



# Next Steps for Work Zone Challenges

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Statewide Work Zone Safety Committee  
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# Four Challenges

- Work Zone Intrusion Warning System (WIWS)
- End of Queue Warning System for Work Zones
- Distracted Drivers Approaching or Within a Work Zone
- General Mobility Impacts Caused by Work Zone



# Major Outcomes

- Institute planning and scoping procedures for ITS/IWZ
- Monitor, test and evaluate ITS/IWZ deployments
- Identify and assess key performance and surrogate measures
- Develop procurement packages and generalized boiler plate special provisions

# Enhancement Opportunities to Address Work Zone Challenges

- Safety & efficiency challenges
- Budget constraints
- Need for low cost, high benefit solutions
- Education, outreach & enhanced awareness
- Early identification improves w/planning, programming, budget, scheduling, ease of deployment and more
- Having a Program brings foresight: for optimizing safety & efficiency OVERALL!

## Planning for ITS/IWZ

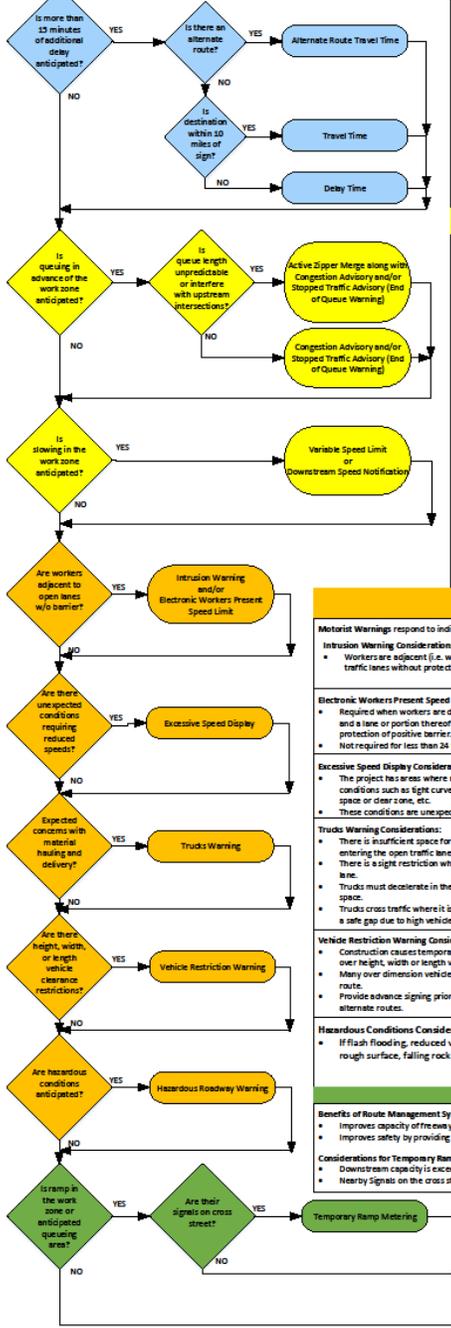
- Scoping Decision Tree
- Scoping Cost Estimates

## Procurement Package

- Boiler Plate Special Provisions
  - Fully Automated Stand-Alone
  - RTMC IRIS Control
- Design Guidance
- Performance Measures, Best Practices and Key Considerations



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### Mobility and Traveler Information

**Considerations for Alternate Route Travel Times:**

- Alternate route travel times are calculated and displayed for selected alternate route(s) and the main route through the work zone to provide options to drivers.
- Travel times on the main route and alternate route(s) vary independently, i.e. one route changes while the other does not.
- Care should be taken to determine proximity to other projects when selecting alternative routes to display travel times.

**Considerations to Ensure Times Displayed are Accurate:**

- Maximum detector spacing is ½ mile.
- Travel Time is used when the time display is within 10 miles of the destination shown on the sign.
- Delay Time is used when the time display is more than 10 miles from the destination shown on the sign.

**Benefits of Mobility and Traveler Information:**

- Allows drivers to decide whether to change routes.
- Provides opportunities to notify others of estimated arrival times.
- Provides sufficient information to calm tempos.

**Options for Travel Time and Delay Time Information Displays:**

- Dynamic Message Sign (DMS), both portable or permanent.
- Static Guide Sign with DMS characters to display time.

### Motorist Advisory

**Considerations for Motorist Advisory Systems:**

- Queue lengths are anticipated to be unpredictable because they vary greatly daily and/or hourly.
- The end of queue encroaches upstream beyond drivers' expectations or are obscured by roadway geometry.
- Queues are expected to encroach on upstream intersections or interchanges.

**Active Zipper Merge:**

- Typically includes a Congestion Advisory and/or Stopped Traffic Advisory.
- Reduces queue lengths by 40%.
- Harmonizes speeds between lanes approaching the lane closure.
- Increases capacity through the work zone.
- Reduces driver frustration and decreases aggressive driving behavior.

**Congestion Advisory:**

- Is used when the congested traffic message can be far enough away that motorists can select an alternate route.
- Is typically combined with a Stopped Traffic Advisory (End of Queue Warning Systems) as motorists approach the work zone.

**Stopped Traffic Advisory (End-of-Queue Warning):**

- Is used to warn drivers of slow or stopped traffic ahead and that prompt action is required.

**Variable Speed Limit:**

- Authorized speed limit for driver safety, to navigate the work zone.

**Downstream Speed Notification:**

- Gives drivers an appropriate speed to travel through the work zone with minimal braking by providing notification ½ mile ahead of slower moving traffic.
- Smooths the transition between faster and slower moving traffic.
- Increases capacity through the work zone.

**Benefits of Motorist Advisory:**

- Alert drivers they are approaching slow or stopped traffic.
- Reduce frequency and severity of rear-end crashes.
- May reduce demand by diverting traffic.

### Motorist Warning

Motorist Warnings respond to individual conditions, i.e. vehicle speed, dimension, weather, etc. that require drivers to take immediate action.

**Intrusion Warning Considerations:**

- Workers are adjacent (i.e. within 12 feet) to open high-speed traffic lanes without protection of positive barrier.

**Intrusion Warning Benefits:**

- Alerts drivers and workers that a vehicle is entering the work space giving enough time for workers and drivers to take evasive action to avoid a crash or reduce severity.

**Electronic Workers Present Speed Limit Considerations:**

- Required when workers are directly adjacent to travel lanes and a lane or portion thereof is closed to traffic without protection of positive barrier.
- Not required for less than 24 hours.

**Electronic Workers Present Speed Limit Benefits:**

- Regulatory speed limits to improve worker safety, intended that the speed limit reduces speed such that the majority of hazards can be safely negotiated.

**Excessive Speed Display Considerations:**

- The project has areas where reduced speed is indicated for conditions such as tight curves, rough surfaces, reduced buffer space or clear zone, etc.
- These conditions are unexpected by the driver.

**Excessive Speed Display Benefits:**

- Warns driver to reduce speed to safely travel through the work zone.

**Trucks Warning Considerations:**

- There is insufficient space for a truck acceleration lane prior to entering the open traffic lane.
- There is a sight restriction where trucks must enter the open traffic lane.
- Trucks must decelerate in the open lane before entering the work space.
- Trucks cross traffic where it is difficult for truck drivers to recognize a safe gap due to high vehicle volumes or sight restrictions.

**Truck Warning Benefits:**

- Drivers are able to adjust speed and lane position to facilitate safe operation of construction vehicles.
- Drivers are less likely to follow vehicles into the work zone.
- Drivers are aware of the presence of slow moving construction vehicles.

**Vehicle Restriction Warning Considerations:**

- Construction causes temporary reduction in vehicle clearance for over height, width or length vehicles.
- Many over dimension vehicles are anticipated to be using the route.
- Provide advance signing prior to major junctions that could serve as alternate routes.

**Vehicle Restriction Warning Benefits:**

- Alerts drivers of over dimension vehicles to stop and seek alternate routes.
- Warns workers that an over dimension vehicle is approaching.

**Hazardous Conditions Considerations:**

- If flash flooding, reduced visibility (fog, smoke), slippery or rough surface, falling rock or debris, etc. are anticipated.

**Hazardous Conditions Benefits:**

- Drivers are alerted to condition and can take corrective action.
- Project personnel can be immediately alerted to the condition so they may take correction action.

### Route Management Systems

**Benefits of Route Management Systems:**

- Improves capacity of freeway by reducing turbulence and shockwaves caused by entering traffic.
- Improves safety by providing uniform traffic speeds.

**Considerations for Temporary Ramp Metering:**

- Downstream capacity is exceeded reducing the maximum volume on the freeway.
- Nearby signals on the cross street or ramp terminals create platoons of vehicles entering the freeway creating turbulence and shock waves.

**Temporary Ramp Metering:**

- Are their signals on cross street?
- Is congestion anticipated on major road?

# Planning for ITS/IWZ

- Part of statewide planning and scoping effort.
- Decision support tools:
  - When to use ITS/IWZ
  - Budgeting for cost

## Mobility and Traveler Information

## Motorist Advisory

## Motorist Warning

## Route Management Systems

# Considerations, Benefit & Costs

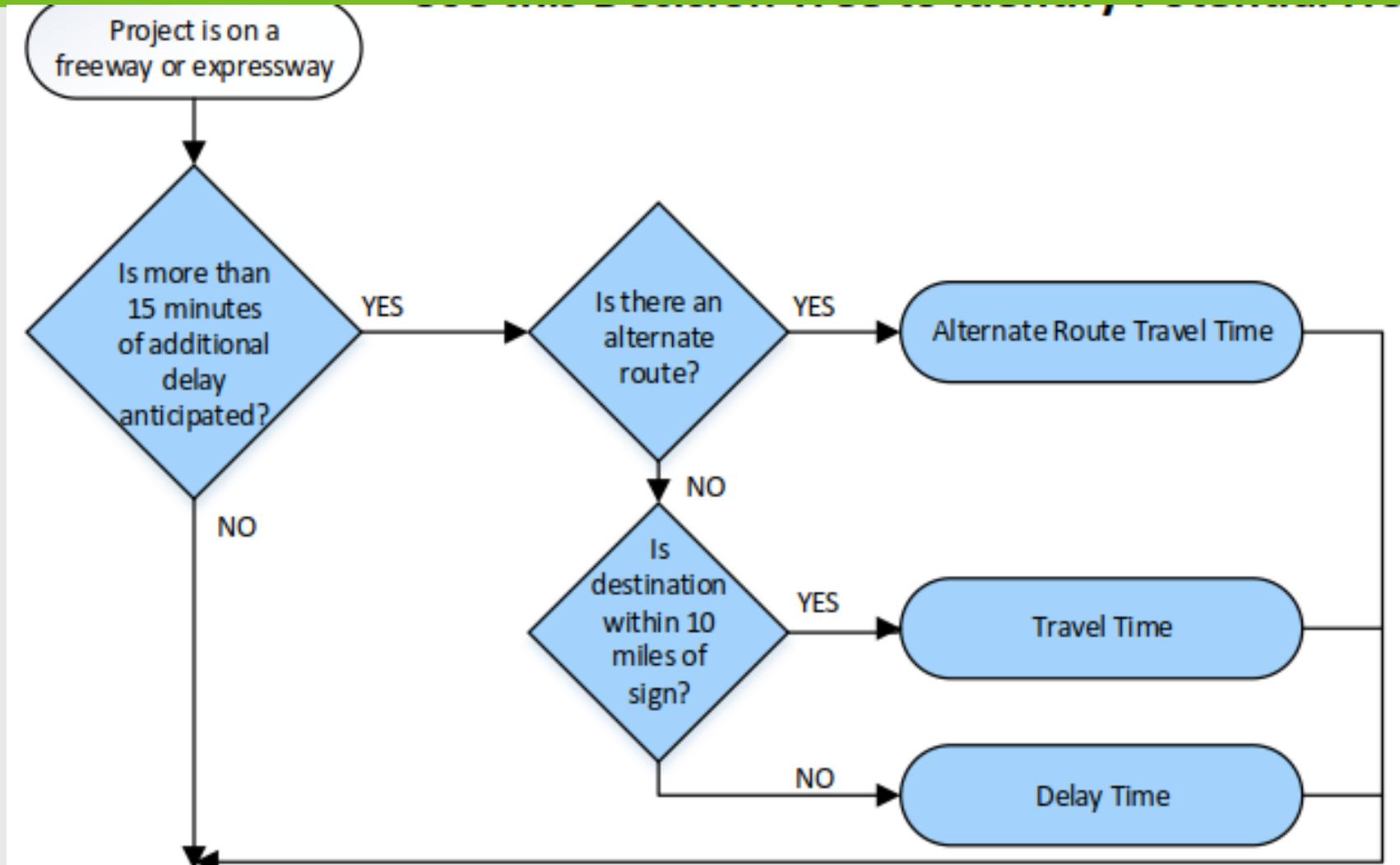
# ITS/IWZ Scoping Decision Tree

## Use Decision Tree to Identify Potential ITS/IWZ Scoping Needs

*to take proper consideration during the planning/scoping phase to enable early and improved identification of ITS/IWZ technology needs, resulting in:*

- Identification of resource needs, including time & resource allocations and efficiencies;
- Improved project cost estimating & project scheduling;
- Technology interoperability;
- Infrastructure readiness/compatibility;
- Cost effective deployments for future expansion & full integration of ITS

# ITS/IWZ Scoping Decision Tree Example for Mobility and Traveler Information



# ITS/IWZ Scoping Decision Tree Example

## Mobility and Traveler Information

### Considerations for Alternate Route Travel Times:

- Alternate route travel times are calculated and displayed for selected alternate route(s) and the main route through the work zone to provide options to drivers.
- Travel times on the main route and alternate route(s) vary independently, i.e. one route changes while the other does not.
- Care should be taken to determine proximity to other projects when selecting alternative routes to display travel times.

### Considerations to Ensure Times Displayed are Accurate:

- Maximum detector spacing is  $\frac{1}{2}$  mile.
- Travel Time is used when the time display is within 10 miles of the destination shown on the sign.
- Delay Time is used when the time display is more than 10 miles from the destination shown on the sign.

### Benefits of Mobility and Traveler Information:

- Allows drivers to decide whether to change routes.
- Provides opportunities to notify others of estimated arrival times.
- Provides sufficient information to calm tempers.

### Options for Travel Time and Delay Time Information Displays:

- Dynamic Message Sign (DMS), both portable or permanent.
- Static Guide Sign with DMS characters to display time.

## Cost Estimates for ITS/IWZ Scoping

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### ASSUMPTIONS AND BASIS FOR COST ESTIMATES FOR ITS/IWZ SCOPING

- These ITS/IWZ cost estimates are based on current MnDOT rental prices.
- All assumptions included below should be used while developing estimates for planning purposes.
- These are preliminary costs are not based on historic project costs or a detailed outreach to the ITS industry in Minnesota and it is recommended they be updated as additional information becomes available.

#### High Level Cost Estimate for Mobility and Traveler Information Systems

High level cost estimates may be used if the duration of the ITS/IWZ need is unknown.

\$200,000 for a system with NO alternate route      \$400,000 for a system with one alternate route

A more accurate estimate can be made if the project duration and the availability of an alternate route are known.

#### Detailed Estimate for Mobility and Traveler Information Systems

- Assumptions for these system estimates:
- Project and alternate route are 10 miles long.
  - Detectors are placed every 1/2 mile.
  - Travel/delay time is provided for both directions.
  - One PCMS is used for each direction.
  - Additional mile cost is for one direction only.

System Control and Management	Contractor Provided*		
	1 week	4 weeks	6 months
Travel/Delay Time (NO alternate route)	\$22,300	\$50,550	\$199,300
Travel/Delay Time (one alternate route)	\$44,600	\$101,100	\$398,600
Cost per additional mile	\$1,900	\$4,100	\$15,200

\*Contact the RTMC Freeway Operations Engineer @ (651)234-7022 to determine feasibility of using the RTMC and IRIS for ITS/IWZ system.

#### High Level Cost Estimate for Motorist Advisory Systems

High level cost estimates may be used if the duration and number of directions for the ITS/IWZ need is unknown.

\$90,000 for each system

Each of the suggested motorist advisory systems have similar costs:

- Active Zipper Merge
- Congestion Advisory
- Stopped Traffic Advisory (End of Queue Warning)
- Variable Speed Limit or Downstream Speed Notification

A more accurate estimate can be made if the number of directions and duration of the deployment are known.

#### Detailed Estimate for Motorist Advisory Systems (cost per system)

- Assumptions for these systems:
- Anticipated queue is three (3) miles.
  - Detectors are placed every 1/2 mile.
  - PCMS are placed every 2 miles (mile 1 and 3 in advance of lane closure taper).
  - Additional mile cost is for one direction only.

System Control and Management	Contractor Provided*		
	1 week	4 weeks	6 months
One Direction	\$9,400	\$22,500	\$93,300
Two Directions	\$18,800	\$44,500	\$186,600
Cost for each mile of additional queue length	\$2,400	\$5,000	\$18,000

\*Contact the RTMC Freeway Operations Engineer @ (651)234-7022 to determine feasibility of using the RTMC and IRIS for ITS/IWZ system.

#### High Level Cost Estimate for Motorist Warning Systems

High level cost estimates may be used if the duration for the ITS/IWZ need is unknown.

\$15,000 for each system

Each of the suggested motorist warning systems have similar costs:

- Excessive Speed Display
- Trucks Warning
- Vehicle Restriction Warning
- Hazardous Roadway Warning

Note:

Intrusion Warning and Electronic Workers Present Speed Limit systems have not been included in this estimate since they are not fully developed nor commercially available.

A more accurate estimate can be reached if the duration of the ITS/IWZ need is known.

#### Detailed Estimate for Motorist Warning Systems (cost per system per site)

- Assumptions for these systems:
- There is a single system at a single site within the project.
  - RTMC and IRIS cannot be used for control, therefore all control and system management is Contractor provided.

Duration	Contractor Provided*		
	1 week	4 weeks	6 months
Single Site – Excessive Speed Display	\$1,080	\$2,440	\$7,000
Single Site – All Others	Not Available	\$4,000	\$15,200

#### Route Management Systems

All Route Management Systems are controlled by the RTMC and IRIS. Contact the RTMC Freeway Operations Engineer @ (651)234-7022 to determine feasibility and cost of these systems.

# Scoping Cost Estimates

## Estimates for ITS/IWZ for Scoping

- Scoping estimates for the various systems
- Facilitates programming budget for ITS/IWZ
- Not the engineers estimate since this is before design

# ITS/IWZ Scoping Decision Tree Example

## High Level Cost Estimate for Mobility and Traveler Information Systems

High level cost estimates may be used if the duration of the ITS/IWZ need is unknown.

\$200,000 for a system with NO alternate route

\$400,000 for a system with one alternate route

A more accurate estimate can be made if the project duration and the availability of an alternate route are known.

## Detailed Estimate for Mobility and Traveler Information Systems

Assumptions for these system estimates:

- Project and alternate routes are 10 miles long.
- Detectors are placed every ½ mile.

- Travel/delay time will be provided for both directions in the work zone.
- One PCMS is used for each direction.
- Additional mile cost is for one direction only.

System Control and Management	Contractor Provided*		
	1 week	4 weeks	6 months
Travel/Delay Time (NO alternate route)	\$22,300	\$50,550	\$199,300
Travel/Delay Time (one alternate route)	\$44,600	\$101,100	\$398,600
Cost per additional mile per direction	\$1,900	\$4,100	\$15,200

\*Contact the RTMC Freeway Operations Engineer @ (651)234-7022 to determine feasibility of using the RTMC and IRIS for ITS/IWZ system.

<http://www.dot.state.mn.us/its/docs/scopingdecisiontree.pdf>

# Boiler Plate Special Provisions

Fully Automated Stand-Alone Systems	RTMC/IRIS Controlled Systems
End of Queue Warning	End of Queue Warning
Travel Time	Travel Time
Active Zipper Merge	Temporary Ramp Metering
Electronic Workers Present Speed Limit	
Truck/Traffic Entering	
Excessive Speed Warning	

- I-35 near Owatonna (SP 7480-126) – District 6
  - End of Queue Warning
- I-35 north of Faribault (SP 6680-113) – District 6
  - End of Queue Warning
  - Active Zipper Merge
  - Travel Time
- TH 169 north of St. Peter (SP 5209-74) – District 7
  - End of Queue Warning within the work zone
- I-35W various locations – Metro District
  - End of Queue Warning
  - Travel Time

# AWARE Intrusion System



## Local Road Research Board Project Advance Warning and Risk Evasion (AWARE) System



# AWARE Intrusion System



# Distracted Driver

Evaluation of Mobile Work Zone Alarm Systems



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MoDOT Final Report Prepared for Missouri Department of Transportation  
June 2015 Project TR201412 Report cmr 15-011



# Distracted Driver Field Demo



# Actions and Discussion

- Use and feedback of IWZ/ITS Decision Tree
  - Are there any loop holes?
  - Do you have any suggested improvements?
- AWARE system is best suited for moving operations
  - How do we demonstrate this system on maintenance operations?
  - How do we engage both construction and maintenance for future deployments?
- AWARE system also has flagging operations applications
  - Is there interest in demonstrating the flagging operations application in Minnesota in 2018?
  - If so, how?
- Iowa DOT will be experimenting with the Distracted Driver System
  - Should we demonstrate this system on a project in Minnesota in 2018?
  - Which project?

# Questions and Feedback Please Contact Us

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<http://www.dot.state.mn.us/its/projects/2016-2020/nextstepsworkzonechallenges/nextstepsforworkzonechallenges.html>