3.0 Technology**

- Incorporates user-focused design and SCMS
- Migration to the new core system begins
- Safety Pilot Model Deployment compliance
- Reduced RSU network concentrated along corridors

**Testing to Facilitate Deployment**

With the new standards and core architecture, the Connected Vehicle Test Bed will feature a more decentralized, simplified, and open structure. We also have begun adding new security features as well as new hardware and software applications. The Connected Vehicle Test Bed strategy will provide a dynamic, evolving environment that keeps up with the state of the practice.

The Test Bed runs in accordance with the latest IEEE 1609/802 and SAE J2735 Standards and will have the mechanisms in place to test changes or modifications to some of these standards. This cannot be done in other testing environments, giving Connected Vehicle Test Bed users a unique advantage.

**The Evolution Continues...**

Florida Test Bed Opens

California Test Bed Support Kicks Off

Growing Number of Test Bed Users

Increased Cooperation With Affiliated Test Beds in AZ, CA, FL, MN, NY, and VA

NHTSA 2014 Rulemaking Process

Southeast Michigan 2014 Architecture Implementation

Support Regional Pilot Deployments

Support Certification Program

Connected Vehicle Demonstration at ITS World Congress 2014 and 2017

**Connected Vehicle Test Bed Progression: Technologically Driven. Customer Focused. Forward-Thinking.**


- Proof of Concept
- Stabilization/Transition
- Test Bed 3.0
- Southeast Michigan Test Bed 2014 Project
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- Test Bed opens as a Proof of Concept
- Primary user: V2I
- Centralized core (SDN)
- RSU network across a large area

Growing Number of Test Bed Users

Increased Cooperation With Affiliated Test Beds in AZ, CA, FL, MN, NY, and VA

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Support Regional Pilot Deployments

Support Automated Driving Early Use Cases

Support Certification Program

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