Intermediate Reference Markers Evaluation Report

September 30, 2005

PENNDOT

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16. Abstract

Intermediate Enhanced Reference Location Signs, commonly referred to as Intermediate Reference Markers (IRMs) have been deployed at several locations throughout the Commonwealth in order to reduce emergency response times as well as to improve incident reporting accuracy

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1. EXECUTIVE SUMMARY

Intermediate Enhanced Reference Location Signs, commonly referred to as Intermediate Reference Markers (IRMs), have been deployed at several locations throughout the Commonwealth in order to reduce emergency response times and improve incident reporting accuracy. The *Manual on Uniform Traffic Control Devices* provides basic guidance on the layout, size and color of IRMs, but does not include specific guidance relative to spacing or performance.

By performing evaluations of such projects, the following benefits are provided by answering some basic questions:

- ✓ **Document our successes** – Has the system provided a realized benefit?
- ✓ **Rationalize our investments versus the benefits** – Do the financial benefits of the system outweigh the costs?
- ✓ **Identify potential improvements** – Can the system concept be enhanced by modifying future deployments?

1.1. DOCUMENT OUR SUCCESSES

Based on both literature reviews and stakeholder surveys there appears to be overwhelming support for the use of IRMs. Stakeholder surveys indicated that:

- ✓ 100 percent of stakeholders feel IRMs are helpful.
- ✓ IRMs result in 25-50 percent reduction in response times based on survey responses.
- ✓ IRMs improve incident reporting accuracy by over 50 percent based on survey responses.

These estimates are consistent with previous surveys conducted in District 8-0 as well the Advanced Regional Traffic Interactive Management Information System (ARTIMIS) deployment which estimated that response times were decreased by 30 percent.

There is a relationship between response time and fatality reduction. While stakeholders estimated that a 0-10 percent reduction in fatalities can be attributed to IRMs, performance models indicate that a 6.5 percent reduction in fatalities may be attributable to IRMs.

1.2. RATIONALIZE OUR INVESTMENTS

1.2.1. Benefit-Cost

Although a 0-10 percent reduction may not seem significant in numerical terms, the benefit when applied to human terms is significant. Applying FHWA economic values for fatalities, it is estimated that the human savings versus the cost of implementation will yield benefit-to-cost ratios exceeding 1.0. The benefits do not include other economic benefits that might be associated with improved accuracy, reduced secondary crashes, and non-incident benefits.

Benefit-Cost Estimates at 1/10th Mile Spacing

Road Type	Yearly Cost ($ million)	Yearly Economic Benefit in Fatality Reduction ($ million)	Benefit-to-Cost Ratio
Urban Interstates	0.09	18	200
Rural Interstates	0.16	21	131
Freeways	0.08	12	150
Arterials	0.98	105	107
Collectors	2.15	36	17

1.2.2. Value-Engineering

Other spacing options provide similar benefit-to-cost ratios. While implementation costs may be reduced by as much as 35 percent with increased spacing, the response times may experience a slight decrease due to visibility issues and first responder accuracy. Ultimately, increased spacing scenarios reduce deployment costs with minimal response increase, thereby providing greater benefit-cost ratios.

Value-engineered alternative sign layouts can decrease deployment costs by up to 7 percent; however, some of the intuitive understanding of enhanced IRM with route shield may be sacrificed. Also, more deviation from the standard MUTCD configuration will occur.

1.2.3. Role of IRMs as E911 Evolves

Based on feedback from emergency management officials and first responders, most feel that the expansion of the E911 does not eliminate the need or benefit of IRMs. Most stakeholders who responded noted that E911 and IRMs provided overlapping and beneficial sources of information allowing for improved accuracy versus IRMs or E911 alone. However, some emergency management officials did note a diminished benefit of IRMs in areas with E911 versus in areas without E911.

1.3. IDENTIFY POTENTIAL IMPROVEMENTS

The evaluation process should include an identification of potential improvements.

It was noted that there was minimal guidance relative to deployment policy. Additionally, there may be some design alternatives that may reduce installation and maintenance costs and in some cases improve visibility. Finally, an educational component should be considered that targets motorists, emergency management officials and first responders since they are the users of the system.

1.3.1. Proposed Deployment Policy

- ✓ Permissible on all interstates and non-interstate freeways pending Department review and per Section 1.20.6 of PennDOT Publication 46, *Traffic Engineering and Operations Manual*.
- ✓ Deployment suggested on roadways with continuous Dynamic Message Sign (DMS) coverage, ADTs exceeding 75,000 or roadways exceeding state wide crash and fatality rates for similar facilities.
- ✓ In urban areas with ADTs exceeding 75,000 or interchange spacing of less than 1.5 miles on average, marker spacing to be set at 1/10th mile intervals.
- ✓ For all other conditions, marker spacing to be set at 2/10th mile intervals, except for areas with vertical crest curves and horizontal curves when mounting should be set at 1/10th mile intervals.
- ✓ Markers should be median mounted and back-to-back where feasible.
- ✓ Deployment should include educational components.
- ✓ Deployment should include mapping distribution to first responders and emergency management officials.

1.3.2. Ramp Reference Markers Deployment Considerations

- ✓ Permissible on interstate (or limited access) to interstate (or limited access) ramps.
- ✓ Not permissible on ramps that are less than 0.2 miles in length.
- ✓ Generally, a second phase deployment once IRMs have been fully installed.
  - With exception of complex and high volume urban interchanges

1.3.3. Proposed Design Considerations

- ✓ Spacing: Consider spacing at 1/10th mile in urban locations, on vertical crest curves and on horizontal curves in the direction of the side (median or shoulder) where IRMs are placed. Rural applications could have 2/10th spacing other than the conditions above; however, emergency response times may be impacted.
- ✓ Color: Continue to utilize green as background color for signs.
- ✓ Layout: Maintain current practice of utilizing letter designation for direction and not including MILE legend.
- ✓ Size: Maintain the current size of IRMs at 15” x 48.” Increase the route crest to 13” (with 6.5” font) from 9.” To make up the 4” difference, decrease edge margins from 3.5” to 2.0” and decrease 4” (2” on each side of line) margin between mileage and tenths to 3” (1.5” on each side of line).
- ✓ Placement: Consider installing future IRM deployments in the median to reduce costs (mount back-to-back), reduce snow plow knockdowns and limit sign clutter.

1.3.4. Proposed Educational Components

- ✓ Integrate education about IRMs into driver education materials
- ✓ Distribute press releases when IRMs are deployed in new areas
- ✓ Introduce educational signs when entering Pennsylvania and in new deployment areas to inform out-of-state motorists.
- ✓ Provide mapping to first responders and emergency management officials.

2. INTRODUCTION

2.1. PURPOSE OF TEST

Intermediate Enhanced Reference Location Signs, commonly referred to as Intermediate Reference Markers (IRMs), have been deployed at several locations throughout the Commonwealth in order to reduce emergency response times and improve incident reporting accuracy.

The deployment of markers within the Commonwealth, as well as elsewhere in the United States, vary in size, color and spacing; however, the recently released *Manual on Uniform Traffic Control Devices* provides basic guidance on the layout, size and color of IRMs, but does not include specific guidance relative to spacing or performance.

2.2. PERFORMANCE MEASURES AND HYPOTHESIS TO BE TESTED

This evaluation report attempts to address the following performance measures and hypothesis.

- ✓ Reduction in Emergency Response Times
- ✓ Reduction in Secondary Crashes
- ✓ Reduction in Fatalities
- ✓ Increased Accuracy of Incident Reporting
- ✓ Customer Satisfaction/Awareness

2.3. EVALUATION REQUIREMENTS BACKGROUND

The Transportation Equity Act for the 21st Century (TEA-21) prescribes that the U.S. Secretary of Transportation of Transportation issue guidelines and requirements for the evaluation of operational tests and deployment projects for Intelligent Transportation Systems (ITS) for projects under their jurisdiction. The goal of the mandate was to develop a basis for continuing support of decision makers addressing policy and investment issues by providing a clear understanding of ITS system effectiveness.

By performing evaluations of such projects, we provide the following benefits by answering some basic questions:

- ✓ **Document our successes** – Has the system provided a realized benefit?
- ✓ **Rationalize our investments versus the benefits** – Do the financial benefits of the system outweigh the costs?
- ✓ **Identify potential improvements** – Can the system concept be enhanced by modifying future deployments?

This evaluation report is consistent with the methodologies presented in the Federal Highway Administration's, *ITS Evaluation Guidelines – ITS Evaluation Resource Guide*.

2.4. DEFINITIONS

IRMs and other systems have a variety of names. For the purpose of clarity, the following names and definitions will be used.

Reference Location Signs
- ✓ Shows an integer distance point along a highway
- ✓ Commonly referred to as milepost markers

Enhanced Reference Location Signs
- ✓ Shows an integer distance point along a highway
- ✓ Also includes direction and route information
- ✓ Commonly referred to as enhanced milepost markers

Intermediate Reference Location Signs
- ✓ Shows a decimal between integer distance points along a highway
- ✓ Commonly referred to as tenth mile markers

Intermediate Enhanced Reference Location Signs
- ✓ Shows a decimal between integer distance points along a highway
- ✓ Also includes direction and route information
- ✓ **Commonly referred to as Intermediate Reference Markers (IRMs)**
- ✓ **The focus of this evaluation**

2.5. CONTACTS

PennDOT Central Office (Bureau of Planning and Research/ Bureau of Highway Safety and Traffic Engineering)	Bob Garrett, Bureau of Planning and Research ✓ 717-787-0800 ✓ rgarrett@state.pa.us Leslie McCoy, Bureau of Highway Safety and Traffic Engineering ✓ 717-214-2994 ✓ lemccoy@state.pa.us
Consultant	Mark Metil, Consultant Project Manager ✓ 717-763-7212 x2321 ✓ mmetil@gfnet.com Bob Taylor, Assistant Project Manager ✓ 717-763-7212 x2309 ✓ rtaylor@gfnet.com

3. RESEARCH AND BENCHMARKING

3.1. INTRODUCTION

The evaluation of current practices regarding IRMs was undertaken by performing a literature review of national, state and regional IRM practices and by interviewing state DOT staff. Most literature on IRMs exists as either a study of specific IRM systems or as general information posted on a DOT website. Follow up investigations were conducted where warranted with key DOT staff in order to clarify and augment existing IRM literature. Additionally, emerging issues regarding both the placement and relevancy of IRM systems were reviewed.

3.2. PENNSYLVANIA DEPLOYMENTS

There are several deployments of various types of IRMs within Pennsylvania. Other deployments are on hold pending the findings and outcomes of this study. It should be noted that while several districts have intermediate reference markers installed, only District 5-0 and 8-0 have enhanced intermediate markers. Standard intermediate reference markers in other districts include variations with decimals as well as fractions.

3.2.1. District 5-0

PennDOT's District 5-0 designed its IRM system between 1999 and 2001. District 5-0 was chosen as a test site for IRMs by the FHWA. At that time, no standards were used for the development or deployment of IRMs; therefore, District 5-0 staff toured IRM sites in the Ohio and Kentucky region (ARTIMIS). The IRMs in District 5-0 were installed in 2001. Initial feedback from 911 centers and the PA State Police have deemed the IRMs "excellent" for reporting and managing incidents.[1]

3.2.2. District 8-0

PennDOT's District 8-0 employs IRMs spaced at 1/10th mile that were deployed in conjunction with the Harrisburg Capital Beltway ITS equipment in 1999.[2] The IRMs were funded through FHWA as part of an incident management study and cost $139,991. The cost per sign was $62.50 based on the installation of 2,250 signs.[3] The IRMs (15" x 48") are larger than those recommended by the MUTCD. The Capital Beltway was chosen for this study since there are many intersecting roadways and through travelers have difficulty identifying their location when reporting an incident.

District 8-0 conducted surveys of the Pennsylvania State Police, county 911 centers and media outlets (TRAFFAX, WNNK) to gauge the effectiveness of the IRMs. The survey respondents reported an 85% - 90% satisfaction rating with the IRMs, since the IRMs not only helped to cut down on the time dispatchers spent per call but also increased the accuracy of incident reporting.

Other key findings in the District 8-0 study are:

- ✓ 69.3% of respondents reported that most or some drivers used the IRMs to report incident location
- ✓ 82.2.% of drivers used the IRMs very accurately or accurately
- ✓ 89.3% of respondents felt that detection and dispatch time had considerably or moderately improved
- ✓ 58.6% of callers used mileage markers to report incidents
- ✓ 83.9% of respondents felt the IRMs and exit renumbering had improved incident location and dispatch considerably or moderately.

3.2.3. Pennsylvania Turnpike Commission

In concert with a new dual exit numbering system, the Pennsylvania Turnpike Commission has embarked on upgrading all 1/10th mile IRMs along the entire 512 miles of roadway. The more than 10,000 new 1/10th mile IRMs feature bolder white lettering that is two-times larger than existing lettering and numbering. Moreover, the markers are eight inches taller than the existing 1/10th mile IRMs and are made of a flexible material that springs back up when run over. The cost for the new mile markers is approximately $210,000.[4]

The Turnpike system is similar to traditional intermediate reference location signs except for the lack of a unit of measure and the use of a decimal. The Turnpike system uses a letter system (black A in photo) for route identification purposes.

Pennsylvania Turnpike Computer Aided Dispatch System

The Pennsylvania Turnpike's Computer Aided Dispatch (CAD) System's Incident Report contains a wealth of information dating to 1999 regarding each incident reported on the 500+ miles of the PA Turnpike system. Motorists may dial *11 on their cellular phones and be connected to the Turnpike's 911 Operations Center in Harrisburg. Radio operators and dispatchers receive the call and ask an initial series of questions including the type of incident, number of blocked lanes, number of people in vehicle(s), and type of cargo.

The CAD system assigns a number to each incident. The incident type and incident location are the two primary data elements that drive the response. Based upon the incident type and incident location, given in latitude, milepost marker down to the tenth of a mile, and direction of travel, certain response agencies are assigned by the CAD to this specific incident type. The agencies may include Turnpike Safety Advisors, Turnpike maintenance (for cones, arrow boards, and absorbent material), PA State Police, local EMS, local fire departments, tow trucks/wreckers, local police departments, and hazmat. The CAD creates a response grid, based upon the incident location to the tenth of a mile, which corresponds to specific state police zones. Incidents are also prioritized by response type.

Importantly, the CAD system time stamps all comments from the radio operator at the 911 Operations Center throughout the entire incident. From the time stamps, incident response times and incident durations can be ascertained. Moreover, the Incident Reports include a detailed line item for each responder, be they fire, police, towing, EMS, maintenance, etc. The status of each responder is recorded along with the time stamp and dispatcher comments. For example, responder status may include dispatched (DS), en route (ER), on scene (OS), available and cleared the scene (AV), road is open (OP), and traffic is restored to normal flow (EP).[5]

3.3. EXISTING NATIONAL GUIDANCE

The *Manual on Uniform Traffic Control Devices (MUTCD)*, 2003 edition provides guidance on the usage and layout of IRMs and other location signing systems. Specific MUTCD guidance is on subsequent pages.

The MUTCD allows the use of IRMs and other reference location signs on expressways, freeways and conventional roadways, but does not provide warrants or guidelines on the deployment of reference location signs. The spacing guidelines state that intermediate signs should be placed at one tenth intervals or some other regular spacing.

The MUTCD requires that reference location signs be of a retroreflective green background with white letter. This varies from several early deployments in other states which utilized a blue background and was permitted in previous editions of the MUTCD.

Sign layout is provided in FHWA's *Standard Highway Signs* (SHS), 2004 edition and is illustrated in **Exhibit 3.1**. In general, IRMs should be 18" X 60" per SHS. For freeways and expressways, legends are a minimum height of 6", mileage lettering is a minimum of 8" per SHS (MUTCD states 10") and the route shield minimum is 13" per SHS (MUTCD states 12").

Section 2D.46 Reference Location Signs (D10-1 through D10-3) and Intermediate Reference Location Signs (D10-1a through D10-3a)

Support:

There are two types of reference location signs:

A. Reference Location signs (D10-1, 2, and 3) show an integer distance point along a highway; and
B. Intermediate Reference Location signs (D10-1a, 2a, and 3a) also show a decimal between integer distance points along a highway.

Option:

Usage

Reference Location (D10-1 to D10-3) signs (see Figure 2D-13) may be installed along any section of a highway route or ramp to assist road users in estimating their progress, to provide a means for identifying the location of emergency incidents and traffic crashes, and to aid in highway maintenance and servicing.

To augment the reference location sign system, Intermediate Reference Location (D10-1a to D10-3a) signs (see Figure 2D-13), which show the tenth of a kilometer (mile) with a decimal point, may be installed at one tenth of a kilometer (mile) intervals, or at some other regular spacing.

Standard:

When Intermediate Reference Location (D10-1a to D10-3a) signs are used to augment the reference location sign system, the reference location sign at the integer kilometer (mile) point shall display a decimal point and a zero numeral.

Size

When placed on freeways or expressways, Reference Location (D10-1 to D10-3) signs shall contain 250 mm (10 in) white numerals on a 300 mm (12 in) wide green background with a white border. The signs shall be 600, 900, or 1200 mm (24, 36, or 48 in) in height for one, two, or three digits, respectively, and shall contain the abbreviation km (MILE) in 100 mm (4 in) white letters.

When placed on conventional roads, Reference Location (D10-1 to D10-3) signs shall contain 150 mm (6 in) white numerals on a green background that is at least 250 mm (10 in) wide with a white border. The signs shall contain the abbreviation km (MILE) in 100 mm (4 in) white letters.

The design details for reference location signs shall be as shown in the "Standard Highway Signs" book (see Section 1A.11).

Reference location signs shall have a minimum mounting height of 1.2 m (4 ft) to the bottom of the sign in accordance with the mounting height requirements of delineators (see Section 3D.04), and shall not be governed by the mounting height requirements prescribed in Section 2A.18.

The distance numbering shall be continuous for each route within a State, except where overlaps occur (see Section 2E.28). Where routes overlap, reference location sign continuity shall be established for only one of the routes. If one of the overlapping routes is an Interstate route, that route shall be selected for continuity of distance numbering.

For divided highways, the distance measurement shall be made on the northbound and eastbound roadways. The reference location signs for southbound or westbound roadways shall be set at locations directly opposite the reference location signs for the northbound or eastbound roadways.

Guidance:

Zero distance should begin at the south and west State lines, or at the south and west terminus points where routes begin within a State.

On a route without reference location sign continuity, the first reference location sign beyond the overlap should indicate the total distance traveled on the route so that road users will have a means of correlating their travel distance between reference location signs with that shown on their odometer.

Standard:

Except as provided in the option below, reference location signs shall be installed on the right side of the roadway.

Option:

Placement

Where conditions limit or restrict the use of reference location signs on the right side of the roadway, they may be installed in the median. On two-lane conventional roadways, reference location signs may be installed on one side of the roadway only and may be installed back-to-back. Reference location signs may be placed up to 9 m (30 ft) from the edge of the pavement.

If a reference location sign cannot be installed in the correct location, it may be moved in either direction as much as 15 m (50 ft).

Guidance:

If a reference location sign cannot be placed within 15 m (50 ft) of the correct location, it should be omitted.

Option:

Enhanced reference location signs (see Section 2E.54) may also be used on conventional roads.

Usage

Size

Placement

Section 2E.54 Reference Location Signs and Enhanced Reference Location Signs (D10-4, D10-5)

Support:

Reference Location (D10-1 through D10-3) signs and Intermediate Reference Location (D10-1a through D10-3a) signs and their applications are described in Section 2D.46.

There are two types of enhanced reference location signs:

A. Enhanced Reference Location signs (D10-4), and
B. Intermediate Enhanced Reference Location signs (D10-5).

Standard:

Except as provided in the option below, Reference Location (D10-1 through D10-3) signs (see Section 2D.46) shall be placed on all expressway facilities that are located on a route where there is reference location sign continuity and on all freeway facilities to assist road users in estimating their progress, to provide a means for identifying the location of emergency incidents and traffic crashes, and to aid in highway maintenance and servicing.

Option:

Enhanced Reference Location (D10-4) signs (see Figure 2E-45), which enhance the reference location sign system by identifying the route, may be placed on freeways or expressways (instead of Reference Location signs) or on conventional roads.

To augment an enhanced reference location sign system, Intermediate Enhanced Reference Location (D10-5) signs (see Figure 2E-45), which show the tenth of a kilometer (mile) with a decimal point, may be installed along any section of a highway route or ramp at one tenth of a kilometer (mile) intervals, or at some other regular spacing.

Standard:

If enhanced reference location signs are used, they shall be vertical panels having blue or green backgrounds with white numerals, letters, and borders, except for the route shield, which shall be the standard color and shape. The top line shall consist of the cardinal direction for the roadway. The second line shall consist of the applicable route shield for the roadway. The third line shall identify the kilometer (mile) reference for the location and the bottom line of the Intermediate Enhanced Reference Location sign shall give the tenth of a kilometer (mile) reference for the location. The bottom line of the Intermediate Enhanced Reference Location sign shall contain a decimal point. The height of the legend on enhanced reference location signs shall be a minimum of 150 mm (6 in). The height of the route shield on enhanced reference location signs shall be a minimum of 300 mm (12 in).

The background color shall be the same for all enhanced reference location signs within a jurisdiction.

The design details for enhanced reference location signs shall be as shown in the "Standard Highway Signs" book (see Section 1A.11).

Enhanced reference location signs shall have a minimum mounting height of 1.2 m (4 ft) to the bottom of the sign in accordance with the mounting height requirements of delineators (see Section 3D.04), and shall not be governed by the mounting height requirements prescribed in Section 2A.18.

The distance numbering shall be continuous for each route within any State, except where overlaps occur (see Section 2E.28). Where routes overlap, enhanced reference location sign continuity shall be established for only one of the routes. If one of the overlapping routes is an Interstate route, that route shall be selected for continuity of distance numbering.

The distance measurement shall be made on the northbound and eastbound roadways. The enhanced reference location signs for southbound or westbound roadways shall be set at locations directly opposite the enhanced reference location signs for the northbound or eastbound roadways.

Guidance:

The route selected for continuity of distance numbering should also have continuity in interchange exit numbering (see Section 2E.28). On a route without enhanced reference location sign continuity, the first enhanced reference location sign beyond the overlap should indicate the total distance traveled on the route so that road users will have a means of correlating their travel distance between enhanced reference location signs with that shown on their odometer.

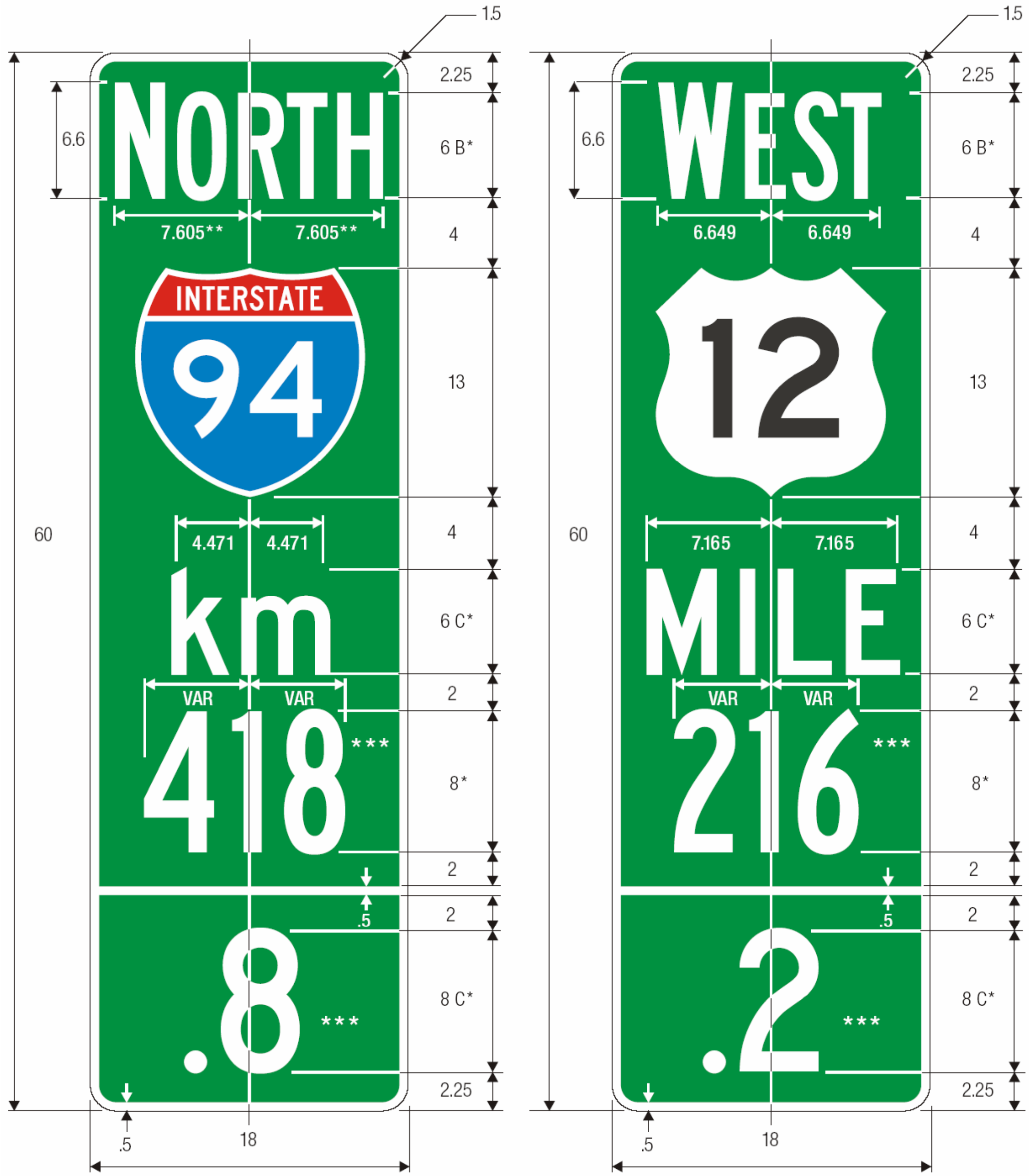
Standard:

Except as provided in the option below, enhanced reference location signs shall be installed on the right side of the roadway.

Option:

Where conditions limit or restrict the use of enhanced reference location signs on the right side of the roadway, they may be installed in the median. In urban areas, Intermediate Enhanced Reference Location signs may be installed on the right side of the roadway, in the median, or on ramps to replace or to supplement the reference location signs. Enhanced Reference Location signs may be installed back-to-back in median locations.

Exhibit 3.1 Standard IRM per FHWA Standard Highway Signs



D10-5

INTERMEDIATE ENHANCED REFERENCE LOCATION

*Series 2000 Standard Alphabets.
**Reduce spacing to fit.
***Optically locate numerals about centerline.

3.3.1. Comparison of Pennsylvania Deployments and National Guidance

A comparison of Pennsylvania deployments versus national guidelines illustrated several differences.

Feature	MUTCD	PA (Typical)
Direction	✓ Spells out direction ✓ 6.6" minimum first letter ✓ 6' minimum secondary letters	✓ Abbreviates direction ✓ 8" minimum
Route Marker	✓ 12" – 13" minimum	✓ 9" minimum
Unit of Measure	✓ 6" minimum	✓ NONE INCLUDED
Mileage and Decimal Mileage	✓ 8" minimum	✓ 8" minimum
Height	✓ 60" minimum	✓ 48" minimum
Width	✓ 18" minimum	✓ 15" minimum
Spacing	✓ Top and bottom – 2.25" ✓ Direction to route – 4" ✓ Mileage and Decimal Mileage – 4"	✓ Top and bottom – 3.5" ✓ Direction to route – 2" ✓ Mileage and Decimal Mileage – 4"

The most significant differences may be the size and layout of the direction, the size of the route marker and the use of units. These issues will be explored further in the evaluations section.

MUTCD

PA

3.4. DEPLOYMENTS IN OTHER STATES

3.4.1. *Indiana*

Indiana

Usage:	As needed In DMS deployment areas 1/10th mile if >75K ADT
Spacing:	2/10th mile 1/10th mile in high volume areas
Placement:	Median
Size:	18” x 60”
Color:	Blue
Other:	Same as MUTCD except color

An important component of Indiana’s TrafficWise System are the 2/10th mile IRMs that are installed in Indianapolis, Northwest Indiana, Southern Indiana near Louisville, Evansville, Fort Wayne, and Kokomo. Indiana’s IRMs are blue signs displayed every two-tenths of a mile in the median of Interstates, although they are placed every one-tenth of a mile in the heavily traveled Borman Expressway (I-80/94) in Northwest Indiana (Chicago suburbs).[6] IRMs are deployed on roadways that are in the deployment area of Dynamic Message Signs (DMS) in select urban areas. Thresholds for deployment of the 1/10th mile IRMs include segments of freeway five miles in length or greater with a current (2004) annual average daily traffic (AADT) of 75,000 or greater.

The 2/10th mile IRMs show the direction of travel, route shield, and the mile marker location on the highway to the tenth of a mile. Indiana’s IRMs follow the MUTCD for size, format, and font; however, these IRMs utilize a blue background. The 2/10thmile IRMs also serve as a key component in the messages displayed on Dynamic Message Signs and broadcasts heard on the Highway Advisory Radio stations. Information regarding the location of an incident or heavy traffic is shown and/or broadcast by the mile marker location of the highway.[7] The Indiana State Police and Freeway Service Patrols have indicated that they are very satisfied with the IRMs in assisting with incident management. Indiana has formed incident management groups around the state comprising local police and fire departments.[8]

3.4.2. *Tennessee*

Tennessee

Usage:	As needed
Spacing:	2/10th mile
Placement:	Median
Size:	NA
Color:	Blue

According to the *Strategic Plan for Highway Incident Management in Tennessee*, reporting the location of a freeway incident can be very difficult and is frequently confusing for motorists and emergency responders. Therefore, the Tennessee Department of Transportation (TDOT) has installed emergency reference markers at 2/10th mile intervals on Interstate highways in Chattanooga, Knoxville, Memphis, and Nashville. Additionally, signs have been placed on structures over the Interstate to identify the cross streets in these cities.[9]

On certain Interstate highways in Chattanooga, Knoxville, Memphis, and Nashville, blue median reference markers serve as street addresses. Presently, TDOT is testing the use of these signs to improve emergency response to Interstate crashes and other incidents. TDOT has installed two signs, one facing each direction, along 228 miles of Interstate highways in the four metropolitan areas. Each sign gives four pieces of information: direction of travel, Interstate route the motorist is traveling, milepost, and tenth of a mile past the indicated mile post.[10]

While not immediately accepted by other agencies, acceptance of the ERMs has grown and continues to grow. Additionally, at the request of other agencies, TDOT installed overhead street name signs at overpasses on urban interstates. No TDOT surveys have been conducted. ERMs are part of the Strategic Plan for Highway Incident Management in Tennessee.[11]

3.4.3. Wisconsin

Wisconsin	
Usage:	As needed
Spacing:	1/10th or 2/10th mile
Placement:	Median, shoulder, light poles
Size:	NA
Color:	Blue

The Wisconsin ITS Design Manual gives engineers familiar with ITS elements the process and information necessary to design ITS elements for the Wisconsin Department of Transportation (WisDOT). The Manual provides a host of information concerning usage, design, and state deployment comparisons. Wisconsin has adopted the blue background for reference markers previously approved by the FHWA in June of 2000. The Design Manual compares the benefits of varying sign types including standard aluminum signs and reflective stickers. Sign placement (median, shoulder, or light poles) is discussed. Sign spacing (1/10th and 2/10th) and sign information are analyzed as are the practices in other states.[12]

Wisconsin's enhanced reference markers are designed to save time in identifying the location of disabled motorists to improve emergency response times to highway incidents. There was a 15-mile segment of highway in Madison where 6 different emergency departments could respond to an incident and there needed to be a better way to determine who could respond fastest. The 2/10th mile IRMs were designed to assist with this determination.[13]

In 2001, the first signs were deployed along I-94 in Milwaukee County and had the following characteristics: standard aluminum sign, green background, 6" characters, deployed in the median on light poles, spaced every 1/10th mile, and displayed direction, route shield, and mile reference. Since the early deployment of the reference signs along I-94, changes were recommended to the standard sign layout. Basic sign layout consists of the following: signs are type 2 reflective, blue background color, white message color, C message series, 8" characters, display of direction, route shield, and mile reference number, no more than two route shields on any sign, and "MILE" is spelled out on each sign.[14] An evaluation of the enhanced reference markers was undertaken in accordance with other statewide ITS measures, therefore the state cannot ascertain specific enhanced reference marker benefits. It was noted that emergency response times decreased from 25 to 10 minutes based upon the use of enhanced reference markers.[15]

3.4.4. *Advanced Regional Traffic Interactive Management Information System (ARTIMIS)*

ARTIMIS

Usage: As needed
Spacing: Most at 2/10th mile; Some 1/10th mile
Placement: Median, shoulder,
Size: 14" x 48"
Color: Most blue

ARTIMIS began in June 1995 and is one of the earliest ITS systems deployed in the U.S. The system provides traffic management and traveler information on 88 miles of the most heavily traveled freeways in the greater Cincinnati and Northern Kentucky region. ARTIMIS comprises a partnership between the Ohio Department of Transportation (ODOT), Kentucky Transportation Cabinet (KYTC), and the Ohio Kentucky Indiana Regional Council of Governments (OKI).

In the Cincinnati-Northern Kentucky Region, there are approximately 40 different emergency jurisdictions that have response authority for the interstates covered by ARTIMIS and only 11 Public Service Answering Points (PSAPs). In one case, a single interchange has three different responding agencies depending upon location. The result in questionable cases was the dispatching of two different departments, or multiple dispatches in different directions.[16]

In order to improve the emergency response process, the ARTIMIS program developed a low-cost, low-technology reference and ramp marker system. These signs were designed based upon standard colors, letter sizes, etc. from the Manual on Uniform Traffic Control Devices (MUTCD). The signs were also sized and spaced such that a person with normal vision, on a clear day, could, after passing a marker, read the next marker without turning around.

To date, the results have been excellent. The Evaluation of Reference Markers report, written by the University of Kentucky, notes that "surveys of participants in the emergency response process offered nearly unanimous endorsement of the reference signs." In addition, "dispatch personnel have indicated that drivers are using the signs for identification of the location where an incident has occurred, with the resultant effect of a more efficient process for responding to incidents and accidents." The largest PSAP, the Hamilton County Communication Center, noted a 30% reduction in response time after installation of the markers. This is especially important during the "golden hour" after an incident where minutes can literally be the difference between life and death. The reduction in response time also translates to a reduction in the traffic backups due to the incidents, which in turn, may lead to fewer secondary crashes and fewer injuries.[17]

In addition, "tow operators have noted special benefits from the reference signs when calls for assistance have been received directly from motorists." Mowing and construction crews have indicated a time savings in setting up traffic control based upon mandatory distance requirements. All of these contribute to a safer freeway by eliminating guesswork and confusion.[18]

Other deployment observations include:

- ✓ Keep all signs on a grass median mounted back-to-back on a single channel post unless the median is extremely wide
- ✓ 500' spacing is most likely needed where the road is not straight.
- ✓ Feedback from non-local residents is positive – gives them an idea of where they are.
- ✓ The largest PSAP has experienced a 30% reduction in response times.
- ✓ They have resolved almost all multiple jurisdictional emergency response issues.
- ✓ Have led to an operational cost savings (50% staff requirement) by reducing incident location uncertainty.
- ✓ Awarded ITS America Best of ITS Award for 2001 for Deployment Shown to Save Lives.

3.4.5. *Lexington-Fayette Urban County Government*

LFUCG	
Usage:	As needed
Spacing:	1/10th and 2/10th mile
Placement:	Median, shoulder,
Size:	18" x 48"
Color:	Green

The Lexington-Fayette Urban County Government (LFUCG), in cooperation with the FHWA and the Kentucky Department of Transportation, installed 2/10th mile IRMs on Interstates 64 and 75 throughout the Lexington, KY metropolitan area. These signs were installed as part of a demonstration project funded through the FHWA. The current design of the intermediate enhanced reference markers is 18"x 48" blanks with a high-intensity green background, a 12-inch interstate shield and 8-inch highway "C" characters. These signs are installed on square posts on barrier walls, shoulders, or medians on the interstate. A 12-inch shield is displayed on each enhanced reference marker under the direction of travel, which is displayed as a single direction character reading from top to bottom.

The enhanced reference markers have reduced the response time for emergency vehicles by providing a more clearly defined location of the incident. This is important as there are numerous ramps throughout the Lexington metropolitan area that could be used for access to the interstates. However, with a center barrier wall dividing a majority of the interstate miles through the area, if the emergency vehicles get on the interstate at an inappropriate interchange relative to the incident, they may in fact not be able to reach the incident scene.[19]

The University of Kentucky conducted an evaluation of the reference markers installed in the Lexington metro area. The condition of the markers was found to be very good and there appeared to be only minor maintenance problems in the time period since installation. The majority of the markers have been installed on median barrier walls and therefore have less exposure to the routine problems related to mowing and errant vehicles which may impact the markers and posts. In addition, opinion surveys were obtained from individuals who had exposure to the marker projects and who understood the intent and usage of the markers. Interviews and surveys of participants in the emergency response process and others involved in traffic management systems indicate nearly unanimous endorsement of the reference markers. Dispatch personnel continue to indicate that drivers are using the markers for identification of locations where incidents occur, with the resultant effect of a more efficient process for responding to incidents and crashes. Tow operators have noted special benefits from the reference markers when calls for assistance were received directly from motorists.

Highway agency personnel and emergency response personnel have also expressed satisfaction with the markers, whether placed at 1/10th or 2/10th mile intervals. It is apparent that more frequently spaced markers offer additional benefit and increased safety in curved sections, and where there are missing markers due to maintenance or vandalism problems. Considering all factors, it appears that the reduced clutter and economy of markers at 2/10th mile intervals outweighs increased benefits from more frequently spaced markers. Moreover, “considering the minimal reduction in benefits that could be expected from the greater spacing, and the decreased cost, the 0.2-mile spacing of reference markers is recommended.”

3.5. Summary of Out-of-state Research

A critical link in the emergency response process is the timeliness and accuracy of location information provided to responding personnel. Based upon the response of emergency responders, traffic congestion may be alleviated or exacerbated. As a result, many state transportation agencies have deployed reference markers at either 1/10th or 2/10th mile intervals on various highways. In virtually every instance of the development and deployment of an IRM system, emergency response times have decreased while the accuracy of incident reporting has increased. Depending upon the size, sign material, and spacing, costs for IRM systems vary. However, it appears that the benefits in both lives saved and in reduced congestion are worth the capital expenditures.

Other States

Usage:	Limited guidance on where to deploy. Mostly as needed except Indiana which deploys in DMS areas and increases spacing to 1/10th mile at higher volumes.
Spacing:	1/10th and 2/10th mile based on policy, geometry and volumes thresholds.
Placement:	Many median mount to reduce pole costs and to reduce conflicts with snow removal.
Size:	14-18” x 48-60”
Color:	Many early deployments were blue, current practice is to use green background
Layout:	Many currently deployed signs do not include the unit of measure. Wisconsin added spelled out “MILE”

4. INTERVIEWS AND SURVEYS

The hypotheses tested were largely evaluated through feedback provided by stakeholders and motorists.

4.1. STAKEHOLDER SURVEY

Surveys were distributed to a cross section of emergency management officials and first responders in order to gauge their satisfaction and thoughts on IRMs. The exact distribution of surveys is as follows:

- ✓ 67 county 911 centers
- ✓ 64 fire and police agencies in areas of IRM deployments
- ✓ 11 PennDOT district traffic engineers for distribution to district ITS coordinators, county responders and freeway service patrols.

The survey is presented as **Exhibit 4.1.**

Exhibit 4.1 Stakeholder Survey

INTERMEDIATE REFERENCE MARKERS STAKEHOLDER SURVEY

The Pennsylvania Department of Transportation (PENNDOT) is conducting a research study to determine the effectiveness of the deployment of Intermediate Reference Markers (IRMs). Your responses will be very valuable in this evaluation and potential future use of IRMs. Please answer the following questions and email or fax the completed survey to Bob Taylor at rtaylor@gfnet.com or 717-763-8150 (fax).

1. For what agency do you work?

____

2. What is your name (OPTIONAL)?

____

3. What best describes your job duties relative to incident response?
- ☐ Emergency management
- ☐ First responder
- ☐ PENNDOT County responder
- ☐ Other

____

4. Do you feel IRMs assist you in responding to incidents?
- ☐ Yes
- ☐ No

5. Rate your satisfaction with IRMs.
- ☐ Very satisfied
- ☐ Satisfied
- ☐ Neutral
- ☐ Unsatisfied
- ☐ Very Unsatisfied

6. If you are emergency management personnel, what percentage of time do people use IRMs to report incidents?
- ☐ 0-25%
- ☐ 25-50%
- ☐ 50-75%
- ☐ 75-100%

7. If you are a responder, what percentage of time do you use IRMs in responding to incidents?
- ☐ 0-25%
- ☐ 25-50%
- ☐ 50-75%
- ☐ 75-100%

8. If you feel IRMs improve the accuracy of incident reporting, estimate the percentage improvement.
- ☐ Less than 10%
- ☐ 10-25%
- ☐ 25-50%
- ☐ Greater than 50%

9. If you feel IRMs contribute to decreased response times, estimate the percentage reduction.
- ☐ Less than 10%
- ☐ 10-25%
- ☐ 25-50%
- ☐ Greater than 50%

10. If you feel decreased response times associated with IRMs also reduces the number of secondary crashes, estimate the percentage reduction.
- ☐ Less than 10%
- ☐ 10-25%
- ☐ 25-50%
- ☐ Greater than 50%

11. If you feel decreased response times associated with IRMs reduces the fatality rate, estimate the percentage reduction.
- ☐ Less than 10%
- ☐ 10-25%
- ☐ 25-50%
- ☐ Greater than 50%

12. How often should IRMs be placed? (Most are currently spaced at 1/10th mile)
- ☐ 1/10th mile
- ☐ 2/10th mile
- ☐ 2/10th mile on straight segments, 1/10th mile on curves
- ☐ 1/10th mile on interstates, 2/10th mile on other freeways
- ☐ Other (please specify in space below)

____

13. Do you feel Sign A provides any additional benefit compared to Sign B?
- ☐ Yes
- ☐ No

A B

14. If the answer to 13 was Yes, please describe the additional benefit.

____

____

____

____

15. In order of priority, what would be the best use of $200,000?

- ____ Signalize one intersection
- ____ Install left turn lanes at one intersection
- ____ Purchase one emergency service vehicle
- ____ Hire two additional first responders
- ____ Install IRMs on 75 miles of major roadway

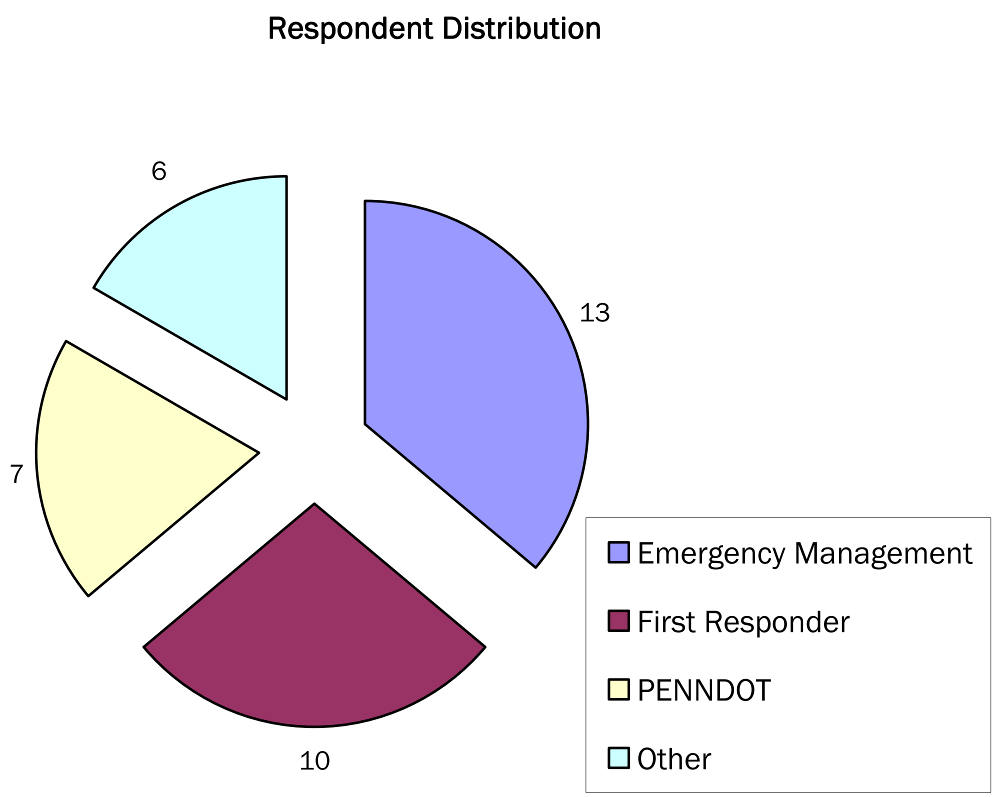
16. On what types of roads should IRMs be installed to maximize their benefit?
- ☐ High volume interstates ($0.9 million)
- ☐ All interstates ($2.2 million)
- ☐ All interstates and freeways ($2.9 million)
- ☐ All interstates, freeways, and other heavily traveled corridors ($8.8 million)
- ☐ All PENNDOT maintained roadways ($44.1 million)

17. Is there a specific roadway that you are aware of where IRMs would help incident response?

____

4.2. SURVEY RESULTS

36 surveys were returned and the chart below shows the respondent distribution.



The respondents selecting "other" category represented:

- ✓ Emergency Management/First Responder
- ✓ Fire and rescue
- ✓ Local police Chief
- ✓ 911 center.

In some cases respondents selected "other" even though they may be more appropriately classified as emergency management or first responders.

While 100 percent of the respondents answered “yes” to question four, “Do you feel IRMs assist you in responding to incidents,” their satisfaction level varied as shown in the table below.

5. Rate your satisfaction with IRMs					
Respondent	Emergency Management Officials	First Responders	PennDOT Officials	Others	Total Percentage by Response
Very Satisfied	7	5	3	5	57
Satisfied	4	4	3	2	37
Neutral	0	1	0	0	3
Unsatisfied	0	0	0	0	0
Very Unsatisfied	0	0	0	1	3
One respondent did not complete this question					

Emergency management officials were asked how often people use IRMs when reporting crashes and first responders were asked how often they use IRMs when responding to an incident. The responses are shown in the two tables below. Respondents that classified themselves as both emergency management and first responders are shown for each question.

6. What percentage of time do people use IRMs to report incidents			
Percentage	Emergency Management Officials	Emergency Management/ First Responders	Total Percentage
0-25%	3	1	29
25-50%	3	1	29
50-75%	3	0	21
75-100%	2	1	21
One respondent did not complete this question			

7. What percentage of time do you use IRMs in responding to incidents			
Percentage	First Responders	Emergency Management/ First Responders	Total Percentage
0-25%	2	1	23
25-50%	3	1	31
50-75%	3	0	23
75-100%	2	1	23
One respondent did not complete this question			

Respondents were asked to estimate the effects IRMs have on incident reporting and response, and the following four summary tables detail how they responded.

8. If you feel IRMs improve the accuracy of incident reporting, estimate the percentage improvement					
Percentage	Emergency Management Officials	First Responders	PennDOT Officials	Others	Total Percentage
Less than 10%	0	0	0	0	0
10-25%	1	2	0	1	13
25-50%	2	2	2	4	31
Greater than 50%	8	5	2	3	56
Four respondents did not complete this question					

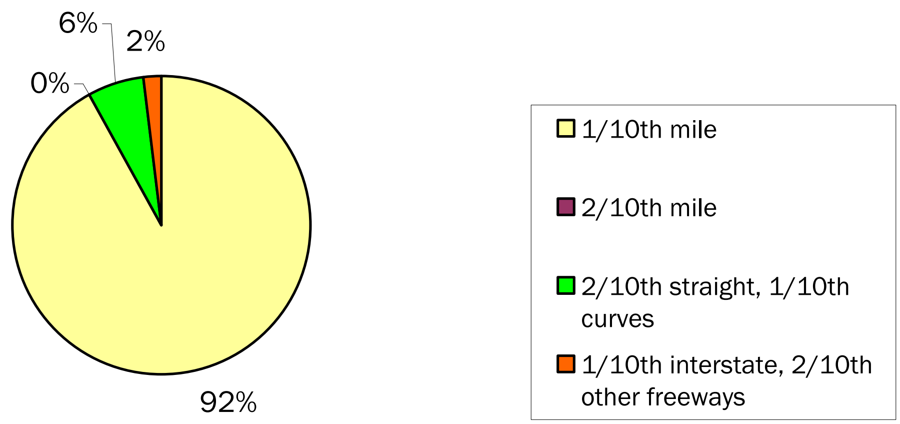
9. If you feel IRMs contribute to decreased response times, estimate the percentage reduction					
Percentage	Emergency Management Officials	First Responders	PennDOT Officials	Others	Total Percentage
Less than 10%	1	3	1	3	28
10-25%	4	0	1	2	24
25-50%	4	4	2	2	41
Greater than 50%	1	1	0	0	7
Seven respondents did not complete this question					

10. If you feel decreased response times associated with IRMs also reduces the number of secondary crashes, estimate the percentage reduction					
Percentage	Emergency Management Officials	First Responders	PennDOT Officials	Others	Total Percentage
Less than 10%	1	3	3	2	35
10-25%	3	4	1	3	42
25-50%	2	1	0	2	19
Greater than 50%	1	0	0	0	4
Ten respondents did not complete this question					

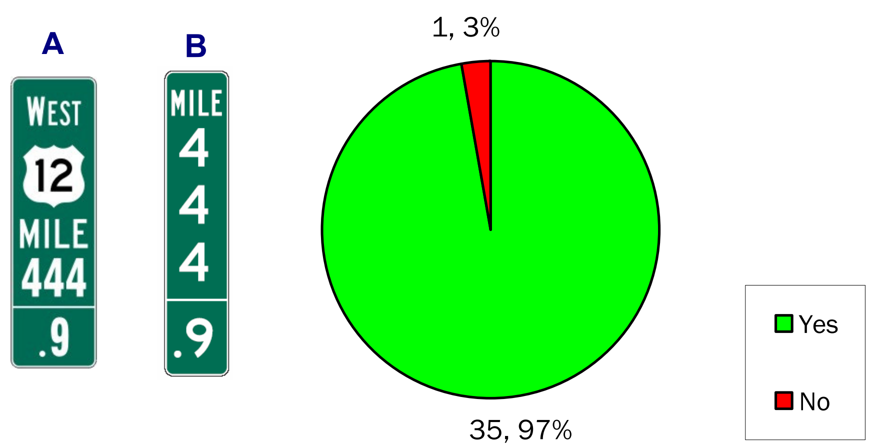
11. If you feel decreased response times associated with IRMs reduces the fatality rate, estimate the percentage reduction					
Percentage	Emergency Management Officials	First Responders	PennDOT Officials	Others	Total Percentage
Less than 10%	4	1	3	3	46
10-25%	1	4	0	2	29
25-50%	1	1	0	2	17
Greater than 50%	1	0	1	0	8
Twelve respondents did not complete this question					

The next two questions dealt with preferences regarding spacing and layout. No respondents reported 2/10th mile only in question 12.

12. How often should IRMs be placed



13. Do you feel Sign A provides any additional benefit compared to Sign B?



Respondents were asked to compare the existing IRM sign versus the new MUTCD standard sign and indicate whether or not the MUTCD sign offered any benefit. If respondents answered yes they were asked to describe the additional benefit. Below is a summary of the responses:

- ✓ Gives direction
- ✓ Gives route number
- ✓ Identifies type of road (i.e. interstate, US route, PA route)
- ✓ Easier to read
- ✓ More information provided
- ✓ Aids 911 dispatch asking questions.

The most common answers were “Gives route number” (19 total) and “Gives direction” (14 total).

For question 15 and 16, respondents were asked to prioritize the expenditure of $200,000 on five items and then identify the types of roads where IRMs should be installed to maximize the benefit. These questions were asked to establish a context within the stakeholder group of how much installing IRMs will cost versus the benefit they will provide.

15. In order of priority, what would be the best use of $200,000					
Category	Emergency Management	First Responders	PennDOT Officials	Others	Combined Weighted Average Ranking
Signalize one intersection	2	2	2	2	2
Install left turn lanes at one intersection	3	4	3	4	3
Purchase one emergency service vehicle	5	5	5	3	5
Hire two additional first responders	4	1	4	5	4
Install IRMs on 75 miles of major roadway	1	3	1	1	1
Some respondents only selected their top priority, an average value of 3.5 was used for the remaining items for comparison purposes ((2+3+4+5)/4)					

16. On what types of roads should IRMs be installed to maximize their benefit					
Category	Emergency Management	First Responders	PennDOT Officials	Others	Total Percentage
High volume interstates ($0.9 million)	0	0	0	0	0
All interstates ($2.2 million)	0	0	1	0	3
All interstates and freeways ($2.9 million)	1	4	1	3	27
All interstates, freeways and other heavily traveled corridors ($8.8 million)	6	5	4	2	52
All PennDOT maintained roadways ($44.1 million)	4	1	0	1	18
Three respondents did not complete this question					

Finally (question 17), respondents were asked to identify roadways in their area where the installation of IRMs would be helpful. The answers varied from rural interstates to urban arterial. Below is a list that summarizes the responses:

- ✓ Interstate 80
- ✓ Interstate 78
- ✓ Interstate 79
- ✓ Interstate 99
- ✓ Interstate 380
- ✓ Pennsylvania Turnpike
- ✓ Route 11/15
- ✓ Route 22 – Allentown Boulevard
- ✓ Route 60
- ✓ Route 222 north of Lancaster
- ✓ Route 283 from Lancaster to the County Line
- ✓ Route 322 between State College and Harrisburg
- ✓ Route 322 between Interstate 83 and Route 422
- ✓ Route 443 between Pine Grove and Friedensburg

4.3. Stakeholder Survey Summary

There were 142 surveys distributed and 36 (25 percent) were returned. Of the surveys that were returned:

- ✓ 100 percent of respondents feel IRMS are helpful (question #4) and 92 percent are satisfied or very satisfied with IRMs (question #5)
  - 56 percent of the respondents are very satisfied with IRMs.
  - 1 respondent is “very unsatisfied” with IRMs. Lawrence County EMA answered very unsatisfied, but answered in a positive manner on other questions. A MESSAGE HAS BEEN LEFT FOR FOLLOW-UP

- ✓ 58 percent of emergency management officials indicated that people use IRMs to report incidents 0-50% of the time (Question #6). This may be an indicator of a needed educational component to IRM deployments as detailed in subsequent sections.

- ✓ 31 percent of first responders indicated that they use IRMs 25-50% of the time when responding to incidents (Question #7). The even distribution of answers to this question may be attributable to varying levels of experience and knowledge of roadways by first responders.

- ✓ 55 percent of respondents said that IRMs increase the accuracy of incident reporting by more than 50 percent (question #8), and no one responded that IRMs provide less than 10 percent improvement in accuracy

- ✓ 41 percent of respondents feel that IRMs decrease response times by 25-50 percent (question #9); however, 28 percent of respondents reported that responses times decreased by less than 10 percent.

- ✓ 42 percent of respondents reported that IRMs decrease secondary crashes by 10-25 percent (question #10), and 35 percent of respondents reported that secondary crashes decreased by less than 10 percent.

- ✓ While responses received as part of question #9 indicated that stakeholders perceive significant response time reductions, the direct correlation of response time reduction to fatality reduction is less than what may be expected. 46 percent of respondents felt that reduced response times associated with IRMs reduces the fatality rate by less than 10 percent (question #11); however, 29 percent said 10-25 percent, 17 percent said 25-50 percent and 8 percent said greater than 50 percent.

- ✓ 92 percent felt that IRMs should be placed every 1/10th mile (question # 12).

- ✓ 97 percent felt that Sign B provided benefit over Sign A because it provides additional information such as route number and direction (questions #13 and 14).

- ✓ Of the investment choice presented in question #15, all respondents ranked "install IRMs on 75 miles of major roadway" as number 1 except first responders who ranked it third to "hire two additional first responders" and "signalize one intersection."

- ✓ 52 percent indicated that IRMs should be installed on all interstates, freeways and other heavily traveled roadways at an estimated costs of $8.8 million (question #16), and there was limited support (1 PennDOT official) for installing them on interstates alone.

- ✓ When asked in question #17 regarding specific roads where IRMs should be installed, response included several classifications of roadway, but rural interstates and rural and urban freeways were common classifications of roadways referenced.

The conclusion of the stakeholder survey indicates that the majority of emergency management officials, first responders, PennDOT Officials and other emergency personnel feel that IRMs benefit them in incident response by providing more accuracy, thereby reducing response times. While there appears to be less perception that IRMs significantly reduce secondary crashes there is some perception that IRMs result in lower fatalities. The correlation of response time reduction and impact to fatality rate will be discussed in the benefit-cost section of this study.

4.4. MOTORIST SURVEY

In addition to stakeholders, motorists were interviewed to gauge their understanding regarding IRMs. Motorist surveys were conducted on July 21, 2005 at the River Office Complex in Harrisburg, Pennsylvania. The 117 motorists interviewed included a cross section of customers at the River Office Complex for a variety of purposes.

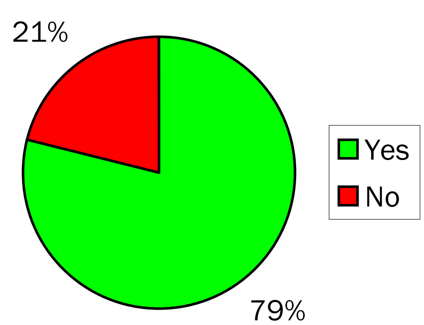
Key survey and interview questions for motorists include:

- ✓ If you were calling 911 to report a crash on a roadway, how would you identify the location?
- ✓ Do you know the purpose of an IRM? (SHOWN PICTURE), if yes, please describe
- ✓ Do you use IRMs in reporting crashes or incidents?
- ✓ Do you use IRMs when you are giving or following directions?
- ✓ For what other purposes might you use IRMs?
- ✓ Do you have any other ideas for identifying crash and incident locations?
- ✓ How often do you travel on an interstate or expressway?

4.4.1. Survey Results

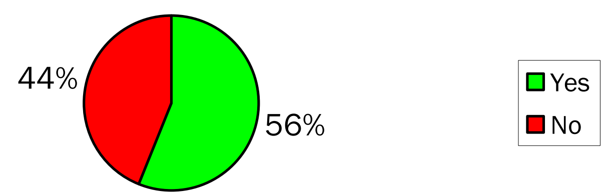
If you were calling 911 to report a crash on a roadway, how would you identify the location	
Mile Marker	34%
Route and Direction Only	40%
Landmark	6%
Other	15%
Five respondents had no comment	

Do you know the purpose of an IRM?



Of those who said yes, 70 percent answered "mile marker" to question three.

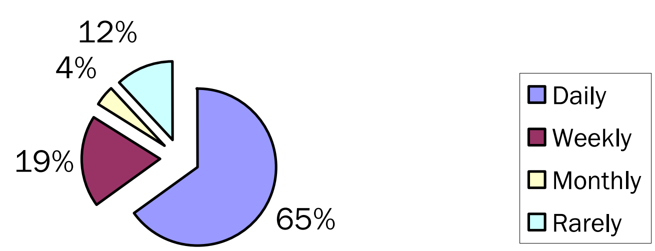
Do you use IRMs when giving or following directions?



Respondents were asked for what other purpose they would use an IRM. Below is a summary of those responses.

- ✓ Reporting emergencies
- ✓ Reporting potholes
- ✓ Recording mileage
- ✓ Identifying location
- ✓ Locating landmarks
- ✓ Route verification
- ✓ Locating speed enforcement officials
- ✓ Reporting disabled vehicles
- ✓ Giving directions
- ✓ Estimating travel time.

How often do you travel on an interstate or expressway?



The respondents were also asked for other ideas in identifying crash and incident locations regarding IRMs and the list below summarizes the responses:

- ✓ Install IRMs every ½ mile
- ✓ Use different colors to distinguish ½ mile IRMs from 1 mile IRMs
- ✓ Place the IRMs closer together
- ✓ Make the sign more understandable
- ✓ Explain what the sign says.

4.5. Motorist Survey Summary

117 motorist surveys were conducted and from those surveys the following results were observed:

- ✓ 70 percent of respondents correctly identified IRMs as "mile markers."

- ✓ While 56 percent of those surveyed use IRMs when giving or following directions only 30 percent of respondents would use IRMs when calling to report an incident. The 30 percent response rate is consistent with the 58 percent of motorist who use IRMs less than 50 percent of the time as reported for question #6.

- ✓ The most common use for IRMs among respondents was:
    - Giving directions
    - Reporting emergencies
    - Recording mileage.

While many of the motorists correctly identified IRMs as "mile markers" there were a limited number of respondents who reported they used them in reporting incidents. This may illustrate a gap in education and outreach when deploying IRMs. This gap may be best illustrated by one respondent who recently received his driver's license. He explained that he would use IRMs to report incidents from now on and was surprised IRMs were not included in his driver's education book since we (PennDOT) expect him to reference them when calling.

5. FIELD OBSERVATIONS

Field observations were limited to issues associated with visibility and mounting. The following summarizes key field observations based on current placement and spacing (approx 500 feet).

5.1. VERTICAL CURVES

- ✓ Sag Curves
  - o No visibility issues at 1/10th mile spacing
  - o Per line of sight only, increased spacing distance is possible
- ✓ Crest Curves
  - o Limited visibility issues on severe crest curves at current 1/10th mile spacing
  - o Increased spacing to 2/10th mile would reduce visibility

5.2. HORIZONTAL CURVES

- ✓ Right-turn Curves
  - o Limited visibility issues on limited radius curves (or blocked line-of-sight) at current 1/10th mile spacing
  - o Increased spacing to 2/10th mile would reduce visibility
- ✓ Left-turn Curves
  - o Radius and line-of-sight have less impact on visibility
  - o Per line of sight only, increased spacing distance is possible

5.3. VISIBILITY

The Institute of Transportation Engineers (ITE) Traffic Engineering Handbook states the standard for sign lettering is 1 inch of text = 50 feet of reading distance (20/23). ITE also states that per visual acuity requirements (20/40) of most jurisdictions, a better standard would be 1 inch of text = 30 feet of reading distance.

In general, most information on IRMs can be seen (per field observations) from one sign to the next sign at the current spacing of 500 feet with the exception of the route number which is legible at 250 feet. The route number is critical in incident reporting, but in many case the person reporting the incident may know the route number even when other IRM information is unknown.

In some cases, the visibility of IRMs is reduced due to the presence of other signs.

Feature	PA Layout (inches)	Estimated Visibility Range [1] (feet)	Field Measurement [2] (feet)
Direction	8	240 - 400	500
Route Marker	9	270 - 450	500
Route Number	4	120 -200	250
Mileage	8	240 - 400	500

1 Distance A per 20/40 acuity. Distance B per 20/23 acuity
2 Distance per corrected 20/20 acuity of two staff members

5.3.1. *Reporting Delay*

Ideally, 1/10th mile spacing provides adequate visibility from one IRM to the next; however, if spacing were increased to 2/10th spacing or greater there would be a momentary delay in vehicular (moving) reporting and a more significant delay to pedestrian reporting associated with disabled vehicles.

Spacing Scenario	Estimated Motorist Reporting Delay vs 1/10th Mile Spacing[1] (seconds)	Estimated Pedestrian Reporting Delay vs 1/10th Mile Spacing[2] (seconds)
2/10th	6.0	132.5
3/10th	12.0	265.0
5/10th	24.1	530.0
1 mile	54.0	1187.5

1 Assumes time (at 60 mph) to cover extra distance versus 1/10th mile
2 Assumes time (4.0 fps) to cover extra distance versus 1/10th mile

5.4. PLACEMENT

Current practice and MUTCD guidance is to mount IRMs on the right hand side of the roadway; however, many states mount IRMs in medians in order to reduce installation costs.

Advantages of median (left) mounting versus right-hand side mounting include:

- ✓ Reduced conflicts with snow removal
- ✓ Reduced signing conflicts
- ✓ In many cases, lower installation costs.

Potential issues with median mounting include:
- ✓ Accessibility
- ✓ Compliance with MUTCD guidelines.

6. FINDINGS AND OBSERVATIONS

6.1. EVALUATION CONCLUSIONS

The evaluation process should **document successes**. As such this evaluation report offers the following conclusions based the feedback of stakeholders surveyed. The literature review did not find any documented studies in other states.

- ✓ IRMs result in a **25-50 percent reduction in response times** based on the most common survey response.
- ✓ IRMs result in a **10-25 percent reduction in secondary crashes** due to quicker response times based on the most common survey response.
- ✓ IRMs result in a **0-10 percent reduction in fatalities** due to quicker response times based on the most common survey response.
- ✓ IRMs **improve incident reporting accuracy by over 50 percent** based on survey responses.
- ✓ **100 percent of stakeholders feel IRMs are helpful** based on survey responses.

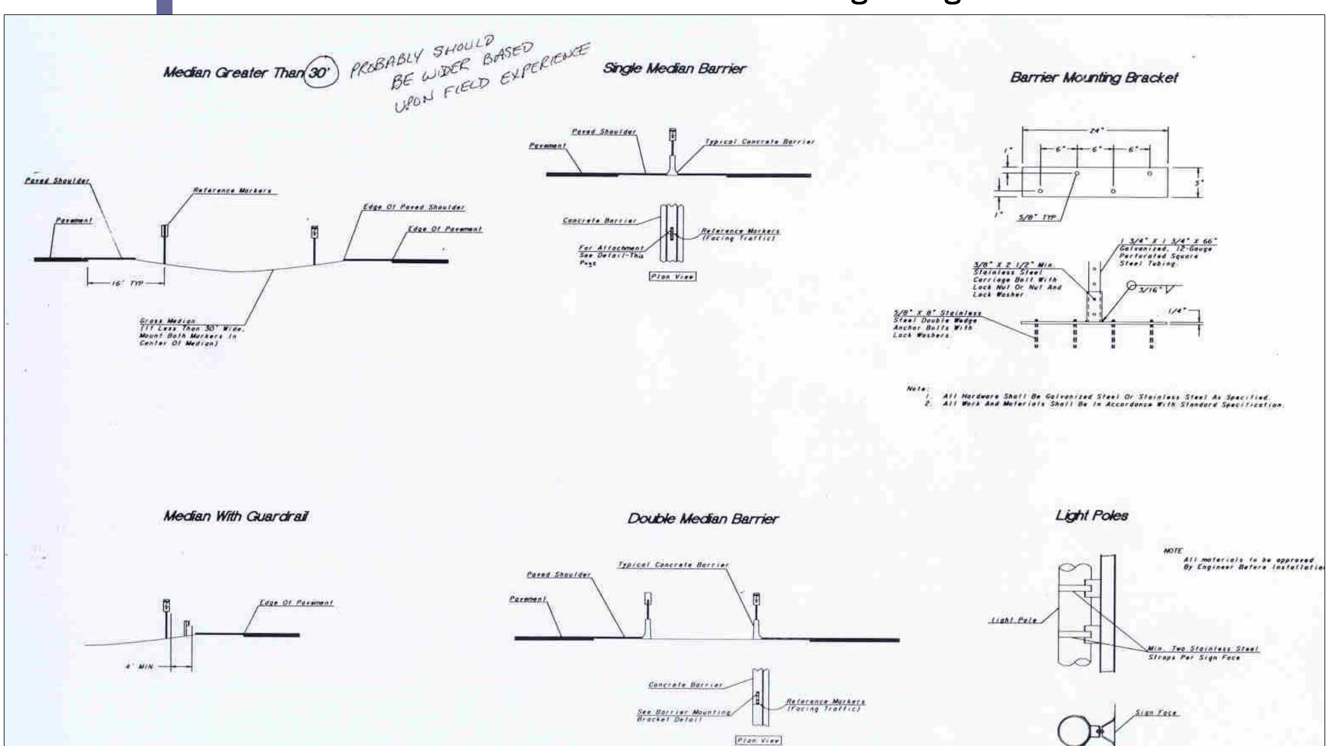
6.2. DESIGN CONSIDERATIONS

Part of the evaluation process is to **identify potential improvements.** Observations from the literature review, surveys and field observations are summarized below as they relate to design considerations.

Design Element	Considerations and Recommendations
Spacing	✓ Review of other states indicates varying practices included 1/10th mile, 2/10th mile and combination spacing. ✓ Field observations and supporting calculations indicate that legibility is limited to 1/10th mile and increased delay may result in incident reporting (6 second delay for moving vehicles, 132 second delay for pedestrians) if spacing is increased to 2/10th mile. ✓ Stakeholders overwhelmingly support the current 1/10th mile spacing. ✓ **Consider spacing at 1/10th mile in urban locations, on vertical crest curves and on horizontal curves in the direction of the side (median or shoulder) where IRMs are placed. Rural applications could have 2/10th spacing other than the conditions above; however, pedestrian response times may be impacted.**
Color	✓ Some states have deployed blue signs per earlier versions of MUTCD. ✓ Current version of MUTCD requires green be used. ✓ Current PennDOT applications are in green. ✓ **Continue to utilize green as background color for signs**
Layout	✓ Most states utilize a letter to designate the direction and do not include a unit of measure. ✓ The current MUTCD spells out direction resulting in increase width versus current deployments. The current MUTCD also includes a unit of measure. ✓ Most motorists surveyed that new what IRMs were understood that the letter designation was the direction and the value on the sign was in miles. ✓ **Maintain current practice of utilizing letter designation for direction and not including MILE legend.**

Design Element	Considerations and Recommendations
Size	✓ Other states had sizes that varied from 14-18" x 48-60." ✓ The current MUTCD (Standard Highway Signs) has a size of 18" x 60" ✓ PennDOT's current deployments are 15" x 48" ✓ The legibility of the route number and crest is a concern. PennDOT deployments utilize a 9" route crest with 4" font. MUTCD layouts utilize a 13" crest with 6.5" font. ✓ **Maintain the current size of IRMs at 15" x 48." Increase the route crest to 13" (with 6.5" font) from 9." To make up the 4" difference, decrease edge margins from 3.5" to 2.0" and decrease 4" (2" on each side of line) margin between mileage and tenths to 3" (1.5" on each side of line).**
Placement	✓ Many states median mount to reduce pole costs and to reduce conflicts with snow removal. ✓ The MUTCD suggests that IRMs be placed on the right hand shoulder. ✓ PennDOT deployments are located in the right-hand shoulder; however, it often gets lost in roadway and commercial sign clutter. ✓ The Pennsylvania Turnpike mounts milepost markers on the median jersey barrier. ✓ **Consider installing future IRM deployments in the median to reduce costs (mount back-to-back), reduce snow plow knockdowns and limit sign clutter. The ARTIMIS system (Exhibit 6.1) can be used as a starting point for median mounting configurations.**
Deployment	✓ Limited guidance on where to deploy in other states. Mostly as needed except Indiana which deploys in DMS areas and increases spacing to 1/10th mile at higher volumes. ✓ MUTCD offers no guidance relative to deployment. ✓ Most stakeholders felt that IRMs should be installed on interstates, freeways and major corridors. In discussions, it was identified that urban deployments assist in accurate route planning and for verification of true number of incidents. Rural applications are useful where there are not obvious landmarks and were E911 coverage may not be complete and incidents are reported through alternate means. ✓ **A proposed deployment policy is stated on the next page.**

Exhibit 6.1 ARTIMIS Mounting Configurations



6.3. Ramp Reference Markers

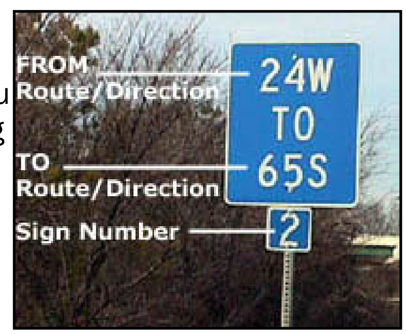
Incident response is not always inclusive of roadway mainlines. Often, crashes occur on ramps due to increase vehicle conflict maneuvers as well as driver awareness. The role and the benefit of ramp reference markers (RRMs) in response to ramp incidents have been questioned. Presently, there is less deployments and guidance than mainline IRMs.

6.3.1. ARTIMIS Ramp Reference Markers

ARTIMIS includes RRMs for major ramps in IRM deployment areas. The ARTIMIS RRM configuration is white lettering on a blue background and includes a "RAMP" title, direction and route (in plan text) and destination.

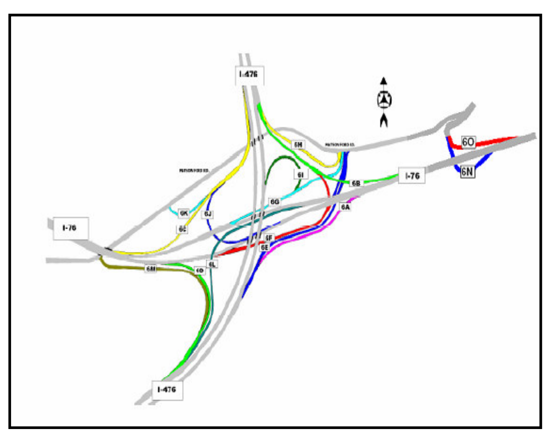
While documented benefits of RRMs were not readily available, the literature review noted that the implementation of RRMs improved incident response as well as allowing for accurate identification of jurisdictional response. This is best illustrated by one example provided in which an ARTIMIS representative noted that within one interchange there were three different jurisdictions which may be responsible for response depending on location.

6.3.2. Tennessee Ramp Reference Markers



Tennessee has also installed RRMs. In general, Tennessee utilizes RRMs on one Interstate to another Interstate. The RRM shown tells you that you are on the ramp from Interstate 24 westbound going to Interstate 65 southbound. The small square at the bottom indicates that this is the second sign on the ramp. All of the Interstate-to-Interstate ramps have three or four RRMs equally spaced along the full length of the ramp.

6.3.3. Schuylkill Expressway Corridor TSM Early Action: I-76/476 Ramp Signs

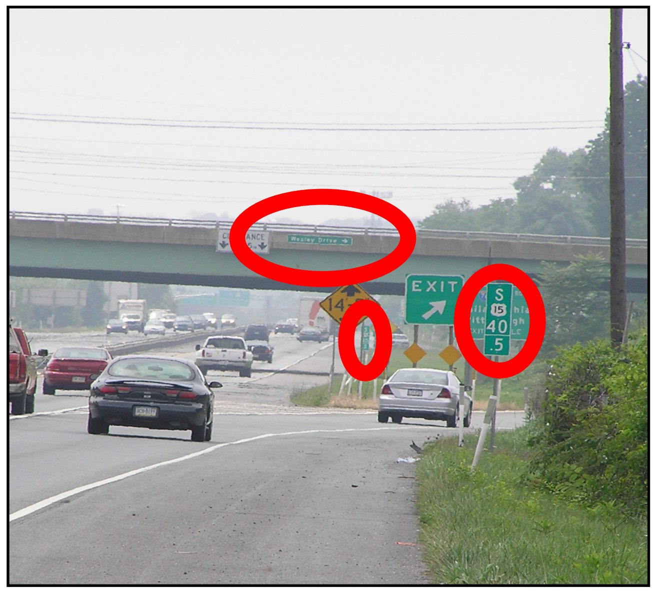


PennDOT 6-0 currently maintains location signs at the interchange of I-76 and I-476. This interchange contains 16 ramps, with each ramp having a unique sign nomenclature. The nomenclature used for the ramps is the number 16 and a letter (A through P). Presently, the current positioning of the ramp location signs does not provide 100 percent viewing coverage for the traveling public.

PennDOT 6-0 has expressed their need to update the current ramp sign nomenclature to a standard that could be utilized throughout the District. Additionally, the Montgomery County EOC has expressed the desire to ensure that the standard is also compatible to the current 911 automated systems.

As part the Schuylkill Expressway Corridor TSM Early Action Project, a ramp signing upgrade was proposed. The ramp signage project includes the identification and deployment of 88 signs to ensure that a ramp location sign is visible from any location on the respective ramp and a standard sign design that can be deployed on any ramp system in the District. At this time a standard layout has not been adopted.

6.3.4. *RRM Design and Deployment Considerations*



The benefit of RRMs is likely limited to free ramp movements from one limited access facility to another limited access facility. Typically, these ramps are much longer in length and may have geometry that is less understandable than traditional diamond interchanges or other interchanges that provide access to non-limited access facilities. Ramps from limited access facilities to local roads typically are shorter in length and have visual cues for the driver to be able to identify his location. Visual cues may include mainline IRMs, street name signs on overpass and interchange intersections and exit signing.

The ARTIMIS and Tennessee RRM layouts are similar. The use of the word “RAMP” on the ARTIMIS version provides little benefit unless it is accompanied with a letter designation as is being utilized in District 6-0. Also, the ARTIMIS version does not include a mechanism to add a sign number as the Tennessee version does. The Tennessee system utilizes sign numbers versus mileage so that spacing can be varied in order to maximize visibility. The benefit of a sign number or mileage may be limited as long as the ramp designation itself can be identified through one or more signs.

The layout of the signs themselves should maximize resources while being intuitive to motorists and allowing for clear action by emergency management officials and responders.

RRM Design Considerations

- ✓ Utilize Tennessee model with modifications
  - ✓ Allow the use of multiple (3-4 typical) on ramps in order to maximize visibility
  - ✓ Permit the use of sign number plaque on ramps with excessive (>0.5 miles) and/or where responders have different response patterns depending on the location where the incident occurred on the ramp
  - ✓ Permit an optional "RAMP X" plaque in areas where emergency management officials and first responders currently utilize letter or number designations.

Deployment Considerations:

- ✓ Permissible on interstate (or limited access) to interstate (or limited access) ramps.
- ✓ Not permissible on ramps that are less than 0.2 miles in length.
- ✓ Generally, a second phase deployment once IRMs have been fully installed.
  - ✓ With exception of complex and high volume urban interchanges

6.4. PROPOSED IRM DEPLOYMENT POLICY

- ✓ Permissible on all interstates and non-interstate freeways pending Department review and per Section 1.20.6 of PennDOT Publication 46, *Traffic Engineering and Operations Manual*.
- ✓ Deployment suggested on roadways with continuous Dynamic Message Sign (DMS) coverage, ADTs exceeding 75,000 or roadways exceeding state wide crash and fatality rates for similar facilities.
- ✓ In urban areas with ADTs exceeding 75,000 or interchange spacing of less than 1.5 miles on average, marker spacing to be set at 1/10th mile intervals.
- ✓ For all other conditions, marker spacing to be set at 2/10th mile intervals, except for areas with vertical crest curves and horizontal curves when mounting should be set at 1/10th mile intervals.
- ✓ Markers should be median mounted and back-to-back where feasible.
- ✓ Deployment should include educational components.
- ✓ Deployment should include mapping distribution to first responders and emergency management officials.

6.5. BENEFIT-COST CONSIDERATIONS

The ultimate determination of a successful initiative is if benefits outweigh costs, thereby **rationalizing our investments versus the benefits.**

To determine what the appropriate spacing for IRMs is, the benefit of installing them at different intervals must be compared to the cost of installation and maintenance. To make this comparison, a number of factors were analyzed for each facility including: estimated average daily traffic volumes, estimated fatality rate, average response time, estimated response time, the number of fatalities, and the economic cost value of fatal crashes.

6.5.1. Deployment Estimates

PennDOT's District 8-0 initially deployed 2,250 signs in 1999 at a cost of approximately $140,000 or $62.50 per sign. For the purpose of benefit-cost analysis, an initial statewide deployment scenario was established by multiplying the miles of roadway (per PennDOT Highway Statistics) X IRMs per mile (20 total at 1/10th) X cost per sign ($62.50).

Level of Deployment	Cost
High volume interstates (urban)	$0.9 million
All interstates	$2.2 million
All interstates and freeways	$2.9 million
All interstates, freeways, and other heavily traveled corridors	$8.8 million
All PENNDOT maintained roadways	$44.1 million

Deployment estimates can be reduced through increase spacing and shared mounting. Specific classification and scenario costs in yearly costs are detailed in the various benefit-cost scenarios.

6.5.2. Maintenance Cost

District 8-0 estimated that yearly reinstalls is approximately 50 signs(2.2 percent) mostly due to snow plow operations or roadway incidents while yearly replacements is approximately 5 signs(0.2 percent) mostly due to incidents. Assuming the same cost per sign for reinstalls and replacements since mobilization costs are increased, it is estimated the yearly maintenance cost is 2.5 percent of the initial deployment cost, which in this case is approximately $3,500 yearly. If snow plow knockdowns can be reduced by relocating IRMs to the median it is conceivable that yearly maintenance costs could be reduced to 1.2 percent.

Type III sheeting has a maximum life of 15 years, but utilizing an average service life (which includes a 3% yearly replacement) of 12 years provides a more conservative estimate of system life cycle. By applying 3.5 percent inflation, it is estimated that life—cycle maintenance costs for 12 years will be 35 percent of the initial deployment costs.

Cost for 1000 IRMs

Factor	Cost
Deployment	$62,500
Initial Yearly Maintenance	$1,500
Total Maintenance for 12 Years with Inflation	$21,900

1 Assumes no knockdown reduction
2 Assumed 3.5% inflation

6.5.3. *Estimated Average Daily Traffic Volumes*

Traffic volumes for each type of facility being considered were obtained from PennDOT's Type 4 Traffic Volume Maps. Ten examples of each roadway type were selected from different areas across the Commonwealth to determine the average daily traffic volumes for each facility type.

6.5.4. *Estimated Fatality Rate*

The estimated fatality rates were obtained from page 7 of the American Association of State Highway and Transportation Officials (AASHTO's) *Highway Safety Design and Operations Guide*, 1997. The rates are formatted by fatal accidents per 100 million vehicle-kilometers. The rates were converted to accidents per 100 million vehicle-miles by using a conversion rate of 0.62.

6.5.5. *Average Response Times*

The average response time for urban interstates was obtained from *The Impact of Rapid Incident Detection on Freeway Accident Fatalities*, released in June 1996 by the Mitretek Center for Information Systems and authored by William M. Evanco. The study, sponsored by FHWA, evaluated the potential that incident detection systems had of reducing the crash notification time, or time between the occurrence of crashes and the notification of emergency medical services. Data was not available for facilities other than urban interstates/freeways so the average response time for other facilities was increased in proportion to the fatality rate.

6.5.6. *Estimated Response Times*

The estimated response time is based on question #9 of the stakeholder survey, which asked respondents to estimate the contribution of IRMs in reducing response times. 41 percent of the stakeholders estimated that IRMs reduce response times to incidents by 25-50 percent. For a conservative analysis, a 25 percent reduction in response time was used. As described in Section 5, when IRMs are spaced at distances greater than 1/10th mile, additional time must be added for the delay of getting to the next IRM. For a spacing of 2/10th mile, six seconds of time will be added to account for extra delay for a motorist to report the incident.

6.5.7. *Number of Fatalities*

The number of fatalities was determined using the equation for calculating crash rates along a segment in the Institute of Transportation Engineers *Traffic Engineering Handbook*, 5th Edition, page 203.

$$N=3.65x10^{-6}*ADT*FR*L$$

Where: N=number of fatalities
ADT=average daily traffic volume
FR=fatality rate, and
L=length of roadway.

Once the number of fatalities was determined from the equation above, the numbers were compared with the PennDOT Bureau of Highway Safety and Traffic Engineering Accident Reporting System Homogeneous Report for 1998 to 2003 to validate the calculated values.

6.5.8. Cost Savings

Comprehensive costs of crashes can be used in performing benefit-cost analyses. These costs represent what society is willing to pay to prevent crashes. These values include values of lost quality of life through empirical studies of what is paid to reduce safety and health risks. In the most recent data obtained from FHWA, the comprehensive cost of a fatal crash is $3 million.

6.5.9. Benefit- Cost Analysis

The benefit-cost analysis for this comparison was also obtained from *The Impact of Rapid Incident Detection on Freeway Accident Fatalities*. The study conducted a statistical analysis based on the number of fatalities, mean vehicle speed, alcohol consumption, young/aged driver fraction, accident notification time and income per capita. The analysis resulted in the following equation:

$$\Delta NF/NF=.27*(\Delta ANT/ANT)$$

Where: ΔNF=Change in number of fatalities
NF=Number of fatalities
ΔANT=Change in accident notification time, and
ANT=Accident notification time.

The equation described above was used for analyzing the data for this project. Local PennDOT roads were not included in this analysis.

A. Benefit-cost of installing IRMs every 1/10th mile on all PennDOT maintained roadways[1]

Facility	Estimated Volume (ADT)	Estimated Fatality Rate (100MVM)	Length of Roadway (miles)	Number of Fatalities	Average Response Time (sec)	Estimated Response Time (sec)	Fatality Reduction	Cost Savings (million)	Sign Cost[2] (million)	Ben-Cost Ratio
Urban Interstates	70000	.55	651	92	6.2	4.7	6	18	0.09	200
Rural Interstates	27000	1.0	1107	109	11.8	8.9	7	21	0.16	131
Freeways	40000	0.8	516	60	6.2	4.7	4	12	0.08	150
Arterials	17000	1.3	6708	541	6.2	4.7	35	105	0.98	107
Collectors	3700	0.9	14796	180	10.0	7.5	12	36	2.15	17

1. Results do not include local roads
2. Annualized cost of installation and maintenance for the life of the sign (12 years)

B. Benefit-cost of installing IRMs every 2/10th mile on all PennDOT maintained roadways[1]										
Facility	Estimated Volume (ADT)	Estimated Fatality Rate (100MVM)	Length of Roadway (miles)	Number of Fatalities	Average Response Time (sec)	Estimated Response Time (sec)	Fatality Reduction	Cost Savings (million)	Sign Cost[2] (million)	Ben-Cost Ratio
Urban Interstates	70000	.55	651	92	6.2	4.8	6	18	0.05	360
Rural Interstates	27000	1.0	1107	109	11.8	9	7	21	0.08	263
Freeways	40000	0.8	516	60	6.2	4.8	4	12	0.04	300
Arterials	17000	1.3	6708	541	6.2	4.8	33	99	0.49	202
Collectors	3700	0.9	14796	180	10.0	7.6	12	36	1.07	34

1. Results do not include local roads
2. Annualized cost of installation and maintenance for the life of the sign (12 years)

C. Benefit-cost of installing IRMs every 1/10th mile on urban interstates, 2/10th mile on other roadway straight segments, and 1/10th mile on other roadway curves[1,2]										
Facility	Estimated Volume (ADT)	Estimated Fatality Rate (100MVM)	Length of Roadway (miles)	Number of Fatalities	Average Response Time (sec)	Estimated Response Time (sec)	Fatality Reduction	Cost Savings (million)	Sign Cost[2] (million)	Ben-Cost Ratio
Urban Interstates	70000	.55	651	92	6.2	4.6	6	18	0.09	200
Rural Interstates	27000	1.0	1107	109	11.8	8.9	7	21	0.10	210
Freeways	40000	0.8	516	60	6.2	4.7	4	12	0.06	200
Arterials	17000	1.3	6708	541	6.2	4.7	35	105	0.58	181
Collectors	3700	0.9	14796	180	10.0	7.5	12	36	1.29	28

1. Results do not include local roads
2. Curves are assumed for 20 percent of other roads
3. Annualized cost of installation and maintenance for the life of the sign (12 years)

D. Benefit-cost of installing IRMs every 1/10th mile on urban interstates (2 signs per post), 2/10th mile on other roadway straight segments, and 1/10th mile on other roadway curves (2 signs per post)[1,2,3]										
Facility	Estimated Volume (ADT)	Estimated Fatality Rate (100MVM)	Length of Roadway (miles)	Number of Fatalities	Average Response Time (sec)	Estimated Response Time (sec)	Fatality Reduction	Cost Savings (million)	Sign Cost[2] (million)	Ben-Cost Ratio
Urban Interstates	70000	.55	651	92	6.2	4.6	6	18	0.08	225
Rural Interstates	27000	1.0	1107	109	11.8	8.9	7	21	0.08	263
Freeways	40000	0.8	516	60	6.2	4.7	4	12	0.04	300
Arterials	17000	1.3	6708	541	6.2	4.7	35	105	0.47	223
Collectors	3700	0.9	14796	180	10.0	7.5	12	36	1.03	35

1. Results do not include local roads
2. Curves are assumed for 20 percent of other roads
3. Assume two thirds of cost for sign, one third cost for post
4. Annualized cost of installation and maintenance for the life of the sign (12 years)

6.5.10. Benefit-Cost Analysis Summary

As the tables above indicate, the deployment of IRMs on all facilities yields substantial benefits versus the cost of installing and maintaining them. While installing IRMs in 1/10th mile intervals offers a high benefit to cost ratio, similar fatality reductions can be achieved with 2/10th mile intervals allowing many more IRMs to be deployed.

Additionally, while the benefit-cost ratio for deploying IRMs on arterials and collectors is high, there are also other ways of identifying incidents on these types of facilities including intersections, businesses and other landmarks. These conditions may reduce the effectiveness of IRMs in those areas.

Increased spacing options and back-to-back median mounting options can decrease overall costs by as much as 35 percent as is detailed below.

Current 1/10th spacing with dual placement on right shoulder

Level of Deployment	Deployment Cost	Life Maintenance Cost (12 years)	Total Cost (over 12 year life)
High volume interstates (urban)	$900,000	$320,000	$1,220,000
All interstates	$2,200,000	$770,000	$2,970,000
All interstates and freeways	$2,900,000	$1,020,000	$3,920,000

Total Cost $8.1 million

1/10th spacing on urban interstates with back-to-back median placement 2/10th spacing on other roads Current 1/10th spacing with dual placement on right shoulder (assumes 1/10th spacing on 20% due to curves)

Level of Deployment	Deployment Cost	Life Maintenance Cost (12 years)	Total Cost (over 12 year life)
High volume interstates (urban)	$700,000	$250,000	$950,000
All interstates	$1,400,000	$490,000	$1,890,000
All interstates and freeways	$1,800,000	$630,000	$2,430,000

Total Cost $5.3 million

6.6. Value Engineering Alternatives

In field observations and design considerations section, it was noted that the size of the route shield limited the visibility of the route number. If the route number and shield remain, it was recommended that the shield size be increased to enhance visibility and to maintain consistency with the MUTCD configuration.

Some have questioned if the use of the route shield is truly value added and that the removal of the shield would decrease sign costs and allow for an increased route number font using conventional text. Others prefer the use of the route shield since it intuitively identifies the type of facility and is a visual cue for identifying the location of the route number.

The use of a color sign shield increases manufacturing costs from $43 to $47 or roughly 9 percent. The installed cost increases from $58.50 to $62.50 or roughly 7 percent. For the $1.8 million deployment costs detailed above this would save approximately $115,000.

The removal of the shield would allow the route number font size to be increased from 5 inches to 8-9 inches without increasing the size of the sign.

> *Does Sign A provide any additional benefit versus Sign B?*

From a value engineering standpoint there may be some arguments for developing a value-engineered layout; however, emergency management officials provided additional insight when asked about a value-engineered alternative.

A B

Emergency Management Official Responses

Sign A may be more costly but I think there may be confusion with Sign B in that both number could be mistaken to represent the mile mark. At first glance is the mile mark 83 or 41? Experienced travelers may know the difference but the casual observer in an emergency situation may make a mistake. From an emergency management/response standpoint, the less likelihood for confusion the better.

Although Sign A would cost more and be slightly smaller, it would be much quicker to register in a persons' brain. Most people driving by will recognize the symbol as compared to Sign B, which does not have the symbol.

I believe it is a value.......

I truly believe that Sign A has added value although difficult to measure. I can tell you as a former dispatcher and relating stories of current dispatchers here, that there are times when the call taker uses EVERY method to determine where one is calling from. As fundamental as it sounds the caller may relate that the marker for 83 is red and blue, this helps determine that it is what it is. Could there be another 83 state or local that has a MM somewhere 41.4?? We just don't know.

The cost benefit analysis needs to be in your hands to recommend the best for the buck. If say 5 extra miles of roads can be marked and maintained with sign B, then that might be the deciding factor. My ONLY recommendation on sign B would be to try and delineate between the direction and route v. the mile and tenth. Perhaps a colored line between those two would be beneficial?

I understand the concerns with cost and production issues; however, Sign A is still the preferred sign for my county. Sign B is confusing and I envision the first response of a caller when asked their location would be in the case of your Sign B, mile marker 83.

It offers a distinction between the mile marker versus the route number for people who may not be familiar with all of the numbers on the post.

Yes, putting myself in the position of the average motorist. I feel that Sign A would be more beneficial, simply because of the route shield which determines whether the road is an Interstate, U.S. Route, or a State Route. I personally think Sign A is less confusing.

While the response offered some variations in opinion, there were also some common themes.

- ✓ Sign A intuitively identifies which number is the route number.
- ✓ The removal of the route shield may increase confusion and require additional coaching from emergency management officials in order to identify locations.

While options may exist to make Sign B more intuitive such as putting the route of top, these variations increase the level of deviation from MUTCD configurations. Ultimately, the Department must adopt a policy based on limited facts and customer feedback whether the enhanced IRMs provide extra value versus value-engineered alternatives.

6.7. EDUCATION ABD AWARENESS

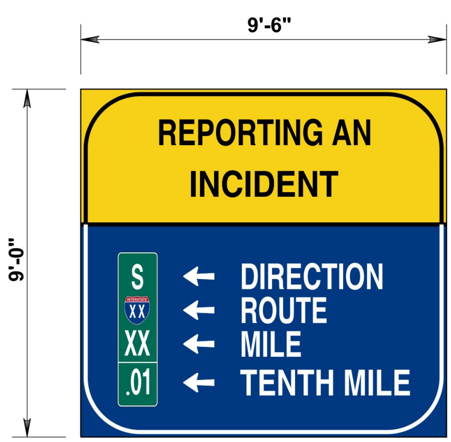
6.7.1. Motorist Education

Through the motorist survey and stakeholder outreach, driver education was identified as an additional consideration. 30 percent of motorists did not know what IRMs were, and only 34 percent of respondents said they would utilize mile markers to report an incident.

Education needs to focus on in-state drivers as well as out-of-state drivers. Some possible strategies to enhance motorist understanding of IRMs include:

- ✓ Integrating education about IRMs into driver education materials
- ✓ Distributing press releases when IRMs are deployed in new areas
- ✓ Introducing educational signs when coming entering Pennsylvania and in new deployment areas to inform out-of-state motorists.
  - o A concept is presented as **Exhibit 6.2.** The MUTCD permits the use of fluorescent pink for incident management signing.

Exhibit 6.2 IRM Educational Sign Concept



6.7.2. *Mapping for First Responders and Emergency Management Officials*

Both first responders and emergency management officials reported that IRMs allow for improved accuracy and reduced response times. Part of the improved accuracy and decreased response can be attributed to better route planning from dispatch to incident. In many areas, a small variation in location may drastically impact the route responders may take.

As part of the planning process, mapping should be provided to first responders and emergency management officials.

6.8. E911'S ROLE AND IRM'S CONTINUED RELEVANCE

For many Americans, the ability to call 911 for help in an emergency is one of the main reasons they own a wireless phone. Other wireless calls come from "Good Samaritans" reporting traffic crashes, crimes, or other emergencies. Prompt delivery of these and other wireless 911 calls to public safety organizations benefits the public by promoting safety of life and property. While wireless phones can be an important public safety tool, they also create unique challenges for public safety and emergency response personnel and for wireless service providers.

The wireless Enhanced 911 (E911) rules promulgated by the Federal Communications Commission (FCC) seek to improve the effectiveness and reliability of wireless 911 service by providing 911 dispatchers with additional information on wireless 911 calls. The wireless E911 program is divided into two parts

- ✓ Phase I requires carriers to report the telephone number of a wireless 911 caller and the location (latitude and longitude or the physical address) of the antenna (cell site) that received the call and the cell directional face (N, E, S, W, NNE, SSW, NE, SE, etc.) which gives a fairly accurate assessment of the general location of the caller.[20]
- ✓ Phase II requires wireless carriers to provide more precise location information, within 50 meters of the caller's handset 67% of the time. It also requires that the caller's physical location be within 150 meters 95% of the time.[21]

Pennsylvania has adopted a very aggressive timeline for its counties and it is anticipated that all counties will be Phase II compliant within 3 years barring the lack of adequate funding or unforeseen circumstances.[22]

The need for IRMs as E911 continues to evolve needs to be addressed. Some question if IRMs will continue to provide benefits since E911 will allow emergency management to identify locations. Others argue that IRMs and E911 provide two independent, but overlapping pieces of information that provide more accuracy in locating incidents.

Based on feedback from emergency management officials and first responders, most feel that the expansion of the E911 does not eliminate the need or benefit of IRMs. Most stakeholders who responded noted that E911 and IRMs provided overlapping and beneficial sources of information allowing for improved accuracy versus IRMs or E911 alone.

Some specific examples where IRMs provide additional benefits to that of E911 include the following:

- ✓ **Improved Accuracy** –E911 requires locating of cellular devices within a certain distance, it does not ensure the caller will initiate the call at the incident. In many cases, calls are initiated upstream from an incident and past upcoming interchanges which can impact response route planning. When used in combination, E911 can provide a general location, but IRMs can assist in improved locating accuracy of the incident versus the reporter of the incident.
- ✓ **Overlapping and Parallel Incidents** – Often, especially in urban areas, confusion over overlapping/parallel (and secondary) incident reporting can occur when E911 is utilized alone resulting in emergency management inefficiency. When used in combination with IRMs, the exact number and location of incidents can be more easily determined. The overlapping incident example is best illustrated by a true experience provided by Dauphin County emergency management officials who are currently equipped with E911 capabilities. During one set of incidents, emergency received calls that originating from both sides of Harrisburg's South Bridge (I-83 over the Susquehanna River). Initially, emergency management officials thought one incident occurred and that some calls were originating upstream of the incident. As they began to respond, they confirmed that in reality, two incidents had occurred. Parallel incidents can occur when a frontage road or another facility runs parallel to another roadway. In this case, E911 may not be an accurate indicator of the incident location.
- ✓ **Limited Coverage Areas** – In some areas of Pennsylvania, cellular coverage is limited and incidents may be reported through secondary means including CB radio.
- ✓ **Unclear Incidents** – Many roadway incidents are obvious and apparent to first responders. In other cases, incidents and concerns may be more difficult to locate without additional locating guidance. Examples include: vehicles over an embankment, unauthorized pedestrians, suspicious activities and objects along or in the roadway.

To further validate these observations, three questions were forward to a sample of emergency management officials.

1. When callers report in an incident using IRMs or mile markers do they general report the location they are calling from or the location of the incident?
2. Will IRMs still be value added as E911 Phase II Implementation occurs?
3. Are there situations where IRMs could improve incident reporting accuracy and verification versus E911 alone?

Emergency Management Official Responses

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1. Generally the location of the incident if they are familiar. If from out of the area, we will ask them to identify an IRM if one is visible.

2. Yes, not as a priority but certainly as additional site identification. Plus some areas are not cellular accessible and Cambria County has numerous areas as such.

3. I think they will aid first responders for site identification and also help in reporting issues in addition to coordinates

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1. Callers will reference a point they are calling from or a general "landmark" (i.e. the bridge over the Perkiomen Creek which by the way, named signs also help with locations). The caller could reference either, many are helpful in reporting the MM "where" the call is. Others may call and say "I'm going E and just passed a crash on the W side, a MM reference further E would be given and then the caller might estimate that it was about 2/10 of a mile back....

2. Yes, although again, the simpler/cheaper version may be sufficient with the primary means of IDing a crash to be the 9-1-1 signal. MM's would still be useful phase II will not be "perfect"

3. Yes again for items other than 9-1-1 such as road maintenance, unsafe conditions, debris, etc, a caller could alert 9-1-1, PennDOT etc and use that MM as a reference point so others can find/fix the problem.

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1. Both. Typically it is the former. If a driver is heading northbound and observes a southbound accident, our E911 Phase II signal will provide a location of the caller. at the time of his or her call. Our call processing protocols require us to specifically ask "What is the address of the emergency?"

2. Absolutely...this is not an either/or proposition.

3. Everybody who traverses our roadways are not necessarily citizens of our area. In the case of Dauphin County, I can unequivocally share with you residents in the lower end would have difficulty explaining to a 9-1-1 telecommunicator where their location was if they were on 22/322. Vice versa, residents in the upper end would similarly have difficultly communicating their location on the beltway or surrounding interstates.

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1. The 911 dispatcher typically ask where they are calling from and where the accident is – see #2

2. Some callers may not be on the scene of the incident – they may have called someone else prior to calling 911 or there may not be cellular service at the location of the incident.

3.See #2

7. Summary

7.1. Document Our Successes

Based on both literature reviews and stakeholder surveys there appears to be overwhelming support for the use of IRMs. Stakeholder surveys indicated that:

- ✓ 100 percent of stakeholders feel IRMs are helpful
- ✓ IRMs result in 25-50 percent reduction in response times based on survey responses.
- ✓ IRMs improve incident reporting accuracy by over 50 percent based on survey responses.

There is a relationship between response time and fatality reduction. While stakeholders estimated that a 0-10 percent reduction in fatalities can be attributed to IRMs, performance models indicate the 6.5 percent reduction in fatalities may be attributable to IRMs.

7.2. Rationalize Our Investments

Although a 0-10 percent reduction not seem significant in numerical terms, the benefit when applied to human terms is significant. Applying FHWA economic values for fatalities it is estimated that the human savings versus the cost of implementation will yield benefit-to-cost ratios exceeding 1.0. The benefits due not include other economic benefits that might be associated with improved accuracy, reduced secondary crashes and non-incident benefits.

Other spacing options provide similar benefit-to-cost ratios. While implementation costs may be reduced by as much as 35 percent, the response times may be slightly decreased due to visibility issues and first responder accuracy. Ultimately, increase spacing scenarios reduce deployment costs with minimal response increase thereby providing greater benefit-cost ratios.

Value-engineered alternative layouts can decrease deployment costs by up to 7 percent; however, some of the intuitive understanding of enhance IRM with route shield may be sacrificed. Also, more deviation from the standard MUTCD configuration will occur.

Based on feedback from emergency management officials and first responders, most feel that the expansion of the E911 does not eliminate the need or benefit of IRMs. Most stakeholders who responded noted that E911 and IRMs provided two overlapping and beneficial sources of information allowing for improved accuracy versus IRMs alone or E911 alone. However, some emergency management officials did note a diminished benefit of IRMs in areas with E911 versus in areas without E911.

7.3. IDENTIFY POTENTIAL IMPROVEMENTS

The evaluation process should include an identification of potential improvements.

It was noted that there was minimal guidance relative to deployment policy. Additionally, there may be some design alternatives that may reduce installation and maintenance costs and in some cases improve visibility. Finally, an educational component should be considered that targets motorists, emergency management officials and first responders since they are the users of the system.

7.3.1. Proposed Deployment Policy

- ✓ Permissible on all interstates and non-interstate freeways pending Department review and per Section 1.20.6 of PennDOT Publication 46, *Traffic Engineering and Operations Manual*.
- ✓ Deployment suggested on roadways with continuous Dynamic Message Sign (DMS) coverage, ADTs exceeding 75,000 or roadways exceeding state wide crash and fatality rates for similar facilities.
- ✓ Spacing in urban areas with ADTs exceeding 75,000 or interchange spacing of less 1.5 miles on average to be set at 1/10th mile.
- ✓ Spacing in all other conditions to be at 2/10th mile except for vertical crest curves and horizontal curves in direction of mounting location which should be set at 1/10th mile.
- ✓ Placement should be median mounted and back-to-back where feasible.
- ✓ Deployment should include educational components.
- ✓ Deployment should include mapping distribution to first responders and emergency management officials.

7.3.2. Ramp Reference Markers Deployment Considerations

- ✓ Permissible on interstate (or limited access) to interstate (or limited access) ramps.
- ✓ Not permissible on ramps that are less than 0.2 miles in length.
- ✓ Generally, a second phase deployment once IRMs have been fully installed.
  - o With exception of complex and high volume urban interchanges

Literature Review Endnotes

[1] Telephone Interview with Tom Walter, PennDOT Engineering District 5-0, February 3, 2005.

[2] Telephone Interview with Bob Conrad, PennDOT Engineering District 8-0, Traffic Unit, February 3, 2005.

[3] Email from Mark Alexander, P.E., Manager, Sign Standard & Manufacturing Section, Pennsylvania Department of Transportation, February 24, 2005.
[4] www.paturnpike.com/tools/newsletters/december00/page03.htm

[5] Telephone Interview with Daniel Bretzman, Manager, Operations Center, PA Turnpike Commission, February 18, 2005.

[6] Telephone interview with Mark Newland, Program Director for ITS, Indiana DOT, February 4, 2005.

[7] www.state.in.us/dot/motoristinfo/trafficwise/about_milemarker.html

[8] Telephone interview with Mark Newland.

[9] *Strategic Plan for Highway Incident Management in Tennessee*, Tennessee Department of Transportation, Office of Incident Management, August 2003.

[10] www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_operations/maintenance/IncidentManagement/Complete%20IM%20Plan.pdf

[11] Email from Frank Horne, Transportation Manager, Office of Incident Management/TDOT HELP Program, Tennessee Department of Transportation, frank.c.horne@state.tn.us, February 8, 2005.

[12] Wisconsin Department of Transportation, Intelligent Transportation Systems (ITS), *Design Manual*, Chapter 15 – Enhanced Reference Markers, December 2000.

[13] Telephone Interview with Jay Obenberger, ITS Traffic Engineer, Wisconsin Department of Transportation, District 1, February 8, 2005.

[14] www.dot.wisconsin.gov/travel/smartways/markers.htm

[15] Telephone Interview with Jay Obenberger.

[16] www.artimis.org

[17] *Evaluation of Reference Markers (Final Report),* KTC-01-16, FH-94-3F (Final Report), Jerry G. Pigman, Research Engineer, University of Kentucky, College of Engineering, Kentucky Transportation Center.

[18] Ibid.

[19] Email from Steven Cummins, P.E., Traffic Signal Systems Manager, Lexington-Fayette Urban County Government, Division of Traffic Engineering, stevec@lfucg.com, February 7, 2005.

[20] Email from Michelle R. Musser, Telecommunications Specialist II, Pennsylvania Emergency Management Agency, mmusser@state.pa.us, February 17, 2005.
[21] Ibid.

[22] Email from Michelle R. Musser, Telecommunications Specialist II, Pennsylvania Emergency Management Agency, mmusser@state.pa.us, February 9, 2005.