Intelligent Transportation System
STANDARDS FOR THE HIGWAY-RAIL INTERSECTION

Report for the Workshop on ITS Standards for the Highway-Rail Intersection

July 22-23, 1999
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16. Abstract
The objective of the ITS HRI Standards Workshop was to characterize and move the development process forward toward the establishment of industry-consensus standards for the use of Intelligent Transportation System technologies at the Highway-Rail Intersection.

In a 1998 report on Safety at Passive Grade Crossings, the National Transportation Safety Board concluded (1) that the long-term solution to eliminating passive crossings and reducing collisions between highway and rail vehicles will be through the use of intelligent transportation systems that will alert the motorist to the presence of the train and (2) that standards for ITS applications need to be established in a timely manner.

FRA recognizes that ITS deployment at the HRI involves a large number and wide range of stakeholders, many of which had never worked together. The workshop had several purposes: First, to identify the standards needed for effective national deployment of ITS at the HRI, and to identify the technical and institutional opportunities and challenges related to the development of these standards. Second, to identify the standards organizations and individuals who need to participate in the development of ITS HRI standards. Third, to begin the dialog among the relevant stakeholders.

More than three dozen specific standards were identified by the breakout groups as needing to be addressed, developed or refined. These are discussed and summarized in the Report. Workshop participants also recognized that a variety of nontechnical issues and barriers need to be successfully addressed to achieve HRI safety improvement. Among the most prominent of these were the fears of tort liability exposure through the introduction of new technology, the need for multi-organizational cooperation, and cost and safety needs to be balanced. In most respects, these issues cannot simply be addressed through standards. They require institutional responses at multiple levels.

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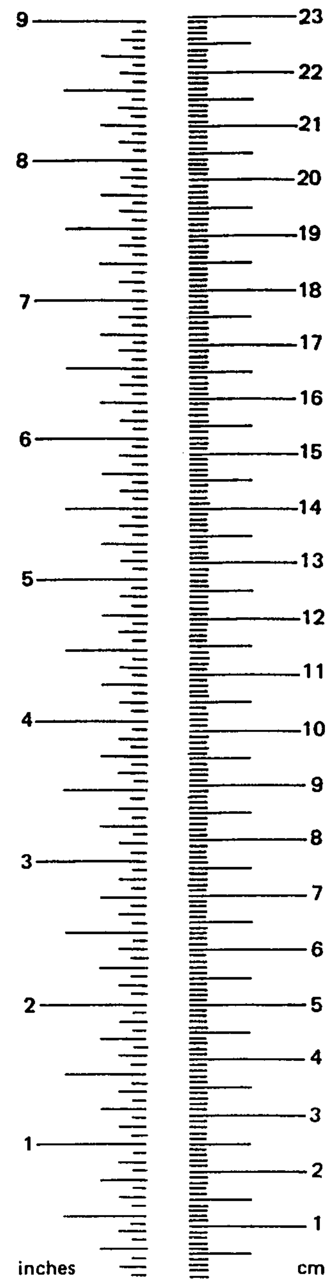
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

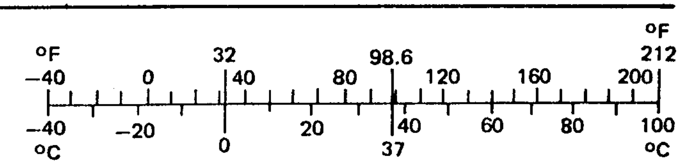
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286. Units of Weight and Measures. Price $2.25 SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



ITS America

U.S. Dept. of Transportation

Report on the Workshop on ITS Standards for the Highway-Rail Intersection
July 22-23, 1999 - Arlington, VA

ITS Standards for the Highway-Rail Intersection
A Two-Day Workshop – July 22-23, 1999

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This report presents the results of the Workshop on ITS Standards for the Highway-Rail Intersection. It does not necessarily represent the policy or viewpoint of the U.S. Department of Transportation or any other sponsor.

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I – Executive Summary

Purpose of the Workshop

The primary objective of the Workshop on ITS Standards for the Highway-Rail Intersection was to characterize and to move toward the establishment of a program to develop industry-consensus standards for the use of Intelligent Transportation System (ITS) technologies in the Highway-Rail Intersection (HRI).

ITS deployment at the HRI necessarily involves a large number and wide range of stakeholders, many of which had never before worked together. The workshop, therefore, had several purposes:

- First and foremost, to identify the standards needed for effective national deployment of ITS at the HRI, and to identify the technical and institutional opportunities and challenges related to the development of these standards

- Second, to identify the organizations and individuals who need to participate in the development of the standards

- Third, to begin or enhance the dialog among the relevant stakeholders

Background

In its summary report on the July 21, 1998 Public Meeting on a study of *Safety at Passive Grade Crossings*, the National Transportation Safety Board (NTSB) concluded that:

> ...the long-term solution to eliminating passive crossings and reducing collisions between highway and rail vehicles will be through the use of intelligent transportation systems that will alert the motorist to the presence of the train. ... In-vehicle safety and advisory warning systems and other applications of intelligent transportation systems (ITS) have the potential to reduce accidents and injuries at passive grade crossings by alerting drivers to an oncoming train. In order to achieve the greatest safety at passive grade

> crossings as quickly as possible, standards for ITS applications must be established in a timely manner.[1]

In this report, NTSB recommended that the Secretary of Transportation:

> Establish a timetable for the completion of standards development for applications of intelligent transportation systems at highway-rail grade crossings, and act expeditiously to complete the standards.[2]

Indeed, the Federal Railroad Administration (FRA) and the ITS Joint Program Office (JPO) of the U.S. Dept. of Transportation are already funding the development and evaluation of a wide range of ITS technologies at the HRI. However, the recognition that there was not yet a coherent program in place, to use the results of these projects and evaluations to move toward a nationally consistent program of HRI safety enhancement, was a major motivation for holding the workshop.

Structure of the Workshop

The workshop took place on July 22-23, 1999, in three major sections:

- The first morning consisted of a series of invited presentations to provide background on:

  + The HRI problem
  + ITS pilot projects and evaluations to date
  + The National ITS Architecture, with particular attention to User Service #30 – The Highway-Rail Intersection
  + Standards, and the current ITS standards program

  (See Section II – Overview of Plenary Presentations)

- During the first afternoon and second morning, six topic-specific breakout groups met to address the state of technology, opportunities for standardization, institutional issues, and who (organizationally and individually) should participate in standards development.

  (See Section III – Breakout Group Structure and Objectives plus Appendix C: Breakout Group Leadership and Appendix D: Breakout Group Questions)

- The second afternoon began with an address by FRA Administrator Jolene Molitoris. (See Section IV) The remainder of the afternoon was devoted to reports from each of the breakout groups and discussion of results. FRA Deputy Administrator Donald Itzkoff received and commented on the results. (These results are summarized in Section V –

[1] National Transportation Safety Board, Public Meeting of July 21, 1998, Abstract of Final Report, *Safety Study: Safety at Passive Grade Crossings*, NTSB/SS/98-02, page 3.
[2] *Ibid.*, page 5.

Conclusions and Recommendations and Appendix E – Consolidated List of HRI Standards).

Major Themes and Conclusions

Recommendations for Standards

Over three dozen specific standards were identified by the breakout groups as needing development or refinement. These are discussed for each breakout group in Section V and collected and recapped in Appendix E.

- Several recommendations related to the development and refinement of signs and signals and the corresponding expansion and adjustment of the *Manual of Uniform Traffic Controls and Devices,* to better reflect ITS considerations in general and HRI issues in particular.

- The various interfaces among trains, rail operations centers, wayside equipment, traffic management centers, traffic controllers, roadside equipment, and vehicles were all identified as areas needing standardization. Multiple groups identified the need for standards for the better coordination of HRI signals with highway and intersection signals. The National Transportation Communications for ITS Protocol (NTCIP), one of the great success stories of the ITS standards program, needs to be expanded to include HRI considerations, including better linkages between rail operations centers and traffic management centers.

- Standards to improve surveillance and obstacle detection were identified, notably in the areas of better standardized sensor technology and the need for better and more consistent methods for interpreting and applying sensor readings.

- Many standards recommendations related to improvements at active crossings and mechanisms for activating currently passive crossings. One potentially important technology is direct in-vehicle warnings. In-vehicle warning capabilities require new and consistent mechanisms for wireless communication to equipped vehicles and uniform protocols and message sets for encoding and decoding the wireless information stream. Many of the recommendations for HRI improvement also depend on better information about where trains are, without necessarily relying on traditional track circuits.

- It was noted that the National ITS Architecture and its standards package #12 for the HRI do not explicitly address mechanisms for making passive crossings active. This is because the Architecture focuses on the movement of information among components of the transportation system, and by definition, there are no such information flows at passive crossings. However, the Architecture does provide models for active crossings to which passive crossings can be migrated.

- Human factors were a consistent theme throughout the breakout groups as well as the focus of Breakout Group 5. Areas for research and standardization included:

  + Working toward more consistent, more reliable, and more easily understood signs and signals, and

  + Management of the information workload by drivers and engineers

  A frequently-expressed concern was to assure that better information not *encourage* gate running or other dangerous behavior, and to assure that user trust does not translate into complacency.

Institutional Issues and Barriers

Workshop participants also recognized that a variety of nontechnical issues and barriers need to be successfully addressed to achieve HRI safety improvement. Among the most prominent of these were:

- The overarching fear of tort liability exposure through the introduction of new technology.

  This notably, but not exclusively, concerns the railroads that are almost invariably a litigation target when crashes occur. Special cases of tort liability concerns surrounded test and demonstration projects, and the period during which proven technology is deployed, since new technology cannot be deployed at every crossing simultaneously. In any case, the risk exists that tort liability concerns will delay or derail the deployment of technology that, if deployed, would have a very positive net safety benefit.

  For example, it was noted that there are an order-of-magnitude fewer locomotives than passive HRIs. Equipping locomotives with communications devices that can directly activate low-cost warning technology at HRIs is clearly more economic than installing in-track sensors at all the crossings. However, the railroads are clear that if they cannot get relief from potential liability associated with such installations, they will not be able to adopt this course, regardless of its other merits.

- The need for multi-organizational cooperation.

  In many areas, a crucial ingredient for achieving HRI safety improvement was the interaction and cooperation of multiple organizations and institutions, many of which do not have a history of working together effectively, if at all. This includes government agencies at varying levels: federal, state, regional, local. It includes government agencies at the same level with different but adjoining responsibilities, for example, for roads, rail, transit, vehicle safety, etc. It includes the cooperation of organizations within and across industries, including infrastructure and equipment manufacturers, automotive and rolling stock manufacturers, electronics manufacturers, roadway authorities, railroad companies, transit operators, organized labor, private property owners, a variety of special interest and advocacy groups such as AAR, AAA, ATA, and others, all of whom have a stake at the HRI. Specific opportunities for such cooperation are discussed in Section V.

- Cost and safety need to be balanced.

  An appropriate balance between cost and safety must be sought. At any level of funding, the less a particular HRI technology costs, the wider spread its deployment can be. However, less expensive technology may also be less effective technology. Careful consideration must be given to how we balance the quality of technology at a particular HRI with making *some* level of active warning available more widely.

In most respects, these issues cannot be addressed only through standards. They require institutional responses at multiple levels to provide direction to the standards development process.

II – Overview of Plenary Presentations

The morning of the first day of the Workshop on ITS Standards for the Highway-Rail Intersection was devoted to a series of invited presentations to provide background and direction for the workshop:

- "Charge to Workshop Participants" – **Dr. Christine Johnson**, Director, U.S. DOT ITS Joint Program Office
- "Safety at the Highway-Rail Intersection" – **George W. Black**, Member, NTSB
- "Overview of HRI Projects and Evaluation" – **Anya Carroll**, Principal Investigator, Accident Prevention Division, Volpe National Transportation Systems Center
- "Role of the Highway-Rail Intersection in the National ITS Architecture" – **Bruce Eisenhart**, Lockheed-Martin Co., National ITS Architecture Development Team
- "ITS Standards – An Overview" – **Richard Weiland**, Weiland Consulting Co., ITS America Council of Standards Organizations

"Charge to the Workshop Participants" – Dr. Christine Johnson

Dr. Christine Johnson directs the ITS Joint Program Office of U.S. DOT and recently became responsible for the FHWA Operations core business area.

Dr. Johnson's remarks focused on: (1) the promise of ITS to help provide warnings at the two-thirds of Highway-Rail Intersections which currently have no active warning devices, and (2) the need for standards to help make this promise universal.

> ***"I really believe that the contribution you make in this workshop will make a difference on whether we have ITS applied to the HRI. And I think it's going to save some lives."***

She remarked on the advances that have taken place in in-vehicle electronics and intelligent capabilities in the past two years and the clear trend toward incorporating communications capabilities into passenger and commercial vehicles. As cars become communications enabled and equipped with devices that deliver transmitted traveler information to the driver, the marginal cost of providing HRI warnings in the car will be relatively modest.

The existence of standards, Dr. Johnson stated, makes a tremendous difference in having this occur. We are depending on standards to make sure that every single automobile of the future will be able to receive the warnings that every single railroad of the future will be transmitting.

Dr. Johnson thanked workshop participants for their presence and expressed pleasure at their diversity. She promised to be an advocate for HRI standards behind the scenes, helping to make sure that Federal support is provided where appropriate and helping to muster support from the industry and from manufacturers.

"Safety at the Highway-Rail Intersection" – George W. Black

Mr. George W. Black is a member of the National Transportation Safety Board, the first registered transportation engineer to hold such a membership.

Mr. Black noted that the role of the NTSB in the workshop was the same as its role in general: to identify safety needs and report on them. He said that he would talk about some of the things that NTSB had learned over the years about safety at the HRI. Some major points:

- Large trucks were involved in nearly 500 HRI crashes in 1998, the majority of them with Amtrak trains.

- Highway congestion is a major factor in causing HRI crashes. Such congestion produces queues across tracks, interferes with traffic operations, and encourages aggressive driving behavior at HRIs.

> ***"Crashes at grade crossings kill more people every year than all commercial aviation accidents."***

- Commuter and light rail crossings present special problems. They are often complex crossings in densely populated areas, and highway/rail signal interconnection is a real issue (as demonstrated by the Fox River Grove crash a couple of years ago).

- Gate running accounts for 22% of accidents and 26% of fatalities. Mr. Black stated that a major cause of gate running is congestion and aggressive driving.

- HRIs accounted for 3508 accidents, 1303 injuries, and 431 fatalities in 1998, the latest reporting year. [Of these, 2306 accidents, 720 injuries, and 220 fatalities occurred at passive crossings.]

- Private crossings accounted for 422 accidents, 124 injuries, and 46 fatalities in 1998. States disclaim responsibility for private crossings, even when their other infrastructure goes along and through the crossing. Mr. Black stated that we owe private crossings the same level of safety as public crossings.

- Crashes involving school buses get a lot of attention, but like all accidents, there are multiple factors that cause them.

The States, Mr. Black observed, need to set a uniform hazard index process, to allow the comparison of crossings from one State to another.

ITS, Mr. Black suggested, provides a real opportunity for creative innovative approaches, which will allow us to move toward simpler and cheaper installations than track circuits are today. ITS standards can lead to system compatibility, simplified and lower-cost maintenance and operations, consistency in the appearance and operation of devices, and the reduction of liability exposure to operators and manufacturers. This is both a challenge and an opportunity.
Mr. Black recommended that participants work to get the attention of local government and get them involved, along with roadway owners and users, the railroads, private sector entities, and the federal government.

"Overview of HRI Projects and Evaluation" – Anya Carroll

Ms. Anya Carroll is Principal Investigator, Accident Prevention Division, Volpe National Transportation Systems Center, U.S. Department of Transportation.

Ms. Carroll provided a summary of a workshop on the Evaluation of ITS Projects at the HRI, which was held at the Volpe National Transportation Systems Center on May 6-7, 1999.
Ms. Carroll reported that the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) made funds available in 1993-94 to test ITS vehicle proximity alerting systems. FRA took the lead in testing these systems at the Transportation Technology Center (TTC) in Pueblo, Colorado, with a particular focus on in-vehicle warning systems. This provided promising ideas for combinations of technologies for future projects. Researchers are now looking at off-track train and vehicle detection capabilities, which they will explore later this year at TTC.

> ***"Train conspicuity is the ability of a driver to detect and recognize a train, or other object in sight."***

The workshop at Volpe focused on technologies now being demonstrated or deployed.
Mr. Joseph Peters (U.S. DOT ITS Joint Program Office) set the direction of the workshop, stating that the testing effort was seeking a "few good measures for safety, mobility, efficiency, productivity, energy use, and emissions savings." This led to introductions to seven high-priority demonstrations in seven different states.

1. California: The Los Angeles transit authority is starting FTA-sponsored experiments with "Second Train" warning signs, in the form of both text and graphics, to warn motorists and pedestrians that gates are staying down after a train has passed because a second train is coming.

2. Maryland: The Maryland transit authority has also been performing FTA-sponsored research on second train warnings, and monitoring driver/pedestrian behavior. Strobe lights call attention to the warning signs. There has been a noticeable public behavior improvement since the installation of the signs.

3. Texas: Texas has implemented the Advanced Warning for Railroad Delays (AWARD) system to advise highway motorists, via dynamic message signs, of potential HRI delays at a particular exit, to allow them to select alternate routes. This work is being integrated with other ITS projects including in-vehicle navigation, information kiosks, and Web pages.

4. Connecticut: Connecticut has installed a combination of 4-quadrant gates with positive train control and obstacle detection to help reduce gate running and to advise railroads of the presence of vehicles or other obstacles on the tracks. This work includes an ongoing analysis of public behavior.

5. Illinois: In Illinois, as part of the Gary-Chicago-Milwaukee Corridor effort, 300 vehicles and five grade crossings will soon test an in-vehicle warning system. Vehicles include school buses, municipal vehicles, transit vehicles, and commercial vehicles.

6. Minnesota: A similar project took place in Glencoe, Minnesota, sponsored by Minnesota Guidestar, involving 29 equipped school buses and five signalized crossings. The system alerts bus drivers to railroad crossings, and provides warnings of approaching trains.

7. New York: In New York, the Long Island Railroad is taking part in a Positive Train Control/ITS project that proposes a better instrumented HRI that minimizes gate down time and advises motorists and pedestrians of the HRI situation. The system will allow traffic to flow freely across HRIs while a train is stopped in the adjacent station, and will provide second train warnings and "do not block intersection" warnings.

Ms. Carroll reported that the second day of the Evaluation workshop, keynoted by Michael Onder (U.S. DOT ITS Joint Program Office), focused on next steps. Common threads among the projects are being explored, as well as differences, along with cost/benefit issues, institutional issues, and architectural consistency. Ms. Carroll reported that the primary conclusions were:

- More testing is needed to mature the technologies
- A federal champion is needed for HRI safety
- Railroads are concerned about using any technology which is not failsafe
- Overcoming institutional issues is essential for successful deployment
- Standards are critical for interoperability and for stimulating industry competitiveness
- There is a strong interest in polled research funding
- Need for more efficient use of NHTSA Section 402 funding
- Need for coordinating how highway funds are used
- Need to close passive crossings where possible and to use ITS at passive crossings which remain open

Complete proceedings of the Volpe Workshop are available from Ms. Carroll at the Volpe Center, DTS-73, 55 Broadway, Cambridge, MA 02142-1093, Tel: (617) 494-3122, Fax: (617) 494-2995, email: CarrollA@volpe.dot.gov.

"Role of the Highway-Rail Intersection in the National ITS Architecture" – Bruce Eisenhart

Mr. Bruce Eisenhart is a member of the National ITS Architecture Development Team from Lockheed-Martin Co.

Mr. Eisenhart explained that the function of an architecture is to identify the boundaries and participants of a system, describe its activities or functions, and provide a framework for planning, defining, and integrating a particular instance of a more general system, in this case, an intelligent transportation system. The National ITS Architecture was needed to help manage the complexity of ITS, assist with ITS integration and to guide the identification and coordination of standards, particularly interface standards.

The National ITS Architecture is based on a series of User Services and the requirements they imply. The Highway-Rail Intersection is one of 31 such user services. HRI is a relative latecomer to the National ITS Architecture, having been defined by the Federal Railroad Administration, the Volpe Center, and the Jet Propulsion Laboratory in early 1996. Integrating HRI into the architecture resulted in an update that was completed in early 1997.

> ***"The National ITS Architecture helps to manage ITS complexity, assist with ITS integration, and guide ITS standards development."***

Key areas of HRI User Service Requirements include the definition of types of users, the identification of real-time and other interfaces, active warning systems, crossings for standard speed and high-speed rail, and collision notification.

The Architecture defines a number of functional subsystems and key terminators at the boundary of the intelligent transportation system. For HRI, the relevant subsystems are Traffic Management, the Roadway, and the Vehicle, which were updated to accommodate HRI requirements. New HRI-relevant terminators are Rail Operations and Wayside Equipment. The updated Architecture includes information flows among these entities.

The Architecture supports standards development by defining the interfaces, which are the starting points for standards development. There are a series of Standards Requirements packages that have been generated from the Architecture; Package #12 relates to the HRI. The complete National ITS Architecture is available on CD-ROM from the ITS Joint Program Office of the U.S. Dept. of Transportation, 400 Seventh Street SW, Washington, DC 20590, or on the World Wide Web at http://www.itsa.org/public/archdocs/national.html or http://www.odetics.com/itsarch.

"ITS Standards – An Overview" – Richard Weiland

Mr. Richard Weiland is President of Weiland Consulting Co., and an internationally recognized expert in ITS standards.

Mr. Weiland provided a general introduction to standards. Standards are agreements among industry participants to do things in one or a small number of ways, to promote consistency, avoid duplication, encourage the market, and provide liability safeguards to producers. Standards can evolve from pure marketplace forces (de facto standards), from the action of government agencies (regulatory standards), or though formal, but voluntary agreements (consensus standards) under the auspices of a Standards Development Organization (SDO). In the absence of a dominant market leader or pressing public health and safety requirements, consensus standards are the most common and robust type of standard. They are difficult because the effort is mainly voluntary and highly political, but the results are typically well-accepted long-lived standards.

> ***"Standards development is not the dispassionate search for the ideal in technology, but the political process of reconciling competing vested interests."***

In the ITS world, the need for standards has been recognized and encouraged by Congress though the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Transportation Equity Act for the 21st Century (TEA-21). The U.S. DOT has had a strong role in identifying requirements and providing focused funding to accelerate the process. Industry has also recognized the need for ITS standards in multiple areas. As a result, they are working toward the development of standards through SDOs, such as the Society of Automotive Engineers, the Institute of Electrical and Electronics Engineers, the Institute of Transportation Engineers, the American Association of State Highway and Transportation Officials, and the American Society for Testing and Materials, among others. ITS America supports and helps lead ITS standards development through its Committee on Standards & Protocols, its Council of Standards Organizations, its administration of the U.S. Technical Advisory Group for the ITS-related standards committee of the International Standards Organization, and through a series of subject-focused task groups.

Mr. Weiland also discussed the specific objectives of the present workshop:

- Identify *standards* needed for sensible implementation of ITS at the HRI
- Identify the *organizations*, including SDOs, that should be involved
- Identify specific *people* who should participate

III – Breakout Group Structure and Objectives

Overall Structure

The primary objective of the workshop was to identify:

- The specific standards that need to be developed to facilitate the national deployment of ITS at the Highway Rail Intersection
- The organizations and stakeholders which need to be involved, and
- The individuals (drawn from workshop participants and elsewhere) who would be appropriate and potentially willing to participate in the development of these standards

Six topic-oriented breakout groups were assigned to address a series of questions that would provoke thought and discussion and lead to answers to the main questions of interest. The breakout group subject areas were:

1. Wayside Equipment and Rail Operations
2. Roadway Subsystem
3. Vehicle Subsystem
4. Traffic Management Subsystem
5. Human Factors
6. Special Cases

The characterization and general charge to each breakout group follows.

Breakout Group 1: Wayside Equipment and Rail Operations

Breakout Group 1 was asked to explore:

- How the presence of a train gets reliably detected and communicated at both active and passive HRIs. The group was asked to deal separately with the case of standard speed rail (SSR; up to 79 mph) and high speed rail (HSR; 80+ mph). Some sub-cases for the group's consideration included:

  + External train detection: Track circuits, radar, laser, sound
  + Train signals its presence: Train-based transmitter, GPS, satellite tracking, PTC, etc.

- Communications with Rail Operations Center, so that the train can:
  + Advise the center of position and status
  + Learn about conditions at the HRI (obstacles, etc.)

- Communications with Traffic Management Center directly and via the Intelligent Controller

Breakout Group 2: Roadway Subsystem

Breakout Group 2 was asked to explore:

- Communications to/from Wayside Equipment

- Control of and communications with roadside field equipment. Are additions to NTCIP, beyond CCTV, traffic signals, and dynamic message signs (DMS), needed to account for HRIs?

- ITS Standards issues related to roadside field equipment (gates, lights, DMS, road surveillance equipment, etc.)
  + Messages
  + Communications

- Interface to communications devices which communicate to road vehicles

- Detection of vehicles and other obstacles on tracks
  + Sensors
  + Communications

Breakout Group 3: Vehicle Subsystem

Breakout Group 3 was asked to explore:

- The types of mechanisms that can be used to warn/assist drivers and pedestrians, and potentially control vehicles. Also the portable devices that may be carried in vehicles or on persons, such as palm-top computers, cellular phones, personal digital assistants, etc. The group was asked not to focus on human factors (user interface), since this was being dealt with by Breakout Group 5. Some sample issues were offered, to spearhead discussion:

  + Should databases for in-vehicle navigation systems include information on grade crossings, so that notification can be provided, e.g., "Railroad Crossing Ahead, Use Caution"? Should a distinction be made between active and passive crossings?

+ Should an on-board collision avoidance system exist that prevents a vehicle from entering the HRI when a train is approaching, for example by applying the brakes or locking the transmission?.

- Communications to/from the devices connected to the Intelligent Controller

Breakout Group 4: Traffic Management Subsystem

Breakout Group 4 was asked to explore:

- Communications with the Intelligent Controller at the HRI:
  + What kinds of messages?
  + What kinds of devices?
  + What kinds of sensors for information capture?

- Management of surrounding traffic (e.g., to route traffic around occupied HRIs):
  + Tracking of overall traffic situation
  + Coordination among Traffic Management Centers

- Communications to/from Rail Operations for HRI coordination:
  + What kinds of messages?
  + Timing and priority considerations
  + Direct center-to-center communications vs. indirect communication via the Intelligent Controller

Breakout Group 5: Human Factors

The task of Breakout Group 5 was to understand and identify the subject matter and process through which human factors related to the HRI will be standardized, including:

- What the driver sees and hears near and at the HRI: external signs and signals, gates and barriers, DMS, in-vehicle warnings (visual / audible)

- What the train crew sees and hears approaching an HRI

- Interactions at the Traffic Management Center and the Rail Operations Center

Breakout Group 6: Special Cases

Breakout Group 6 was asked to explore ITS Standards issues for special HRI cases, including:

- High speed rail
- Light rail
- High profile crossings

and so on.

Breakout Group Leadership

Each breakout group was assigned a leadership team consisting of a professional facilitator from U.S. DOT, a subject matter technical advisor drawn in advance from the ranks of the workshop participants, and an architecture advisor from the National ITS Architecture Development Team. (See Appendix C).

Breakout Group Questions

Each breakout group was given a series of questions to consider. The series was structured to stimulate breakout group thinking about a wide range of HRI technology and safety concerns within its assigned area, but leading up to the fundamental workshop consideration: What should be standardized and by whom?

Breakout Groups 1, 2, 3, 4, and 6 were focused on particular technology and application areas and each had the same series of questions to address within the context of their assigned area.

Breakout Group 5 (Human Factors) had a slightly different series, to reflect the crosscutting nature of Human Factors.

The two series of questions appear in Appendix D.

IV – Luncheon Address by the Hon. Jolene M. Molitoris

LUNCHEON ADDRESS BY

THE HONORABLE JOLENE M. MOLITORIS

Administrator, Federal Railroad Administration
ITS HRI Standards Development Workshop
Crystal City Marriott, Arlington, Virginia
July 23, 1999

Introduction by Thomas Woll:

It isn't every day that I have the opportunity to introduce the Administrator of the Federal Railroad Administration. Today I'm very pleased to do so as our speaker for this Luncheon. She is keenly involved and interested in all that we are accomplishing in the course of this Workshop and the development of standards for the HRI User Service, and she will also be the recipient of all of your hard work over these last two days.

I had the pleasure of first meeting the Administrator in 1986 when she was the Deputy Director for the State of Ohio Department of Transportation; a position that she held for eight years. Administrator Molitoris is a strong visionary and advocate of high-speed rail (if you don't believe me, check out her license plate), and in that capacity, I had the pleasure of working with her for many years in the high speed rail area, since we both were members of the High Speed Rail/Maglev Association. This organization awarded her the President's Award for Outstanding Achievement on two separate occasions.

In 1993, she was appointed by President Clinton to be the first woman Federal Railroad Administrator, and she is, I believe, the longest serving Administrator. Under her leadership, the first ever U.S. Rail Summit was convened by freight, passenger, and commuter rail interests to address rail safety issues. Also under her leadership, the Railroad Safety Advisory Council was formed as a new and innovative way to develop new safety rules and regulations. As a proactive advocate of rail safety, she has been actively involved in achieving partnerships between government and industry which has resulted in numerous infrastructure initiatives and the movement of FRA itself toward a more customer driven and efficient agency.

Her accomplishments are many; her legislative successes are many; and her creation of industry partnerships is many.

She is not only one of this country's most able visionaries and enthusiastic administrators, but she is also a great person to work for.

Please give a warm welcome to my boss, the Federal Railroad Administrator, the Honorable Ms. Jolene Molitoris.

Federal Railroad Administrator Jolene Molitoris:

Thank you, Tom, for the really warm and gracious words. It is a pleasure to be introduced by you and it is a pleasure to be here. The only thing he forgot to tell you is that, I am also the tallest administrator that has ever been at the Federal Railroad Administration.

It is really a joy to be here. I am so pleased that Deputy Administrator Don Itzkoff is also here with me.


Photo by Timothy DePaepe

You are here to do historic work, and that is why both Don Itzkoff and I and so many of our colleagues and FRA staff are here. What you really are about is building the foundation for the future. And you know, one hundred and sixty days from today, we will be stepping into the year 2000. I don't know about you, but I think it is exciting. It is a whole new opportunity to create our vision of the future. When you have been a part of an Administration as long as I have been, six and a half years, and when the year 2000 arrives, there will be a changing of the guard, the Clinton Administration will come to a close. As this happens, we begin to think about the legacies, the accomplishments, and the results that we have tried to develop. What we will really do is to help bring safety to a new level in the new millennium. That is what you are about here. So, for me, this is an historic occasion, and it is an honor to be a part of it.

I would like to take a few minutes to thank some people because I am very impressed with the quality of this meeting, the organization of it, and real opportunity it is affording for vigorous and lively discussions in the breakout sessions. Without those, you can't come up with better answers. We know partnerships are how things get done. But, we also know that certain people have to take responsibility and I know that Rick Weiland, Tom Woll and Steve Ditmeyer all have been very involved along with so many others in setting up this Workshop, so I want to thank you gentlemen for being so diligent in working together to make this Workshop happen.

I would also like to recognize and thank the Federal Highway Administration, the Federal Transit Administration, and the various railroad organizations like the Association of American Railroads, American Railway Engineering and Maintenance-of-Way Association, the Railway Progress Institute, labor unions, American Association of State Highway and Transportation Officials, and others for partnering in their particular roles helping to organize this two day event. Also, I must recognize John Collins (CEO of ITS America) and Christine Johnson (Director of the ITS Joint Program Office), who have co-sponsored this workshop. They are important partners for us. I would also like to thank the standards development organizations for the work that they will do, as a result of these two days of meetings, to develop an infrastructure and legacy for the future.

Finally, I would like to recognize George Black (National Transportation Safety Board [NTSB] Member). George spoke to you yesterday. I know that NTSB Chairman Jim Hall would have been here if he had not been focused on the terrible and sad John Kennedy airplane tragedy that occurred this past week. I want to emphasize that there is a special partnership between NTSB and FRA that is stronger than it has ever been before. We know that our goals are the same. Safety and saving lives is why we are in business. That is why you are gathered here to do the kind of important work that you are doing. So, I am very grateful to all of the people, those many that I haven't mentioned, who have been very important, and to those of you that have been investing your own energy. The breakout sessions are only interesting if you get involved. So, I thank you so much for attending and being involved.

A few words about grade crossing safety. When President Bill Clinton asked me to join his team in 1993, there were certain issues that were priorities for me. Now when most people look at my background on the FRA Website, high speed rail jumps to the forefront because we started very early in Ohio and I did work nationally and internationally in that area. But, you could ask anyone at the Department of Transportation in Ohio, and in fact, Secretary Peña asked me this question when I first met him and we first talked about me joining the team. He said, "What is your top priority?" He expected, I think, for me to say, "High Speed Rail." Well, I said without blinking and eye or taking a breath, "Safety was the number one priority." Because, you can't go fast, you can't go fund technology development, and you can't go anywhere if you don't go safely. That is the key foundation upon which we all build.

I was the first President of the Operation Lifesaver Organization in Ohio who was also an employee of the Department of Transportation. It was a pride and a honor. I was very proud to serve in that capacity and it was an honor for me to assume that position because I was from the Ohio Department of Transportation and I felt that it raised the level of awareness among all parts of the Ohio Department of Transportation about highway-rail crossing safety. Many of the familiar faces that I see here in this room were my partners and colleagues from that time and before I came to the U.S. Department of Transportation. It is a wonderful constituency and a wonderful transportation family of which I am glad to be a member. I think that all of us are fortunate that we are in a business that is really the foundation of our country and our country's history. It is the foundation for one out of every seven jobs in this country. It is the foundation for an economy that continues to boom and continues to produce new jobs in increasing numbers. We are in the right business at the right time, and it is exciting to be with you in this business.

In 1994, Secretary Peña, Vice President Al Gore and President Bill Clinton, decided that the loss of life at crossings was just unacceptable. That is why the Rail Safety Summit was held. That is why the U.S. Department of Transportation's Highway-Rail Crossing Action Plan of 55 initiatives was created. And, U.S. Transportation Secretary Slater is carrying this legacy forward. He is a very passionate advocate for this issue; there is no one more visible and more passionate than Secretary Slater. He is very proud of what we are doing and very pleased that I would come here and give you this message of support because this is a Secretary that is focused on safety. He calls it our North Star. Secretary Slater supports the kind of investment that it takes to do the kinds of things that you are developing.

When highway-rail grade crossing safety became a transportation safety priority, the 55-point plan for increasing safety was developed. The key was that, instead of having it in separate compartments, it was a synergistic plan involving all the service modes for the first time in partnership. I believe the kind of results and the growth of safety really has come about because of these partnerships. Not only just partnerships within the Department of Transportation, but partnerships across our entire industry, with communities across the country, with State Departments of Transportation, with the railroad companies, with law enforcement organizations, and so on. But, no partnership is more important than the one with Operation Lifesaver. We have increased funding for Operation Lifesaver by almost three hundred percent since the Clinton/Gore Administration took office. We are proud of that because it represents an investment that has produced extraordinary results. We have saved lives in extraordinary numbers.

However, you and I will remember the recent highway-rail accident at a crossing in Bourbonnais, Illinois. You and I remember waking up that day and seeing those horrific pictures on the TV screen. I remember receiving a call very early in the morning to tell me about this terrible tragedy. As long as there is a Bourbonnais, as long as there is one life that is lost at a highway-rail crossing, our work is not done. So, our achievements should be celebrated and give us hope that we can reach the zero tolerance goal. That is what needs to be in the forefront of all of our minds. At Bourbonnais, Illinois, we lost eleven lives. Also, other people's lives were touched in ways that will never leave them the same – the engineer, the crew. The impact on those lives is really one that I can only think about, but never fully understand.

We are working on a number of initiatives, with you, that have been effective and I think are worth mentioning. First of all, we have our slogan, "Always Expect a Train." This is a public service initiative and educational program, which has reached out across the country to let people know that they must always be aware of a train when they come to a crossing. They always have to expect a train, whether it is at a crossing with flashing lights and gates or whether it is at a passive crossing with simple warning signs. No matter what time of day, they have to be alert and look for any oncoming train traffic.

In addition, we have a partnership with FHWA to revise the commercial drivers license rule to provide for more severe punishments for breaking the law. We expect that rule will be out very soon. *[Editor's Note: The final rule was published in the Federal Register in September 1999.]* This is crucial because the message of obeying the law and never trying to beat a train or going around the gate arms or through flashing lights, is one that must be first and foremost with every truck driver.

What we are about here today is setting standards. The setting of standards will lead to new technology, which will help us improve safety. In order to have new technology, we must have money to invest in it. One of the things that gives me great hope is that President Clinton and Vice President Gore, along with the Congress, made some decisions about financing levels for transportation. For the first time, in 1999, our budget exceeded $50 billion. These funds can be used for highway-rail crossing safety improvements in ever-greater numbers. For example, $154 million in 1999 is exclusively dedicated to the installation of crossing warning devices and safety hazard elimination. We want to emphasize that, and, in a letter to all of the Governors throughout the country, the Secretary has emphasized this point. Your Governor, and your Director or Secretary or Commissioner of Transportation , can also use other funds for crossing safety improvements. Those funds can be used for installing lights and/or gates, grade separations, or closures. You can now do that. You can utilize additional funds in the amount of $314 million more. Now, what we need to do and will continue to pursue, is to encourage States to be courageous about using those funds in this manner because the return on investment is very good.

Let's talk about some of the new technologies. Most of you know about them, but let's review them again. First of all, I believe, there are many technologies that can get us to our goal of zero accidents at crossings. However, there is not a single solution that will solve this problem. Consequently, it is important that we partner with one another to really bring high technology to the intersection of the highway with the railroad for resolution of this problem.

We at FRA have created partnerships to help achieve our goals and solve some of our problems. Sometimes I say *little* FRA because, in comparison to other agencies in the Department, we are small. We have only 750 people. But, I have to tell you, I am terribly prejudiced about this, they are 750 of the best people on the planet. I am so fortunate to work with them and to have the privilege to be the FRA Administrator. Through their creativity, their leadership, and their initiative, they have partnered with the Air Force and are converting their decommissioned Ground Wave Emergency Network (GWEN) sites into Nationwide Digital Global Positioning System (NDGPS) sites. This partnership with the Air Force means that these Cold War era transmitters and towers can be reused. The NDGPS will provide location identification information to an accuracy of ±1.5 meters at locations throughout the lower 48 States and Alaska. I was present with Secretary Slater at the ceremony last March (1999) which marked the commencement of work on the system. It was very exciting and it was a tribute to the people who are visionary and work hard to make things happen.

We have worked in partnership with ITS in a really extraordinary way. We have worked on projects such as arrestor nets, positive train control, four-quadrant gates, photo enforcement, and others in many states. I will mention just a few of the States: Minnesota, Connecticut, Texas, Illinois, New York, California, Michigan, North Carolina and Maryland. Other concepts have been tested in Pueblo, Colorado, at our Transportation Technology Center. Some of these tests and demonstrations were funded by the ITS Joint Program Office. So, we feel a very close connection with Christine Johnson and all of her team, with John Collins and all of the ITS America Board. It is my pleasure to serve on that Board because we believe that together we can truly attack this safety issue.

With all of the hard work that we do, if we don't get positive results, I don't think we are doing the job correctly. But, in fact, the results are there. We have had, in the last five years, a reduction in fatalities at crossings of 31 percent. That is truly significant. We have reduced injuries 29 percent. But, as I mentioned earlier, the accident at Bourbonnais, Illinois, shows we have a lot of work to do before we get to our goal of zero accidents. Last year, 431 people lost their lives and 1,303 were injured at crossings. I believe these deaths can be prevented. If we can reduce deaths by 31 percent, we can go further.

I want to discuss our Federal Railroad Administration Grade Crossing Managers. I see a few of them here. This is a position for which there was not a job description available five years ago. However, former Secretary Peña and now Secretary Slater were so focused on the challenge of improving safety at crossings that they authorized FRA to hire eight Grade Crossing Managers, one for each of our Regions. Now, in the new budget, we will be authorized to hire eight more as Assistants. These Grade Crossing Managers are really our champions. They show us that, no matter how much technology or funding or planning there is, we are really in a people business. It's one to one. It's reaching out to communities, drivers, students, and legislative bodies all over this country. They do an extraordinary job and I would like them to stand up. If you don't know who they are, you can take time during the remainder of the day and introduce yourself to them.

I am from Columbus, Ohio, and there we have two rivers that meet, the Olentangy and the Scioto. We always talk about the confluence of these rivers. I think that what we have here today is a confluence. A confluence of experience, creativity, and points of view that when brought together can make the ITS User Service # 30 the most successful of all the User Services. I believe that partnership between the Federal Highway Administration, the ITS Joint Program Office, the FRA, and all of the private sector representatives who are here, can really establish this User Service # 30 of the ITS Architecture as a model for how we work together to achieve success.

Bruce Eisenhart from National ITS Architecture Team spoke to you yesterday. I received a little feedback about his presentation. I want to recognize that this important work cannot go forward to achieve results if we don't have a good organizational foundation and sound planning. Your stakeholder commitment, I think, is really extraordinary in terms of the ability to get this job done. In addition, the three other steps, the standards, the development and funding regulations, and the implementation are all pieces that have to work together. And, I want to pledge to you, that, FRA stands ready to support ITS in all the elements that relate to solving this grade crossing problem.

Linda Meadow, who I see in the audience, is a strong supporter of photo enforcement and was very successful with it in California. We need to get photo enforcement on target in all the States in this country. There are a lot of people who say that this is the beginning of "Big Brother." However, we need to develop arguments that say, no, it's all about keeping brother and sister, mother and father, aunt and uncle, alive. So, we are committed to focusing on new legislation in all States around the country and, we believe, your work is going to help us.

Driver education is another area, which is very important. If the message of safety at highway-rail grade crossings gets to people when they are young, then they will perform in ways that are positive and not take the risks that some people are doing today.

This afternoon Deputy Administrator Itzkoff will remain here at the Workshop to get the results of your very hard work. We look forward to receiving these results. I can tell you, without a doubt, that Secretary Slater is as focused on improving highway-rail grade crossing safety as you and I. He supports the Department of Transportation's leadership in this area. The Federal Railroad Administration has historically focused on leading this effort and we are pleased that we have FHWA, FTA and NHTSA as partners in this effort.

You have my personal commitment that FRA will provide leadership in this area and that I personally will closely follow what you are doing and expect to hear about the outcome of your work. I will be very focused on getting to the day when you can stand up and say, "Here are the proposed standards." It is my understanding that normally it may take more than one and a half years to get some standards developed because the development process requires such standards to go through various steps, procedures, committees, and other things. I think that is what we might call bureaucracy. We don't want such bureaucracy. We need to get this important work done faster, faster than a year and a half. That's my challenge to you; accelerate the process.

Bob Gallamore is sitting over there and knows that he has heard this speech before in the arena of Positive Train Control. We have to do this work right. But, try and think of it this way. If you were in the private sector, and some of you are, and if the work that you were doing was really going to make the difference to your bottom line, to the profit that your company would make, and in the amount that you would bring home to help educate and feed your family, could you get it done sooner than a year and a half? I think you could.

And so, I will close by saying to you, I believe in you. I believe in what you can do. And, I would challenge the organizers, and each of you, to consider how important these standards are. With that driving force in mind, figure out a way to do it sooner than a year and a half.

Thank you so much for inviting me for being here for your great work.

Thank You by Richard Weiland:

My sincere thanks to the Administrator for a wonderful and inspiring speech. I think we have our work cut out for us. In a very few minutes we are going to get some insight on what that work is, when we receive the results of the six breakout groups. Again, thanks to all of you for coming to this Workshop.

V – Breakout Group Results and Conclusions

Overview

This section provides a summary of the results and conclusions of each of the breakout groups. In general, these summaries follow the same general order:

- Characterization of the group and its scope
- Challenges and institutional barriers
- Notable existing standards
- Recommendations for future standards development work

Breakout Group 1 – Wayside Equipment and Rail Operations

Breakout Group 1 decided to include the following interfaces in its considerations:

- Train ↔ Wayside Equipment
- Train ↔ Rail Operations
- Wayside Equipment ↔ Rail Operations
- Wayside Equipment ↔ Highway Controller
- Rail Operations ↔ Traffic Management Center

It concluded that there were a number of factors that made the management, operation, and (consequently) standardization of this area difficult, including:

- The reluctance of the railroads to deploy technology that is not failsafe
- The fact that the HRI is within the purview of both the highway community and the rail community
- The variation of the characteristics and designs of highway controllers from one state to another
- The number of different perspectives and levels from which the HRI problem can be addressed, including bottom-up component-oriented approaches and top-down system-oriented approaches

The Group concluded that the primary safety issues surround the interfaces to Wayside Equipment: making sure that the equipment responds reliably and consistently across the range of operational conditions. The concern was expressed that many of the new ideas brought forward for inexpensive active warnings were not presently failsafe, and that responding to this critical requirement might drive costs up. If the devices and their activation are not failsafe, the HRI hazard may be made worse: the presence of active devices creates the implication that, if no warning is being produced, then a train is not approaching. Thus the presence of these devices may decrease routine driver and pedestrian vigilance, with fatal consequences if the devices fail.

The group then focused on technology for sensing trains and for sensing obstacles at the HRI. Detection of train presence with constant warning time is well understood. However, the technology for detecting roadway obstacles in the HRI is not mature or even well understood. For example, how is the system to distinguish a disabled vehicle in the intersection from one, which is simply stopped for traffic?

Although the technology discussed was generally consistent with the National ITS Architecture description of the HRI, the group also discussed the prospect of a single controller to handle both Wayside Equipment and Roadside Equipment (i.e., folding the Wayside Equipment Terminator into the Roadway Subsystem). This was regarded as controversial and no conclusion was reached, other than the importance of coordinating rail-controlled and highway-controlled signs and signals. The group also discussed communications directly between trains and roadside devices, bypassing the intelligent roadside controller. However, this was not regarded as a suitable subject for standardization at this point.

In discussing institutional issues and barriers, Group 1 noted that the HRI implies the need for both new technology and new institutional agreements. Issues surrounding the introduction of new technology at the HRI included:

- Liability issues, which were regarded as a gating issue in introducing new technology, especially for the railroads: New technologies can create new opportunities to sue.
- Understanding federal criteria and expectations: what can and cannot be done at the HRI
- How tests of new technology are to be conducted and what authority provides the approvals
- Retraining costs in the face of innovation
- The resistance, which often comes from municipalities, to any change of their HRIs. There are many stakeholders to satisfy, which implies education and outreach, as well as making sensible technology choices.

The group identified relevant *existing standards* as including:

- The *Manual of Uniform Traffic Controls and Devices* and associated federal rulemaking (49CFR234)
- The AAR's Advanced Train Control Specification (ATCS) Spec 200
- Work of the IEEE Rail Transit Vehicle Interface Committee

The group identified but rejected regulatory standardization for the link between the Rail Operations Center and the Traffic Management Center.

The areas Breakout Group 1 felt were suitable for traditional consensus-based standardization were:

- The roadside interface between rail equipment and highway equipment. This could be referred to the IEEE Rail Transit Vehicle Interface Committee. It could also be an extension of NTCIP. The geographic scope of standards for this interface should at least encompass all of North America (U.S., Canada, Mexico).
- The interface between the Rail Operations Terminator and the Traffic Management Subsystem. Relevant standards organizations were the IEEE Rail Transit Vehicle Interface Committee, and ITE/AASHTO for enlarging the Traffic Management Data Dictionary.

The group identified other important areas of standardization that it felt should be handled outside the ITS realm:

- Interface between Trains (light and heavy rail) and Wayside Equipment
- Interface between Trains and Rail Operations (a Positive Train Control activity)

Breakout Group 2 – Roadway Subsystem

Breakout Group 2 included within its considerations:

- Traffic signals, dynamic message signs, signals, gates, and barriers
- Protocols for and interfaces to the Intelligent Controller
- Surveillance
- Dedicated short-range communications issues
- Passive crossings

The group identified a series of institutional issues, concerns, and barriers:

- The dividing line between highway and rail authority at the HRI, including who is responsible for maintenance and long-term management
- Where liability rests and the railroads' concerns for failsafe systems
- How to get the railroads to buy into ITS and defusing the view, held by some, that ITS is a threat to railroad operations
- Coordinating and harmonizing the activities of state and local agencies
- Reconciling the focuses of different federal agencies (e.g., safety vs. mobility)
- The need to integrate information regarding new ITS systems into the information and materials used by Operation Lifesaver
- The need to consider ITS in future private and commercial drivers licensing
- Right of way ownership

- Improving safety and mobility and introducing new technology in a multi-jurisdictional environment

The group identified relevant existing standards as including:

- The *Manual of Uniform Traffic Controls and Devices*
- AREMA standards for communication and signaling
- The FHWA *Grade Crossing Handbook*
- AASHTO Green Book: *A Policy on Geometric Design of Highways and Streets*

Breakout Group 2 felt that a terminology standard and operating concept guidelines would be helpful in bridging the gap between highway and rail interests. Other specific areas for standardization were:

- Traffic signals:
  + The interconnection of HRI signals with road intersection signals
  + Consideration of more uniform warnings (e.g., resolving the different meaning of flashing red lights on traffic signals vs. HRI signals)

- Dynamic message signs (DMS):
  + Uniform messages, abbreviations, and icons
  + Compatibility of messages across applications
  + Better uniformity of overall DMS design

- Surveillance to help in the area of :
  + Signal violation detection
  + Traffic/congestion management
  + Incident detection and notification
  + More efficient train detection

- Obstacle detection:
  + Signal/warning to driver
  + Message to train – what it is and when it is sent. This includes developing a consistent definition of a blocked HRI.
  + Use of new technologies like wireless video and other innovative obstacle detection devices: Determine the performance characteristics.

- Intelligent Controller (IC)
  + Protocol standardization to reconcile ITS software (e.g., NTCIP) with railroad company software; more generally upgrading older rail communication protocols to newer "ITS friendly" protocols
  + Establishing performance standards for the IC
  + IC Interfaces: standardizing and harmonizing wayside equipment control techniques, hardware and messages

- Dedicated Short-Range Communications (DSRC)
  - + HRI-related message sets for communications between the IC and a roadside DSRC reader/transmitter; and for communications between the DSRC device and the vehicle; and as received in-vehicle by the driver

- Passive Crossings
  - + Signing and messages
  - + On-board vehicle devices (HRI extension of current or near-term Advanced Traveler Information System (ATIS) devices in vehicles)

Breakout Group 3 – Vehicle Subsystem

Breakout Group 3 characterized its scope as encompassing communications between a highway user and a crossing. The highway user may have a relevant device built into the vehicle, or the device may be portable. The group considered issues at active crossings and at passive crossings with future capabilities to be determined. They focused on the system interface, but excluded human factors, which were being addressed by Group 5. The group noted that, at least for the foreseeable future, ITS systems would supplement, but not replace, primary HRI warning systems.

Exploring communications between the crossing itself and an in-vehicle or portable receiver was readily agreed upon. Communications directly between the train and in-vehicle (portable) devices was more controversial. In particular, railroad representatives were strongly opposed to this interface.

Operational issues included some concerns which were similar to those of Breakout Group 2, notably: who acquires/installs/maintains train detection devices? Current track circuits are maintained by the railroads. However, the responsibility for non-track based detection is less obvious. Railroad representatives said that the railroads do not want maintenance responsibility for transmitters that communicate to in-vehicle and portable devices; this should be the responsibility of highway authorities or ATIS service providers, and receiver maintenance should be the responsibility of the device manufacturer, provider, and/or purchaser. Liability concerns are intertwined with this issue.

Infrastructure costs are another issue. Roadside equipment costs may have to be borne by the public sector, and ITS enhancements may compete for funds with conventional HRI improvements.

The group also observed that the rate of automotive fleet turnover means that in-vehicle warnings will be widely deployed only over a long time span and that parallel operation of existing HRI safeguards will be required for many years.

Making large numbers of currently passive crossings at least minimally active will require new, low-cost mechanisms for train detection. One cost issue is that commercial power is not available at many passive crossings.

In-vehicle warning systems have some associated safety risks. There is a need to work toward ubiquitous coverage and very high reliability. Reliance on ITS technology may increase the risk at unequipped crossings or when system failures occur. False alerts may cause the system to be ignored. In-vehicle warning systems may also not improve the behavior of "beat the train" risk takers. There is even a risk that in-vehicle-warning systems could encourage "beat the train" behavior, especially if warning times are excessive.

Breakout Group 3 noted a number of existing standards for the interfaces they were considering, including:

- For the interface between information service providers (ISPs) and in-vehicle or portable devices: SAE J2353 and J23254 (data dictionary and message set for advanced traveler information systems (ATIS))
- For the interface between roadside DSRC and devices: notably the DSRC protocol stack. Layers 1 and 2 have been standardized by the American Society for Testing and Materials (ASTM), and layer 7 has been standardized by IEEE (IEEE 1455). The RADAR industry group is also working in this area
- For the interfaces to the DSRC roadside transmitter/receiver from Wayside Equipment and the railroad controller: recommended practices from AREMA Committee 36 (Highway-Rail Grade Crossing Warning Systems) and ITE

The group also identified standards that need to be developed for these interfaces:

- For ISPs and in-vehicle or portable devices: Enhancements of the existing standards to incorporate HRI information (SAE)
- For the interface between roadside DSRC and devices: Enhancements of the DSRC protocols to incorporate HRI requirements, reliability performance standards, and recommended practices for installation (ASTM, IEEE, SAE, AASHTO, ITE, federal and state regulators)
- For the interfaces to the DSRC roadside transmitter/receiver from Wayside Equipment and the railroad controller: New and revisited standards and practices, for signal activation only, and for incorporating additional train information: length, speed, direction, presence of second train, etc. (ITE and AREMA with participation of equipment manufacturers, researchers, and service providers).

The group identified a number of issues related to standards development:

- On-board collision avoidance systems that assume partial control of the vehicle are not yet ready for standardization. Only advisory/information systems are recommended for near-term standards development.
- Information needs to be provided at two levels: existence of a crossing and whether a train is present
- Standards are needed to make sure that the technology being newly introduced at passive crossings is as reliable as at existing active crossings
- The timing and availability of warnings must take vehicle speed (as well as train speed) into account

- RF alone is insufficient for in-vehicle warnings; information is needed to allow the vehicle system to determine the relevance of the warning (e.g., distinguishing a vehicle path that is parallel to the tracks from one which is intersecting).

Breakout Group 4 – Traffic Management Subsystem

Breakout Group 4 felt that an expansion and refinement of the National Transportation Communications would meet the need for most new traffic management standards for ITS Protocol (NTCIP). Representatives of the SDOs working as the NTCIP partnership (ITE, AASHTO, NEMA) stated that they will address the recommendations of the National ITS Architecture's Standards Requirement Package #12, including wireline communications between the roadside and wayside and between the Traffic Management Center and the Rail Operations Center. Indeed, the NTCIP Joint Committee had already authorized an HRI standards working group, with Dr. Tom Urbanik (Texas Transportation Institute) as Chair. Some recruiting for this group took place during the workshop.

Group 4 identified a number of groups beyond the partnership for participation in the development of these standards, including U.S. DOT, Transport Canada, and the Mexican Ministry of Transportation; representatives of TRB Committees; AREMA and AAR; the Railway Progress Institute; and railroad companies.

Group 4 also agreed that FHWA's Standards Requirements Package #12 was incomplete in that it only addressed the application of ITS technologies to active crossings. Group 4 urged FRA and FHWA to proceed with a wireless communications strategy and a standards requirements package that would address the application of ITS technologies to the thousands of passive HRIs in urban and rural areas.

Breakout Group 5 – Human Factors

Breakout Group 5 focused on Human Factors issues across all of the relevant technologies and applications. They prepared a goal statement for standards in this area:

> *We need to define a human-centered methodology which will serve as a filter through which all components of the ITS interface will be designed and implemented, including the determination of the appropriate level of operational variables. This human-centered methodology should seamlessly integrate those aspects that relate specifically to the HRI interface with the overall driver workload that is created by all of the other ITS elements.*

The group began by identifying a series of human factors research issues related to the HRI:

- Displays, controls, data entry, modes of operation, information and control, decision making, combinations of these items and how to make the ITS technology human centered
- Automation and human performance issues:
  + Complacency and trust

    + Potential conflicts in "message" delivered by familiar signal devices
    + Distractions and false alarms
    + Workload
    + Situation awareness
    + User "mental model" of the system and mode awareness
- How most effectively to deliver public education
- Behavior modification, through law enforcement, driver education, photo enforcement, public information and education, and media/advertising
- Driver perception of speed and distance

The group observed that a large number of human factors studies have been done and are available. Their results need to be interpreted from the perspective of the HRI.

The institutional issues and barriers identified by Group 5 included:

- Participation of multiple industry groups with different perspectives and expectations (e.g., rail vs. highway engineering)
- Multi-agency responsibility for HRI policy (e.g., FHWA and FRA)
- Lack of human factors consideration at the outset of HRI exploration. Going forward, human factors from the highway and rail sides must work together

The group observed that success in improving HRI safety depends on close cooperation among railroad and highway engineering and field maintenance personnel.

The first set of standards considered by Group 5 focused on what the vehicle driver sees and hears near and at the HRI. The primary consideration is how clear and concise to convey what is expected of the driver when he arrives at the HRI. One issue is whether HRIs should have the same signs and signals as other intersections or be treated as a unique case. Standards requirements relating to the vehicle driver are:

- Criteria for the use of gates and barriers, and for closing crossings.
- Minimum equipment standards. A minimum baseline that will maximize the effectiveness of human factors aspects of ITS.
- Standards for multiple aspects of dynamic message signs:
    + Data and messages
    + Size, shape, geometry
    + Use of text vs. graphics
    + Colors
    + Sign placement
- In-Vehicle Warning Systems. It is vital that a uniform, recognizable, unique signal is associated with approaching trains at an HRI. A determination needs to be made of which types of vehicles should have warning systems installed, at least initially, and what types of messages take priority (e.g., fire engine vs. train). The focus should be on warning of approaching trains, not just that a crossing is there.

The second set of standards focused on what the train crew sees and hears when approaching the HRI. Issues include the data regarding operational status of the crossing and how that data is presented to the engineer. Standards requirements are:

- Equipment reliability standards
- Standards for manual vs. automated train response

The third set of standards related to interactions at the Traffic Management Center and the Rail Operations Center. Issues surrounded the types of data that should be transmitted between the centers and the resolution of incompatibilities between the data presentation styles at the centers. Aspects include displays, controls, and modes of information, manual vs. automated controls, decision making, and combinations of these aspects.

The fourth area of standardization related to general automation and human performance issues:

- Complacency and trust issues require the establishment of appropriate reliability standards
- Potential conflicts in the delivered "message" need to be resolved
- Distractions and false alarms need to be explored and performance standards established
- Workload, situational awareness, and user mental model are all potentially fruitful areas for standardization, once appropriate research is complete
- Standards are needed to support system operator resource management and the fitness of resources for operation (including fatigue and drug/alcohol impairment)

Breakout Group 5 identified the following groups as needing to play a role in these standardization efforts:

- The railroads
- Federal and state regulators for highway and rail, including NTSB and the Surface Transportation Board, FHWA, FRA, and FTA.
- AAA, AAR, AASHTO, AREMA, ATA, Operation Lifesaver
- Union representatives
- Equipment manufacturers
- University researchers
- Human factors organizations (e.g., American Psychological Association, Division 21; Human Factors and Ergonomics Association)
- National Education Association and American Federation of Teachers

Breakout Group 6 – Special Cases

Breakout Group 6 focused on a number of special cases for the Highway-Rail Intersection:

- High speed rail
- Light rail transit
- High profile (humped) crossings

- Passive crossings, including private crossings

High Speed Rail

The group identified operational issues for high-speed rail (HSR) as including:

- The need for a consistent definition of HSR (80-125 mph was one suggestion)
- The need for more positive barriers, especially when speeds exceed 110 mph
- The number of parties involved in HSR operations and crossings. A freight or other railroad often owns the track. Passenger rail companies (Amtrak) operate high-speed trains. The federal government typically funds technology.
- A more user friendly system is needed

The group identified HSR safety issues:

- Collisions at speeds over 60 mph will be fatal to drivers, cyclists, and pedestrians
- Derailments from collisions are more likely at high speeds, representing an additional hazard to train crews and passengers and the community in general
- Safety must be achieved without adding costs that make HSR uneconomic
- Some safety risks, including those presented by introducing new technology, can be mitigated by more formal safety analyses, including processes for the ongoing verification and validation of the performance of microprocessor-based technology

The group characterized the state of current technology for HSR. The core technologies for achieving HSR are available in the marketplace, but the application of this technology is not well understood. In particular, costs and benefits are not known with any accuracy. The group suggested that HSR, in general, is not well understood outside a relatively small inner circle.

The group identified the fundamental institutional issues related to HSR as:

- The need for multi-organization cooperation across the public and private sectors for HSR to succeed
- Tort liability concerns. Protection from tort liability during demonstration programs was particularly noted.

The group agreed that standards would be highly beneficial in helping to realize HSR. Multiple incompatible approaches to HSR need to be harmonized to help create markets, reduce costs, and build public confidence. Consistency is needed on a national level, although there may be some specifically regional concerns in such areas as environmental impact.

Specific areas for standardization were:

- Communicating train location to roadway and traffic management subsystems
- Standard warrants for warning devices
- Updates to the *Manual of Uniform Traffic Controls and Devices* to accommodate ITS systems

The group felt that the marketplace alone would have difficulty in establishing these standards in an effective and timely manner, and that federal rule making may be required. The group suggested first building a voluntary consensus and then codifying this consensus as federal regulations.

The groups which need to participate in HSR standardization include: the railroads and AAR, federal road and rail regulators, state regulatory agencies, equipment manufacturers, university representatives and researchers, labors unions (notably the Brotherhood of Railroad Signalmen), ITE, IEEE, AREMA, NCUTCD, AASHTO, ASCE, Transport Canada, Mexican MOT, RPI, UIC, ISO, and TRB. The standards themselves should be written and approved within AREMA, AASHTO, ITE, IEEE, and NCUTCD.

Light Rail Transit

The group identified operational issues for light rail transit (LRT) as including:

- LRT is a complex joint activity of transit agencies and other local, state, and federal agencies, with the cooperation of railroads, property owners, utilities, and city/county traffic authorities.
- Much of the capital comes from federal sources, but purchasing is local
- Getting competing agencies (both local and national) to pull toward a common goal is a challenge
- Interoperability of railroad and traffic signals

The group identified LRT safety issues:

- There are hazards to road users, including pedestrians
- "Second train coming" is a particular concern, given frequency of occurrence
- Increased safety and cost containment must go hand in hand
- As with HSR, some LRT safety risks, including those presented by introducing new technology, can be mitigated by more formal safety analyses, including processes for the ongoing verification and validation of the performance of microprocessor-based technology

The group's characterization of the state of available technology for LRT was similar to its assessment of HSR technology: the technology itself is mature, but the application of the technology is not generally well understood.

The group felt that institutional issues related to LRT were the same as those for HSR, notably including the need for multi-organizational cooperation and for tort liability protection especially during demonstration programs.

The group agreed that standards would be beneficial for LRT in the general areas of vehicle and crossing site condition, in detecting and relaying obstacles to trains, in helping to reroute commercial vehicles, and for collision notification. The group called out the need for national consistency, primarily as a way to make technology more affordable. Specific areas for standardization were the same as for HSR.

The groups which need to participate in LRT standardization include: federal road and rail regulators, state regulatory agencies, equipment manufacturers, university representatives and researchers; APTA, UITP, ITE, IEEE, AASHTO, NCUTCD, ASCE, ASME, CUTA, RPI, UIC, and ISO

High profile (humped) crossings

The group identified operational issues for high profile crossings (HPX) as including:

- The need for cooperation among railroad and highway authorities
- The need for the participation and cooperation of commercial vehicle interests
- The lack of a consistent definition of HPX
- Finding money for capital improvements, research, operations, maintenance, and training

The group identified HPX safety issues:

- There are potential hazards for trains, vehicles, the general community, and the environment
- Increased safety and cost containment must go together
- As with HSR and LRT, some HPX safety risks, including those presented by introducing new technology, can be mitigated by more formal safety analyses, including processes for the ongoing verification and validation of the performance of microprocessor-based technology

The group characterized main technology issue for HPX as relating to design definition. Technology for mitigating problems at HPX exists, but the application of the technology, along with costs and benefits, is not well understood.

The group identified the fundamental institutional issues related to HPX as being the same as for HSR and LRT (cooperation, tort liability protection), plus the need to involve commercial vehicle interests.

The group agreed that standards would be beneficial particularly for HPX design, which would be helpful both for safeguarding both vehicle and crossing site conditions. Standard technology to reroute commercial vehicles around or notify them of HPX would be beneficial. Obstacle detection and collision notification is also important.

Specific areas for standardization were:

- Communicating train location to the roadway and traffic management subsystems
- Design of HPX geometry
- Design of vehicle undercarriages

- Adaptation of MUTCD to include HPX warning

The groups which need to participate in HPX standardization include: federal road and rail regulators, state regulatory agencies, equipment manufacturers, university representatives and researchers; TTMA, ATA, SAE, ASCE, AREMA, ITE, AASHTO, NACE, TRB.

Passive crossings, including private crossings

The group identified operational issues for passive and private crossings (PPXs) as including:

- Passiveness itself: the fact that warning devices do not change their appearance or message as a train approaches
- The need for railroad and highway authorities not only to work constructively together, but to involve and include private property owners as well
- Insufficient funds to upgrade all PPXs to active status, certainly as active crossings are now constituted

The group identified PPX safety issues:

- Large number of crashes, currently, relative to traffic volumes
- Possible complacency as passive crossings are made active, since not all crossings can be made active at once (or maybe ever)
- Reliability and effectiveness of less expensive active warning technologies

The group characterized the state of current technology for PPXs:

- Some technology is available and being tried, but additional testing, demonstration, and research is necessary, for which funding is not yet reliably available
- Such funding could come from state/federal/private partnerships, and the sooner the better
- Cost/benefit picture is not yet well understood

The group identified the fundamental institutional issues related to PPXs as:

- Because passive crossings currently do not consume, generate, or process information, they fall outside the National ITS Architecture. This needs to be remedied.
- Responsibility for private crossings is fuzzy.
- Public/private cooperation is needed for standards to be developed and adopted.
- The activation of passive crossings presents a wide range of potential tort liability risks for which protection is needed, especially during demonstration and deployment rollout.

The group agreed that standards are needed to create nationally consistent approaches for activating PPXs, including possible updates to the MUTCD. Specific areas for standardization were:

- In-vehicle warnings
- Low-cost road warning devices for low volume crossings

The groups, which need to participate in PPX standardization, are essentially the same as those for HPX.

Appendixes

Appendix A – Final Workshop Agenda

AGENDA

ITS Standards for the Highway-Rail Intersection
A Two-Day Workshop – July 22-23, 1999

Wednesday, July 21

7:00-9:00pm	Advance Registration / Sign-In

Thursday, July 22

7:30am	Registration and Continental Breakfast
8:30am	Welcome
8:45am	"Charge to Workshop Participants" – **Dr. Christine Johnson**, Director, U.S. DOT ITS Joint Program Office
9:05am	"Safety at the Highway-Rail Intersection" – **George Black**, Member, NTSB
9:25am	"Overview of HRI Projects and Evaluation" – **Anya Carroll**, Volpe National Transportation Systems Center
10:00am	** Morning Break **
10:30am	"Role of the Highway-Rail Intersection in the National ITS Architecture" – **Bruce Eisenhart**, Lockheed-Martin Co., National ITS Architecture Development Team
11:15am	"ITS Standards – An Overview" – **Richard Weiland**, Weiland Consulting Co., ITS America Council of Standards Organizations
11:45am	Explanation of Breakout Session Process
12:00 noon	Lunch on Your Own
1:00pm	Breakout Sessions Begin
3:00pm	** Afternoon Break **
3:30pm	Breakout Sessions Resume
5:00pm	Adjourn for Day

Friday, July 23

8:00am	Continental Breakfast
8:30am	Checkpoint Plenary Session
9:00am	Breakout Sessions Resume
10:00am	** Morning Break **
10:30am	Breakout Sessions Resume
11:45am	Breakout Sessions Conclude
12:00 noon	Workshop Luncheon (Provided) Featured Presentation, **Hon. Jolene Molitoris**, Administrator, Federal Railroad Administration
1:30pm	Presentation of Breakout Session Conclusions Distinguished Guest to Receive Conclusions: Donald Itzkoff, Deputy Administrator, Federal Railroad Administration
2:30pm	** Afternoon Break **
3:00pm	General Discussion of Conclusions and Next Steps
4:00pm	Adjourn

Appendix B – Workshop Notebook Table of Contents

Workshop Notebook Contents
ITS Standards for the Highway-Rail Intersection July 22-23, 1999 – Arlington, VA

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Appendix C – Breakout Group Leadership

Group #1: Wayside Equipment and Rail Operations

Facilitator: Dean Hollingsworth
Technical Advisor: William Browder
Architecture Advisor: Bruce Eisenhart

Group #2: Roadway Subsystem

Facilitator: Patricia Smith
Technical Advisor: Otto Sonefeld
Architecture Advisor: Charnita Wilson

Group #3: Vehicle Subsystem

Facilitator: Brenda Mahaffey
Technical Advisor: Michael Onder
Architecture Advisor: Ronald Ice

Group #4: Traffic Management Subsystem

Facilitator: Arlene Patel
Technical Advisor: Sheldon "Bo" Strickland
Architecture Advisor: Doug Siesel

Group #5: Human Factors

Facilitator: Randall Dickinson
Technical Advisor: Thomas Raslear
Architecture Advisor: Gary Carver

Group #6: Special Cases

Facilitator: Donald Thomas
Technical Advisor: Linda Meadow
Architecture Advisor: Robert Glass

Appendix D – Breakout Group Questions

Technology/Application Area Questions

Breakout Groups 1, 2, 3, 4, and 6 (that is, all but Group 5 – Human Factors) were oriented toward particular technology areas. Each was asked to address the following questions:

A. Characterize your group

Characterize your area and define its content and boundaries. Use the Breakout Group descriptions as guidance, but not as a straightjacket.

B. What are the operational issues?

Whose responsibility is it to acquire/install/maintain/operate this technology? Who else needs to cooperate or participate? What makes the management and operation of this technology hard/easy? Where does the money get spent (equipment? labor? right of way? power?)

C. What are the safety issues?

What hazards are addressed by this technology with respect to drivers? pedestrians and bicyclists? Train crews? How effective does this technology promise to be?

Does the technology create its own safety risks? How can these be mitigated?

D. What is the state of available technology? What are the research issues?

To what extent is this technology already well understood? readily available in the market?

To what extent does significant research still need to be successfully performed before this technology can be ready for use? Who should do this research? What is the time frame? How much will it cost? Who should pay?

E. How does it interface with the ITS Architecture?

Are relevant technologies and standards approaches consistent with the National ITS Architecture, particularly with User Service #30, the Highway-Rail Intersection. Where are there conflicts with the Architecture?

F. What are the institutional issues/barriers?

Does success depend on the cooperation of organizations and entities that do not have a history or working together effectively? How can this be mitigated?

What legal barriers need to be addressed (e.g., tort liability). Are there interjurisdictional regulatory issues that need to be resolved? Where do legitimate vested interests collide in advancing this technology?

What gaps exist in the level of understanding/knowledge/training on the part of the general public, government, railroads, labor, equipment suppliers, planners, etc.?

G. Where would standardization be beneficial?

Are there multiple, incompatible approaches that need to be harmonized? How would standardization help to promote widespread deployment? What effect would this have on costs? Who might be **dis**advantaged by standards?

Is this an area that requires national consistency in order to work effectively and/or be affordable? Regional consistency?

What relevant standards already exist? Do these need to be updated or adapted to accommodated HRI issues?

Can the marketplace work out standards? Is a formal process needed? Where would regulatory standardization (rule making) be appropriate?

Specifically, what needs to be standardized?

H. What groups should participate in the standardization of this area?

Railroads? Federal regulators for road and rail? State regulators for road and rail? Equipment manufacturers? University representatives? Researchers?

I. What individuals should participate in standards development?

Please identify **people**, by name and affiliation, which should/can/will participate in standards development in this area. Draw on people present today, and others known to people present today

J. Which standards development organization(s) should handle particular standards topics?

Human Factors Questions

Breakout Group 5 (Human Factors) had a slightly different collection of questions, reflecting the fact that their orientation was not to a specific technology area:

A. Characterize your group

Characterize your area and define its content and boundaries. Use the Breakout Group descriptions [above] as guidance, but not as a straightjacket.

B. What is the state of available technology? What are the research issues?

To what extent is this technology already well understood? readily available in the market?

To what extent does significant research still need to be successfully performed before this technology can be ready for use? Who should do this research? What is the time frame? How much will it cost? Who should pay?

C. What are the institutional issues/barriers?

Does success depend on the cooperation of organizations and entities that do not have a history or working together effectively? How can this be mitigated?

What legal barriers need to be addressed (e.g., tort liability). Are there interjurisdictional regulatory issues that need to be resolved? Where do legitimate vested interests collide in advancing this technology?

What gaps exist in the level of understanding/knowledge/training on the part of the general public, government, railroads, labor, equipment suppliers, planners, etc.?

D. Specifically, what needs to be standardized?

Please remember that today's job is not to establish human factors standards related to ITS in the HRI, but rather to understand and identify the subject matter and process through which these human factors will be standardized.

Please consider:

- What the driver sees and hears near and at the HRI: external signs and signals, gates and barriers, DMS, in-vehicle warnings (visual / audible)
- What train crew sees and hears approaching an HRI
- Interactions at the Traffic Management Center and the Railroad Operations Center
- Consider:
  + displays

+ controls
+ data entry
+ modes of operation
+ information
+ control
+ decision-making
+ combinations of the above

+ How to make ITS technology human-centered

- Automation and human performance issues:
  + complacency and trust
  + potential conflicts in "message" delivered by familiar signal devices
  + distraction / false alarms
  + workload
  + situation awareness
  + user mental model of the system and mode awareness

Which items require national consistency in order to be effective and/or affordable?

What relevant standards already exist? Do these need to be updated or adapted to accommodated HRI issues?

Can the marketplace work out standards? Is a formal process needed? Where would regulatory standardization (rule making) be appropriate?

E. What groups should participate in the standardization of this area?

Railroads? Federal regulators for road and rail? State regulators for road and rail? Equipment manufacturers? University representatives? Researchers?

F. What individuals should participate in standards development?

Please identify **people**, by name and affiliation, which should/can/will participate in standards development in this area. Draw on people present today, and others known to people present today

G. Which standards development organization(s) should handle particular standards topics?

Appendix E – Consolidated List of HRI Standards

Existing Standards Relevant to the HRI

The Breakout Groups identified a number of existing standards that should be noted in thinking about future standards development activities. The Breakout Groups suggested that several of these existing standards be updated or revised to accommodate HRI considerations.

Infrastructure Design

- The *Manual of Uniform Traffic Controls and Devices for Streets and Highways* (MUTCD) and associated federal rulemaking (49CFR234).
- FHWA *AP-175 Railroad-Highway Grade Crossing Handbook*, published by the National Technical Information Service as Publication No. NTIS-PB-87-137527/AS.
- AASHTO Green Book: *A Policy on Geometric Design of Highways and Streets, 1994.*

Wired Communications

- The National Transportation Communications for ITS Protocol (NTCIP), developed jointly by AASHTO, ITE, and NEMA, standardizes communications between certain transportation centers and field equipment, and provides a foundation for HRI-related infrastructure-based communications.
- Recommended practices from AREMA Committee 36 (Highway-Rail Grade Crossing Warning Systems) and ITE for the interfaces to the Dedicated Short-Range Communications (DSRC) roadside transmitter/receiver from wayside equipment and controllers.
- Association of American Railroads (AAR) Advanced Train Control Specification (ATCS) Spec 200, covering the interface between the rail operations center and wayside equipment.

Wireless Communications

- SAE J2353 and J23254 (Data Dictionary and Message Set for Advanced Traveler Information Systems) for the interface between information service providers (ISPs) and in-vehicle or portable devices.

- DSRC protocol stack for the interface between roadside and in-vehicle or portable devices. Layers 1 and 2 have been standardized by the American Society for Testing and Materials (ASTM), Group E17.51, and Layer 7 has been standardized by IEEE (IEEE 1455: Standard for Message Sets for Vehicle/Roadside Communication).

Train Communications

- IEEE P1474: Standard for Communications Based Train Control *(under development).*

- IEEE P1544: Standard for Transit Communications Interface Profiles for Rail Applications *(under development).*

- AREMA standards for communication and signaling, transferred from AAR when AREMA was created.

Standards Needed at the HRI

This list consolidates and harmonizes the recommendations of the individual breakout groups. Many items in the list have multiple subparts, each of which will potentially result in the development of one or more related standards. Candidate standards development organizations (SDOs) appear after each recommendation. Suggestions for other participating organizations appear in Section V – Breakout Group Results and Conclusions. Recommended new standards are:

1. Expansion of Traffic Management Data Dictionary to encompass HRI. (AASHTO, ITE).

2. Expansion of Advanced Traveler Information Systems Data Dictionary and Message Set to encompass HRI. (SAE).

3. Expansion of DSRC message sets to encompass HRI messages/warnings to in-vehicle and portable devices. (IEEE)

4. Expansion of National Transportation Communications for ITS Protocol (NTCIP). (AASHTO, ITE, NEMA):

    - Center-to-center links between traffic management centers and railroad operations centers
    - Field equipment links between rail operations centers and wayside equipment

- Field equipment links between traffic management centers and intelligent controllers
- Field equipment links between intelligent controllers and HRI-related signs and signals.
- Field equipment links between intelligent controllers or wayside equipment and DSRC base stations for in-vehicle warnings
- Coordination of HRI signals with nearby roadway traffic signals

5. Standards for additional interfaces between light rail wayside equipment and highway field equipment (IEEE Rail Transit Vehicle Interface Committee).

6. Standards for additional interfaces between rail operations and traffic management centers (IEEE Rail Transit Interface Committee).

7. Expansion of the *Manual of Uniform Traffic Controls and Devices* (MUTCD) to include signs and warnings specifically oriented to high-speed rail and high-profile crossings. (AASHTO, FHWA).

8. Revision of AASHTO Green Book to include design specifications for high-profile crossings. (AASHTO, AREMA).

9. Standard glossary of terms for the HRI (AREMA, ITE)

10. Uniform HRI warning signs and signals (AASHTO, AREMA, IEEE, ITE)

11. Standard for dynamic message signs (DMS) at HRIs (AASHTO, ITE)

    - Uniformity of DMS design
    - Uniform messages, abbreviations, and icons
    - Use of text vs. graphics
    - Use of color
    - Sign placement
    - Compatibility with in-vehicle signing/warnings

12. Standard practices for HRI surveillance (IEEE, ITE).

    - Signal violation detection
    - Traffic/congestion management
    - Incident detection and notification
    - Train detection

13. Standard for HRI obstacle detection (AASHTO, IEEE, ITE)

    - Definition/classification of obstacles
    - Sensor technology and analysis
    - Performance/reliability requirements for obstacle detection and reporting
    - Data elements and messages for advising drivers of obstacles at HRIs

- Data elements and messages for advising train crews of obstacles at HRIs
- Standard for automated vs. manual train response to obstacle warning

14. Standards for the intelligent controller (IC) [*cf.,* Expansion of NTCIP, #4 above]. (AASHTO, ITE, NEMA).

    - Performance standards for the IC
    - Control techniques
    - IC hardware
    - IC ↔ field equipment message sets

15. Standards for in-vehicle HRI warnings. (AASHTO, ITE, SAE)

    - Conditions for issuing a warning
      + As vehicle approaches a crossing
      + To advise approach/presence of train
      + Taking into account speed of train, speed/path of road vehicle
    - Performance standards for issuing warnings
      + False alarm issues
    - Messages, icons, "ear-cons" for HRI warnings
    - Coordination with external warnings (e.g., DMS)
    - Coordination with other in-vehicle information and warning efforts for:
      + Communications interface from ISP or roadside to in-vehicle device
      + Overall consistency of approach
      + Message priority
      + Complacency and trust issues
      + Other human factors

16. Updated standards and practices for train detection and signal activation. (ITE, AREMA).

    - Incorporating such additional train information as length, speed, direction, presence of second train, etc.
    - Updated reliability requirements

17. Minimum equipment standards for use of gates and barriers. (AASHTO, AREMA)

18. Recommended practices for closing crossings. (FHWA, FRA, NHTSA, NTSB)

19. Standards for Human Factors at Traffic Management and Rail Operations Centers. (AAR, AASHTO, APA, HFEA, ITE) .

    - Resolution of multiple messages and multiple ways to present information
    - Displays, controls, modes of information, manual vs. automated controls, decision making, and combinations of these aspects

- System operator resource management and the fitness of resources for operation (including fatigue and drug/alcohol impairment)

20. Standard for vehicle undercarriages to accommodate (standard) high profile crossings. (SAE).

21. Standard for [low cost] HRI warning devices at low volume crossings. (AASHTO, AREMA, ITE, NEMA).

Appendix F – Workshop Participants

1. Matthew Ablett, Manager, Product Development, Railroad Controls, Ltd., Smyrna, GA
2. Forrest Ballinger, Senior Signal Specialist, Harmon Industries, Inc., Grain Valley, MO
3. James Barrett, Product Manager, WABCO Railway Electronics, Cedar Rapids, IA
4. K. Bedure, Railroad Programs Coordinator, Michigan DOT, Lansing, MI
5. Duane Bentz, Planning Engineer, North Dakota DOT, Bismarck, ND
6. George Black, Member, National Transportation Safety Board, Washington, DC
7. Mark Bowering, President, RSO Corporation, San Marcos, CA
8. Rashmi Brewer, Project Engineer, Minnesota DOT, St. Paul, MN
9. Kenneth Briers, Rail Operations Analyst, Parsons Transportation Group, Washington, DC
10. William Browder, Director of Operations, Assn of American Railroads, Washington, DC
11. Vincent Burns, Principal Traffic Engineer, New Jersey DOT, Freehold, NJ
12. Anya Carroll, General Engineer, USDOT/RSPA/Volpe Center, Cambridge, MA
13. Gary Carver, Standards Program Coordinator, Jet Propulsion Laboratory, Washington, DC
14. Broady Cash, Principal Engineer, ARINC, Inc., Annapolis, MD
15. John Cavanaro, Project Engineer, Systra Consulting, Inc., Boston, MA
16. James Cheeks Jr., Standards Development Manager, Institute of Transportation Engineering., Washington, DC
17. Anne Chettle, Director of Public Affairs, High Speed Ground Transportation Association, Washington, DC
18. Joseph Cielecki, Regional Manager, Rail Services, DMJM, Lawrenceville, NJ
19. Julie Cirillo, Chief, Safety Technology Div, Federal Highway Administration, Washington, DC
20. Fred Coleman, III, Asst. Professor, University of Illinois, Urbana, IL
21. Mike Coplen, Human Factors Program Manager, Federal Railroad Administration, Reston, VA
22. Grady Cothen, Deputy Assoc. Administrator, Federal Railroad Administration, Washington, DC
23. Roy Courtney, Director, Development & Deployment, ITS America, Washington, DC
24. Sean Crain, Electrical Engineer, Federal Railroad Administration, Washington, DC
25. Jim Curry, Area Manager, Southern California, PB Farradyne, Inc., Orange, CA
26. R. Davis, B&B Electromatic, New York, NY
27. Timothy DePaepe, Director of Research, Brotherhood of Railway Signalmen, Mt. Prospect, IL
28. Randall Dickinson, Regional Crossing Manager Federal Railroad Administration, Clifton Park, NY
29. Steven Ditmeyer, Director, Office of Research & Development, Federal Railroad Administration, Washington, DC
30. William Ede, Performance Manager, Transportation Systems, CANAC, Inc., Montreal, QB Canada
31. Bruce Eisenhart, Chief Engineer, Lockheed Martin, Manassas, VA
32. Trevor Ekeh, Intern, Federal Railroad Administration, Washington, DC
33. Charles Emely, Executive Director, AREMA, Landover, MD
34. Roelof Englebrecht, Research Associate, Texas Transportation Institute, College Station, TX

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Appendix G – Acronyms and Abbreviations

AAA	American Automobile Association
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
APA	American Psychological Association
APTA	American Public Transit (Transportation) Association
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
ATCS	Automatic Train Control Specification
ATIS	Advanced Traveler Information Systems
AWARD	Advanced Warning for Railroad Delays
CCTV	Closed Circuit Television
CUTA	Canadian Urban Transit Association
DMS	Dynamic Message Sign
DOT	Department of Transportation
DSRC	Dedicated Short-Range Communications
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GPS	Global Positioning Satellite
HFEA	Human Factors and Ergonomics Association
HPX	High Profile (Humped) Crossing
HRI	Highway-Rail Intersection
HSR	High Speed Rail (80+ mph)
IC	Intelligent (Traffic Device) Controller
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Standards Organization
ISP	Information Service Provider
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
LRT	Light Rail Transit

MUTCD	*Manual of Uniform Traffic Controls and Devices*
NACE	National Association of County Executives
NCUTCD	National Committee on Uniform Traffic Control Devices
NEMA	National Electrical Manufacturers Association
NHTSA	National Highway Transportation Safety Administration
NTCIP	National Transportation Communications for ITS Protocol
NTSB	National Transportation Safety Board
PPX	Passive/Private Crossing
PTC	Positive Train Control
RPI	Railway Progress Institute
SAE	Society of Automotive Engineers
SDO	Standards Development Organization
SSR	Standard Speed Rail (up to 79 mph)
STB	Surface Transportation Board
TEA-21	Transportation Equity Act for the 21st Century
TRB	Transportation Research Board
TTC	Transportation Technology Center
TTMA	Truck and Trailer Manufacturing Association
UIC	International Railroad Union (*Union Internationale des Chemins de Fer*)
UITP	International Association of Public Transport (*Union Internationale des Transports Publics*)
WG	Working Group

U.S. Department of Transportation
Federal Highway Administration
Federal Railroad Administration

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