A Status Report on ITS at the Highway-Rail Intersection

by

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ABSTRACT

It has now been several years since the Highway-Rail Intersection (HRI) became an official part
(User Service #30) of the National Intelligent Transportation Systems (ITS) Architecture.
However, the effort to bring ITS to bear on the problems of HRIs has only recently begun to take
off. The primary focus of the HRI/ITS effort is to improve safety through the appropriate
application of new computer, sensing, and communication technologies at grade crossings. FRA
has initiated an HRI/ITS standards program, in which AREMA is an active player along with
multiple other standards development organizations. FRA is also in the midst of developing a
strategic plan for the use of ITS at HRIs. In addition, a number of research initiatives are
beginning to focus on saving lives, time, and money at HRIs. This paper will provide a survey
of current progress, status, activities, opportunities, and challenges for applying ITS to Highway-
Rail Intersections and the ways in which this exploration is beginning to spill over into other
aspects of railway deployment and railroad operation.

INTRODUCTION

The general objective of Intelligent Transportation Systems (ITS) is to save lives, time, and
money through the application of computers, communications, and sensors to surface
transportation. The Highway-Rail Intersection (HRI) user service is a fairly recent addition to the ITS arena. The emphasis is squarely on saving lives, by using technology to help prevent crashes at and around the places where roadways cross railroad tracks.

An important component of the HRI/ITS program is to encourage the development of industry consensus standards that in turn encourage the deployment of HRI technology, to make life-saving benefits available as quickly and as broadly as possible. The Federal Railroad Administration, the U.S. DOT ITS Joint Program Office, the railroads, suppliers, and multiple standards development organizations, have joined forces to define requirements for HRI-related standards and begin their development. The initial focus has been on linking rail wayside equipment with traffic controllers to better coordinate rail and roadway systems at HRIs, and on laying the groundwork for in-vehicle warning systems.

Much of the original impetus for the HRI/ITS program was to address safety at passive crossings. However, standards work and deployment in this area have been slow in coming. This is due primarily to the need first to get a better understanding of two foundation issues: human factors related to the HRI and appropriate low-cost technology for activating passive crossings. Work to explore these foundation issues is now starting to get underway, along with the development of an FRA-sponsored strategic plan for Intelligent Transportation Systems at the Highway-Rail Intersection.

**SOME HISTORY**

Rail issues in general are latecomers to the world of Intelligent Transportation Systems (ITS). Although ITS defines itself as the application of information technologies (computers, communications, sensors) to surface transportation, in its original 1989 incarnation ITS limited the universe of surface transportation to road transportation (Intelligent Vehicle–Highway
Systems), although light rail and commuter rail were incorporated fairly quickly as public transportation was brought under the umbrella. Even in these very special rail situations, the focus was mainly on providing good schedule and status information to travelers, and not on system management or interactions with other travel modes.

*Introducing Rail into the National ITS Architecture.*

By 1994, the first generation National ITS Architecture [The current version of the National ITS Architecture is available on CD-ROM from the U.S. DOT ITS Joint Program Office, 400 7th Street SW, Washington, DC, 20590, or on the web at http://www.iteris.com/itsarch/] was announced in the Federal Register. The Architecture, made up of 29 different user services ranging from pre-trip planning to electronic fee payments, pretty much ignored rail. However, in January 1995, largely at the instigation of Mr. Hoy Richards (now the publisher of the *Highway & Rail Safety Newsletter*), the Federal Railroad Administration announced its intention to work toward the incorporation of a new user service, the Highway-Rail Intersection (HRI). “HRI” is a new term for grade crossing, and it is a term with a message, namely that safety at these intersections is a joint concern of highway and rail interests and that enhancing safety at HRIs is largely a matter of more effectively keeping road vehicles (and pedestrians) out of intersections that a train is at or approaching.

By early in 1996, the user service was drafted and entered the U.S. DOT and Architecture review and approval process. In January 1997, the Highway-Rail Intersection became the 30th user service. [Two additional user services were subsequently incorporated into the Architecture: Archived Data Management Services (#31) and Maintenance and Construction Operations (#32).]
Encouragement from NTSB

In 1998, the National Transportation Safety Board published a comprehensive study of safety at passive crossings(1). Among many other conclusions, the NTSB stated its belief that

“...a long-term solution to eliminating passive crossings and reducing collisions between highway and rail vehicles will be through the use of intelligent transportation systems (ITS) that will be able to alert the motorist to the presence of a train.” [p.80]

NTSB noted that:

“ITS applications cost far less than installing lights and gates and will also convert passive crossings into active crossings. For the train detection and transmitting equipment ... at each crossing, most cost estimates are below $5,000 per crossing, and all cost estimates are below $10,000 per crossing. As noted earlier, it costs about $150,000 per crossing for standard warning devices. Depending on the cost of the ITS infrastructure, it is likely that the cost of ITS technology will be less than that for standard active warning devices. The Safety Board supports efforts to encourage development of ITS applications.” [p.81]

NTSB, observing that it would take 15-20 years before all vehicles could be equipped with in-vehicle warning devices, also noted that:

“...interim ITS solutions may also be possible, such as signs or signals that can alert a motorist to the presence of a train without depending on expensive track cuitry. Less complex ITS applications have been proposed by the FHWA for use at grade crossings, including variable message signs and roadside beacons activated by wireless communications signals emitted by train detection equipment.” [p.81]

NTSB further concluded that:
“...to achieve the greatest safety at passive grade crossings as quickly as possible, standards for ITS applications must be established in a timely manner. The Safety Board believes that the DOT should establish a timetable for the completion of standards development for ITS applications at highway-rail grade crossings, and it should act expeditiously to complete the standards.” [p.83]

This guidance from NTSB was sufficient impetus to begin the process of establishing an ITS program within the Federal Railroad Administration, with an emphasis on experimental trials of ITS technology and standards to support the introduction of ITS at HRIs.

**Initial Field Trials**

The Federal Railroad Administration has helped to sponsor seven different operational field tests of ITS-related technology (see Table 1).

Details of the projects, including selected results, can be found in the Proceedings of a May 1999 workshop: “ITS Technology at Highway-Rail Intersections: Putting it to the Test” [available at http://www.itsdocs.fhwa.dot.gov/jpodocs/proceedn/9jf01!.pdf].

While most of these operational field tests had positive results, they have mostly not been followed up with more widespread deployment. Partly this is due to the reluctance of railroads to participate actively in deploying the technology, for fear of assuming additional liability. Partly it is due to the ad hoc nature of the field tests, which were not designed to readily translate into deployment. The experience from this suite of tests reinforced NTSB’s counsel that a consistent approach and the development of standards is an important ingredient to adding safety at HRIs.
HRI/ITS Standards Program

Standards Planning

In response, FRA conducted a stakeholder workshop (2) in July of 1999 to determine requirements for ITS-related standards at the HRI. The workshop identified several dozen standards relevant to enhancing safety at the HRI, although not all of them are related to ITS (e.g., standard geometry for high-profile crossings, HRI-oriented updates to the Manual of Uniform Traffic Control Devices, uniform national guidelines for closing crossings, etc.).

The Workshop was followed up by a SDO Kickoff Meeting, in January 2000, to determine which standards were ready to be developed, and to determine which SDOs wanted to take lead or support responsibility for each such standard (see Table 2).

Participating SDOs included the American Association of State Highway and Transportation Officials (AASHTO), the Association of American Railroads (AAR), the American Public Transportation Association (APTA), AREMA, the Institute of Electrical and Electronics Engineers (IEEE), the National Electrical Manufacturers Association (NEMA), and the Society of Automotive Engineers (SAE). For a number of traffic management protocols, collectively called the National Transportation Communications for ITS Protocol (NTCIP), AASHTO, ITE< and NEMA work together as the NTCIP Group. Also not an SDO as such, ITS America also participated in the meeting and has agreed to take on development responsibility for an HRI/ITS Glossary.

As shown in Table 3, a number of proposed standards were judged “not ready for development.” In some cases this was because underlying technology was not yet well enough understood. In other cases, resources were not presently available to undertake the work.
Standards Status

Of the standards deemed ready for development, several have efforts under way or gearing up.

The most advanced are:

- The Interface between Wayside Equipment and Advanced Transportation Controller, which is being pursued under WG14 of IEEE’s Rail Transit Vehicle Interface Standards Committee as IEEE P-1570: *Standard for the Interface Between the Rail Subsystem and the Highway Subsystem at a Highway Rail Intersection*. Under the leadership of Bill Petit (Safetran Systems), this effort has proceeded through three drafts and is close to being ready for ballot.

- Development of standards for the Advanced Transportation Controller are proceeding under the joint auspices of AASHTO, ITE, and NEMA, and work includes consideration of HRI interfaces, including signal priority issues.

The Glossary of HRI Terms is ready to begin at ITS America, and is currently awaiting the execution of a contract with FRA to help provide contractor support for this effort. Other efforts on the “ready” list are in various stages of resource gathering, committee formation, etc.

Among the deferred standards, the ones related to in-vehicle warnings are the most likely to move shortly into active status. The allocation by the FCC of spectrum in the 5.9 GHz band for ITS applications using dedicated short-range communications (DSRC) has significantly enhanced the priority of technology and standards related to short-distance in-vehicle warning systems initially for traditional roadway concerns like construction zone warnings, but potentially including HRI warnings as well. Recognizing that it will be a long time before the general automobile fleet is equipped with in-vehicle warning systems, early efforts will probably
focus providing in-vehicle warning systems for specialized groups of vehicles (school buses, transit vehicles, public safety vehicles).

The deferred standards which are the most troubling are those related to human factors and to low-cost technology for activating low-volume HRIs.

**Human Factors.** The deferral of human factors standards is troubling because, ultimately, all HRI safety concerns revolve around human factors: How to effectively advise motorists (bicyclists, pedestrians) that a train is really coming and how to effectively prevent risk-taking behavior at HRIs. At the January 2000 SDO Kickoff Meeting, no real home could be found for human factor’s related standards. Responsibility was (and is) diffuse for human factors, and there is no obvious vested commercial interest to be served by these standards.

However, in June 2001, FRA’s Office of Research & Development initiated a solicitation for a task order contract to develop human factors guidelines for ITS at the HRI. The work is expected to be completed within two years of award and will be based, in part, upon the recommendations of the July 1999 stakeholders workshop on ITS standards for the HRI. The development of these guidelines is intended as an intermediate step toward the development of consensus-based standards. As the guidelines are used and referenced, FRA expects that needed refinements will be discovered and documented, and that the refined results will culminate in the development of consensus standards and a community of concerned stakeholders to promote the development and adoption of these standards.

**Low-Cost Technology for Low-Volume HRIs.** The other troubling set of deferred standards are those relating to low-cost technology for the activation of currently passive, typically relatively low volume HRIs. These crossings were the specific concern of the NTSB in its 1998 safety study, and little progress has been made in moving this area forward. [Although it should
be noted that a pilot project is being explored in Minnesota to try out various low-cost approaches, and FRA has offered research funds to the states of Illinois and Alaska to include tests of alternative HRI technology in their existing tests of Positive Train Control technology.

Part of the reluctance to advance this area results from liability concerns related to the deployment of less-than-full-blown track circuit and lights/gates systems. Some may arise from a perception by the manufacturers and installers of traditional systems that low-cost technology is a competitive threat rather than a high volume opportunity.

In any case, fairly little is currently known about the characteristics, costs, benefits, advantages, and risks of alternative technology. A White Paper on this subject, prepared for the FRA (Weiland, unpublished), outlines potential initial steps of an investigation of these technology alternatives. FRA is considering whether to pursue such an investigation.

**Strategic Plan**

Meanwhile, the FRA has recognized the value of developing an overall strategic plan for the deployment of ITS at HRIs, and it has engaged a contractor to develop the plan. Approaches for pursuing HRI/ITS Standards and HRI technology alternatives will be addressed by the Strategic Plan. At this writing, the Plan is at the internal working draft stage with first full version expected to be completed before the end of 2001.

**Conclusion**

In short, while the Highway-Rail Intersection has made good progress in working its way into the fabric of Intelligent Transportation Systems, there is still a lot of work to do before the positive benefits of introducing ITS at HRIs can be fully realized. This work includes setting strategic directions for HRI/ITS, exploring technology alternatives for activating passing
crossings, investigating human factors aspects, and expanding and accelerating the HRI/ITS
standards program.

REFERENCES

1. National Transportation Safety Board: “Safety at Passive Grade Crossings, Volume 1:
   Analysis, Publication NTSB/SS-98/02

   Intersection, July 22-23, 1999, Arlington Virginia, Report No. FRA/RRS.00/01, FHWA-OP-
   00-002, February 29, 2000.
### Operational Field Tests

<table>
<thead>
<tr>
<th>Operational Field Tests</th>
<th>Where</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Vehicle Warning System to warn of approaching trains. Installed in 30 school buses.</td>
<td>Twin City area</td>
</tr>
<tr>
<td>Second Train Warning System</td>
<td>Maryland</td>
</tr>
<tr>
<td>Advanced Warning for Railroad Delays - AWARD Uses dynamic message signs to advise about occupied crossings at highway exits</td>
<td>San Antonio</td>
</tr>
<tr>
<td>Four Quadrant Gate System and locomotive obstacle warning system</td>
<td>Connecticut</td>
</tr>
<tr>
<td>In-vehicle warning systems installed in 300 school buses, public safety vehicles, and commercial vehicles covering five commuter</td>
<td>Chicago Area</td>
</tr>
<tr>
<td>Light-Rail Second Train Warning, using fiber optic signs</td>
<td>Los Angeles</td>
</tr>
<tr>
<td>Improved Crossing. Provides a number of warning and surveillance improvements, plus emergency vehicle priority</td>
<td>Long Island, NY</td>
</tr>
</tbody>
</table>

**TABLE 1 – Early Operational Fields Tests of ITS Technology at Highway-Rail Intersections**

<table>
<thead>
<tr>
<th>Proposed HRI/ITS Standard</th>
<th>Lead</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface between Wayside Equipment and Advanced Transportation Controller</td>
<td>IEEE, NTCIP</td>
<td>AAR, APTA, AREMA</td>
</tr>
<tr>
<td>NTCIP Center-to-Center Protocol Linking Rail Operations Center and Traffic Management Center</td>
<td>NTCIP</td>
<td>AAR, AREMA, IEEE</td>
</tr>
<tr>
<td>Standards for In-Vehicle Warnings, including rules for issuing, messages, icons, ear-cons, coordination with DMS</td>
<td>SAE</td>
<td>ITE</td>
</tr>
<tr>
<td>Expand Advanced Traveler Information Systems Data Dictionary and Message Set to incorporate HRI elements and messages</td>
<td>SAE</td>
<td>AAR, AREMA</td>
</tr>
<tr>
<td>Standards for Advanced Transportation Controller (including HRI considerations)</td>
<td>NTCIP</td>
<td></td>
</tr>
<tr>
<td>Glossary of HRI Terms</td>
<td>ITS America</td>
<td></td>
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</tbody>
</table>

**TABLE 2 – HRI/ITS Standards Ready for Development**
Deferred Standards | Lead | Support
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Expand DSRC Message Set to Include mobile/portable HRI warnings | IEEE | |
Expand Traffic Management Data Dictionary to incorporate HRI elements and messages | AASHTO, ITE | AAR, AREMA |
NTCIP Center-to-Field Equipment Protocol Linking Advanced Traffic Controller and DSRC Base Station for IV warnings | NTCIP | SAE |
Low-Cost HRI Warning Devices at Low Volume Crossings | | |
Practices for HRI Roadway Surveillance | DOT TWG, ITE, SAE | |
Standards for HRI Obstacle Detection | | |
Human Factors at the HRI, at Rail Operations Centers, and Traffic management Centers | | |

TABLE 3 – Deferred HRI/ITS Standards