



Project Summary Report O-4413-S

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Project O-4413: Advance Warning of Stopped Traffic

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Advance Warning of Stopped Traffic on Freeways: Summary of Project Activities

Stopped traffic on freeways poses safety and operational concerns to drivers, transportation agencies, contractors, and enforcement and emergency service personnel. Safety issues relate to driver ability to make a gradual transition from freeway speed to a stopped condition without erratic maneuvering or a collision. Operational concerns relate to the reliability and predictability of the freeway network.

The rear-end collision is the primary type of multi-vehicle incident, comprising over 50 percent of crashes by some research findings and caused generally by normal-speed traffic encountering stopped traffic. Drivers frequently have minimal or no warning about downstream queuing, and information given on static signs is difficult to keep current with rapidly fluctuating queues in congested areas.

Stopped traffic on freeways may occur for a number of reasons. This research investigated three major causes related to slow/stopped traffic: recurrent congestion due to over-capacity conditions during peak periods, congestion due to construction/maintenance zones, and congestion due to incidents. Warning drivers in advance of a stopped traffic condition requires detection and a means of alerting the driver to the condition ahead.

Issues relating to vehicle type and the freeway's geometric design further complicate this situation. Trucks have longer stopping distance requirements, although their sight distance may be longer than for passenger cars due to elevated driver height. All vehicles can be impacted by sight constraints to the tail end of a queue due to horizontal/vertical curves or obstructions such as overpasses. Trucks can create sight obstructions for passenger cars. Rural conditions and expectations differ from urban conditions.

What We Did...

In the first phase, the research team conducted a literature review to determine current practices for advance warning of stopped traffic, observed field locations with stopped traffic, and determined warning techniques applicable to Texas. In the second phase, researchers tested two advance warning techniques using static warning signs on Dallas freeways. The research team synthesized the field test results and developed recommendations for further research and ways to improve signing.

What We Found...

Researchers identified current practices of international agencies and state departments of transportation (DOTs) for

detection and advance warning of slow/stopped traffic on freeways. Researchers collected information on queue detection and warning techniques used by 14 international agencies and 15 state DOTs. Detection devices included video cameras, radar (microwave or Doppler), loops, infrared, ultrasonic, and optical. Queue warning practices and techniques included:

- dynamic message signs (DMS)
 - some trailer-mounted and/or portable DMS,
- variable speed signs,
- static signs (text and symbol),
- queue-activated roadside beacons,
- incident response vehicles tracking the end of queue, and
- enforcement vehicles with special driving methods.

After identifying current practices, researchers assessed the potential effectiveness of these practices and techniques in addressing Texas Department of Transportation (TxDOT) concerns about advance warning of stopped traffic. When considering the complexity of implementation and operation, current standards, and estimated cost of installment, researchers selected three techniques as having the most promise for application by TxDOT:

1. series of static signs with text message and flashers,



2. series of static signs with international congestion ahead symbol and flashers, and
3. series of portable DMS with messages appropriate to warn drivers of upcoming traffic conditions.

Observational Field Studies

The research team conducted observational field studies in order to provide comparative information on topics such as queue formation, including the nature of queuing by lane and length of queue and speed of queue propagation (i.e., tracking the speed at which the queue develops). Researchers observed queues at three sites in Dallas and found that approaching drivers have a variety of experiences depending on their time of arrival at the queue tail and their lane of travel (see Figure 1).

Researchers found sustained, repetitive, and excessive queue propagation speeds that in many instances impacted multiple freeway lanes. The findings on urban freeways in Texas are comparable to findings on rural interstates in Iowa where backward-moving queues grew at speeds as high as 30 to 40 mph.

Field Studies of Advance Warning Signs

Researchers received approval for experimentation from the Federal Highway Administration (FHWA) to test two new warning signs. The first warning sign had the text message WATCH FOR STOPPED TRAFFIC. The second warning sign used a variation of the international congestion ahead symbol for which the primary modifications were making linear taillights and adding a license plate. Figure 2 shows pictures of both signs, which were 48-inch by 48-inch yellow diamond warning signs.

The Researchers Recommend...

The following list provides general recommendations and findings from this research:

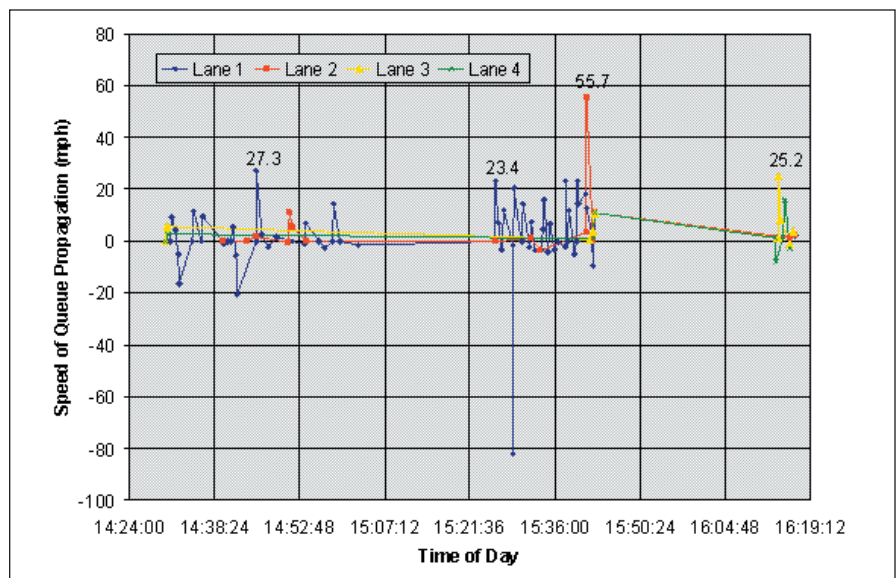


Figure 1. US 75 Queue Propagation Data – All Lanes.



Figure 2. Congestion Warning Signs Used in Field Tests.

- Queue warning systems, in order to be effective, should be installed in consideration of rapidly fluctuating queues. This means that warning signs or devices placed too close to the queue tails might be overrun, with the possibility of drivers encountering the queue before they see the sign. Warning signs placed too far from the queue, if the downstream location of the queue is given, can become inaccurate between the time drivers view the sign and encounter the queue.
- Conditions change too quickly for human operators to handle appropriate warning sign adjustments, necessitating an automated system for real-time adjustments to locate queues.
- Located queues, for which drivers are advised of the distance to the

queue tail, will require multiple detection stations, as well as multiple advance warning sign locations.

After conducting the literature search and current practices review, it became evident to researchers that no sign standard exists which specifically warns about the possibility of encountering stopped traffic on the freeway. The breadth and variety of sign sizes, shapes, messages, field placement, and use of technology were significant, as well as indicative of the need to warn drivers of possible congestion. Additionally, the reasons for deploying such signs are varied. Thus, the potential exists to develop a new standard which addresses the need to warn the driver, while increasing effective communication to the driver via standardized messages. This



Table 1. Advance Warning: Selection Strategy Chart (Version 1).

Problem Type	Problem Description	Primary Warning Strategy	Shape	Color	Possible Text Message/ Pictogram ¹	Detection/ Flashers	Supplemental Plaque	Deployment Strategy	Cost ²
Sight Distance Constraints	Vertical and horizontal curves block driver's view	Static or variable signs with some form of queue detection	Diamond, Rectangle, or Panel	Yellow or High Intensity Yellow	WATCH FOR STOPPED TRAFFIC	Optional	With Pictogram ¹ : Watch for Stopped Traffic or Watch for Congestion	<u>Sign 1</u> 1500' before typical queue <u>Sign 2</u> 1000' before Sign 1, or before max queue; gate-posting OK	\$ to \$\$
					WATCH FOR CONGESTION				
					Congestion Pictogram ¹				
Recurrent Congestion	Predictable congestion	Static or variable signs with some form of queue detection	Diamond, Rectangle, or Panel	Yellow or High Intensity Yellow	WATCH FOR STOPPED TRAFFIC	Optional	With detection and flashers: When Flashing	<u>Sign 1</u> 1500' before typical queue <u>Sign 2</u> 1000' before Sign 1, or before max queue; gate-posting OK	\$ to \$\$
					WATCH FOR CONGESTION				
					Congestion Pictogram ¹				
Construction/Maintenance Zones	Queues caused by reduced capacity from lane closures	Single or multiple detection stations and multiple signs (static or variable)	Diamond	Orange	WATCH FOR STOPPED TRAFFIC	Optional or desirable	With detection and flashers: When Flashing	<u>Sign 1</u> 1500' before typical queue <u>Sign 2</u> 1000' before Sign 1, or before max queue <u>Sign 3</u> 1-5 miles prior to Sign 2; gate-posting OK.	\$\$ to \$\$\$
					CONGESTION AHEAD				
					Congestion Pictogram ¹				
Incidents	Unpredictable time and location of congestion	Rely on use of existing ITS devices	N/A	N/A	WATCH FOR STOPPED TRAFFIC	N/A	N/A	As Available	0
					CONGESTION AHEAD				

¹ Pictogram not currently approved for use.

² \$ — Low Cost; \$\$ — Moderate Cost; \$\$\$ — High Cost.

research, after investigating alternative techniques used internationally, nationally, and at the state and local levels, was primed to develop sign messages for testing which could be a first step to a new standard. Promising text and pictogram messages were

developed and evaluated within this project.

A Selection Strategy Chart was developed and is shown in [Table 1](#). This chart addresses four basic problem types for which freeway drivers might need advance warning of stopped

traffic and assists in the selection of appropriate warning strategies. These problem types are sight distance constraints, recurrent congestion, construction and maintenance zones, and incidents.



For More Details...

The research results, conclusions, and recommendations are documented in [Reports 0-4413-1, *Advance Warning of Stopped Traffic on Freeways: Current Practices and Field Studies of Queue Propagation Speeds*](#), and [0-4413-2, *Advance Warning of Stopped Traffic on Freeways: Field Studies of Congestion Warning Signs*](#).

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TxDOT Implementation Status—April 2005

This research evaluated issues relating to stopped or very slow traffic on freeways due to congestion. Two products were required for this project: 1) selection strategy flow chart version 1 and 2) guidelines for the implementation of advance warning techniques for stopped traffic. Both products are incorporated in Chapter 4 of technical report 0-4413-2, *Advance Warning of Stopped Traffic on Freeways: Field Studies of Congestion Warning Signs*. Many factors remain to be addressed in future research; however, observations conducted in this project can provide guidance to those testing and implementing operating systems for advance warning of slow/stopped traffic on freeways.

For more information, contact Mr. Wade Odell, P.E., RTI Research Engineer, at (512) 465-7403 or email wodell@dot.state.tx.us.

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