Connected
Vehicle TEST BED

Testing Connected Vehicle Technologies
in a Real-World Environment

What are Connected Vehicles?

Connected vehicle technology leverages the potentially transformative capabilities of wireless communication to make surface transportation safer, smarter and greener. The trend is inevitable - 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.

The U.S. Department of Transportation (USDOT), in cooperation with the automotive industry and other partners, strives toward the goal of enabling networked wireless communications among all vehicles types and is promoting development and deployment by the private and public sectors.

Real-Life Conditions. Open Testing Environment. State of the Art.

The Connected Vehicle Test Bed is a federally-funded resource available to developers to test how connected vehicle technologies will perform under real-world operating conditions. The Test Bed has been established to provide a real environment where intersections, roadways and vehicles are able to communicate through wireless connectivity.

It consists of a network of 50 roadside equipment (RSE) units installed along various segments of live interstate roadways, arterials, and signalized and unsignalized intersections, in Novi, Michigan - just 30 miles outside of Detroit. These RSEs 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:
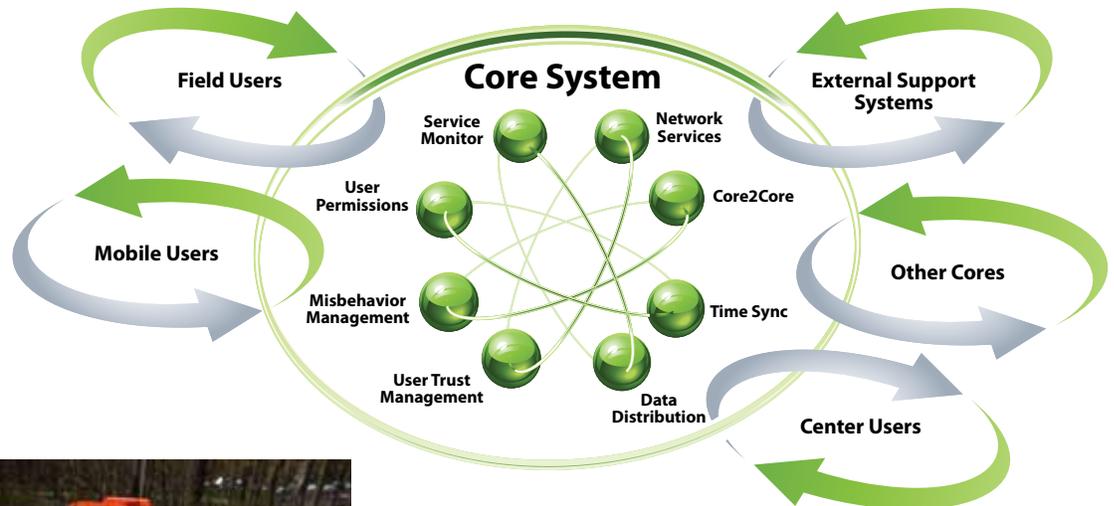
- Connected vehicle infrastructure and equipment to perform tests at **no cost to the user**.
- Preexisting agreements with local agencies **eliminating the need for complex testing arrangements** with roadway operators.
- **Highly skilled staff** who can help users test a variety of complex scenarios.

Customer-Driven Focus: Keeping Up with the State of the Practice

The New Core System

The diagram below provides an architectural overview of the Connected Vehicle Test Bed components. It is comprised of a core system that is utilized by a number of external systems and users.

Field Users · Core System (Service Monitor, Network Services, User Permissions, Core2Core, Misbehavior Management, Time Sync, User Trust Management, Data Distribution) · External Support Systems · Mobile Users · Other Cores · Center Users

- New RSEs 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.

As the Test Bed transitions to the new core architecture, some services are still available for use:

- 22 intersections broadcasting SPaT and GID information.
- 3 new portable RSE units that allow for private testing or for 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 ITS and connected vehicle systems.

Our goal for these improvements 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.

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 model operating environment. These upgrades will provide a better level of service and offer additional functionalities, including:

- Security Certificate Management System (SCMS).
- Local Certificate Distribution System (LCDS).
- Improved IPv6 functionality and capabilities.
- Roadside Equipment (RSE) Data-Logging.

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 Operations Laboratory at the Turner Fairbank Highway Research Center.
- Modifying our network of RSEs and installing tester-specific software for easier access to the network and data.

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

Florida Test Bed Opens

California Test Bed Support Kicks-Off

- Test Bed transitions to new management
- Expansion to Telegraph Road
- Centralized core (SDN)
- Larger RSE network across a wider area

2007	2008	2009	2010

Proof of Concept   **Stabilization/Transition**

Testing to Industry Standards

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 will run 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.

- 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 RSE network concentrated along corridors

The Evolution Continues...

Growing Number of Test Bed Users

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

NHTSA Agency Decision 2013

Connected Vehicle TEST BED

Core Architecture Implementation

Support to U.S. DOT Dynamic Mobility Applications Program

Connected Vehicle Demonstration at ITS World Congress 2014

2011	2012	2013	2014
	Test Bed 3.0		**Future**

Out of the Lab and onto the Road

How Can You Use the Connected Vehicle Test Bed?

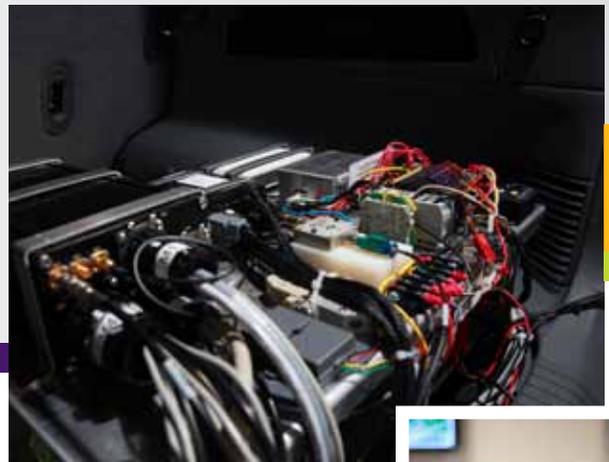The Connected Vehicle Test Bed is available to customers interested in:

- Testing equipment such as vehicle awareness devices (VADs), aftermarket safety devices (ASDs), in-vehicle safety devices (ISDs), radios, and roadside equipment (RSEs).
- 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 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) or 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 RSEs, RSEs 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 and 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
- Hirschmann
- Eaton
- Argenia
- Wayne State University
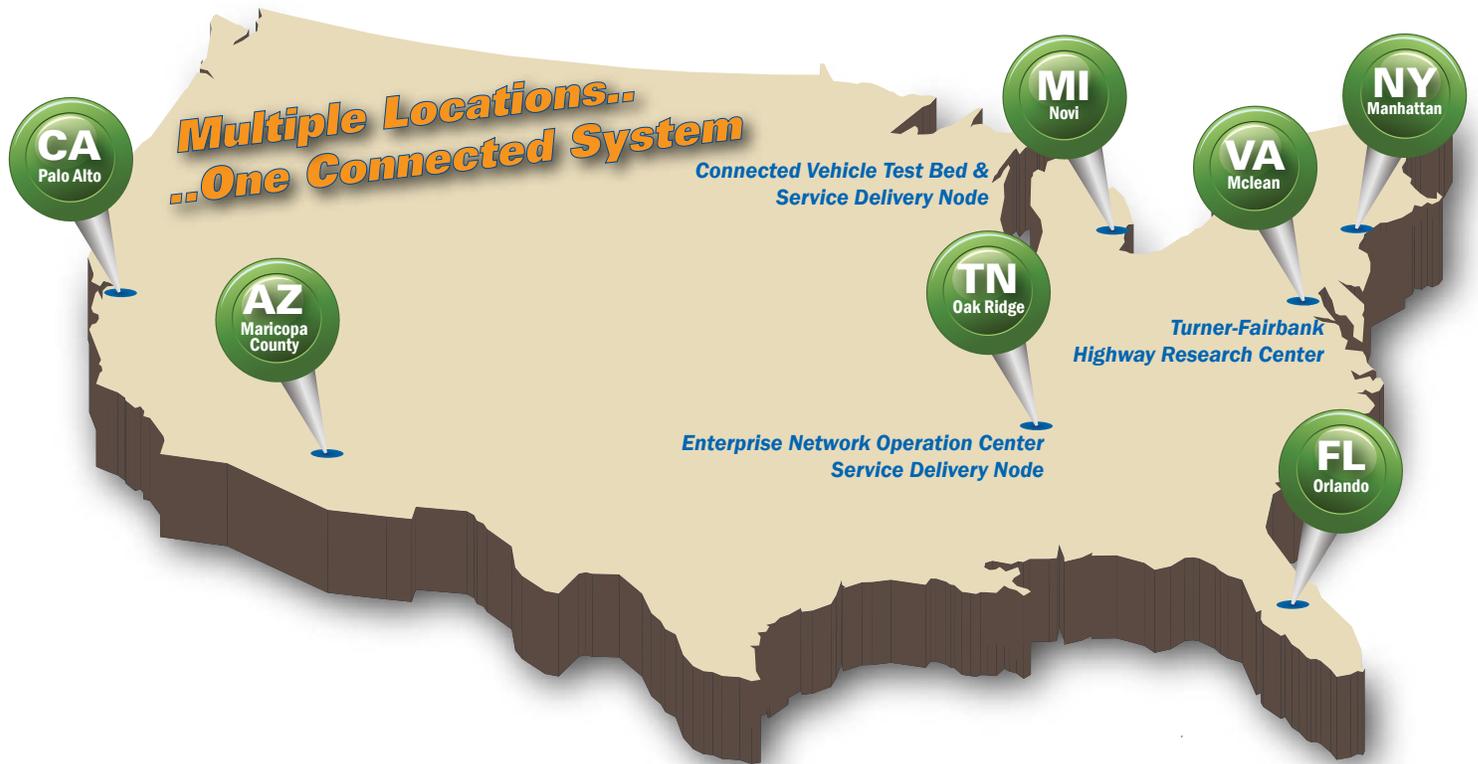- MET Labs
- Ricardo
- University of North Texas

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

In addition to the location in Michigan, Test Bed capabilities have been expanded to affiliated and interoperable test beds in Virginia, Florida, California, New York, and Arizona. These sites specialize in specific testing capabilities, such as traffic and mobility, commercial vehicles, and other functions. The Test Bed will continue to expand its capabilities with other partner demonstration sites.

Multiple Locations-- ..One Connected System

- **CA** Palo Alto
- **AZ** Maricopa County
- **MI** Novi
- **NY** Manhattan
- **VA** Mclean
- **TN** Oak Ridge
- **FL** Orlando

Connected Vehicle Test Bed & Service Delivery Node

Turner-Fairbank Highway Research Center

Enterprise Network Operation Center Service Delivery Node

How Do I Get Connected?

Step 1

ARRANGE a site visit or tour of the Test Bed by contacting the Connected Vehicle Operations Chief: Jeremy Durst

Telephone: 248.374.5098

Email: jeremy.s.durst@saic.com

Step 2

OBTAIN test plan requirements and usage forms by contacting the Connected Vehicle Test Bed User Services Manager: Gary Golembiewski

Telephone: 703.676.2383

Email: gary.a.golembiewski@saic.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!

INFRASTUCTURE & COMPONENTS

SAFETY, MOBILITY, & ENVIRONMENTAL APPLICATIONS

IN-VEHICLE DEVICES

Contact:
Walton Fehr, Systems Engineering and Test Bed Manager
U.S. Department of Transportation
Intelligent Transportation Systems Joint Program Office
Telephone: 202.366.0278
E-mail: walton.fehr@dot.gov

Test Bed Partners

U.S. Department of Transportation

Science Applications International Corporation (SAIC)

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

Connected
Vehicle TEST BED

Scan this QR code using a smart
phone and get connected.

U.S. Department of Transportation