VII Michigan Test Bed Program
Concept of Operations

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Introduction

This document is the Concept of Operations for a VII test bed in Michigan. The intent of this document is to describe, in general terms, the VII test bed program being planned and deployed in Michigan. This is intended to be a "living" document, with amendments occurring as a result of changes in technologies, program participants, and advances in the states-of-the art and practice with respect to VII. It is a collaboration of input from multiple stakeholders from the public and private sectors, as well as academia. However, MDOT seeks input into the VII program from other potential stakeholders, as the ultimate deployment of VII will require the efforts of many organizations with diverse backgrounds and areas of expertise. Those stakeholders currently involved in the process (where stakeholders include the public sector, private developers, universities and other parties), have provided MDOT with high level objectives, which are not necessarily quantifiable or testable at this point in the program.

The Concept of Operations is the highest level document required as part of the systems engineering process (as described later in this report). As such, it intends to document the high-level goals and objectives of the Michigan VII Test Bed program. Where technical information, such as architectures and device locations, are provided or shown, they are intentionally generic in nature. Future documents, including the development of formal functional requirements, will include more specific project and program architectures and technical requirements, and will pin-point exact geographic locations for devices. Likewise, the goals and objectives outlined herein are intended to be at a high-level, and not necessarily quantifiable or testable. As the specifics of the test bed emerge in later iterations of the Concept of Operations and other systems engineering documents, quantifiable and testable objectives will be included.

I. Background

Vehicle-Infrastructure Integration (VII) is an emerging Intelligent Transportation Systems (ITS) initiative aimed at creating linkages between intelligent vehicles and infrastructure systems, and between intelligent vehicles and other intelligent vehicles for use in a variety of applications. Whereas traditional ITS technologies rely on infrastructure-based systems to collect and

process data, VII systems would enable intelligent vehicles to collect data, communicate data to the infrastructure, and receive communication regarding safety hazards, travel conditions or other information valuable to users. Today's marketplace is teeming with mature technologies that are technically and economically feasible. One question remains to be answered – are they capable of supporting VII?

The state of Michigan, as home to the US auto industry, has the unique opportunity to support the development and testing of a range of technologies and products in partnership with automotive manufacturers and suppliers. Supporting this testing will require an investment in the public infrastructure necessary to create functional "test beds" for use in evaluating the technical feasibility, deployment issues and various potential use cases of VII. This document outlines a Concept of Operations to support the vision and deployment of a state-of-the-art VII Michigan Test Bed Program.

II. Purpose of the Test Bed Program

The concept of VII holds the promise of forever changing the way MDOT and the public-sector do business in regards to operations and maintenance. However, much work is required for VII to be implemented in the United States. The technical and institutional challenges are extensive and will require time to overcome. Furthermore, VII is not even possible without the ability for vehicles to communicate data with the roadside infrastructure, and for backhaul communications to potentially carry this vast amount of data to control centers or other central locations. Once data is communicated to the infrastructure, the data can be shared, fused, packaged and disseminated from a wide range of providers to a wide range of users, while assuring the anonymity of the source vehicle, operator and passenger.

The three key subsystems being evaluated as part of this program are:

- On Board Equipment (OBE) – the components installed in vehicles which may or may not include integration with the various vehicle systems. This equipment includes the in-vehicle wireless communications components in the vehicle necessary for the vehicle to communicate with the infrastructure (V2I) and other vehicles (V2V).
- Road Side Equipment (RSE) – the components installed along the roadside, specifically the wireless equipment necessary for vehicle to infrastructure (V2I) communications, and the network interlink.
- Network Subsystem – the backhaul network necessary to connect roadside devices to one another and to connect roadside devices to the various central processing locations.

The VII Michigan Test Bed Program will provide opportunities for MDOT, industry and academia to test a range of products and technologies associated with the technical feasibility related to:

- Intelligent vehicles collecting data
- Intelligent vehicles communicating the collected data to infrastructure
- Intelligent vehicles receiving data
- Utilizing existing infrastructure and technologies to transfer data from a roadside device to a central processing location, including buffering and storing data

In addition, the VII Michigan Test Bed Program will:

- Archive collected data for the purpose of allowing stakeholders to research and develop the means to fuse, package and disseminate information to other users (e.g., Independent Service Providers, telematics, etc.) and infrastructure (e.g., CCTV cameras, Dynamic Message Signs, etc.) in support of their agency or organization's goals and objectives

- Develop a scaleable approach that allows for other stakeholder participation and the creation of additional test beds for specific needs of the stakeholders and to advance the state-of-the-art and the state-of-the-practice of VII application and technology development

In short, the VII Michigan Test Bed Program will provide a real-world laboratory to test a range of products and technologies and foster the development of new technologies and applications. The testing phases include an evaluation of the subsystems, applications and proving the concept of VII in a real-world testing environment. The longer-term vision of the test bed is to evaluate full use cases for VII that require either advanced technologies or a higher level of saturation of VII-enabled vehicles in the vehicle fleet.

VII Michigan is intended as a complimentary program to efforts in California, Minnesota and Florida, along with international efforts in Ontario, Canada and Wales, United Kingdom, aimed at providing an incubator for testing of a variety of on board and road side elements and applications. One primary goal of the program is the sharing of findings and experiences with others in order to further the full realm of VII research and development. The lessons learned as part of the VII Michigan program are intended to feed into the forthcoming field trials and formal Field Operational Tests (FOT) being proposed by the United States Department of Transportation (US DOT).

III. Concept of Operations

The American National Standards Institute / American Institute of Aeronautics and Astronautics (ANSI / AIAA) standard states that a Concept of Operations (COO) should be “somewhat all things to all people”. While this statement appears to be vague, it does effectively communicate the breadth of audience and range of topics that a COO will need to address. As shown in **Figure 1**, a COO attempts to answer the Who, What, When, Where, Why, and How for a system in general terms.

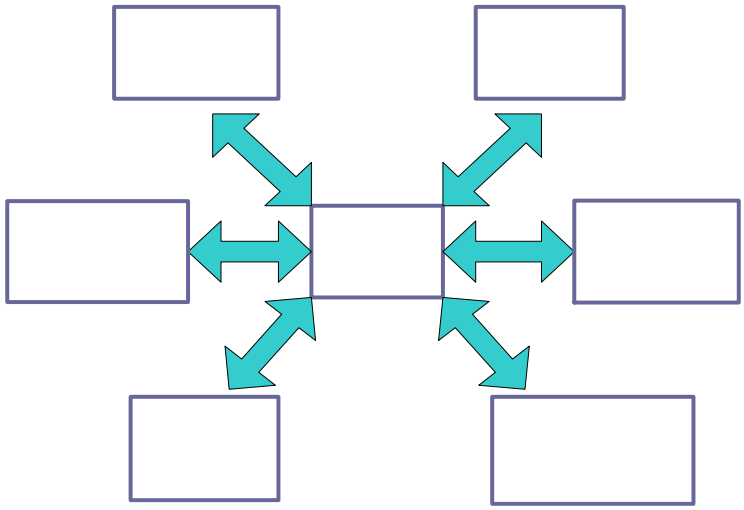

Figure 1: Flow Diagram of Major Questions a COO Will Answer

A. Who – Who are the Stakeholders Involved with the Michigan VII Test Bed Program?

Test beds will be designed, implemented and evaluated through the efforts of a wide range of stakeholders in both the public and private-sector arena. Current public-sector stakeholders include:

- Michigan Department of Transportation (MDOT)
- Federal Highway Administration (FHWA)
- Road Commission for Oakland County (RCOC)

Current private-sector stakeholders are listed below. The number of private-sector stakeholders is anticipated to grow as testing of new products and technologies are sought. Later in 2005, MDOT plans to develop a Request for Information (RFI) for the purpose of attracting additional communications suppliers and automotive equipment suppliers to the VII Michigan Test Bed Program.

- Original Equipment Manufacturers (OEMs)
- Communications Carriers
- Automotive Equipment Suppliers
- Traffic Control Equipment Suppliers
- Research Institutions
- Telecommunications Equipment Suppliers
- Communication Infrastructure Companies
- Network Services (Network and Application Service providers)
- System Integrators & Infrastructure A&E firms

B. What – What are the Known Elements and the High-level Capabilities of the Michigan VII Test Bed Program?

Test beds are anticipated to consist of four different subsystems– on board equipment, roadside equipment, network management and data processing. Test facilities are anticipated at the OEM Facilities, supplier and other test bed participant facilities, and MDOT and other local road agencies, on roads and parking lots and in laboratories, research facilities, and control centers. **Figure 2** outlines conceptual linkages between the various test bed elements, and does not prescribe a design for attributes that will be particular to each separate Test Bed. As such, it is meant to be a guide to use for the planning, design, implementation, operation and maintenance of test bed elements and interfaces. It should be noted that the test bed architecture is using the Internet as a means to transmit data from the roadside device to the test bed participants. Each participant will be responsible for securing their data packets.

Vehicle Equipment Subsystem

The Vehicle Equipment Element within the Test Bed will consist of privately-owned vehicle fleets that will collect data for use in testing the feasibility to collect and communicate data to / from the infrastructure. Vehicle fleet equipment will be the full responsibility of each individual test bed participant or participant team. In addition, it is envisioned that, for the duration of the VII Michigan Test Bed Program, each Test Bed will utilize a dedicated fleets of vehicles, owned by those organizations participating in the Test Bed activities. This arrangement will provide less problematic access to vehicle data due to privacy agreements made with employees rather than the general public.

Data from vehicles will be:

- Collected for use by both the private-sector and the public-sector stakeholders

- Archived for the purpose of allowing stakeholders to research and develop the means to fuse, package and disseminate information to other users (e.g., Independent Service Providers, telematics, etc.) and infrastructure (e.g., CCTV cameras, Dynamic Message Signs, etc.) in support of their agency or organization's goals and objectives.

The VII test bed fleet will transmit data packets using Internet Protocol (IP), to each respective test bed participant or participant team's VII server. Data required by MDOT, including the data format, will be set forth in a requirements document that will be shared with the private-sector stakeholders for their use in designing a Test Bed.

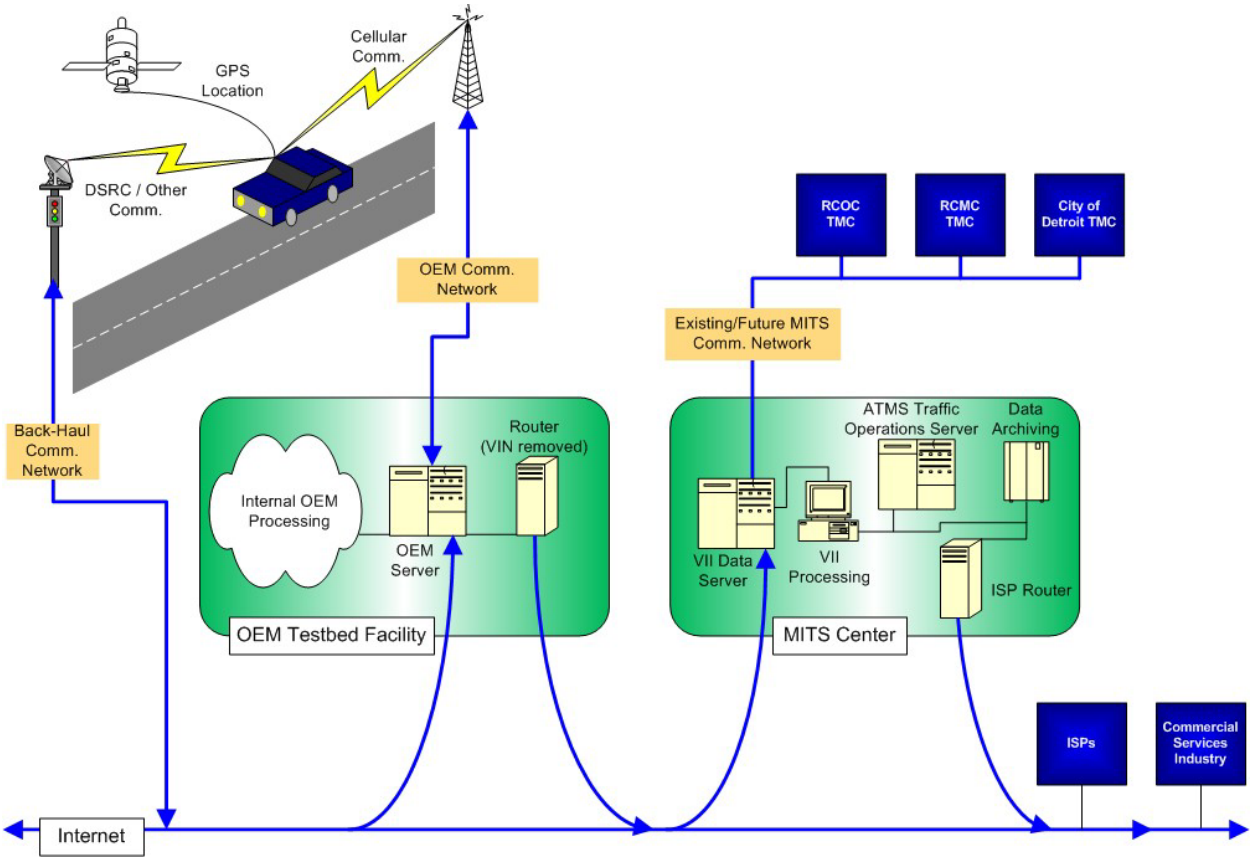

Figure 2 – Michigan VII Test Bed Concept

Roadside Equipment Subsystem

The Roadside Equipment Element within the Test Bed may include a variety of system components that will depend on the design developed for each particular Test Bed. For Test Beds that will utilize a non-cellular communications medium, the roadside equipment will be located within the public-sector right-of-way and is anticipated to receive data from Test Bed vehicles. Data will either be processed or forwarded along the Internet to OEM Test Bed facilities, depending on the nature of the test activities. Subsequently data will be transmitted to MDOT once the data is anonymized (the Vehicle Identification Number (VIN) or other identifiers, are removed from the data packet).

Network Management Subsystem

The fundamental building blocks of the VII concept are coordinated deployments of communication technologies in all vehicles by the automotive industry and along all major U.S. roadways by the transportation public-sector. Short-haul vehicle-to-roadside communications are anticipated to occur via high-speed licensed (e.g., Dedicated Short Range Communications) or unlicensed (e.g., 802.11, WiMAX, etc.) short range wireless communications. Data will then be back-hauled via wired or wireless media that may be leased or agency owned, to an Internet field portal, for transport to the OEM Test Bed servers. Initial test bed deployments will focus on the use of 802.11-based technologies to facilitate vehicle-to-roadside communications.

Private Sector Test Bed Facilities Element
At a minimum, Private Sector Test Bed facilities will collect, store, anonymize and disseminate data from either the Vehicle Fleet or Roadside Equipment Elements to the MDOT/Public-Sector Element and the Vehicle Fleet. The private sector test bed participants will then forward the appropriate anonymized data to the public sector participants via the internet for public sector use and analysis. The raw data may be used by the private sector partners for their own purposes. Existing private sector Test Bed facilities within the VII Michigan Test Bed Program (as of August 2005) include:

- Ford Motor Company (Dearborn)
- DaimlerChrysler (Auburn Hills)
- Nissan Motors North America (Farmington Hills)
- Collision Avoidance Metrics Partnership (CAMP) (Farmington Hills)
- Motorola (Farmington Hills)
- General Motors (Detroit)
- University of Michigan Transportation Research Institute (UMTRI) (Ann Arbor)

MDOT/Public-Sector Element
Each OEM Test Bed Facility will interface via the Internet with a server housed within the Michigan Intelligent Transportation Systems Center (MITSC). The MDOT server will be dedicated to collecting, processing, and distributing anonymized VII data. MDOT will be responsible for disseminating final VII data to other public-sector partners, including:

- Road Commission for Oakland County
- Road Commission of Macomb County
- City of Detroit

In later stages of the Program, data may further be shared with other industry stakeholders for use in traveler information applications, including Information Service Providers (ISPs), commercial services industry, and media outlets. As these later stages approach, issues associated with sharing this data, such as confidentiality and non-disclosure agreements for certain information, will be addressed at the local level based on the decisions made and directions being set forth at the national level.

C. When – What is the Time-Sequence of VII Michigan Test Bed Program Activities that will be Performed?

The VII Michigan Test Bed Program is a multi-phased program which will be implemented over time from 2005 through 2008 to coincide with development efforts in the private sector and Field Operational Test plans in the public sector. Major segments of the region-wide Test Bed (Phase 3) are planned for deployment by the 4th quarter of 2007. This region-wide Test Bed (Phase 3) will be an expansion of the initial, localized Test Beds (Phase 1), that will eventually be expanded in geographic coverage (Phase 2). These expanded Test Beds, along with additional future Test Beds, will ultimately be linked in Phase 3 to evaluate the interoperability of the various locations and technologies. **Figure 3** depicts the high-level phased approach.

Figure 3 depicts the test bed locations in a clouds reference. Future meetings and developments in the VII community – both locally and nationally – will determine the exact locations of various roadside devices, and their coverage ranges. For example, some of the test bed areas described below are intended to provide continuous coverage along an entire corridor or series of corridors. Others are focused at specific intersections.

To accomplish this deployment, the following two things must occur by summer 2008:

1. Deployment of a Test Bed that will utilize a combination of products and technologies to demonstrate the technical feasibility and interoperability of collecting and forwarding VII data thru the use of open-standards and an open-architecture. This "Interoperable Test Bed" could leverage the above-captioned individual Test Beds as well as other Test Beds that have yet to evolve.
2. Continued support within the public and private sectors of the VII program that ensures that the VII program is not limited to either a geographic area or a subset of automobile manufacturers.
3. Successful testing and pre-deployment activities that demonstrate a marked improvement (or demonstrate significant potential improvements) in safety and congestion, while demonstrating the ability of VII to meet the overall goals of the National and Michigan VII programs, as well as those of the suppliers and original equipment manufacturers at an acceptable cost to benefit ratio.
4. The successful deployment of a series of individual Test Beds that prove the technical feasibility to collect and forward data in a fashion that can support VII. The VII Michigan Test Bed Program is well along the way of successfully deploying multiple Test Beds, including the following:

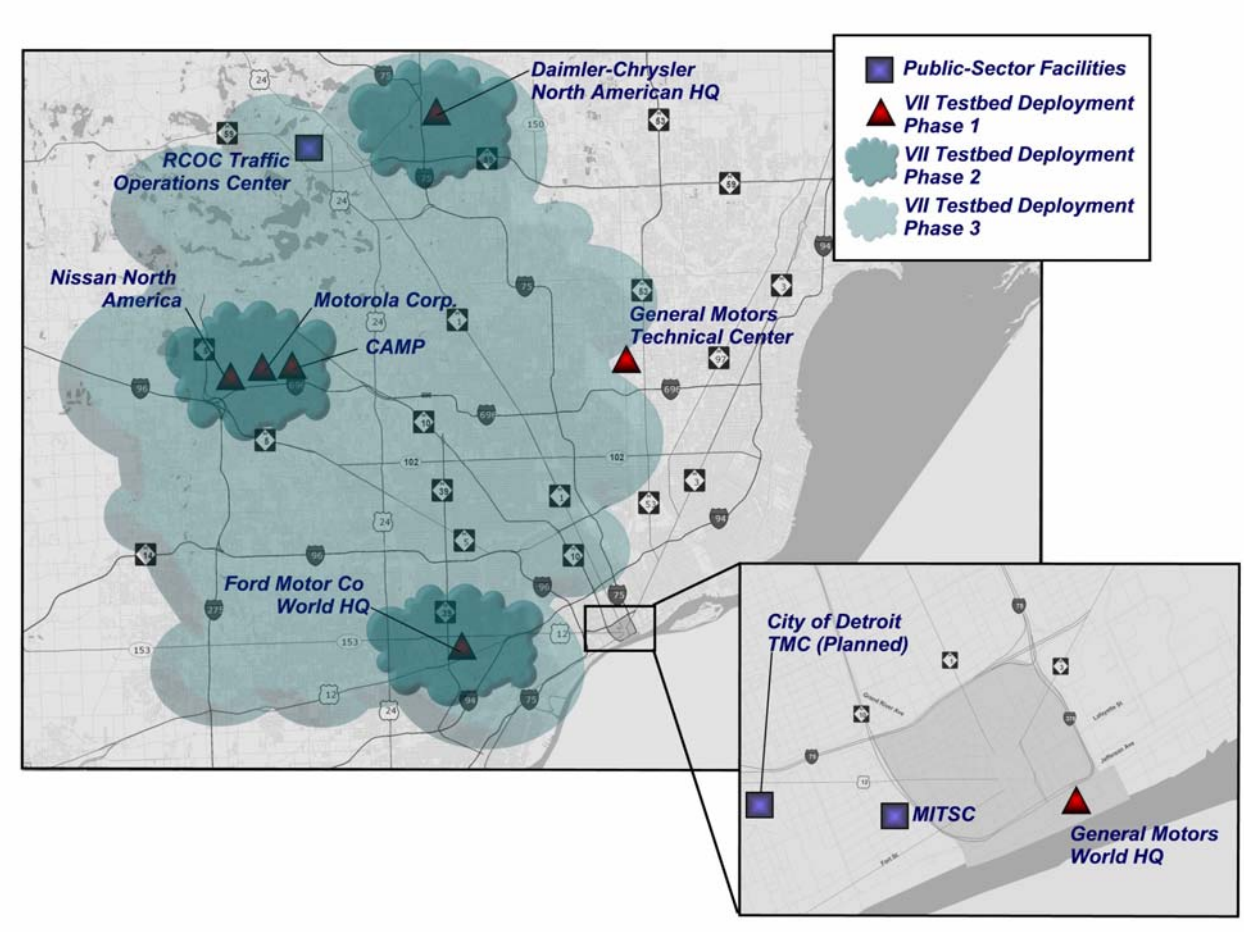

Figure 3 – Phased Test Bed Deployment

- Ford Test Bed - Ford Motor Company, MDOT, Wayne County and the City of Dearborn are partnering to develop a test bed near Ford's facilities in Dearborn. The initial deployment will include the installation of a Motorola Canopy short-haul wireless network around three intersections along City roadways aimed at achieving full wireless VII coverage of a triangular configuration formed by three roadways.

- DaimlerChrysler Test Bed – DaimlerChrysler, MDOT and RCOC are partnering to develop a test bed along the roadways surrounding DaimlerChrysler's Auburn Hills headquarters and technical center. The test bed will include deployment of DSRC-surrogate (802.11) radios at signalized intersection locations along public roadways.

- General Motors Test Bed – General Motors is evaluating the use of data collected from its OnStar™ cellular network for use in VII applications. In partnership with MDOT, GM will begin sharing anonymized OnStar™ data via the Internet with MDOT for MDOT use. The GM test bed in Warren includes detection to permit GM to validate the accuracy of probe vehicle data in comparison with data collected from traditional ITS methods.

D. Why – What Do Organizations Lack that the VII Michigan Test Bed Program will Provide?

The VII Michigan Test Bed Program will provide an incubator for testing a variety of products and technologies for VII applications. As part of the program, MDOT and other public-sector partners are providing financial and technical resources, as well as access to the public right-of-way, to help encourage the private sector to take part in open VII testing. While multiple Test Beds are currently being designed in the metro Detroit area, the VII Michigan Test Bed Program will encourage and support the testing of products and technologies developed by other private-sector stakeholders within the context of:

- Existing Test Beds
- Additional Test Beds
- Multiple Test Beds
- Integrated Test Beds

Once operational, the VII Michigan Test Bed Program will enable the various partners to gain a better understanding of how to use the wealth of data possible from a full-scale VII deployment. In addition, the program will provide a mechanism to begin to explore institutional issues associated with VII, including data property rights, data security, inter-agency/company agreements, competitive market issues and others.

The VII Michigan Test Bed Program will ultimately allow the beginnings of use-case testing in order to allow each organization the opportunity to evaluate how well VII data will be able to fulfill their goals. Amongst a wide variety of potential commercial applications, OEM's are interested in VII's potential to improve vehicular safety. MDOT and other public agencies have a variety of interests in VII data to assist with public safety, operations and maintenance of the transportation system. Some of the opportunities to be demonstrated by the Test Bed program include:

- Ability of VII to improve traffic safety
  - Active collision avoidance
  - Passive hazard warnings
  - In-vehicle warnings
  - Work-Zone notification
  - Identifying potential roadway design deficiencies to MDOT
  - Others
- Ability of VII to enhance transportation planning through improved:
  - Origin / Destination (O/D) data
  - Modeling
  - Forecasting
- Ability of VII to improve asset management programs
  - Pavement
  - Bridge
  - Sign inventories
  - Traffic Signals
- Ability of VII to improve maintenance programs
  - Snow / ice removal
  - Pot hole mapping
  - Road shoulder areas
- Ability of VII to relieve congestion thru improved traffic control strategies
  - Traffic signal actuation and operations
  - Work zones
  - Ramp metering
  - Improved performance measurement and management
  - Border crossings
  - Transit Signal Priority
  - Other opportunities
- Ability of VII to relieve congestion thru improved traffic management strategies
  - Incident management
  - Work zones
  - Improved notification to police, fire and EMS for responding to incidents
  - Improved performance measurement and management
  - Border crossings
  - Transit Signal Priority
  - Other opportunities
- Ability of VII to improve traveler information dissemination
  - En-route accident/construction/event alerts
  - Real-time detour/reroute information
  - Tourism / commerce information
  - Real-time multi-modal transfer information
  - Other opportunities

Furthermore, larger, more overarching institutional issues may need to be addressed and solutions identified to demonstrate interoperability, including:

- Who should process the VII data?
- Who should fuse the VII data?
- Who should own the VII data?
- Is data retention and backup required (which data and for how long)?

The VII Michigan Test Bed Program will also:

- Advance VII state-of-the-art technologies, research and practice
- Demonstrate and confirm how to make various systems and technologies work together across jurisdictional and proprietary boundaries in a real-world environment
- Collect data from multiple sites with different physical and traffic operations characteristics
- Provide for an environment to study international border crossing opportunities
- Demonstrate and confirm interoperability among all stakeholder participants
- Demonstrate and provide for a scaleable model VII Test Bed deployment for others who may be interested in developing their own Test Bed
- Shed light on potential private and public-sector DOT capital and annual maintenance costs needed to deploy and / or support the VII initiative
- Strengthen relationships among the VII Test Bed participating stakeholders
- Maximize the value of the public investment by deploying communications infrastructure that can be used for non-VII applications, such as ITS and traffic signal system communications.

E. Where – Where are the Geographical and Physical Locations of the VII Michigan Test Bed Program?

The VII Michigan Test Bed Program includes both field test locations and data processing / distribution locations:

- Field Test Locations - Initial field test locations where communications infrastructure and other equipment will be deployed for VII testing and validation include:
    - Auburn Hills (DaimlerChrysler)
    - Southfield (DaimlerChrysler)
    - Dearborn (Ford)
    - Farmington Hills (Nissan, Motorola and CAMP)
    - Warren (General Motors)

- Data Processing Locations – Using the Internet as the medium for collecting and disseminating VII data allows for a nearly limitless geographic range for the data processing function of the program, constrained only by the availability of high speed and reliable Internet access. However, it is anticipated that the OEM's and public agency partners will maintain data processing functions at the following locations:
    - Auburn Hills (DaimlerChrysler)
    - Dearborn (Ford)
    - Detroit (General Motors, MDOT-MITSC)
    - Farmington Hills (Nissan, Motorola and CAMP)
    - Pontiac (RCOC)

F. How – What Resources are needed to Design and Build the VII Michigan Test Bed Program?

Given the number and range of participating public and private-sector stakeholders in the VII Michigan Test Bed Program, it is essential to set forth a framework for the purpose of defining roles and responsibilities prior to identifying the requisite resources to advance the Test Bed deployments. The demarcation of roles and responsibilities is as follows:

Private-Sector Role

As shown in **Figure 4**, the private-sector will be responsible for the planning, design, implementation, integration, testing, operations and maintenance of the following elements for all Test Beds:

- Vehicle fleet (including any vehicle-to-vehicle communications hardware)
- Cellular, or other non-roadside based, communications systems
- Test Bed participant facilities/servers
- Test Bed participant Internet connection and security systems and protocols
- Any infrastructure installed on private property
- In-vehicle communications and processing (including data packetization and sending/unwrapping data)

In addition, the private sector partners will be responsible for:

- Advising MDOT as to the desired communications infrastructure to be tested at each location.
- Anonymizing and disseminating the data collected to MDOT via the Internet

An open-standards, open-architecture approach should be taken that would support and enable:

- Other private stakeholder products, protocols, and technologies to be tested
- Accepting data from other VII Test Beds (e.g., VII California, others, etc.)
- Coordination with the relevant SAE Message Set Committees (including those associated with DSRC, V2V and VII) and other pertinent standards-setting committees
- Coordination with VII Michigan vehicle probe message sets / bitmapping
- Communication with any OEM's VII-equipped vehicle with any of the test bed communications devices

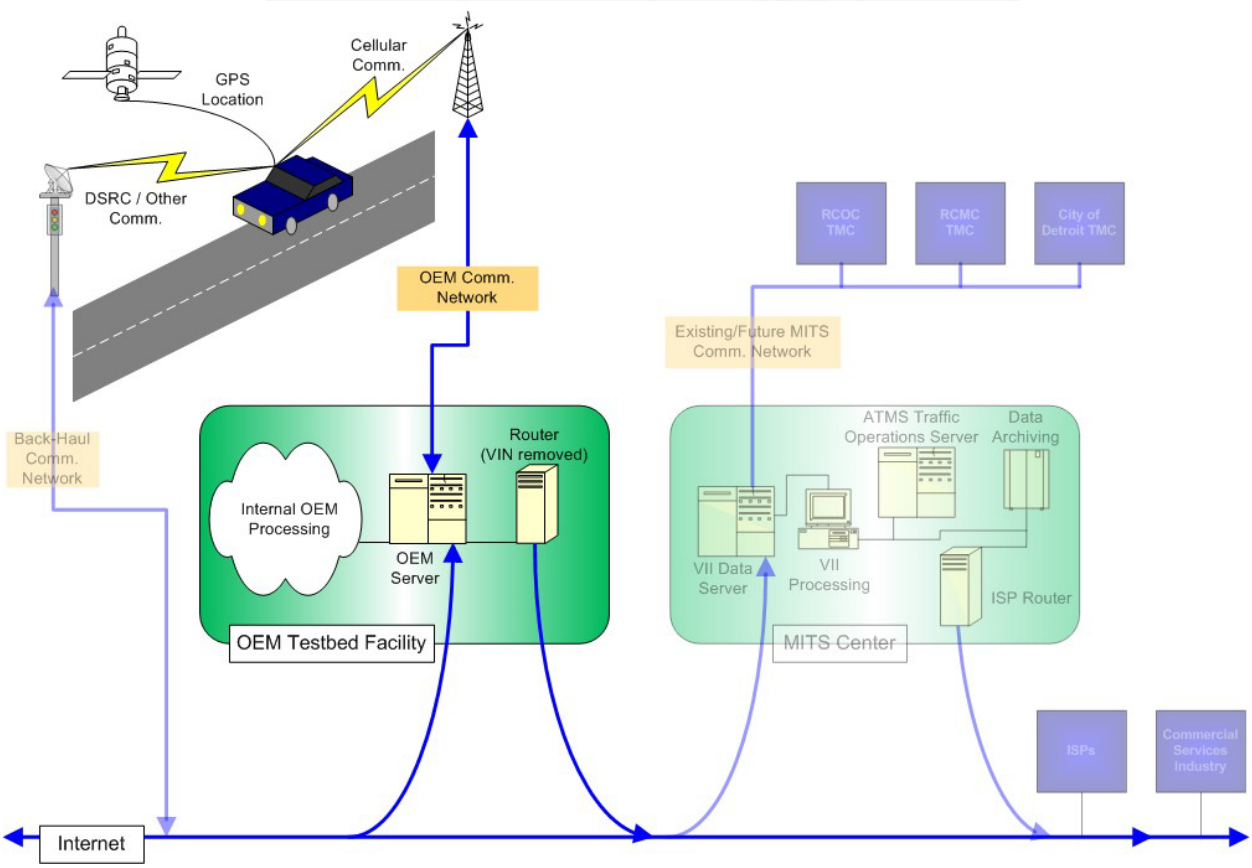

Figure 4: OEM / Private-Sector Roles and Responsibilities

Public-Sector Role

As shown in **Figure 5**, the public-sector will be responsible for the following elements for all Test Beds on public right of way:

- Development of a strategic plan for VII activities in Michigan, that includes a Mission, Vision, Goals and strategic initiatives
- Design, deployment and integration of roadside-based communications networks (subject to input from and financial agreements with each individual test bed partner) (Alternately, this could be done via a Joint Development Agreement (JDA) between 2 or more participants that have a common work package to undertake)
- Establishment of field Internet connections (subject to input from and financial agreements with each individual test bed partner)
- MITSC Internet connection and security systems
- Design, deployment, integration and maintenance of inter-agency communications linkages via the MITS communications system.
- Development of a requirements document that sets forth public-sector stakeholder requirements (e.g., data, roadside field device related issues such as design, installation, testing, right-of-way, etc.). This document will be made available to the private-sector stakeholders involved with each individual Test Bed to ensure that the specific public-sector needs are sufficiently addressed by the private-sector stakeholders.
- Archiving data provided by the OEM's. The public-sector data archive will be different than the private-sector data archive (if undertaken) as the type, format and use of the data differs between the public and the private-sectors.

- Development of a Michigan VII web site to post information regarding VII activities in Michigan, including this document (and future revisions), the Michigan VII Strategic Plan, test bed results and other information. (www.michigan.gov/mdotvii)
- Provide fleets of vehicles as appropriate and permitted, to test various VII components and subsystems and systems.
- Work with emergency service providers to incorporate their needs into the VII test bed program, both to improve current operations and to provide opportunities to test new technologies being developed primarily for emergency vehicles.
- Support the development efforts of communications protocols, systems interoperability and other components that will support VII as a standards-based development effort.
- Reviewing and approving standards within the VII community to promote interoperability amongst test bed participants.

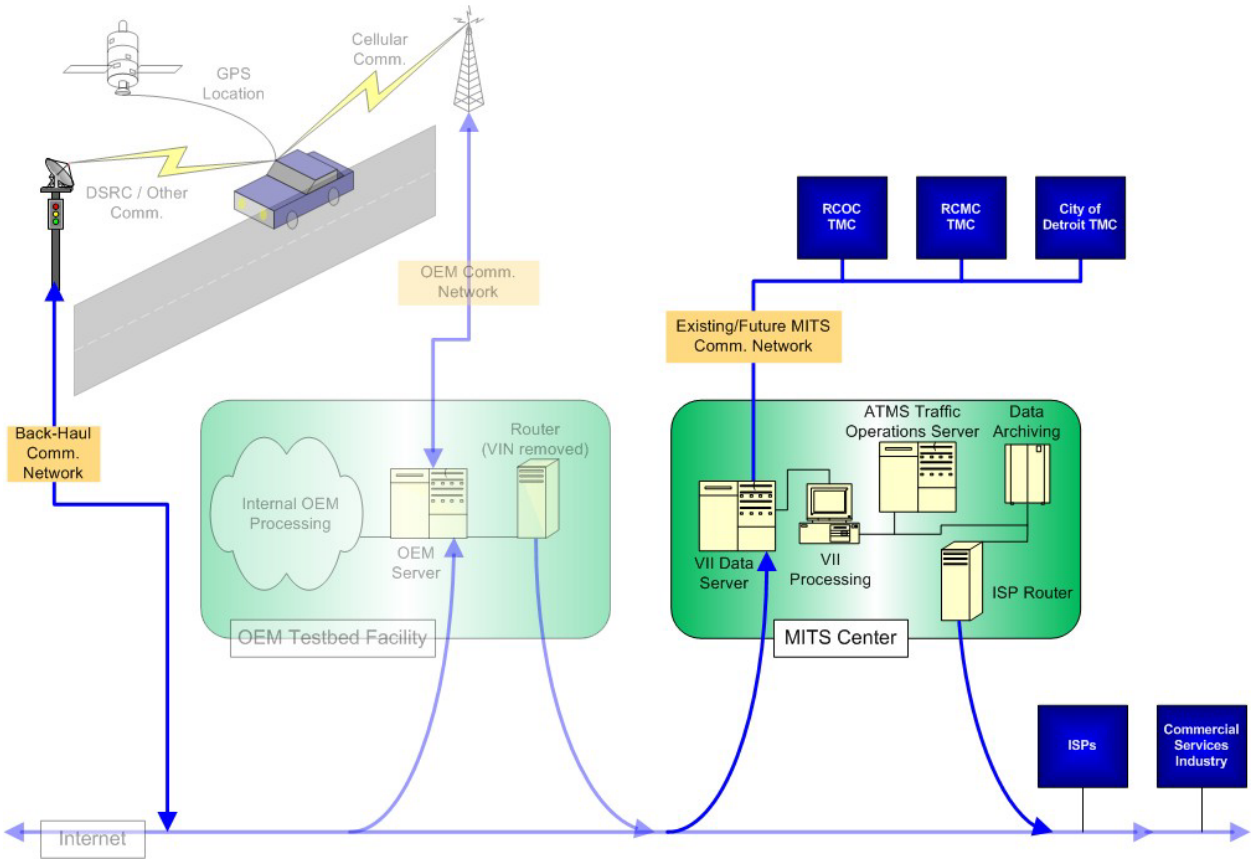

Figure 5: MDOT / Public-Sector Roles and Responsibilities

Private-Sector Requisite Resources

As each Test Bed is different, the participating private-sector stakeholders will be responsible for defining their requisite resources to implement their Test Bed elements. One common resource that will be provided for each Test Bed deployment will be the “anonymizing” of data (stripping of VIN numbers or other private identification source data) prior to distributing it outside of the Test Bed system. An option that may be considered is attaching anonymous vehicle identifications to vehicle data (can be done through anonymous Internet protocol such

as IPv6), which would allow a user system to produce, as an example, traffic flow from vehicle location data.

Public-Sector Requisite Resources
Public-sector stakeholders will need to work closely with each OEM to define what specific data and protocol will be required for fulfilling operational needs presented by the Michigan VII Program. The following provides a source of reference for defining the data to be transmitted to the public-sector stakeholders as this data becomes available and the public sector has the availability to use the data:

- Vehicle location data
- Vehicle speed data
- Anonymous vehicle ID (if applicable, although for some applications in the test bed environment, more descriptive vehicle ID's may be required, needed and used)
- Air bag activation (for incident detection/verification)
- Hazard / distress signal (for disabled vehicle and incident detection/verification)
- Antilock brake system state (for surface conditions and traffic operations)
- Wiper system on/off and speed ((for surface conditions, maintenance operations, and traffic operations)
- Headlights on/off (for traffic operations)
- Exterior temperature (for surface conditions, maintenance operations, and traffic operations)
- Fog lamps (for travel conditions and traffic operations)
- Rear window defrost (possibly for travel conditions)
- Brake applied status (verification of operational braking)
- Turn signal (could be used in traffic control operations)
- Obstacle distance
- Rain sensor (for surface conditions, maintenance operations, and traffic operations)
- Sun sensor (for maintenance operations)
- Road condition sensor (for maintenance and asset control operations)

The public-sector will follow an interdisciplinary-based systems engineering process as shown in **Figure 6** to develop the above-captioned requirements document to be shared with the private-sector stakeholders of each Test Bed. Following a structured process will be essential if the VII Michigan Test Bed Program is to be successful. The widely accepted systems engineering process will:

- Ensure participating public and private-sector stakeholders needs are satisfied throughout a Test Bed's life cycle
- Reduce the risk of unnecessary or unrealistic requirements
- Ensure an efficient investment of MDOT funds
- Avoid problems of the past
- Improve Test Bed reliability and stability
- Improve the chance of seeing Test Beds come to fruition on-time and on-budget
- Aid in attracting other private-sector stakeholders to develop their own Test Bed for the purpose of testing new products and technologies

<u>High Level Requirements</u>
Upon acceptance of the Concept of Operations (COO), the next step in the systems engineering process is to complete requirements development for the interface between the OEM Test Bed

Facilities and MDOT/Public-Sector Element. Functional requirements will define what, and not how, functions, expected outcomes, expected interface definitions and performance objectives are to be met by the Test Bed from the MDOT (or other public-sector stakeholders) perspective. Types of requirements are likely to include:

- Functional requirements
- Interface requirements
- Data requirements I.e. what type of information should be stored
- System life-cycle cost requirements
- Performance requirements
- Testing requirements

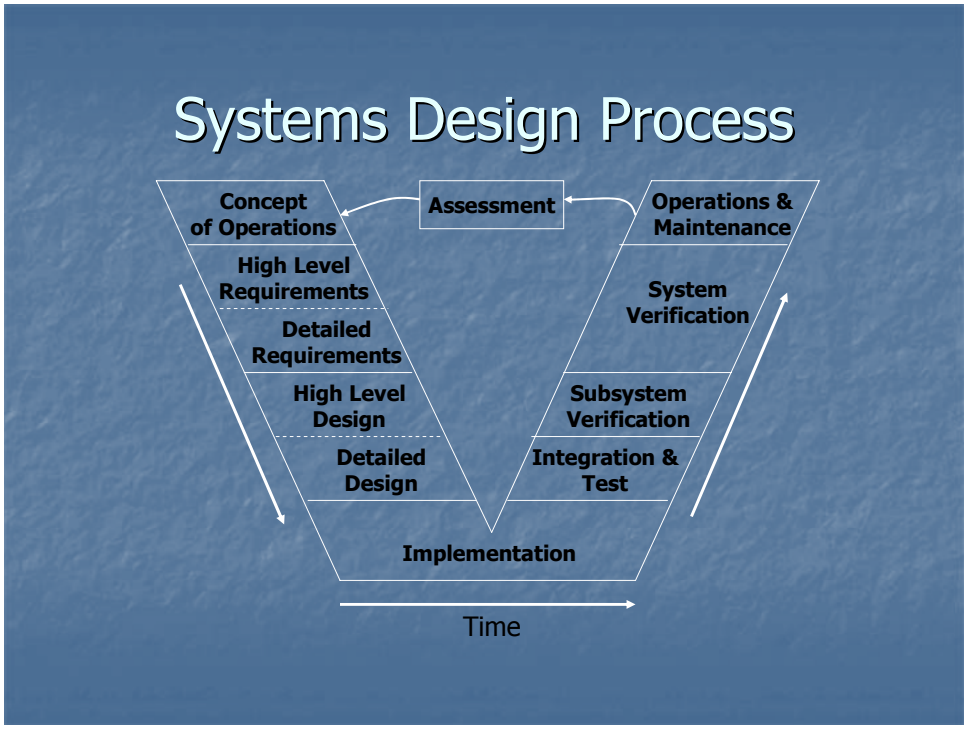

Figure 6: Public-Sector Test Bed Design Approach

System Design

The system design will help ensure the proper selection of system components and their interconnection so as to meet the system requirements and the preparation of specifications that describe the design. This is the phase of the system engineering process where MDOT will finalize the decision on what type of long-haul communications will be deployed between the Test Bed Control Center(s) and MITSC.

After system design, deployment, testing, operations and maintenance of the selected communications infrastructure are the remaining steps.