Advanced Warning for Railroad Delays in San Antonio

Lessons Learned From The Metropolitan Model Deployment Initiative

Providing Enhanced Information to the Public

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Preface

This report demonstrates the benefits of deploying and operating an integrated highway/rail system, along with the potential barriers to implementation. In particular, it discusses the lessons learned associated with the Advanced Warning to Avoid Railroad Delays (AWARD) project deployed in San Antonio, Texas, in concert with the Metropolitan Model Deployment Initiative (MMDI).

As one of four sites participating in the Metropolitan Model Deployment Initiative effort, San Antonio committed to pursuing integrated deployments of Intelligent Transportation Systems (ITS). Among the goals of deploying these integrated systems was to provide information to motorists about delays associated with train blockages. However, institutional challenges associated with the deployment did not allow the system to function as it was originally designed. This report outlines the lessons learned from this deployment and describes the potential challenges that must be overcome in order for similar systems to be successful.

ITS at Highway Rail Intersections

At-grade highway-rail intersections give rise to traffic control problems that have a bearing not only on traffic safety, but also on traffic flow performance. Railroad crossings in the vicinity of freeway access ramps pose particularly acute problems, since long blockages of traffic due to passing trains can lead to backup on the freeway ramps and potentially interrupt freeway operations. In an effort to prevent these problems, San Antonio has adopted a program that integrates highway-rail operations with advanced traveler information systems (ATIS) in the AWARD project.

The AWARD system includes acoustic and Doppler radar sensors placed at selected locations along the railroad tract to detect the presence, speed, and length of trains before they approach grade crossings. Data from the sensors are transmitted to the TransGuide Control Center where computer programs calculate the predicted time and duration of blockages at grade crossings at or near freeway exits. This information enables TransGuide operators to control variable message signs (VMSs), placed at strategic locations along the freeway, to alert motorists of potential delays and allow them to select alternative exits. The information can also be transmitted to traveler information kiosks and to in-vehicle navigation units located in public agency vehicles.

Goals of the AWARD System

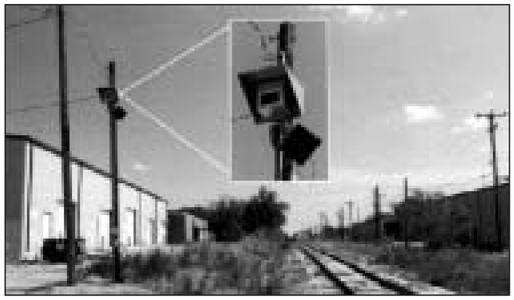


Figure 1. AWARD Site Installation

The AWARD system implemented in San Antonio is a new way of handling intermodal traffic problems. The design of the system is based upon the following goals:

- Provide a successful proof-of-concept for ITS at highway-rail intersections and an architecture that can be expanded and implemented at other locations.
- Provide advance information on train crossings to TransGuide operators, emergency service providers, and travelers.

San Antonio's AWARD System

The original San Antonio Metropolitan Model Deployment Initiative proposal called for a rail-crossing system that focused on safety. The system was designed to use sensors and cameras at the railroad crossing to detect the presence of vehicles on the tracks as the train approaches. Wireless communication would transmit a warning and image of the situation directly to the cab of the oncoming train in time to allow the train to stop and avoid striking the vehicle.

Unfortunately, the railroads were hesitant to participate in the program. While they have a strong commitment to safety, they were concerned that the utilization of the system would shift liability from the vehicle to the railroad. This concern was further exacerbated by the system being untested and not guaranteed as fail-safe.

Instead of abandoning the highway-rail project altogether, San Antonio modified the project to focus on traveler information. With this focus, San Antonio did not have to wait for the railroads to agree to its use.

The resulting project, AWARD, is a non-intrusive system. As depicted in Figure 1, AWARD was implemented using detectors located on poles mounted on city or state rights-of-way so that it would not intrude on railroad rights-of-way. Because the equipment does not interface with any railroad equipment, no agreements with the railroad companies were required.

The new system allowed San Antonio to demonstrate that ITS can be successfully deployed at highway-rail intersections. The modified system collects information on a train's arrival at an intersection and the duration of the train. This information can then be relayed to variable message signs, in-vehicle navigation units, or other forms of traveler information.

System Details

The AWARD system uses acoustic vehicle detectors and Doppler radar to detect the presence and characteristics of a train. The sensors are placed upstream and downstream of the highway-rail intersection. Data collected from the sensors are used to predict the time and duration of intersection blockages. San Antonio compared several sensing technologies in determining which types of sensors to use. Table 1 lists the advantages and disadvantages of each.

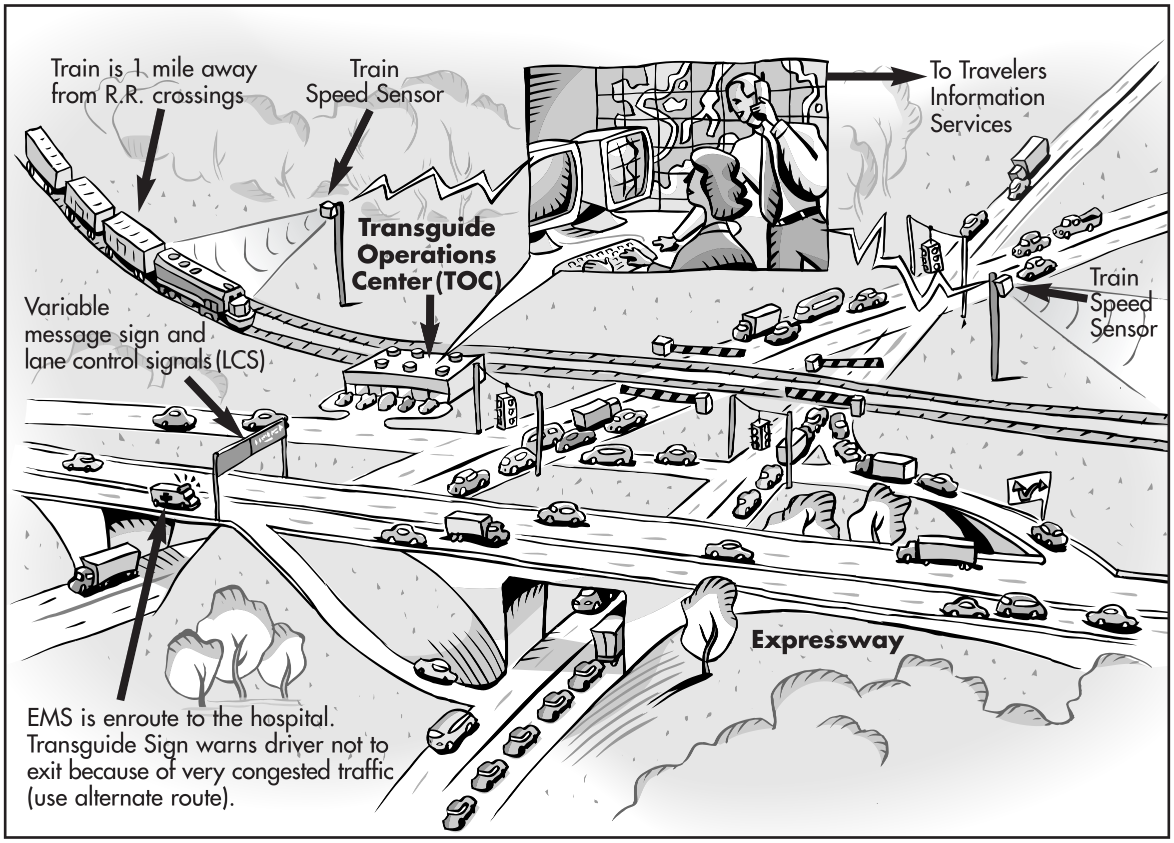
Table 1. AWARD Sensor Comparison [1]

Technique	Advantages	Disadvantages
RF Tag Readers Most train cars in the United States have electronic tags detailing the length of the car. Tag readers placed beside the track could read this tag and calculate the speed and length of the train.	Tag readers are supplied by several manufacturers. Available commercial systems are suitable for use in outdoor environments. Determining the time intervals and length of railroad cars would allow accurate calculation of train speed and length.	The sensing range of tag readers is low, requiring that readers would have to be placed on railroad rights-of-way. The cost of tag readers is higher than other systems.
Acoustic Vehicle Detectors Trains entering the sensitive "footprint" of the sensor would be detected by acoustic emission. Two sensors located a known distance apart could determine train speed.	Acoustic detectors are in use as a non-intrusive alternative to loop detectors. Commercially available systems are suitable for outdoor use.	Velocity detection required two detectors a fixed distance apart at each location. Speed can only be measured at the front and rear of the train. Acceleration can only be derived from two velocity measurements. Since variations in speed and acceleration cannot be measured, calculations of length and crossing arrival times will be inaccurate. Field box installation requires significant on-site calibration.
Laser Radar (LIDAR) Distance to an object is measured by a reflected beam of light. Speed is calculated by change in distance measurements.	Laser radar guns are readily available due to their use in law enforcement. The laser radar instrument provides range and speed data.	Laser radar must track asingle point on an object to acquire an accurate speed measurement. A rigid-mounted unit can measure only the locomotive and cannot track points on the sides of moving train cars.
Doppler Radar Speed is measured by frequency shift of the reflected radio frequency beam.	Radar guns are readily available due to the law enforcement industry. No Federal Communications Commission (FCC) license is required for low-power (short-range) use. The Doppler technique provides direct speed measurement. Speed can be measured from thesides of moving train cars.	Radar guns have some sensitivity problems with low-speed objects, but this sensitivity can be overcome with modifications to the standard designs.

[1] *TransGuide Model Deployment Initiative Design Report,* Southwest Research Institute, 1998, p. 24.

Components to measure speed, length, acceleration, and expected time of arrival at the intersection were installed at three grade crossings in San Antonio. The system is linked to the AWARD master computer located at the TransGuide Operations Center where the information is processed. An existing variable message sign on the freeway is used to alert travelers of the anticipated delays due to congestion and to report alternate route information. Delay and routing information can also be disseminated through other advanced traveler information systems media such as in-vehicle navigation units, web sites, or kiosks. Figure 2 shows the conceptual overview of how the AWARD system works.

Figure 2. AWARD Conceptual Overview



Deployment and Operating Costs

The costs for the AWARD system can be broken down into two categories, one-time fixed costs and annual operations and maintenance costs. The fixed costs include the initial installation and development of the system. The recurring annual costs involve personnel and hardware/software maintenance and upgrades. As seen in the table, the most significant cost for the AWARD system was development labor. Some fixed costs of AWARD were reduced significantly by pooling resources with other projects within the Metropolitan Model Deployment Initiative.

The Texas Department of Transportation (TxDOT) is the only agency participating in the cost of the master computer and operation and maintenance of the AWARD program. The AWARD master process resides on a Sun Microsystems platform with two other master processes, so the cost of the computer was shared between projects. However, all costs were borne by the Texas Department of Transportation, funded out of the Metropolitan Model Deployment Initiative program.

The acoustic and Doppler radar sensors (six upstream and six downstream at each location) were purchased from a manufacturer instead of being developed. This use of off-the-shelf technology allowed for lower sensor costs. The largest recurring cost involves staffing for the TransGuide Operations Center. Remaining software and hardware upkeep costs are very low.

Table 2. AWARD Costs

Equipment Description	Fixed Costs	Annual Costs
Share of AWARD train sensors	$55,164.00	
Development labor costs	$230,490.00	
33% Share of AWARD/ Kiosk/In-Vehicle Navigation master computer	$5,130.51	
20% Share of Southwest Research Institute development labor costs	$60,000.00	
Share of AWARD sensor maintenance		$2,752.71
Share of AWARD leased phone lines		$3,552.41
4% Share of 25 TransGuide personnel		$20,665.00
4% Share of software maintenance and upgrades		$5,904.28
4% Share of hardware maintenance and upgrades		$933.64
Totals	$ 350,784.51	$33,808.04

System Usage

The second goal of the AWARD system was to provide advance information on train crossings to TransGuide operators, emergency service providers, and to the traveling public. The system was successful as a proof-of-concept; however, the services provided by AWARD were either not used or not needed at this time.

Information from the AWARD system was successfully relayed to TransGuide operators who control the freeway variable message signs. A study was performed to determine the effects of the AWARD system's traveler information on traffic patterns at one of the three locations when AWARD was deployed. The study used field interviews to determine the effects of the system on traffic operations for this location. Microscopic simulation models were also used to determine the effectiveness of information relayed through variable message signs on reducing vehicle delay on freeway and access roads near the grade crossings.

The results of the field interviews show that the presence of a train at this location rarely causes traffic to spill out onto the freeway lanes. The system was used to warn motorists of very unusual activities more often than to warn of traffic delays caused by trains. At this location, there are typically only two or three trains crossing in any given day, and they mostly pass through the intersection during off-peak periods. Trains typically take 3 to 7 minutes to cross the exit ramps. While vehicle delays can be as high as 10 minutes, the queues of vehicles that form during the train passage rarely spill onto the freeway lanes.

Researchers used the Queens University Synthetic Origin and Destination Generator and INTEGRATION modeling programs to determine the impact of the AWARD system. The results of the simulation efforts were in accordance with field experiences. The model predicted that traffic queues build on the freeway exit ramp during the presence of a passing train, but rarely spill out onto the freeway lanes. This finding supports the observation that trains crossing at this location rarely interrupt freeway traffic operations. In most cases, the model predicted that entering the queue and waiting for the train to pass would be more beneficial for motorists than taking an alternate route. It should be noted that the Texas Department of Transportation rarely uses the variable message signs for the purpose of suggesting an alternate route, due to institutional issues involved with diverting traffic from freeways, managed by the Texas Department of Transportation, to arterial streets, managed by local governments.

Information on train blockages was relayed to emergency services providers through in-vehicle navigation units. However, interviews with drivers showed that the feature was rarely used because of problems with the units and lack of knowledge of the AWARD feature.

Potential Benefits from the AWARD System

Researchers determined that there was no compelling need for the use of the variable message sign component of the AWARD system at the location. However, future traffic patterns may create such a need, and the system components would be in place in the event that large increases in traffic volumes occur. In order to determine the situations under which AWARD would be beneficial, additional modeling was performed assuming increases in traffic demand and a more aggressive use of the variable message signs. Higher traffic demands may be a function of overall traffic growth in San Antonio or large, temporary increases caused by special events. Aggressive use of the variable message signs would entail posting train crossing warnings as soon as they occur instead of waiting for a queue to spill onto the freeway.

Assuming a growth of 25 percent in vehicle miles traveled and average train crossing time of 6 minutes, a series of simulation runs was conducted to determine travel time savings based on a variety of levels of driver compliance with variable message signs. The system-wide results of these simulations are presented in Figure 3, and the results for the drivers most affected by the system are shown in Figure 4. Those considered most affected are drivers who are traversing the network from origin-destination pairs 1-6, 1-11, and 1-12 in Figure 5.

Figure 3. Travel Time Impacts of AWARD for All Vehicles in Network

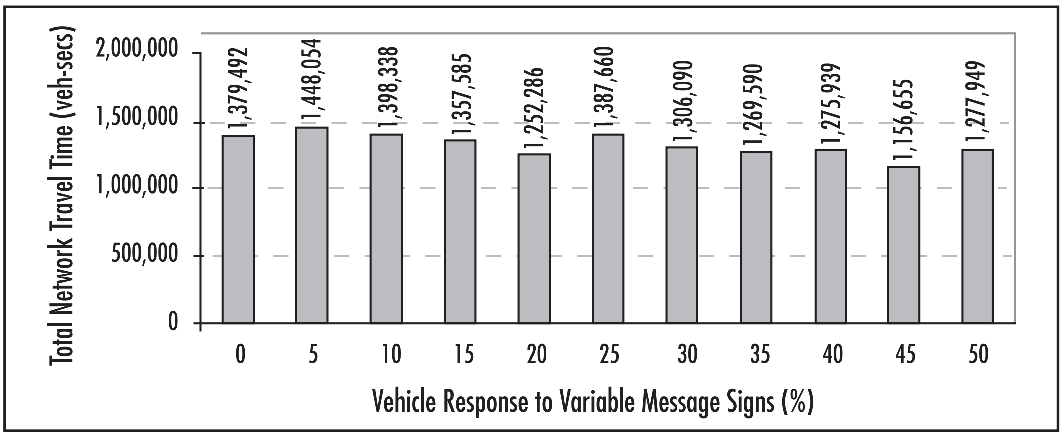
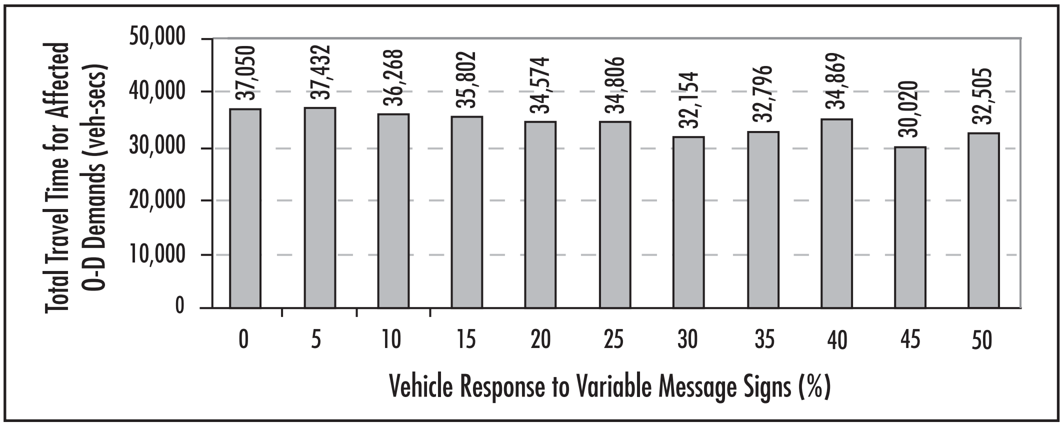


Figure 4. Travel Time Impacts of AWARD for Affected Origin-Destination Pairs

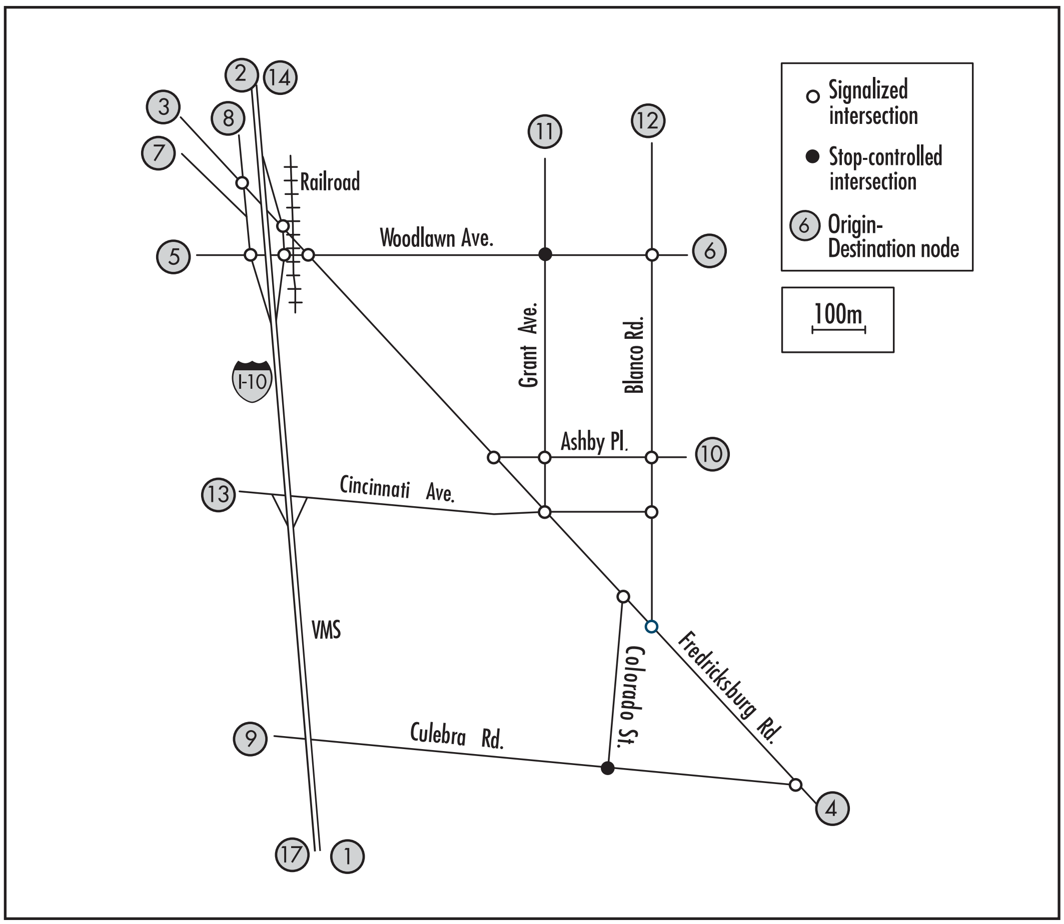


Travel time benefits can be achieved by using the AWARD system; however, the benefits are highly dependent on the degree of driver compliance to the variable message signs. For example, the assumption of a 10 percent driver compliance rate resulted in a small travel time savings of 2.1 percent for the affected origin-destination pairs and no appreciable impact network-wide. It is only when compliance rates are beyond 15 percent that travel time savings are accrued for both the affected origin-destination pairs and the network as a whole (see Table 3).

Table 3. System-Level Impact of AWARD under Certain Conditions

Impact/Six-minute Train	Total System Travel Time	Crashes per Million km	Total Fuel Consumption
No Variable Message Signs	10.2 vehicle-hours	3.016	2109 liters
20% Variable Message Signs Response	9.6 vehicle-hours	2.753	Slight increase
Percentage Change	6.7%	8.7%	Slightly

Figure 5. AWARD Simulation Network



Lessons Learned

The AWARD project has demonstrated that it is technically and institutionally feasible to deploy an integrated highway-rail traveler information system. Not only does the system function as designed, but it was also built in a manner that was non-intrusive to the railroads. This latter achievement assisted in the rapid, on-time deployment of the system.

As deployed, the AWARD system is unlikely to have a substantial impact on San Antonio at this time. As the analysis indicated, the current combination of train delays and traffic demands is too low to offset the increased travel costs of rerouting. Consequently, the system has rarely been used.

However, with future growth the system may offer benefits. Assuming a 25 percent increase in demand and the adoption of a more aggressive operating strategy, reductions in system travel time savings as large as 9.2 percent were predicted for a typical train crossing event and a 20 percent compliance with the variable message signs.

These benefits are sensitive to driver compliance. If the compliance rate drops to 10 percent, then the system travel time benefits are lost entirely. Conversely, if compliance were to increase to 45 percent, then the system travel time savings would nearly double to 19.2 percent. However, it remains to be seen whether such rates can be achieved in the field.

ITS Web Resources

ITS Joint Program Office:
www.its.dot.gov

ITS Cooperative Deployment Network:
www.nawgits.com/icdn.html

ITS Electronic Document Library (EDL):
www.its.dot.gov/itsweb/welcome.htm

ITS Professional Capacity Building Program:
www.pcb.its.dot.gov

Federal Transit Administration
Transit ITS Program:
www.fta.dot.gov/research/fleet/its/its.htm

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