separate efforts were undertaken in order to develop costs that better reflect the operating conditions in northern Michigan. Several sources were used to develop costs:

- The Michigan ITS Typical Deployment report and Systems Communications reports were reviewed. It includes descriptions, conceptual drawings and unit cost estimates for typical deployments of ITS components, including freeway management, arterial management and some specialized applications such as railroad grade crossing applications and "smart" park-and-ride lots.
- MDOT cost data for operations and maintenance of the Detroit and Grand Rapids systems were obtained, as well as costs for recent ITS capital purchases. The System Communications report included alternative operating and communications strategies for implementing alternative deployments. While the Typical Deployment report focused on field deployment, this report focuses primarily on center-to-center requirements.

These sources were used to develop data for input into the IDAS cost module. IDAS provides information, such as assumed equipment life, that is used to develop life-cycle costs for the identified projects. Preliminary estimates of life-cycle costs and resource requirements were developed for the initial IDAS runs and then modified based on a review of the results. While preliminary design work is essential to refine cost estimates, the results of this study provide a reasonable initial estimate for up-front capital and ongoing O&M costs required for successful deployment of identified alternatives.

Table 18 shows the unit costs assumed for the study area deployments. These are based primarily on procurements in Michigan but supplemented with information from the IDAS database. This includes both capital items, which were amortized based on the number of years and a 3% interest rate and operations and maintenance costs, which are designated in the years column by an entry of Annual.

Table 18 - Unit Costs

Units	Years (1)	Description	Unit Price
Ea	10	ITS Cabinet (Ground Mounted)	$15,000
Ea	10	Microwave Vehicle Detection System (MVDS)	$25,000
Ea	5	Midblock Detector	$15,000
Ea	10	CCTV Camera	$45,000
Ea	10	CCTV Camera with MVDS	$55,000
Ea	20	Dynamic Message Sign (DMS)	$180,000
Yr	Annual	Communications for DMS	$500
Mi	30	Fiber Optic Backbone	$175,000
Ea	30	Wireless Communications Link - Unlicensed (5 miles or less)	$12,000
Ea	30	Wireless Communications Link - Licensed Backhaul	$150,000
Ea	30	Wireless Communications Tower (200')	$250,000
Ea	30	Retrofitted 800MHz Radio Tower	$50,000
Ea	20	Highway Advisory Radio Site	$50,000
Ea	10	Highway Advisory Sign w/ Flashing Beacon	$14,000
LS	10	Highway Advisory System Software	$74,000
LS	10	Highway Advisory Radio Central Equipment	$5,000
LS	10	Highway Advisory Software Integration	$50,000
LS	10	ATMS Software Set-up	$25,000
Ea	10	Refurbish Existing Network Surveillance Systems	$150,000
Ea	Annual	Operation of Parking Management System	$125,000
LS	Lump sum	Maintenance of Traffic (less than 7 signals)	$11,000
LS	Lump sum	Maintenance of Traffic (7 or more signals)	$16,000
Ea	15	Wireless Interconnect for Master Intersection	$11,000
Ea	15	Wireless Interconnect for Slave Intersection	$5,000
Ea	15	Replacement of Signal Controller	$5,000
Ea	Annual	Full Time Freeway Service Patrol Driver	$62,400
Ea	Annual	Full Time Freeway Service Patrol Supervisor	$83,200
Ea	Annual	Freeway Service Patrol Vehicle	$62,400
Ea	Annual	Weekend Only Freeway Service Patrol Driver	$18,000
Ea	Annual	Weekend Only Freeway Service Patrol Supervisor	$24,000
Ea	10	RWIS Control System	$25,000
Ea	10	ITS Control System	$40,000
Ea	15	Reduced Power RWIS ESS	$68,000
Ea	15	Basic RWIS ESS	$78,000
Ea	15	Enhanced RWIS ESS	$116,500
Ea	10	Anti-Icing System	$150,000
Ea	Annual	Annual Maintenance and Replacement Costs per RWIS ESS	$8,000
Ea	Annual	Annual Training and Operational Costs per RWIS ESS	$700
Ea	Annual	Annual Maintenance Costs per Anti-Icing System	$6,500
Ea	Annual	Annual Cost of Telephone Connection	$500
Ea	Annual	Annual Training and Operational Costs for TMC	$500,000
Ea	Annual	Smart Work Zone Mobilization	$100,000
Ea	Annual	Monthly rental of equipment	$20,000
Ea	1	TMC: Level II New facility	$500,000
Ea	1	TMC: 1/2 of Level II New facility	$250,000
Ea	5	AVL System for regional transit vehicles	$500
Ea	5	System Interface	$10,000
Ea	10	Computer Hardware	$15,000
Ea	10	System Software	$815,000
Sys	Annual	Operations and Maintenance for Traffic Management System	$150,000

(1) This column shows the assumed annual life of each component.

These components were combined in order to form the deployment packages analyzed for the project. The deployment combinations shown where specifically developed as part of this process for the study area are shown in the following **Table 19**. Detailed results of the benefit/cost evaluation are shown in Section 4.

Table 19 - Major Components of ITS Deployment Packages

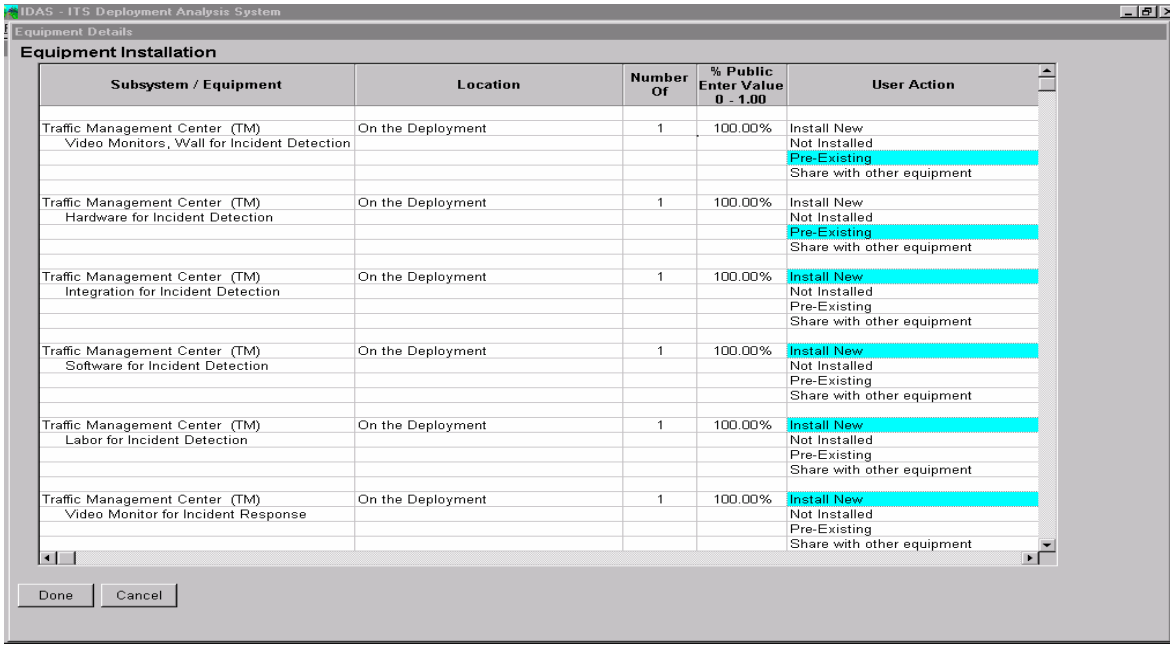
Qty	DEPLOYMENT PACKAGES AND EQUIPMENT
	Freeway Service Patrol Package
3	Freeway Service Patrol Vehicle
6	Weekend Only Freeway Service Patrol Driver
4	Weekend Only Freeway Service Patrol Supervisor
	Traffic Signal Improvement Package
29	Maintenance of Traffic (less than 7 signals)
15	Maintenance of Traffic (7 or more signals)
44	Master Wireless Link
225	Slave Wireless Link
	Freeway Management System
51	Dynamic Message Sign (DMS)
4	Communications for DMS
56	CCTV and Freeway Vehicle Detection
100	CCTV Camera
87	Freeway Vehicle Detection
212	ITS Ground Mounted Cabinet
4	ITS Control System
87	Fiber Optic Backbone (Miles)
26	Licensed backhaul to TMC
27	Wireless Communications Towers
95	2/10th Mile Markers Signing for Urban Areas (Miles)
43	Lighted Trailblazer Sign
22	Arterial CCTV Camera
86	Arterial Vehicle Detection
Annual	Annual Training and Operational Costs for TMC
	Road Weather Information System
1	RWIS Control System
9	Reduced Power RWIS ESS
11	Basic RWIS ESS
5	Enhanced RWIS ESS
17	Anti-Icing System
Annual	Annual Maintenance Costs per Anti-Icing System
Annual	Annual Maintenance and Replacement Costs per RWIS ESS
Annual	Annual Training and Operational Costs per RWIS ESS
Annual	Annual Cost of Telephone Connection
	Highway Advisory Radio Package
14	Highway Advisory Radio Sites
16	Highway Advisory Sign w/ Flashing Beacon
	Smart Work Zones
5	Smart Work Zones in Region (2008)
15	Months of Smart Work Zone Lease/Rental (2008)
	Advanced Public Transportation Systems
2	Automated Vehicle Location Hardware, Software and Dispatcher Interface
89	Bus AVL Units
Annual	Maintenance and Dispatching Labor for AVL system

Once alternatives are evaluated in IDAS, the software produces several cost-related outputs that are valuable in refining the alternatives and developing an implementation plan:

- Inventory of ITS equipment needed to deploy the identified alternatives;
- Identification of potential cost-sharing opportunities where ITS equipment may be shared between two different deployments.
- Summary of the capital and ongoing O&M costs of the planned ITS improvements for the public and private sectors;
- Forecast of the life-cycle stream of costs for the improvement on a year-by-year basis; and
- Estimate of the average annual cost for each individual improvement and for all improvements.

The inventory of equipment needed will be produced by the IDAS software for each improvement specified by the model user. **Figure 21** shows a sample inventory of some of the equipment necessary to deploy an incident detection system. This inventory is based on ITS equipment packages required in the ITS National Architecture to deploy the various improvements; use of the same ITS equipment as in the National ITS Architecture guarantees compatibility of the plan with the Architecture. After initial review of the inventory developed by IDAS and the costs incurred in the development of the existing ITS system, packages and deployments were modified.

Figure 21 - IDAS – ITS Deployment Equipment Details



Subsystem / Equipment	Location	Number Of	% Public Enter Value 0 - 1.00	User Action
Traffic Management Center (TM)	On the Deployment	1	100.00%	Install New
Video Monitors, Wall for Incident Detection				Not Installed
				Pre-Existing
				Share with other equipment
Traffic Management Center (TM)	On the Deployment	1	100.00%	Install New
Hardware for Incident Detection				Not Installed
				Pre-Existing
				Share with other equipment
Traffic Management Center (TM)	On the Deployment	1	100.00%	Install New
Integration for Incident Detection				Not Installed
				Pre-Existing
				Share with other equipment
Traffic Management Center (TM)	On the Deployment	1	100.00%	Install New
Software for Incident Detection				Not Installed
				Pre-Existing
				Share with other equipment
Traffic Management Center (TM)	On the Deployment	1	100.00%	Install New
Labor for Incident Detection				Not Installed
				Pre-Existing
				Share with other equipment
Traffic Management Center (TM)	On the Deployment	1	100.00%	Install New
Video Monitor for Incident Response				Not Installed
				Pre-Existing
				Share with other equipment

Based on the agreed-upon list of ITS equipment for the preferred alternative(s), a detailed breakout of the life-cycle costs was estimated using IDAS and presented in the IDAS reports as year-by-year breakouts of anticipated costs. This stream of costs includes the up-front capital costs necessary for deployment, the equipment replacement costs necessary to replace obsolete equipment in later years, and the continuing O&M costs necessary to operate the improvements.

The stream of life-cycle costs for the various improvements is used as the basis of the average annual cost figure in IDAS. This average annual cost figure was used for comparison with the average annual benefits figure calculated by the model to provide a benefit-cost ratio for the alternative.

3. DEPLOYMENT PLAN

3.1 Deployment Plan Projects

Developing the initial list of projects to study within the Deployment Plan began, as noted earlier, with the Architecture itself. Based on the input from the Southwest and University region and its stakeholders, a number of ITS services and associated Market Packages were identified. Translating those services and Market Packages into projects is the first step of the deployment plan. This translation was done initially at a functional level by the Study Team and that initial list is presented in **Table 20** below. This table contains the following elements:

- The Architecture category the project falls under;
- A brief project title;
- A relative cost estimate for that type of project;
- Expected benefits of that project;
- Relevant Market Package from the Architecture; and
- The Market Package's Regional priority.

This initial list however, is only the first step in developing projects to study in the Deployment Plan. The next step involved a screening process which would eliminate projects that were not appropriate for the scope of the Deployment Plan. The screening process would also, through stakeholder input, develop detailed projects which could then be analyzed and ranked against each other.

The subsequence sections describe the portions of the deployment that are unique to the Southwest Region and portions of the University Region study area.

Table 20 - Initial List of Deployment Plan Projects

Market Package Regional Priority	Category	Project	Cost	Benefit Parameters	Relevant Market Package
HIGH	Advanced Transit Management System	AVL systems	$$$	– Increased ridership – Reduced schedule delays – Reduction in operating cost per hour/unanticipated overtime costs	APTS1 – Transit Vehicle Tracking
HIGH	Advanced Transit Management System	Electronic Fare Payment	$$$	– Reduced fare collection costs – Possible operating cost reductions due to more efficient operation (faster boarding times)	APTS4 – Transit Passenger and Fare Management
HIGH	Advanced Transit Management System	DMS with Real-Time Bus Schedule Information	$$	– Improve rider experience	APTS8 – Transit Traveler Information
HIGH	Travel and Traffic Management and Maintenance and Construction Management	Roadway Closure Management System	$	– Reduced frequency of roadway closures – Reduced accidents related to closures – Reduced delay related to closures	ATIS1 – Broadcast Traveler Information MC08 – Work Zone Management
HIGH	Traveler Information	Kiosks with Fare and Traveler Information	$$	– Improve rider experience	ATIS1 – Traveler Information
HIGH	Traveler Information	Web Site Information	$$$	– Reduced delays – Improved travel time information	ATIS2 – Interactive Traveler Information
HIGH	Travel and Traffic Management	Network Surveillance	$$	– Reduced incident response time – Reduced incident-related delays – Reduced secondary crashes	ATMS01 – Network Surveillance
HIGH	Travel and Traffic Management	Sharing of CCTV Video Feeds	$$$	– Reduced incident response times – Reduced incident related traffic delays – Reduced operating cost (from more efficient deployment of resources)	ATMS06 – Traffic Information Dissemination

Market Package Regional Priority	Category	Project	Cost	Benefit Parameters	Relevant Market Package
HIGH	Travel and Traffic Management	Regional Parking System Management for Commercial Vehicles (Interstate)	$$	– Reduced travel time by guiding CV's to closest open spot – Reduced crashes resulting from illegal/unsafe parking	ATMS17 – Regional Parking Management
HIGH	Travel and Traffic Management	Real-Time Speed Detection and Monitoring	$	– Reduced crashes from more effective speed reduction – Reduced operating costs for data collection	ATMS19 – Speed Monitoring
HIGH	Emergency Management	Common Radios	$$$	- Reduced incident response times - Reduced incident related traffic delays - Reduced operating cost (from more efficient deployment of resources)	EM01 – Emergency Call-Taking and Dispatch
HIGH	Emergency Management	Emergency Signal Preemption	$ per	– Reduced emergency vehicle response time – Improved vehicle safety	EM02 – Emergency Routing
HIGH	Emergency Management	Vehicle Tracking for MSP, Local Public Safety, and Maintenance Vehicles	$$$	– Reduced incident response times – Reduced operating costs	EM02 – Emergency Routing
HIGH	Emergency Management	Evacuation and Disaster Traveler Information System	$$	– Improved information dissemination and management of evacuations / emergencies	EM02 – Emergency Routing
HIGH	Maintenance and Construction Management	Maintenance Tracking using GPS for Maintenance Vehicles and Snowplows	$$$	– Reduced response time for maintenance crews – Reduced winter maintenance costs – Reduced Weather-related crashes	MC01 – Maintenance and Construction Vehicle and Equipment Tracking
HIGH	Maintenance and Construction Management	RWIS System	$$$	– Reduced weather-related crashes – Reduced winter maintenance costs	MC03 – Road Weather Data Collection MC04 – Weather Information Processing and Distribution
HIGH	Maintenance and Construction Management	Anti-Icing Installations Connected to RWIS	$$	– Reduced crash rate – Reduced incident-related delays – Reduced operating cost	MC05 – Roadway Automated Treatment

Market Package Regional Priority	Category	Project	Cost	Benefit Parameters	Relevant Market Package
HIGH	Maintenance and Construction Management	Smart Work Zone and Work Zone Management Systems	$$	– Reduced work zone related delays – Reduced work zone-related crashes	MC08 – Work Zone Management
MEDIUM	Advanced Transit Management System	CCTV and Panic Buttons for Security	$$	– Possible ridership increase – Improved rider safety and security	APTS5 – Transit Security
MEDIUM	Traveler Information	Traveler Information at Rest Stations and Truck Stops	$	– Improved information for CVO operators	ATIS1 – Traveler Information
MEDIUM	Traveler Information	511	$$$	– Reduced delays – Improved travel time reliability	ATIS2 – Interactive Traveler Information
MEDIUM	Travel and Traffic Management	Real-Time Speed Detection and Monitoring	$	– Reduced crashes from more effective speed reduction – Reduced operating costs for data collection	ATMS19 – Speed Monitoring
MEDIUM	Commercial Vehicle Operations (non-MDOT)	Weigh-in-Motion Stations	$ per	– Reduced enforcement cost – Longer lasting roads	CVO06 – Weigh-in-Motion
LOW	Emergency Management	Roadway Service Patrols on Major Corridors	$$	– Faster incident response times – Reduced secondary crashes – Reduced fatalities due to faster response – Reduced delays	EM04 – Roadway Service Patrols
LOW	Travel and Traffic Management	Signal Coordination at RR Crossings	$$	- Reduced travel time - Improved travel time reliability	ATMS13 – Standard Railroad Grade Crossing
LOW	Travel and Traffic Management	Drawbridge Management System	$$ Per	– Reduced delays – Improved travel time reliability	ATMS20 – Drawbridge Management

3.1.1 Freeway Closure Notification

The study area includes freeways that are frequently closed as a result of weather and traffic incidents. When these events occur, traffic is routed off of the freeway at the last interchange prior to the freeway segment in which the weather or a traffic incident has impacted the freeway. A crash that results in a hazardous material spill or a fatality can close a freeway for an extended period of time. In addition, some freeway segments would need to be closed in the event of a nuclear power plant situation, so that motorists are warned about entering a zone that may contain radiation.

ITS infrastructure is a critical element that can provide traveler information in advance of the freeway closure, allowing motorists and commercial vehicles to choose an alternate route. With sufficient advanced information, the motorist delay as a result of the freeway closure can be minimized. This section describes ways in which the ITS system can provide traveler information in advance of the freeway closure.

When deployed, DMS signs located throughout the study area will allow freeway closure information to be posted well in advance of the actual freeway closure location. For example, if I-94 is closed near Galesburg, DMS would provide freeway closure information on freeway sections approaching I-94 (such as US-131, US-127, I-69, and I-194) and at multiple points along I-94. A portion of the traffic affected by the closure would then have the opportunity to reroute to another freeway or highway.

Commercial vehicle shipping is particularly impacted by freeway closures. Manufacturing facilities that depend on just-in-time (JIT) inventory control are affected when shipments do not arrive in time, which has an adverse economic impact. Since many commercial vehicles have contact with a dispatch center, notification of a freeway closure could occur via the dispatch center. Email, text message or other electronic notification can be provided to the dispatch center, which will allow dispatch to provide information to commercial vehicles in the vicinity of the freeway closure. A manually-sent email distribution list is currently maintained by MDOT to notify its partner maintenance agencies along the I-94 corridor when closures occur, which could be used to notify commercial vehicle dispatch centers as well. In the future, automated messages of various types can be sent to all interested parties when the new ATMS software is deployed and utilized within the study area.

In the future, communication with passenger vehicles and commercial vehicles will provide a direct method of notifying motorists. This application will require the deployment of vehicle infrastructure integration (VII), which will include an extensive communications infrastructure along roadways. In addition to freeway closure information, real-time traffic and weather information may also be provided directly to the vehicle. MDOT and its partner VII partners are currently investing in VII test beds to evaluate the capabilities and benefits of VII in southeast Michigan, and is one of the lead states involved with the national VII initiative.

3.1.2 Advanced Emergency Route Deployment

Due the severe effect closures of I-94 have on drivers, commercial vehicles, and local and state economies, MDOT has developed and signed emergency routes along the entire stretch of I-94 in the Southwest Region and Portions of University Region study area. Some of these emergency routes direct traffic through urban areas with high traffic signal density. In order for an emergency management route to operate smoothly though these urban areas, the traffic signals need to be coordinated, and have the ability to automatically switch timing schemes to accommodate the increased traffic volume exiting from I-94. To make this system work, an advanced emergency route system is needed along the urban routes with high signal density.

The advanced emergency route system idea was suggested during stakeholder discussions at the Deployment Plan Meeting on August 21, 2007. The conceptual plan of this system includes the following on emergency routes that are serviced by:

- Signal interconnects for all signals on the emergency route
- System detection upstream from key intersections
- Video surveillance at key intersections
- Lighted trailblazer signs upstream from key intersections

The lighted trailblazer signs will provide positive guidance to drivers unfamiliar with the area, and will likely increase the comfort level of drivers who wish to return to I-94. A key intersection is defined as an intersection where the emergency route directs the driver to make a turn from one road onto another road. A typical incident management route along I-94 is can be seen in **Figure 22**. Like many I-94 incident management routes, the figure shows two of these key intersections: one at the location where the road leading away from I-94 intersects the road running parallel to I-94, and one at the location where the road running parallel to I-94 intersects the road leading back towards I-94.

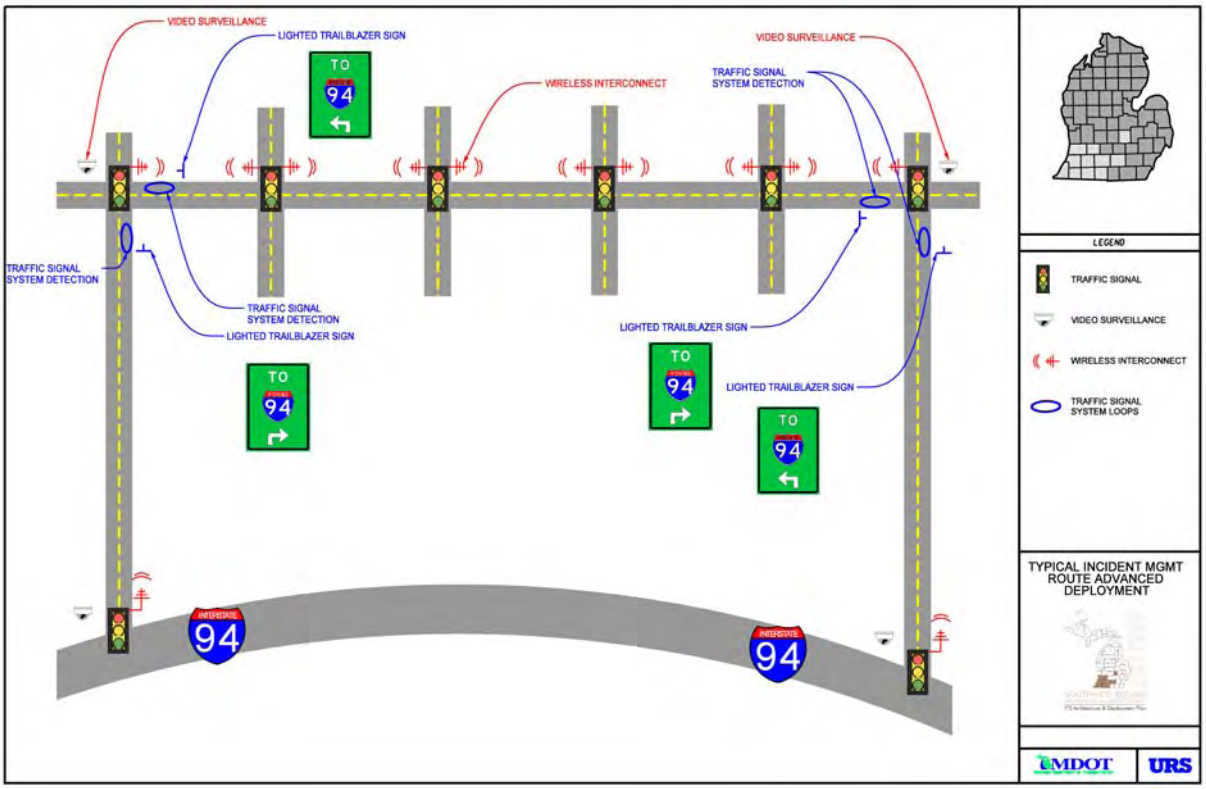
The increased traffic volumes on the incident route associated with traffic diverting from I-94 are detected by the system detection at the key intersections. When a pre-determined volume threshold is reached, the traffic signal system will automatically update to an emergency management timing plan. This timing plan will activate the lighted trailblazer signs upstream from key intersections. When the emergency route timing plan is activated at a key intersection, the other signals in the emergency management route are also updated to the emergency management timing plan through the signal interconnect. When the system detectors detect volumes below a pre-determined volume threshold, the signals will return to normal operation.

This advanced emergency management route system will improve the utility and reduce the delay of vehicles that use urban arterials when incidents occur on I-94. **Table 21** identifies urban corridors recommended to receive this system.

Table 21 - Advanced Emergency Route Deployment

I -94 Closure Points	Incident Management Routes	Total Number of Signals
Coloma TSC		
Exit 23 - Exit 27	Red Arrow Highway to Hilltop Rd to M-63 (Niles Ave) to I-94	5
Exit 27 - Exit 28	M-63 (Niles Ave) to Miners Rd to M-139 to I-94	1
Exit 28 - Exit 30	M-139 to E. Napier Ave to I-94	7
Kalamazoo TSC		
Exit 72 - Exit 74	9th St to Stadium Dr to US-131 to I-94	6
Exit 74 - Exit 75	US-131 to Center Ave to Oakland Dr to I-94	7
Exit 75 - Exit 76	Oakland Dr Ave to Milham Rd or Kilgore Rd to Westnedge Ave to I-94	13
Exit 76 - Exit 78	Westnedge Ave to Kilgore Rd to Portage Rd to I-94	15
Exit 78 - Exit 80	Kilgore Rd to Sprinkle Rd to I-94	5
Marshall TSC		
Exit 95 - Exit 97	Helmer Rd to Beckley Rd to Capital Ave to I-94	2
Exit 97 - Exit 98	Capital Ave to Beckley Rd to M-66 to I-94	6
Exit 98 - Exit 100	M-66 to Beckley Rd to Beadle Lake Rd to I-94	5
Exit 100 - Exit 103	Beadle Lake Rd to Columbia Ave to E Michigan Ave to I-94	6
Jackson TSC		
Exit 136 - Exit 137	M-60 to I-94BL to Airport Rd to I-94	7
Exit 137 - Exit 140	Airport Rd to West Michigan Ave to M-106 (Cooper St) to I-94	20
Exit 140 - Exit 142	M-106 (Cooper St) to West Michigan Ave to M-127 to I-94	9

Figure 22 - Advanced Incident Management Route Deployment



3.1.3 Commercial Vehicle Parking Information

Overnight commercial vehicle parking is a significant issue for the Southwest Region. In particular, the I-94 corridor currently experiences a demand for truck parking that exceeds the available capacity. The USDOT requirements for hours of commercial vehicle operation and the just-in-time nature of delivery makes identifying the right place for overnight parking a challenge to trucking companies.

In addition to private truck stops, there are 2 MDOT-operated truck parking areas in the Southwest Region, which are rest areas that have been converted for exclusive truck use. Truck parking also occurs at the MDOT-operated rest areas.

The stakeholders expressed an interest in providing information about availability of truck parking. In response, the freeway deployment plan includes CCTV at all MDOT-operated rest areas and truck parking areas. The video can be shared via the Internet with truck dispatch personnel who may direct truck operators as to where to park overnight. Kiosks at MDOT rest areas may be utilized in a similar way by independent truck operators looking for overnight truck parking opportunities.

Ultimately, mitigating the overnight truck parking issue may lead to a public-private partnership. In one form, this partnership may include private truck stops, MDOT-operated rest areas, truck company dispatch, and the MDOT-operated ITS system to share information and possibly facilitate a truck parking space reservation system.

In 2008, MDOT will be studying commercial vehicle parking along the I-94 corridor across the state.

3.1.4 Traffic Management Center Configuration

Statewide, there are currently two MDOT TMCs in operation in the Metro Region (Detroit) and Grand Region (Grand Rapids), and two additional TMCs are in the planning phase, the Statewide TMC in Lansing and North Region in Gaylord.

In the next 5 years, the Southwest Region does not plan to develop a TMC specifically for the Southwest Region. The capabilities and equipment will be available at the Southwest Region office, but dedicated staff (operators) are not likely to be assigned to this task. Existing Southwest Region staff will operate the system when required, and assistance by another TMC will be requested on an as-needed basis. As the ITS system deployment matures, the Southwest Region may elect to have dedicated, on-site staff at the Southwest Region Office or at another TMC, such as the West Michigan TMC.

The University Region will utilize the facility developed for the Statewide TMC in Lansing. Similar to the Southwest Region, University Region staff will operate the system when required, and assistance by another TMC will be requested on an as-needed basis. As the ITS system deployment matures, the University Region may elect to have dedicated, on-site staff at the State-wide TMC.

The MDOT TSCs will also have access to the ATMS software either via the Internet or the MDOT network. TMCs developed by local agencies will have limited access via the Internet.

3.1.5 DMS and HAR Deployment at Major Interchanges

HAR provides additional message capability beyond the limitations of the text that can be placed on a DMS. This capability is likely to be particularly helpful in critical locations where travelers have options that are nearly equal in quality to avoid an incident or traffic congestion. For example, delays at the international border crossings with Canada in Detroit or Port Huron and incidents along I-94 may require the HAR messaging capability for a commercial vehicle to select the path with the least delay, which would include either I-69 or I-94.

A combination of DMS and HAR are shown at six critical points on the freeway system: the I-94 interchanges with I-196, US-131, and I-94, and the points of entry into the state near US-12 at the interchanges with I-94, US-31, and I-69. These locations offer motorists with the opportunity with diverting to other state routes and/or freeways.

A study conducted by the Ohio-Kentucky-Indiana Regional Council of Governments found that 24% of vehicles saved an average of 17 minutes of travel time as a result of deploying DMS messages. HAR messages were utilized by 5% of vehicles, resulting in 25% of those vehicles saving an average of 4 minutes of travel time.

HAR deployment at key decision points that provides timely and accurate information will be used by motorists. However, updating the messages at 15 to 30 minute intervals and selecting equipment that provides a high-quality audio experience is critical to maintaining the credibility of the system. The operational aspect of HAR must be fully developed and funded prior to deployment in order to maximize its benefits.

3.1.6 ITS Communication Assumptions

The ITS communications assumptions included in the deployment plan were developed to help develop the capital, operations, and maintenance cost estimates. The area of communications is continuously developing and changing, similar to the rapid changes over

the past 10 years. ITS communications is typically comprised of backhaul (long-distance communications) and shorthaul (communications between a field device and the backhaul communications system). The most significant cost factor lies with selecting the backhaul communications system.

In the urban areas, fiber-optic cable was used as the backhaul communications system as a result of the higher density of ITS field devices and the resulting higher communications bandwidth (capacity) requirements. The capacity of the fiber-optic cable could be fully utilized by sharing fiber with other agencies, which may result in cost-sharing for maintaining the communication system.

In the rural areas, wireless communications was used as the backhaul communications system due to the longer distances between ITS devices and lower communications bandwidth requirements. Towers were located at 10-mile intervals to transmit ITS data back to a central point, and the towers that serve the existing Michigan Public Service Communications System (MPSCS, or 800 MHz system) were used when applicable from a geographic perspective. The MPSCS is owned by the State of Michigan and is primarily used by the Michigan State Police. Further discussions are needed to confirm that the MPSCS towers can be used in this manner, or as part of separate wireless communications system.

These assumptions have a significant impact on the capital cost of the ITS deployment, and each communications type has its advantages and disadvantages. In general, wireless communications is less expensive to deploy than fiber-optic cable, but does not currently have comparable bandwidth capacity. However, the bandwidth of wireless communications continues to grow and is becoming less expensive. The maintenance requirements and typical operational issues with each communications system are different, requiring specialized skill sets for maintenance purposes. Fiber-optic cable is susceptible to inadvertent cuts by construction activity and requires immediate repair operations if cut, however wireless communications equipment is more vulnerable to frequency interference as reliance on wireless communications continues to grow.

Further refinement of the communications concepts will occur as each ITS deployment is designed. MDOT will be conducting an ITS communications study of the I-94 corridor within the next year.

3.1.7 2/10th Mile Markers

2/10th Mile markers are included in the freeway deployment for urban areas of Kalamazoo, Jackson, Battle Creek, and Benton Harbor / St Joseph. These signs have shown to improve the ability to accurately locate incidents. In Comstock Township, emergency vehicles are dispatched in both directions on I-94 between mile markers 81 and 88 to avoid missing the incident location, since there are limited locations to turn around if the incident location was incorrectly identified.

3.2 Screening Process

The projects that were initially derived from the Regional Architecture and presented in **Table 20** represent all of the potential projects that are discussed in the Architecture. Some of these projects are not appropriate for the scope of the Deployment Plan, so a screening process was developed to narrow the focus of the types of projects as well as develop regionally specific projects. This screening process is the subject of this section.

Thirty-four projects were initially derived from the Architecture. Of these projects, five were eliminated from consideration from this plan for the following reasons:

- Tracking CV Contents - *Removed for lack of viable benefits data*
- CV Central Permitting Systems - *Removed for lack of viable benefits data*
- Roadside Equipment for Automated Highway System - *Removed because covered under statewide VII initiative currently under development*
- Intersection Collision Avoidance Systems - *Removed because covered under statewide VII initiative currently under development*
- Data Archive for Traffic, Incident, and Weather Data - *Removed for overlapping other project functions*

In order to develop regionally specific projects with project limits and specific deployments, the 29 remaining projects were then grouped into eleven project packets. These project packets were based on real-world deployment functionality and designed to illustrate how these individual projects would be deployed together in order to achieve the desired benefits. For example, DMS signs would typically not be deployed to provide traveler information without detection or CCTV cameras, which would ensure the traveler information is accurate and timely. The final list of these project packets is presented in **Table 22**. The table includes primary as well as secondary deployments. The secondary deployments were meant to represent project components that would not necessarily be needed to achieve the packets base functionality, but could be added to augment and improve its functionality.

The initial list of 29 projects as well as the eleven project packets were presented to the Southwest and University Region stakeholders in a Deployment Plan Workshop held on August 21, 2007. At this meeting, the stakeholders were asked for their input in ranking the project packets. A pair-wise comparison exercise was utilized to solicit their opinions and the results are presented in **Table 22** in order of their priority.

The stakeholders were also broken out into three break-out groups around three key functional areas:

- Weather and Maintenance
- Commercial Vehicle Operations and Transit
- Traffic Incident Management and Freeway and Arterial Management

During these break-out sessions, stakeholders worked with the Study Team and developed regionally specific projects; including project limits as well as locations of key field devices. This effort resulted in the final list of projects which would be used in the deployment plan analysis outlined above. These projects are presented in Section 3.3.

Table 22 - Deployment Plan Project Packets

Project Packet	Project
Traffic Management Packet	Network Surveillance Real-Time Speed Detection and Monitoring Roadway Service Patrols on Major Corridors Emergency Signal Preemption Common Radios Sharing of CCTV Video Feeds Roadway Closure Management System Evacuation and Disaster Traveler Information System
RWIS Packet	RWIS Surveillance (CCTV) Frost Tubes Anti-Icing Installations Connected to RWIS
Work Zone/Construction Packet	Roadway Closure Management System Smart Work Zone and Work Zone Management Systems
Winter Maintenance Vehicles Packet	Maintenance Tracking using GPS for Maintenance Vehicles and Snowplows Anti-Icing Installations Connected to RWIS Common Radios Vehicle Tracking for MSP, Local Public Safety, and Maintenance Vehicles
Bridge Packet	Drawbridge Management System
Arterial Packet	Emergency Signal Preemption
Traveler Information Packet	511 Web Site Information Traveler Information At Truck Stops
Transit Packet	AVL CCTV and Panic Buttons for Security Electronic Fare Payment Kiosks with Fare and Traveler Information DMS with Real-Time Bus Schedule

Project Packet	Project
Maintenance Vehicles Packet	Vehicle Tracking for MSP, Local Public Safety, and Maintenance Vehicles Common Radios
WIM Packet	Weigh-in-Motion Stations
Parking	Local Parking System Management

3.3 Final List of Projects for Analysis

The final list of projects presented in **Table 23** was developed by the stakeholders during the Deployment Plan Workshop. These are the projects which will be analyzed with the IDAS model for the Southwest and University Region Deployment Plan and ultimately combined into a statewide ITS Investment Plan. **Table 23** provides short descriptions of each project; denotes each project with a unique project identifier so it can be easily referenced; and identifies whether the project occurs on a Corridor of significance or has any anticipated economic development impact.

Table 23 - Final List of Southwest and University Region Deployment Plan Projects

Project #	Name	Description	Corridor of Significance (y/n)	Economic Development Impact (y/n)
SWITS - 001	ATMS Rural 1	Coloma TSC (Berrien, Cass and Van Buren Counties)	●	●
SWITS - 002	ATMS Rural 2	Kalamazoo TSC (Allegan, Kalamazoo and St. Joseph Counties)	●	●
SWITS - 003	ATMS Rural 3	Marshall TSC (Barry, Branch and Calhoun Counties)	●	●
SWITS -004	ATMS Rural 4	Jackson TSC (Jackson County)	○	●
SWITS - 005	ATMS Rural 5	Lansing TSC (Shiawassee County)	○	●
SWITS - 006	ATMS Urban 1	Benton Harbor / St. Joseph Metro Area	●	●
SWITS - 007	ATMS Urban 2	Battle Creek Metro Area	●	●
SWITS - 008	ATMS Urban 3	Kalamazoo Metro Area	●	●
SWITS - 009	ATMS Urban 4	Jackson Metro Area	●	●
SWITS - 010	IM Route 1	Coloma TSC: 24 Routes (16 MDOT Signals, 20 Local Signals)	●	●
SWITS - 011	IM Route 2	Kalamazoo TSC: 11 Routes (26 MDOT Signals, 45 Local Signals)	●	●
SWITS - 012	IM Route 3	Marshall TSC: 13 Routes (7 MDOT Signals, 17 Local Signals)	●	●
SWITS - 013	IM Route 4	Jackson TSC: 7 Routes (19 MDOT Signals, 5 Local Signals)	●	●
SWITS - 014	Arterial 1	Coloma TSC: 9 Projects (58 Total Signals)	○	○

SWITS - 015	Arterial 2	Kalamazoo TSC: 17 Projects (121 Total Signals)	○	○
SWITS - 016	Arterial 3	Marshall TSC: 15 Projects (86 Total Signals)	○	○
SWITS - 0017	Arterial 4	Jackson TSC: 9 Projects (83 Total Signals)	○	○
SWITS - 018	Arterial 5	Lansing TSC: 2 Projects (14 Total Signals)	○	○
SWITS - 019	RWIS 1	Southwest Region	○	○
SWITS - 020	RWIS 2	University Region	○	○
SWITS - 021	Freeway Service Patrols	Peak Hours Service Patrols	●	○
SWITS - 022	Bridge anti-icing systems	RWIS connected to automated anti-icing systems	●	○
SWITS - 023	Highway Advisory Radio	Located close to 6 major decision points	●	○
SWITS - 024	Smart Work Zones	Smart work zones during construction	○	○
SWITS – 025	AVL deployments	Deployment of AVL systems on transit vehicles with scheduling software	○	○

4. ANALYSIS OF SOUTHWEST AND PORTIONS OF THE UNIVERSITY REGION ITS ALTERNATIVES

4.1 Project Categorization

A total of twenty-five ITS deployments were identified for further analysis in **Table 24**. Some of these have a geographic component while others vary based on technology. For purposes of evaluating benefits and costs, these projects must be combined into implementation packages that form a logical system. CCTV cameras, for example, are considered part of a Traffic Management System but do not inherently provide benefits. There must be staff in place to watch them, interpret what they see and disseminate information to those who can make use of it. Users may include incident responders, transportation agency personnel or the general public. Accurate representation of benefits and costs requires that various elements be modeled together as a system. The deletion of one key element may reduce or eliminate the benefits, but that element in and of itself, may not produce benefits. It is also important to note that benefit estimates are being developed at the sketch planning level and that the MDOT Statewide model is being utilized. The Statewide model does not have a high level of detail on County and local roads. Therefore results are most reliable when reviewed at a higher level, such as major corridor, County or possibly metropolitan area.

There are also a number of deployments that support multiple functions and projects. Plans for operating the systems in the Southwest Region and University Region have not yet been finalized but it is likely that some operations, particularly those involving freeway management, will be centered in the West Michigan TMC in Grand Rapids. Systems such as Freeway Management, Freeway Service Patrols and RWIS can provide greater benefits if coordinated through both the TMC and virtual connections to TSC's and County Road Commission. The operation of the IDAS model was documented in Section 2, along with the benefit parameters and cost assumptions. The benefit summaries below have been developed for the study area and modeled by category. In the case of both freeway management systems and arterial control systems geographic the results were disaggregated geographically.

Based on review of the plan by stakeholders, these runs may be modified to test the addition or removal of specific deployments. **Table 24** shows the how the deployments have been grouped for IDAS analysis.

Table 24 - Study Area Projects by Category

Project #	Name	Description	Comments
Freeway Management Systems			
SWITS – 001	ATMS Rural 1	Coloma TSC (Berrien, Cass and Van Buren Counties)	Rural FMS deployments within the Coloma TSC boundaries
SWITS – 002	ATMS Rural 2	Kalamazoo TSC (Allegan, Kalamazoo and St. Joseph Counties)	Rural FMS deployments within the Kalamazoo TSC boundaries
SWITS – 003	ATMS Rural 3	Marshall TSC (Barry, Branch and Calhoun Counties)	Rural FMS deployments within the Marshall TSC boundaries
SWITS – 004	ATMS Rural 4	Jackson TSC (Jackson County)	Rural FMS deployments within the Jackson TSC boundaries
SWITS – 005	ATMS Rural 5	Lansing TSC (Shiawassee County)	Rural FMS deployments within the Lansing TSC boundaries
SWITS – 006	ATMS Urban 1	Benton Harbor / St. Joseph Metro Area	Urban FMS deployments in Benton Harbor / St Joseph Metro Area
SWITS – 007	ATMS Urban 2	Battle Creek Metro Area	Urban FMS deployments in Battle Creek and Marshall Metro Areas
SWITS – 008	ATMS Urban 3	Kalamazoo Metro Area	Urban FMS deployments in Kalamazoo Metro Area
SWITS – 009	ATMS Urban 4	Jackson Metro Area	Urban FMS deployments in Jackson Metro Area
Freeway Service Patrols			
SWITS - 021	Freeway Service Patrols	Peak Hours Service Patrols	Freeway Service Patrols in Kalamazoo and Jackson Metro Areas
Smart Work Zones			
SWITS - 024	Smart Work Zones	Smart work zones during construction	Installed at locations with lane or shoulder closure for extended period
Arterial Management Systems			
SWITS – 010	IM Route 1	Coloma TSC	24 Routes (16 MDOT Signals, 20 Local Signals)
SWITS – 011	IM Route 2	Kalamazoo TSC	11 Routes (26 MDOT Signals, 45 Local Signals)
SWITS – 012	IM Route 3	Marshall TSC	13 Routes (7 MDOT Signals, 17 Local Signals)
SWITS – 013	IM Route 4	Jackson TSC	7 Routes (19 MDOT Signals, 5 Local Signals)
SWITS – 014	Arterial 1	Coloma TSC	9 Projects (58 Total Signals)
SWITS – 015	Arterial 2	Kalamazoo TSC	17 Projects (121 Total Signals)

Arterial Management Systems (continued)			
SWITS – 016	Arterial 3	Marshall TSC	15 Projects (86 Total Signals)
SWITS – 017	Arterial 4	Jackson TSC	9 Projects (83 Total Signals)
SWITS – 018	Arterial 5	Lansing TSC	2 Projects (14 Total Signals)
Road Weather Information Systems			
SWITS – 019	RWIS 1	Southwest Region	20 ESS locations
SWITS – 020	RWIS 2	University Region	4 ESS locations
SWITS - 022	Bridge anti-icing systems	RWIS connected to automated anti-icing systems	17 possible locations
Advanced Traveler Information Systems			
SWITS - 023	Highway Advisory Radio	Located close to 6 major decision points	- Single HAR near New Buffalo (I-94), Niles (US12 and US31) and Coldwater (I-69 and M-66) - HAR Station groups at I-69/I-94, I-94 US-131 and I-94/US-31/I-196
Advanced Public Transportation Systems			
SWITS – 025	AVL deployments	Deployment of AVL systems on transit vehicles with scheduling software	- Deployments proposed for Kalamazoo area transit systems and Van Buren County system with 89 vehicles total.

Figure 23 - **Figure 31** show the locations of the above projects that have a defined geographical component. **Figure 32** illustrates where construction on MDOT facilities is planned between 2008 and 2011.

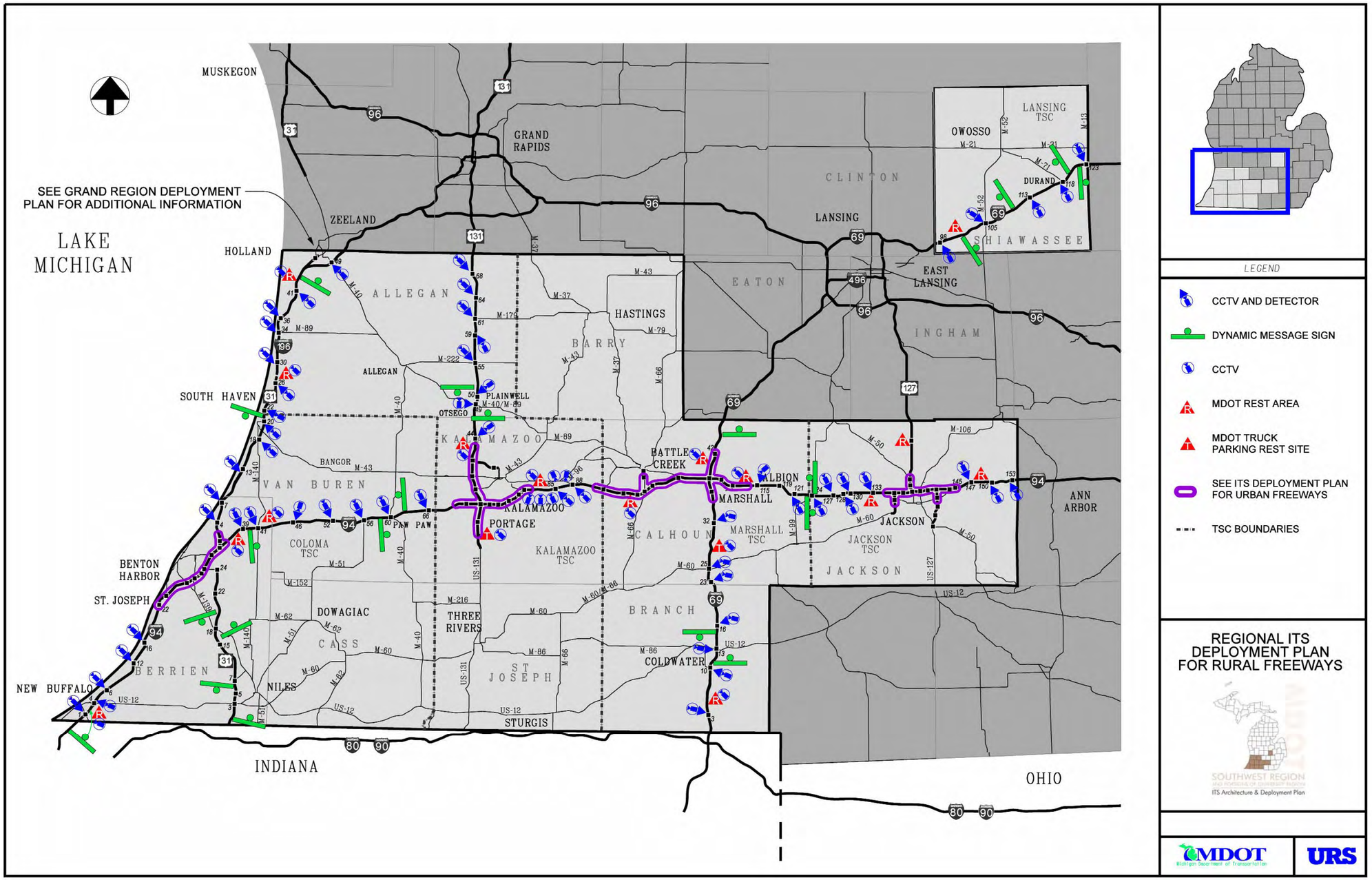


Figure 23 - ITS Deployment Plan Projects - Rural Freeways

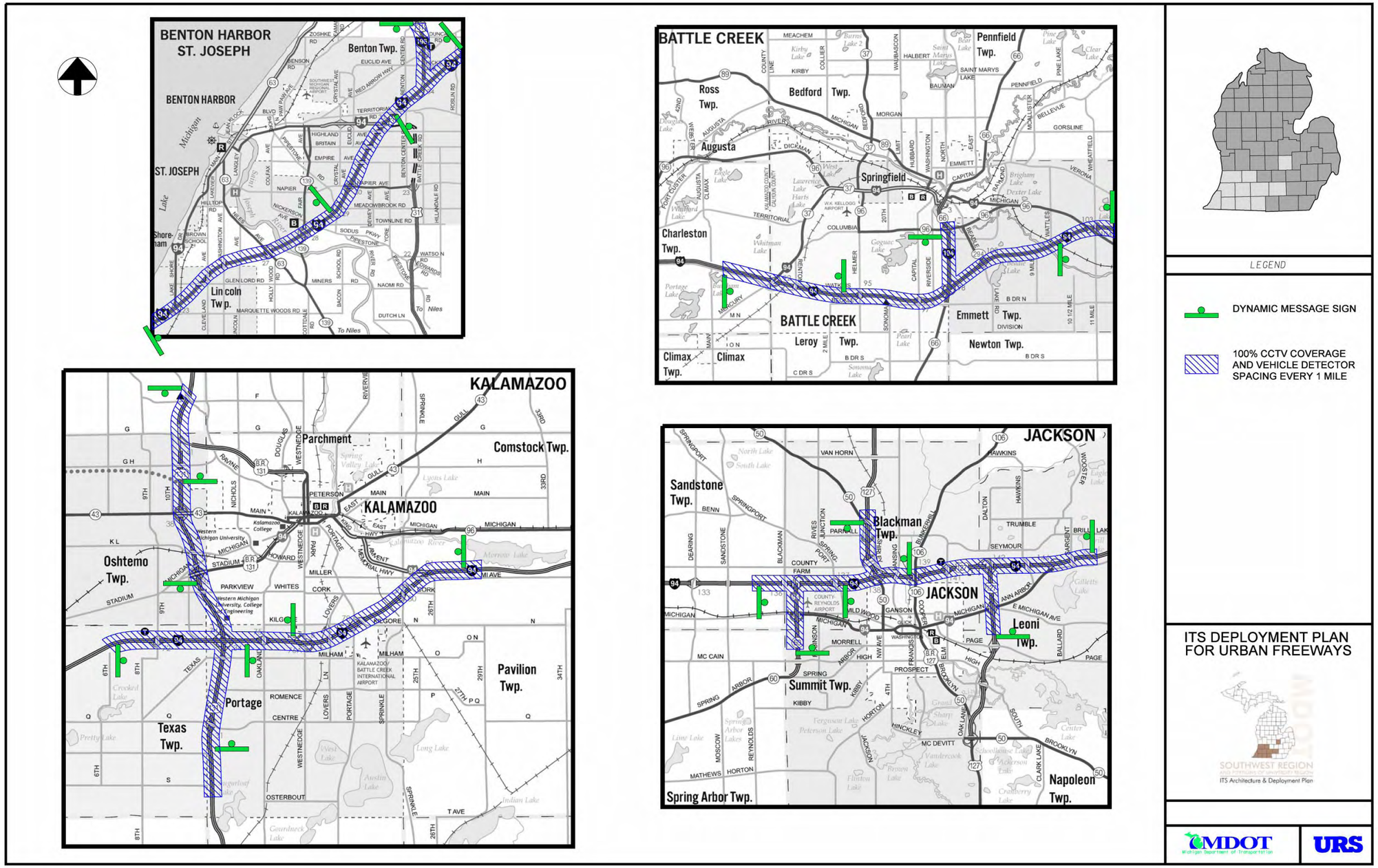


Figure 24 - ITS Deployment Plan Projects - Urban Freeways

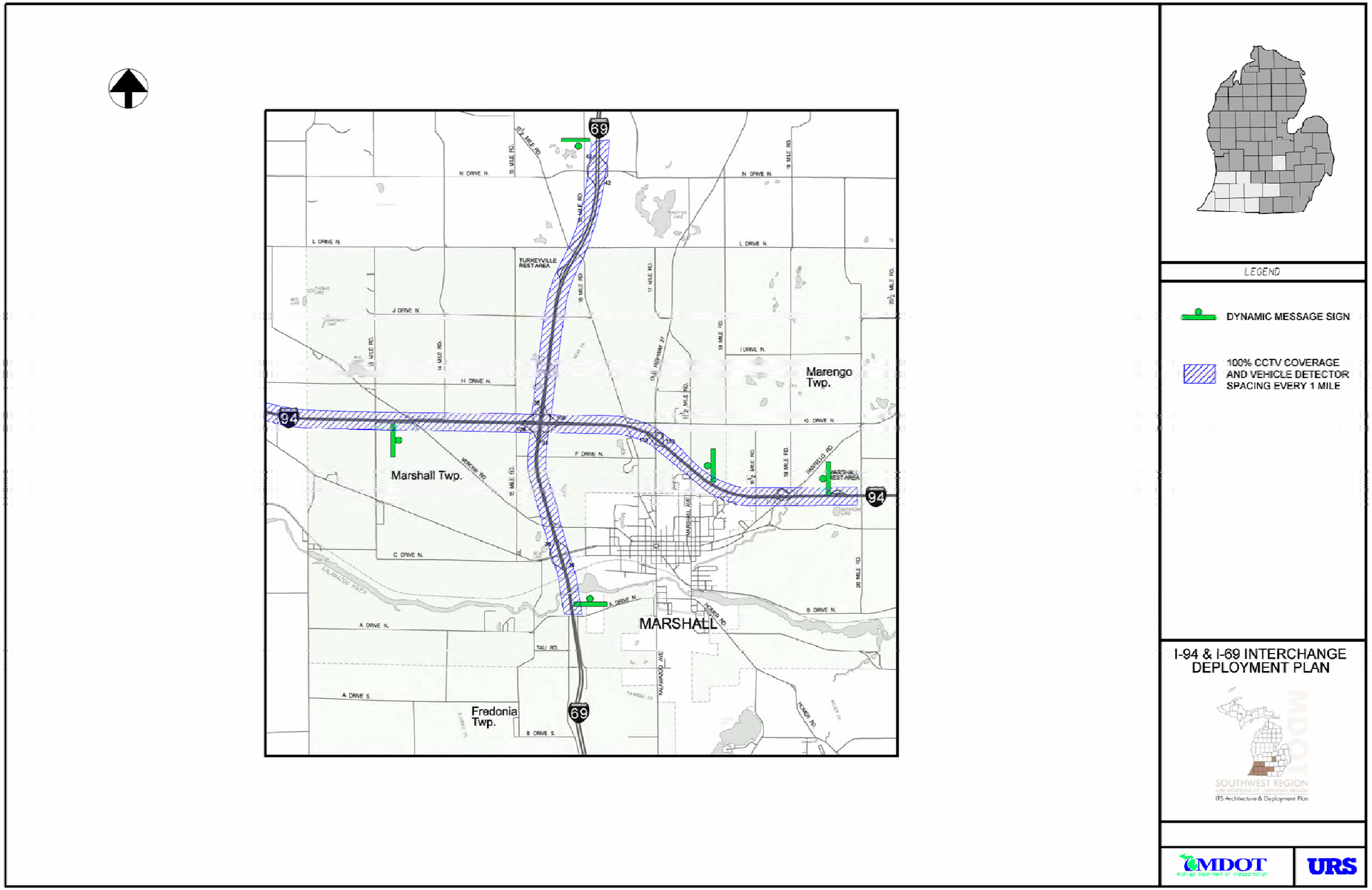


Figure 25 - ITS Deployment Plan Projects - I-94 and I-69 Interchange

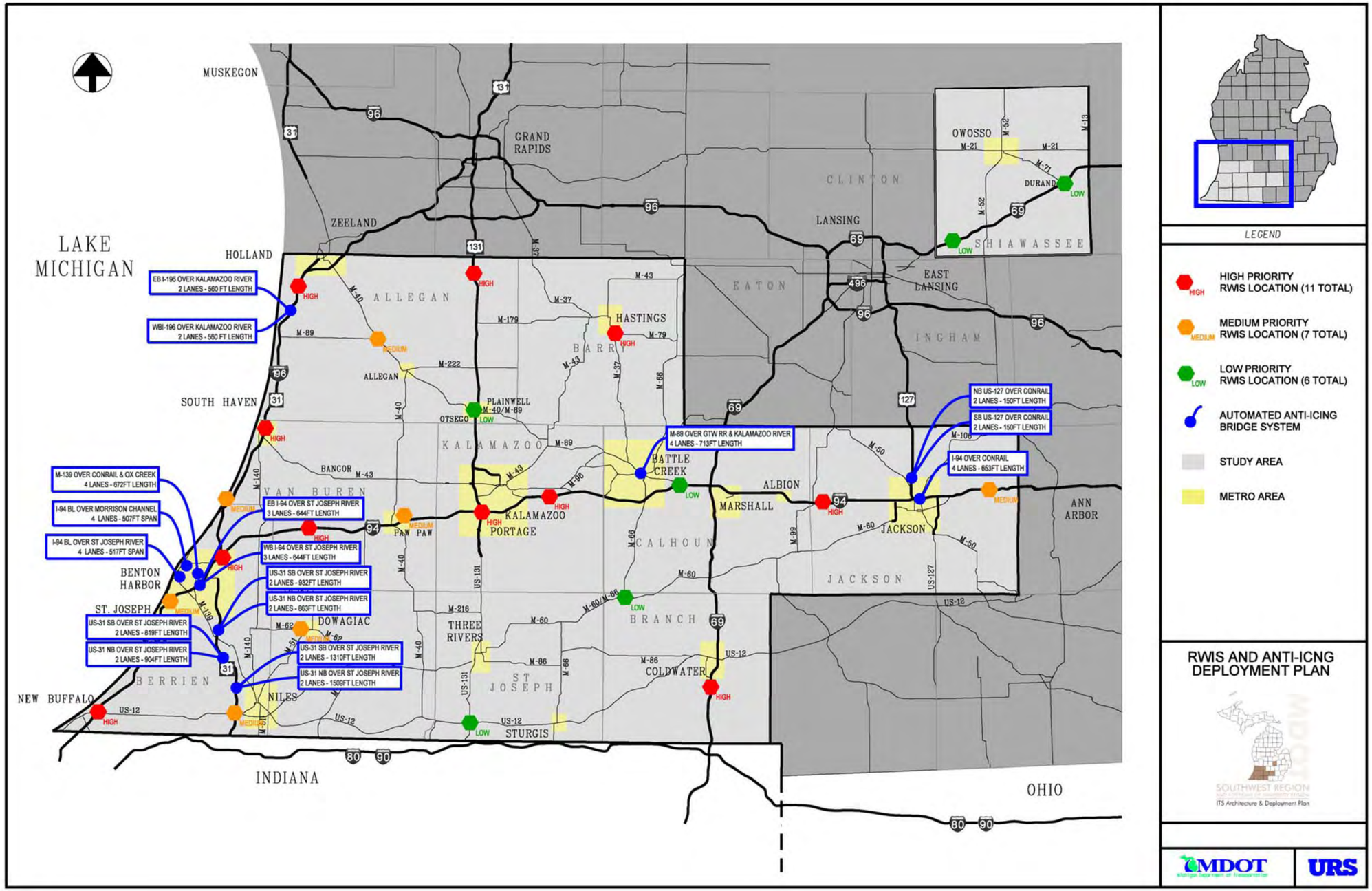


Figure 26 - RWIS and Anti-Icing Deployment Plan

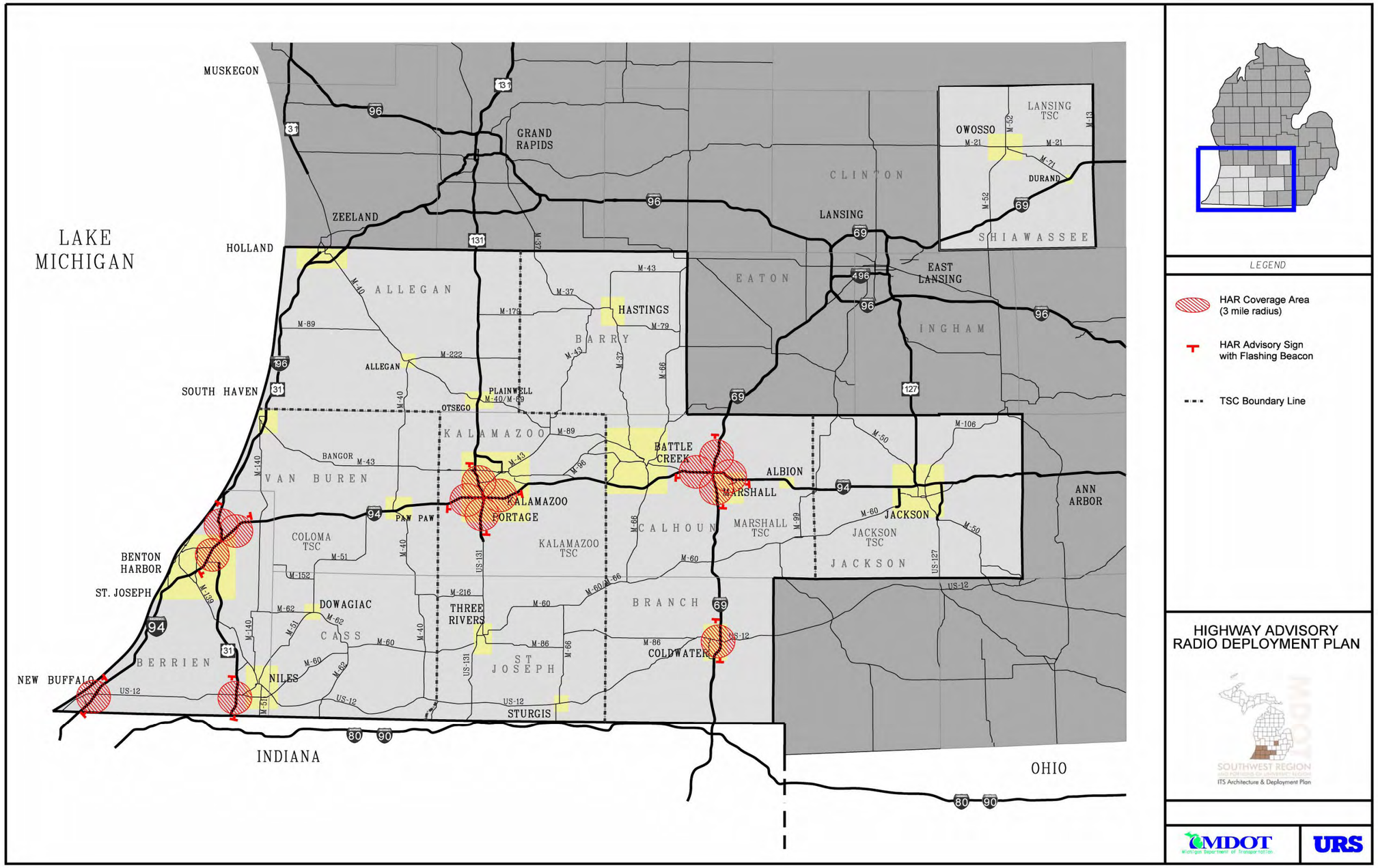


Figure 27 - Highway Advisory Radio Deployment Plan

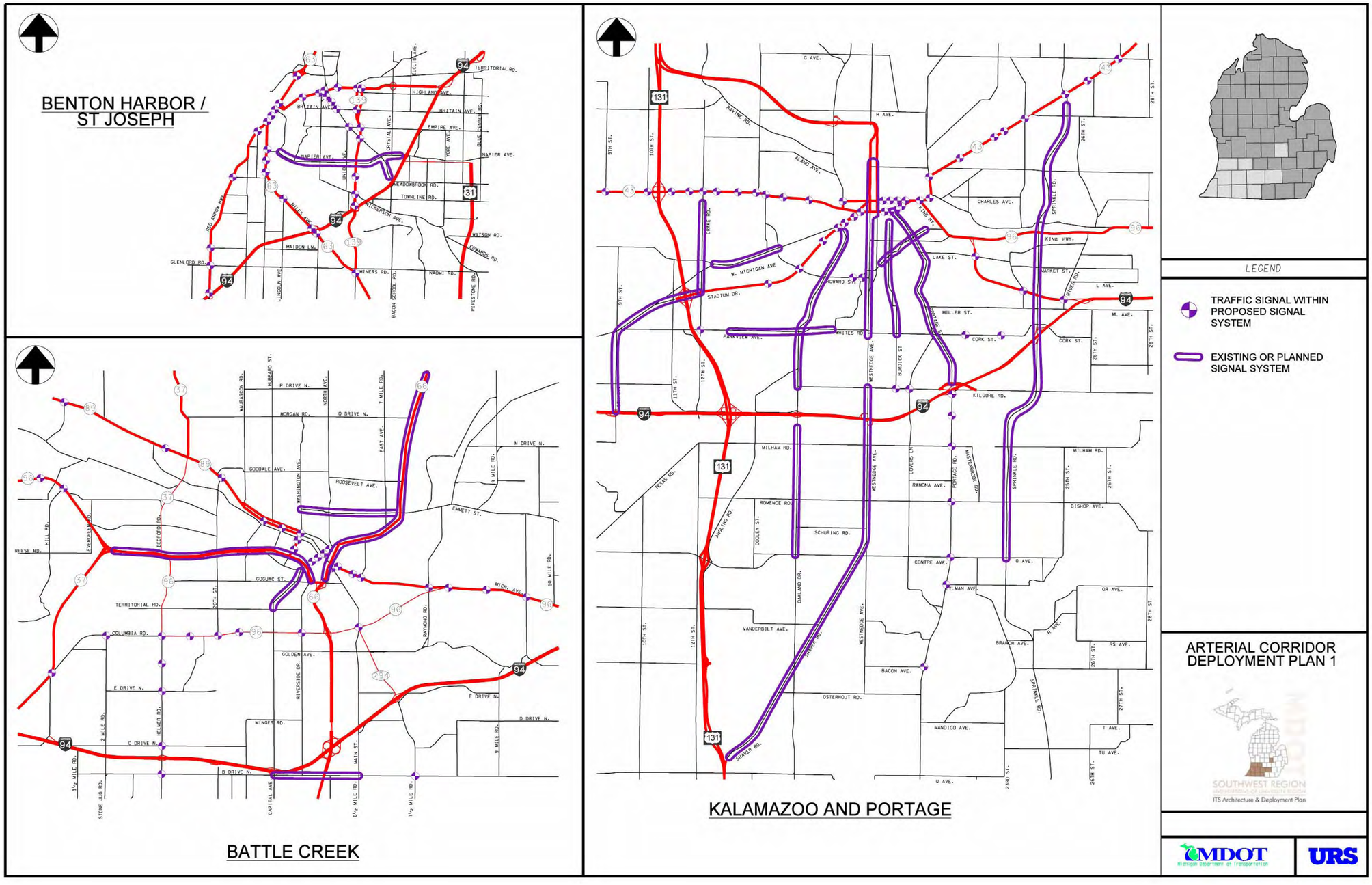


Figure 28 - Arterial Corridor Deployment Plan

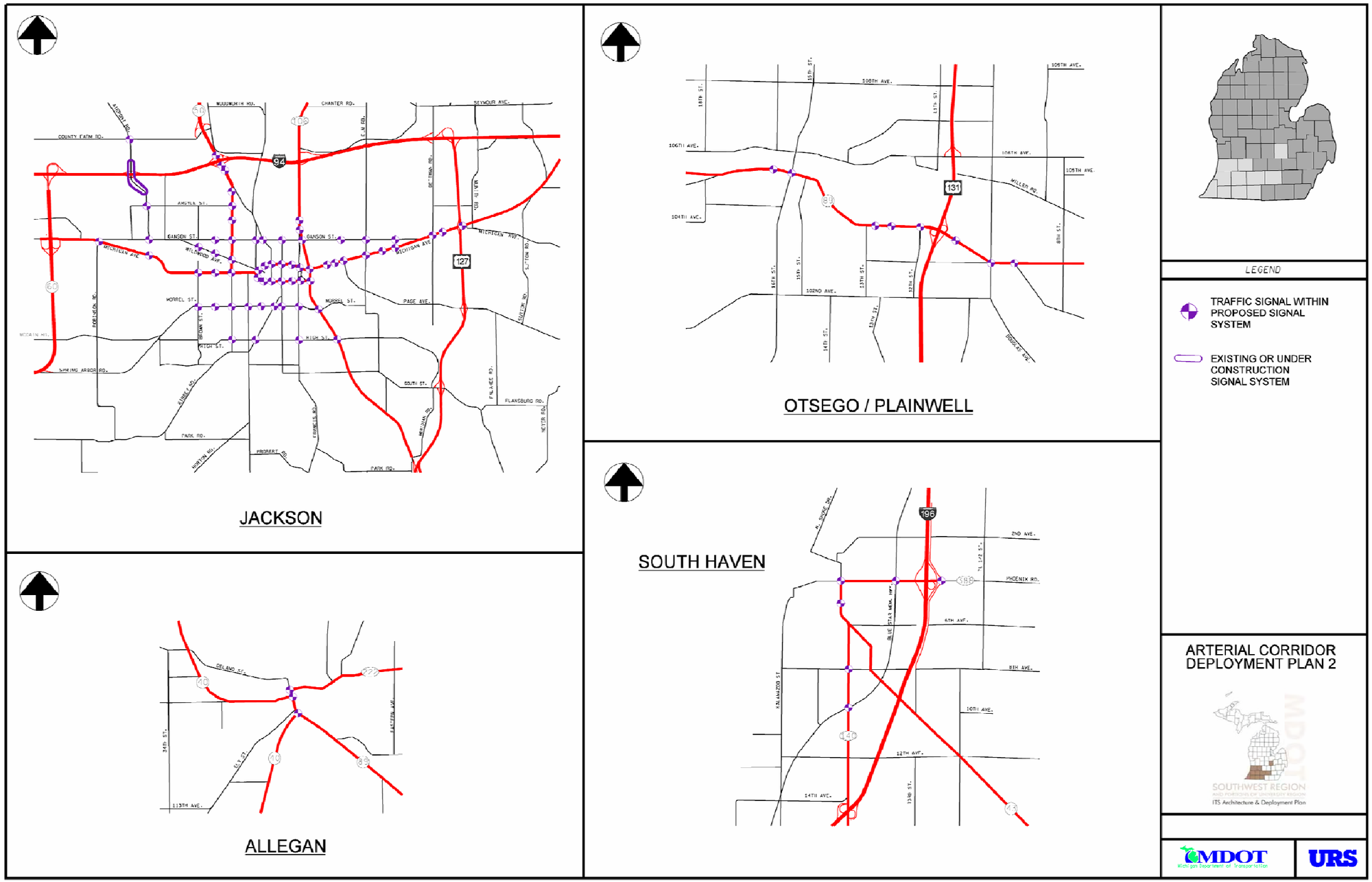


Figure 29 - Arterial Corridor Deployment Plan

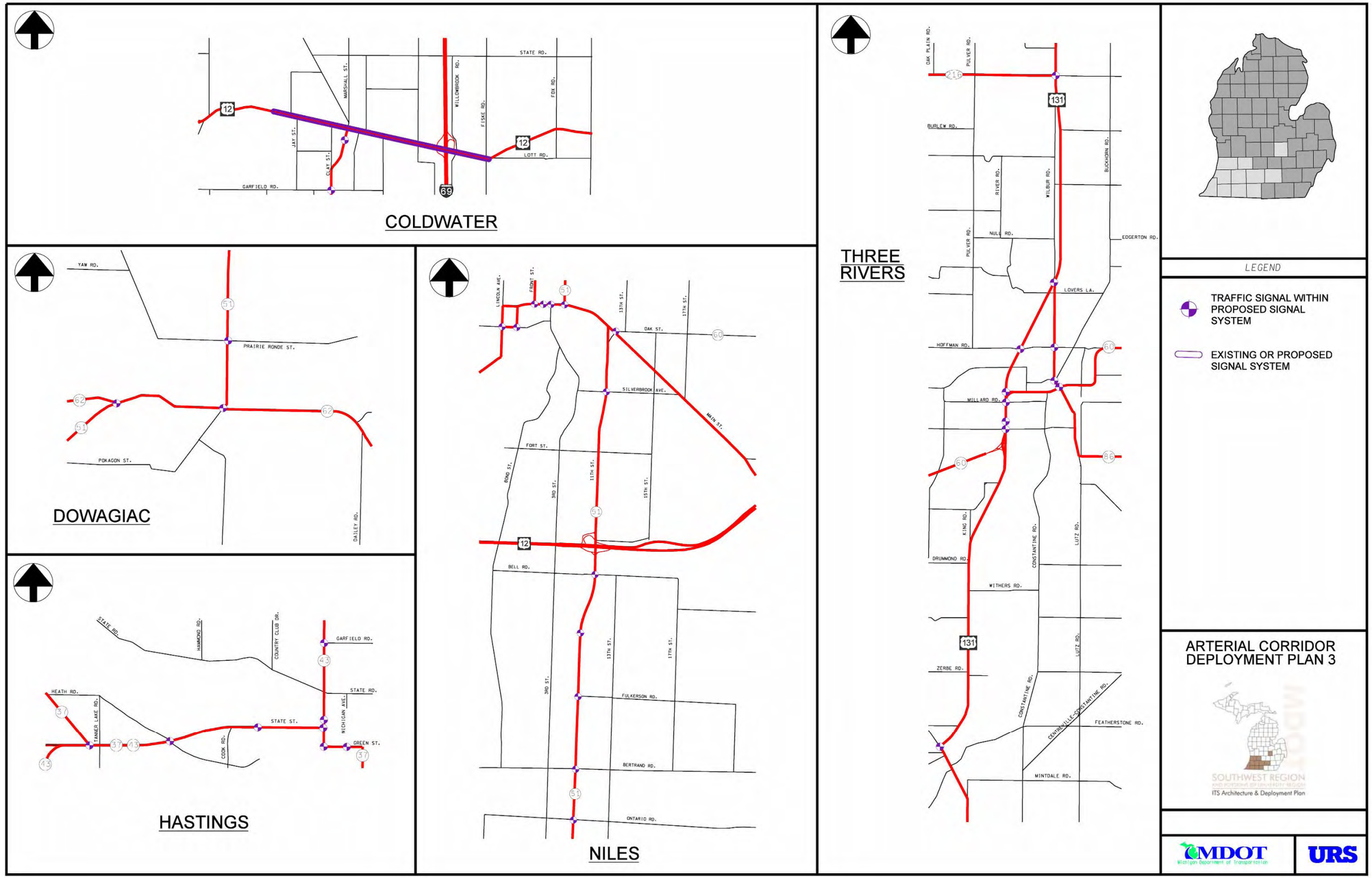


Figure 30 - Arterial Corridor Deployment Plan

Figure 31 - Arterial Corridor Deployment Plan

4.2 Results of Benefit/Cost Analysis

Four packages of ITS deployments were evaluated using the IDAS model. Results are shown below by package, with benefits combined into four categories:

- Travel time savings
- Crash reduction benefits
- Operating Costs, including both fuel savings and agency cost savings
- Environmental benefits, primarily air quality improvements

Annualized costs are a combination of amortized capital costs and annual operations and maintenance costs. IDAS uses a life cycle costing methodology that assigns a life to each capital component. A 3% interest rate was used to annualize this cost.

4.2.1 Freeway Management Systems

The regional freeway management system is by far the most significant ITS project proposed for the Southwest Region with over $50 million of improvements proposed on all of the region's major freeways. Projects include deployment of 51 Dynamic Message Signs, CCTV cameras and Vehicle Detectors. Communications is a significant part of the project with fiber optic connections proposed along freeway segments in the urban areas of Jackson, Kalamazoo, Battle Creek and Benton Harbor/St. Joseph. Wireless communication is proposed for rural deployments. The regional freeway management system also includes video surveillance at rest areas specifically for commercial vehicle parking management. These images will be provided to all travelers via the internet and rest area kiosk to better inform travelers of current parking conditions. **Table 25** below summarizes the benefits and costs of the proposed freeway management system. In addition to the total benefits and costs for the freeway management system, **Table 25** divides the benefits and costs into six geographic areas; four urban projects, rural segments of I-94 and all other rural freeways, including US-31, I-69, US-131 and I-196. All deployments show a relatively high level of net benefits with an overall benefit/cost ratio of close to 9.3. Benefit/cost ratios are similar for all deployments with the exception of the Battle Creek metropolitan area deployment. The relatively high cost in Battle Creek in relation to benefits is driven in part by the large amount of fiber optic installation required in that region. One might expect a higher level of benefit on the rural portions of I-94 than in other portions of the region. However, many of the major decision points along I-94 are covered by the urban deployments. Also, there is a high level of deployment proposed on other freeways including US-31 and I-69. The ITS control system at each TSC and the Southwest Region Office is also included, as well as 2/10th mile markers in the urban areas of Kalamazoo, Jackson, Battle Creek and Benton Harbor / St Joseph. Also included are the advanced emergency route deployments which enhance the traffic signal system operations along emergency routes serviced by a high density of traffic signals. Due to both high capital costs, as well as a high level of operations and maintenance cost this project would need to be phased in over a period of time. **Table 25** shows aggregate benefits for the entire region.

Table 25 - Freeway Management Systems Annual Cost Savings Breakdown

Location	Total Annual Benefits	Annualized Cost	Capital Cost	Annual O&M	Net Annual Benefits	B/C Ratio
Battle Creek	$4,317,609	$1,290,000	$11,334,000	$205,000	$3,027,609	3.4
Benton Harbor/St. Joseph	$5,961,588	$615,000	$5,507,500	$125,000	$5,346,588	9.7
Kalamazoo	$8,565,998	$970,000	$8,504,000	$170,000	$7,595,998	8.8
Jackson	$11,334,805	$750,000	$6,372,000	$150,000	$10,584,805	15.1
I-94 Rural	$12,100,000	$1,120,000	$9,480,000	$215,000	$10,980,000	10.8
All other rural freeway	$13,280,000	$1,250,000	$10,420,000	$280,000	$12,030,000	10.6
Total	$55,560,000	$5,995,000	$51,617,500	$1,145,000	$49,565,000	9.3

4.2.2 Freeway Service Patrols

Freeway Service Patrols (FSP) were identified as an alternative to help clear incidents during peak periods. FSP's were proposed in the Kalamazoo region on I-94 and US-131 and in the Jackson area on I-94. Approximately 40 miles of freeway would be covered for approximately 70 hours per week. Service would be provided on weekdays when large volumes of commercial traffic use these freeways. The FSP's have a positive but relatively low benefit/cost ratio, with benefits consisting of a mix of improved travel time reliability, fuel cost savings and crash reductions. The low benefit/cost ratio is primarily a result of recurring labor costs for supervisors and drivers. Capital costs are low but the FSP would be able to take advantage of the large investment in CCTV cameras and detection equipment shown under the Freeway Management System.

Table 26 summarizes the overall costs savings associated with the Freeway Service Patrols.

Table 26 - Freeway Service Patrol Annual Cost Savings

Benefits and Costs	Monetary Values
Travel Time Savings	$574,203
Crash Reduction	$165,750
Operating Costs	$543,335
Emissions	($0)
Total Annual Benefits	$1,283,288
Annualized Cost	$817,443
Net Annual Benefits	$465,845
Benefit/Cost Ratio	1.6
Capital Cost	$187,200
Annual O&M cost	$707,200

4.2.3 Smart Work Zones

Smart Work Zones use ITS technology to monitor work zones and approaches. CCTV cameras, detectors, and DMS are part of these systems, which are often offered by vendors as packages. Information from the Smart Work Zone can be sent to TMCs and websites for broader dissemination. Motorists may save time by taking an alternate route to avoid the work zone. They may also change their departure time or make a stop if there is a backup in

a work zone. The Freeway Management System will support the Smart Work Zone program by allowing information to be disseminated to a wider audience.

Smart work zones were analyzed by modeling all 2007 MDOT Southwest Region and portions of University Region construction projects that involved either lane or shoulder closures on trunkline routes. The benefits are then projected forward for future years. Proposed projects for 2008-2011 are shown in **Figure 32**. Reduced capacities for the 2007 projects were calculated and run through the IDAS model. Time savings came from two sources, more efficient flow of traffic through the work zone and use of faster alternative routes to avoid areas where capacity was reduced. The travel time savings were significant but were offset slightly be negative benefits in crash reduction, operating cost and emissions. This is due to some shift of traffic from higher class to lower class roadways. Both net benefits and the benefit/cost ratio are very high. It is important to note these benefits are measured against the delays that would occur with construction activity without smart work zones. They do not entirely offset the impacts of the work zones. It is also important to note that the MDOT Southwest Region has been very active in implementing mitigation activities related to work zones. Therefore a portion of the benefits projected are already being achieved through other means.

For this project, it was assumed that equipment would be rented or leased on an annual basis. Therefore all costs are considered Operations and Maintenance. An alternative scenario is for MDOT to purchase the equipment. All associated costs should be included with the construction project planning process, and are not eligible for funding through the MDOT ITS Program Office budget. **Table 27** summarizes the overall costs savings associated with Smart Work Zone deployment.

Table 27 - Smart Work Zone Annual Cost Savings

Benefits and Costs	Monetary Values
Travel Time Savings	$27,595,466
Crash Reduction	($428,496)
Operating Costs	($643,630)
Emissions	($195,138)
Total Annual Benefits	$26,328,202
Annualized Cost	$874,182
Net Annual Benefits	$25,454,020
Benefit/Cost Ratio	43.0
Capital Cost	-
Annual O&M cost #	$874,182

Assumes all equipment is rented or leased.

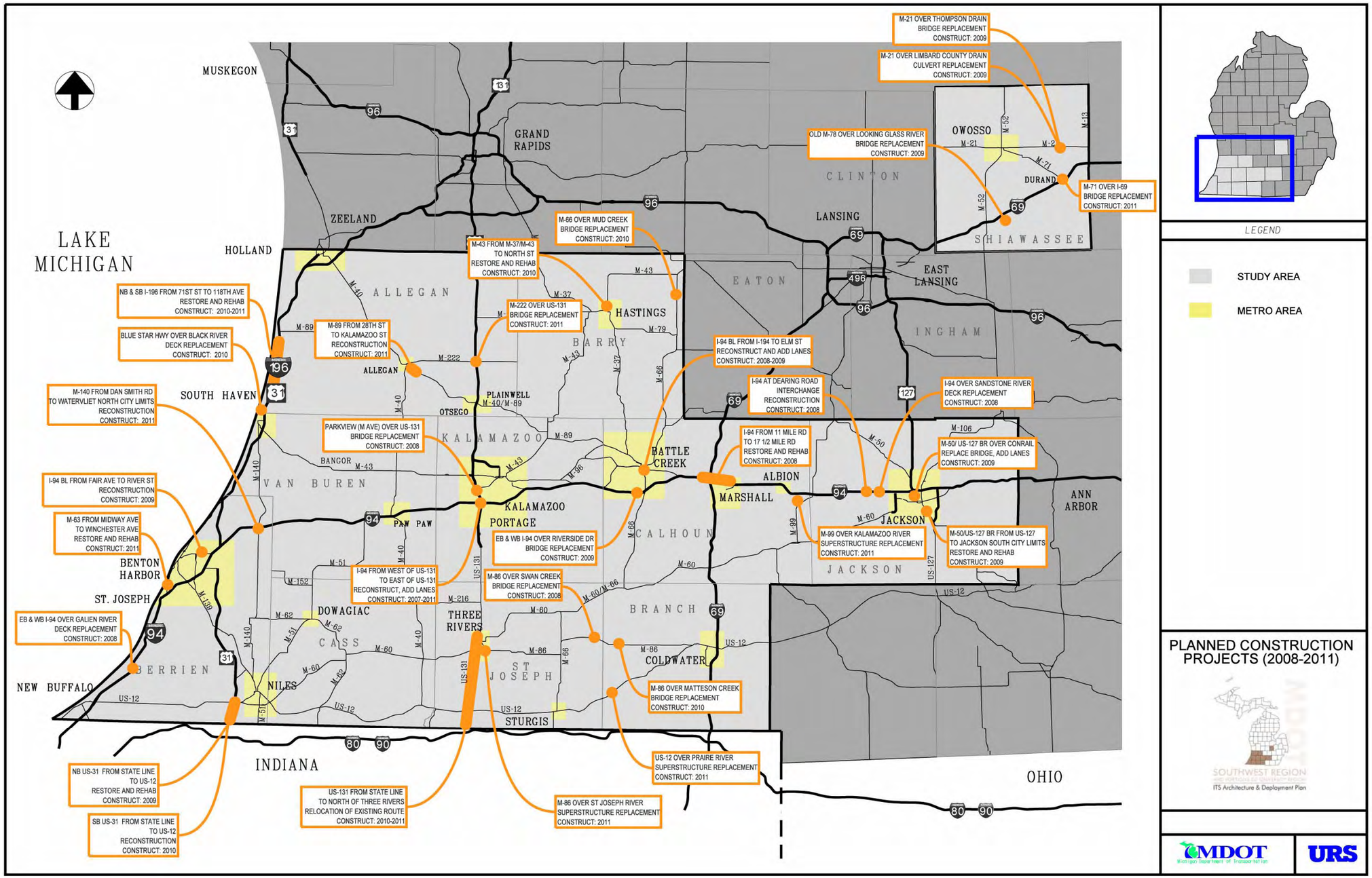


Figure 32 - Scheduled Work Zones 2008-2011

4.2.4 Traffic Signal System Improvements

A wide range of traffic signal improvements were proposed across the region including corridor improvements, controller upgrades and development of alternate route corridors for incident management planning. The results were disaggregated by County, since over 200 signals in the region were proposed for some type of improvement. The two least populous counties in the region, Branch and Cass, had only minor improvements proposed at isolated signals. As a result, only the nine larger counties were included in this analysis. The results showed that proposed signal improvements in Kalamazoo and Calhoun Counties showed both high net benefits and high benefit/cost ratios. Smaller systems in Van Buren and Allegan Counties had lower net benefits but positive B/C ratios. The other five counties in the analysis had benefit/cost ratios of less than one. While this is not a surprising finding for rural counties such as Barry and Shiawassee, one would expect more positive results from urbanized areas such as Berrien and Jackson Counties. One possible explanation is that the corridors selected for improvement in Jackson and Berrien Counties are concentrated near the downtown areas. In both Kalamazoo and Calhoun Counties, some of the improvement corridors bypass the downtown, providing higher speeds and a greater level of improvement. It is clear that as improvement plans are further developed a more detailed analysis, using both regional travel demand models and possibly microsimulation tools, is needed to set priorities among corridors in the region.

Table 28 shows benefit cost data broken down by County. The estimated annualized cost of all traffic signal improvements in the region is estimated at approximately $1 million, with a total capital cost of just over $3 million and an annual estimated operations and maintenance cost of approximately $600,000. It should be noted that much of the proposed operations and maintenance cost is already being incurred for existing signal operations.

Table 28 - Traffic Signal System Improvement Annual Cost Savings

County	Total Annual Benefits	Annualized Costs	Net Annual Benefits	B/C Ratio
Kalamazoo	$2,248,278	$280,000	$1,968,278	8.0
Calhoun	$933,273	$125,000	$808,273	7.5
Van Buren	$97,208	$22,000	$75,208	4.4
Allegan	$104,836	$35,000	$69,836	3.0
Barry	$12,306	$32,000	($19,694)	<1.0
St. Joseph	$39,056	$74,000	($34,944)	<1.0
Berrien	$116,344	$157,000	($40,656)	<1.0
Shiawassee	$5,230	$67,000	($61,770)	<1.0
Jackson	$51,573	$214,000	($162,427)	<1.0
Total	$3,608,104	$1,006,000	$2,602,104	3.6

4.2.5 Roadway Weather Information Systems (RWIS)

The proposed RWIS would include 24 Environmental Sensor Stations (ESS) to be installed around the regions. An RWIS Concept of Operations has not yet been prepared for the either region. MDOT intends to prioritize ESS sites on a state-wide level as part of a future RWIS study. For purposes of the deployment plan, ESSs were spread across the region, focusing on major trunkline roads. Initially, benefits were calculated only for the days when snow exceeds one inch. This figure is estimated from National Weather Service data at 25 days per year although there is a significant variation with heavier snowfalls generally occurring

in the western portion of the region along the Lake Michigan shoreline. An additional 20% was added for days where snow is less than one inch. RWIS will also be helpful during periods of heavy rain and fog, and may have some benefits for summer as well as winter maintenance. In addition the deployment includes 17 automated anti-icing installations located on bridges. Sensors would trigger an automatic anti-icing spray when surface are about to freeze. RWIS is also an important supporting deployment for the proposed Traffic Management System. Net annual benefits are approximately $2.1 million while the benefit/cost ratio is just over 4. Benefits are primarily obtained from crash reduction with additional savings from reduced winter maintenance cost. Unlike other regions in the State, MDOT does a large portion of the winter maintenance with its own staff. This may help to increase the winter maintenance benefits of RWIS since coordination will be easier.

Table 29 summarizes the overall annual cost savings associated with RWIS deployment.

Table 29 - Road Weather Information System (RWIS) Annual Cost Savings

Benefits and Costs	Monetary Values
Travel Time Savings	$31,362
Crash Reduction	$2,464,790
Operating Costs	$807,929
Emissions	$0
Total Annual Benefits	$3,304,081
Annualized Cost	$805,148
Net Annual Benefits	$2,498,932
Benefit/Cost Ratio	4.1
Capital Cost	$4,837,000
Annual O&M cost	$226,300

4.2.6 Highway Advisory Radio

Six HAR installations are proposed for the project. Three are single locations near major junctions at New Buffalo (I-94), Niles (US-12 and US-31) and Coldwater (I-69 and US-12). There are also three station groups at the I-69/I-94 interchange, the I-94/US-131 interchange and near I-94/US-31 and I-196. HAR would be used in conjunction with the Freeway Management System when more complex message need to be provided to travelers. For example, DMS may not be adequate to provide full information on the duration of major incidents or alternate routes that are in operation. MDOT is interested in using the proposed HAR at the I-94/I-69 interchange to provide information to commercial drivers on delay times being experienced at international crossings in Detroit and Port Huron. The potential benefits of the proposed HAR installations are relatively strong. It may be difficult however to avoid double counting since the DMS in the Freeway Management System will provide similar information. The benefit/cost ratio is also somewhat inflated by the fact that operating costs are included under the Freeway Management System. **Table 30** shows cost savings from the proposed HAR system.

Table 30 - Highway Advisory Radio System Annual Cost Savings

Benefits and Costs	Monetary Values
Travel Time Savings	$1,391,084
Crash Reduction	$0
Operating Costs	$0
Emissions	$0
Total Annual Benefits	$1,391,084
Annualized Cost	$120,033
Net Annual Benefits	$1,271,051
Benefit/Cost Ratio	11.6
Capital Cost	$1,067,000
Annual O&M cost *	$0

* Operating costs in Fwy Management

4.2.7 Advanced Public Transportation System

Two proposals are included in the Southwest Pre-deployment plan for Advanced Public Transportation Systems. Both involve the implementation of Automated Vehicle Location and scheduler systems. In the Kalamazoo Region fixed route service is provided by Kalamazoo Metro Transit and paratransit service is provided through the Care-a-Van system. Both systems, including 75 vehicles, would be outfitted with AVL. The Van Buren County transit system, which provides paratransit service with 14 vehicles, is also interested in incorporating AVL technology. The benefits provided by these improvements are shown as operating cost savings, although some authorities use the benefits to provide additional service with the same budget. If this were the case a similar level of benefits would be found in travel time savings. The benefits and benefit/cost ratios are relatively modest but very similar to those estimated for other transit system deployments around the State. **Table 31** shows cost savings from the proposed advanced public transportation system.

Table 31 - Advanced Public Transportation System Cost Savings

Benefits and Costs	Monetary Values
Travel Time Savings	$0
Crash Reduction	$0
Operating Costs	$606,000
Emissions	$0
Total Annual Benefits	$606,000
Annualized Cost	$255,000
Net Annual Benefits	$351,000
Benefit/Cost Ratio	2.4
Capital Cost	$895,000
Annual O&M cost	$145,000

4.3 Summary of Results

Table 32 through **Table 37** show the comparison of benefits and costs between different ITS packages. It is important to note that these results represent only one portion of the criteria that will be used by MDOT to select projects for implementation. Other considerations include eligibility of various funding sources; compatibility with the priorities of MDOT's ITS program as well the agency's overall program priorities; ability to incorporate in major construction projects; and compatibility with other regions' investment strategies. The benefit and cost data, however, provide useful guidance into which investments provide the best return.

Table 32 - Deployment Packages Total Annual Benefits

Deployment Package	Total Annual Benefits
Freeway/Traffic Management Systems	$55,560,000
Freeway Service Patrols	$1,283,288
Road Weather Information Systems	$3,304,081
Traffic Signal Improvements	$3,301,670
Smart Work Zones	$26,328,202
Highway Advisory Radio	$1,391,084
Advanced Public Transportation Systems	$606,000
TOTAL	$91,774,324

Table 33 - Deployment Packages Net Benefits

Deployment Package	Net Annual Benefits
Freeway/Traffic Management Systems	$49,565,000
Freeway Service Patrols	$465,845
Road Weather Information Systems	$2,498,932
Traffic Signal Improvements	$2,261,670
Smart Work Zones	$25,454,020
Highway Advisory Radio	$1,271,051
Advanced Public Transportation Systems	$351,000
TOTAL	$81,867,518

Table 34 - Deployment Packages Annualized Cost

Deployment Package	Annualized Cost
Freeway/Traffic Management Systems	$5,995,000
Freeway Service Patrols	$817,443
Road Weather Information Systems	$805,148
Traffic Signal Improvements	$1,040,000
Smart Work Zones*	$874,182
Highway Advisory Radio	$120,033
Advanced Public Transportation Systems	$255,000
TOTAL	$9,906,806

*All associated costs should be included with the construction project planning process, and are not eligible for funding through the MDOT ITS Program Office budget.

Table 35 - Deployment Packages Benefit/Cost Ratios

Deployment Package	Benefit/Cost Ratios
Freeway/Traffic Management Systems	9.3
Freeway Service Patrols	1.6
Road Weather Information Systems	4.1
Traffic Signal Improvements	3.6
Smart Work Zones	30.1
Highway Advisory Radio	11.6
Advanced Public Transportation Systems	2.4

Table 36 - Deployment Packages Capital Cost

Deployment Package	Capital Costs
Freeway/Traffic Management Systems	$51,617,500
Freeway Service Patrols	$187,200
Road Weather Information Systems	$4,837,000
Traffic Signal Improvements	$3,060,000
Smart Work Zones *	$0
Highway Advisory Radio	$1,067,000
Advanced Public Transportation Systems	$895,000
TOTAL	$61,663,700

* All costs classified as O&M

Table 37 - Deployment Packages Operations and Maintenance Cost

Deployment Package	O&M Costs
Freeway/Traffic Management Systems	$1,145,000
Freeway Service Patrols	$707,200
Road Weather Information Systems	$226,300
Traffic Signal Improvements	$633,600
Smart Work Zones *	$874,182
Highway Advisory Radio #	$0
Advanced Public Transportation Systems	$145,000
TOTAL	$3,731,282

* All costs classified as O&M
\# All costs classified as Freeway/Traffic Management Systems

While there are a number of components in the Southwest Region and portions of University Region ITS Deployment Plan, the Freeway Management System stands out as the major cost item and the deployment with the highest level of benefits. The Smart Work Zone projects also have a high level of benefits, with RWIS and traffic signal benefits following. It assumed that the existing West Michigan TMC could house the management and control of these systems but some additional capital and operating costs would be incurred in order to do so. The use of an existing TMC would provide substantial savings despite these additional costs. It should be noted that traffic signals may be in need of upgrade due to age, and in these cases any travel time benefits gained are secondary to the need to maintain the Department's assets.

4.4 Project Timeframes

Project priorities were based on a number of factors, including: benefit/cost analysis, availability of funding, funding eligibility of proposed projects, geographic scope of project benefits and the feasibility of phasing projects into place over time. Needs as expressed by local stakeholders were included when setting priorities. While benefits may be similar between different projects, some projects may offer more immediate relief to a problem. An assessment of emerging technologies is another key consideration. Certain deployments may show high benefits, but at a substantial capital cost. MDOT, through its work on the VII program and other technology initiatives, is a national leader in looking ahead to emerging technologies. If there is likelihood that a specific technology can be replaced by something more cost-effective during its life cycle, agencies may prefer to forego large investment and instead use a temporary solution that will not preclude the emerging technology.

Based on the analysis conducted for this report and the input from the stakeholders, the following project implementation plan is identified for near-term, medium term, and long term deployments. For the purposes of this assessment, short-term deployments are anticipated to be implemented within 0-3 years; medium term in 4 to 8 years; and long-term deployments are expected to occur in more than 8 years.

Table 38 - Southwest Region Short-Term (0 – 3 Years) ITS Deployment Plan Projects

Short-Term Deployments	Components	Comments
Freeway Management System	- Initiate urban deployments in Jackson, Kalamazoo, Battle Creek and Benton Harbor/St. Joseph.	- These are areas of highest volume along the I-94 corridor which is a Corridor of Highest Significance. Projects will need to be phased in over time but DMS and CCTV at major decision points should be highest priority.
Smart Work Zones	- Adequate capacity to cover trunkline construction with lane and shoulder closings that may result in significant delays and cannot be mitigated by other means. Initial focus on I-94 and summer construction on recreational routes.	- Project shows very high positive impact in terms of both net benefits and benefit/cost ratio. - However mitigation activities already underway in Southwest region have been effective and full deployment may not be needed.
Road Weather Information Systems	- First phase deployment with roughly 50% of proposed 24 ESS - Deployment of anti-icing devices at roughly half of 17 locations proposed.	- A regional study is needed to develop RWIS concept of operations and locate ESS. A two-phase implementation is assumed here although this will depend on the outcome of the study. - MDOT intends to prioritize ESS sites on a statewide level as part of a future RWIS study. - Anti-icing systems need to be tested before full deployment.
Traffic Signal System Improvements	- Initiate upgrades in Kalamazoo and Calhoun Counties, which show highest level of benefit. - Initiate other upgrades based on age and condition of equipment.	- Individual corridors should be evaluated in more detail through either regional models or microsimulation.
Highway Advisory Radio	- Deploy at key decision points in conjunction with DMS, such as freeway-to-freeway interchanges and major entry points into the state.	
Advanced Public Transportation Systems	- Deployment of AVL and scheduler system on fixed route vehicles of Kalamazoo Metro Transit and paratransit vehicles in Kalamazoo County.	

Table 39 - Southwest Region Medium-Term (4 – 8 Years) ITS Deployment Plan Projects

Medium Term Deployments	Components	Comments
Freeway Management System	- Continue deployment of urban freeway management systems initiated in short-term - Initiate deployment of rural freeway management system along I-94 corridor.	
Road Weather Information System	- Second phase implementation of RWIS - Second phase implementation of anti-icing deployments	- Timing and specific sites to be determined based on study and evaluation of 1st phase deployments. - Need to track continuing developments in technology, particularly data available from mobile sensors through VII - 1st phase assessment of anti-icing systems will help
Traffic Signal Systems	- Continue deployment of systems based on further analysis - Projects to be partially determined by need for equipment replacement	- Need to review results from short-term deployments.
Highway Advisory Radio	- Re-evaluate need for deployment in proposed locations not deployed in Phase 1.	- This technology may be superseded by more advanced methods of communication with motorists.
Freeway Service Patrols	- Consider for implementation depending on traffic conditions	- Does not appear justified in short term based on benefits - Reconsider in subsequent timeframes if conditions warrant.
Advanced Public Transportation Systems	- Deployment of AVL and scheduler system on vehicles of Van Buren County Transit	

Table 40 - Southwest Region Long-Term (Over 8 Years) ITS Deployment Plan Projects

Long- Term Deployments	Components	Comments
Freeway Management Systems	- Continue deployment of Freeway Management System as funding permits.	- Depending on funds available complete I-94 deployments and continue with other major corridors - Potential increased use of in-vehicle devices (VII) for traveler information may reduce need for DMS.
Road Weather Information System	- Third phase implementation of RWIS	- Timing and specific sites to be determined based on study and evaluation of 1st phase deployments.
Traffic Signal Systems	- Projects to be determined by evaluation of previous deployments and need for equipment replacement	