Testimony of Jo Strang,
Deputy Associate Administrator for Railroad Development,
Federal Railroad Administration,
U.S. Department of Transportation,
before the Subcommittee on Railroads
of the Committee on Transportation and Infrastructure,
U.S. House of Representatives
June 10, 2003

Mr. Chairman and members of the Subcommittee, I very much appreciate the opportunity to appear before you today on the subject of new railroad safety technologies and, specifically, the future of Positive Train Control, the role of the Nationwide Differential Global Positioning System, and safety standards for locomotives and railroad passenger equipment. I supervise the Federal Railroad Administration's (FRA) research, development, and demonstration efforts, so I necessarily pay a great deal of attention to new safety technologies. In the job I held immediately prior to this, I supervised the National Transportation Safety Board's (NTSB) accident investigators, so I am all too familiar with the consequences of railroad safety problems. With me is David Tyrell, Senior Engineer, of the Volpe National Transportation Systems Center, Research and Special Programs Administration, U.S. Department of Transportation, who has done a great deal of very valuable work on crashworthiness for FRA, some of which is summarized in his technical paper attached to my testimony.

As this Subcommittee is aware, FRA's safety mission can be simply stated: help prevent fatalities, injuries, property damage, and the release of hazardous materials related to railroad operations. In recent months, working with the Transportation Security Administration and other agencies, we have also placed new emphasis on enhancing the security of railroad operations.

Under current law, FRA's jurisdiction extends to all areas of railroad safety. We have issued rules on a wide range of subjects including track, signals and train control, locomotives and other equipment, grade crossing signal devices, and operating practices, and we enforce those rules as well as rules related to hazardous materials transportation by rail. We conduct inspections of railroad operations to determine the level of compliance with the laws and regulations, and we use a variety of enforcement tools when necessary to encourage compliance. We help educate the public about safety at highway-rail grade crossings and the dangers of trespassing on railroad property. FRA works closely with the NTSB on those accidents that NTSB investigates. FRA also investigates a broader range of railroad accidents under its own authority, including those involving three or more deaths at a highway-rail grade crossing, a employee fatality, damages that exceed $1,000,000, or serious injuries to passengers.

FRA monitors the railroad industry's safety performance very closely by requiring reports of accidents and injuries, and inspecting railroads and shippers of hazardous materials extensively. FRA's safety data base is available on its Web site (see www.fra.dot.gov). FRA uses this information to guide its accident prevention efforts and continually strives to make better use of the wealth of available data to achieve its mission.

FRA also obtains valuable information and insights about the industry from its Railroad Safety Advisory Committee (RSAC), which was formed in 1996 to provide advice and recommendations to FRA on railroad safety matters. The Committee consists of representatives drawn from organizations representing various rail industry perspectives, associate members from the agencies with railroad safety regulatory responsibility in Canada and Mexico, and other stakeholders. Staffs of the NTSB and Federal Transit Administration also participate in an advisory capacity.

In aid of that safety mission, FRA has a very active research and development program focused entirely on developing new railroad safety technologies and practices and refining existing ones. FRA's Next Generation High-Speed Rail Program sponsors technology development and demonstrations, including major Positive Train Control demonstrations because FRA rules prohibit speeds above 79 miles per hour (mph) without some form of enforced train control. FRA's Transportation Technology Center (TTC) in Pueblo, Colorado, is the foremost railroad safety research facility in the world. As many of you know, FRA operates the TTC through a public/private partnership with the Association of American Railroads (AAR). TTC is where, for example, FRA conducts the full-scale crash tests of rail vehicles that we will discuss later.

The Current State of Railroad Safety across the Nation

As judged by most indicators, the safety trends on the Nation's railroads are very favorable. While not even a single death or injury is acceptable, progress is being made in the effort to improve railroad safety. The most recent revisions of the preliminary data for calendar year 2002 show that since 2001 there have been many improvements in rail safety. Train accidents are down 11 percent, and the rate per million train-miles is down almost 14 percent. Employee on duty casualties are down 16 percent, and the rate per 200,000 employee-hours is down 12 percent. At highway-rail crossings, incidents are down five percent, fatalities are down almost 16 percent (to 355), and injuries are down 14 percent, for historic low numbers and rates.

Most unfortunately, however, trespasser fatalities are up six percent (to 543) and continue to constitute the largest single category of rail-related deaths.

Let me quickly provide a little additional data as background for the Positive Train Control (PTC) and equipment issues.

Train accidents preventable by PTC fall into both the freight and passenger categories. The latest reviews by the PTC Working Group of FRA's Railroad Safety Advisory Committee (RSAC) indicate that in the past four years from 1998 to 2001 between 37 and 55 "PTC-preventable accidents" have occurred annually, involving a cumulative total of approximately 30 fatalities and 514 injuries and $78,318,251 in railroad property damage. In the freight arena, we experience between one and twelve fatalities annually in freight train collisions that might be prevented by PTC; and although fatalities are infrequent, we continue to experience instances of trains getting into roadway work zones where there is a serious threat of loss of life.

Passenger railroads continue to offer the traveling public one of the relatively safest forms of transportation available. In the six-year period 1997 through 2002, nine rail passengers were killed in train collisions and derailments, and 13 more in highway-rail grade crossing collisions, out of the approximately 2.4 billion passenger trips in the same period. According to the National Safety Council (see attached chart on passenger death rates), the number of deaths per 100 million railroad passenger-miles is quite comparable to the rate for airline passengers, both of which are a small fraction of the rate for automobile passengers.

Nevertheless, these fatalities and the more numerous serious injuries that accompanied them are unacceptable to the traveling public and to FRA. We can improve on this record, and we are focusing on a wide range of actions to prevent train accidents and–where they are not prevented–to make them more survivable. Today's hearing focuses on three of those efforts: first, PTC; second, the Nationwide Differential Global Positioning System (NDGPS), which is used as a component of PTC; and third, locomotive and passenger equipment safety.

PTC

"Active" safety is preferred over "passive" safetyt. That is, we always seek first to avoid accidents. However, we do recognize that accidents will occur, so we also focus on developing locomotive and passenger equipment crashworthiness standards, as I will discuss later. Existing "active" safety programs include such things as control of alcohol and drug use, enforcement of the Track Safety Standards, and requirements for signal and train control technology.

"PTC" refers to advanced train control technology that can prevent–

Collisions between trains;

Derailments caused by excessive speed; and

Casualties to roadway workers within their limits of authorities.

(These are PTC's core functions. It may also be used to prevent grade crossing crashes. See attachment.)

FRA has provided an extensive roadmap toward implementation of PTC in the 1999 Report of the RSAC on Implementation of Positive Train Control Systems. In brief, FRA is promoting the implementation of PTC by–

Providing regulatory relief so that tests and demonstrations may be conducted;

Putting in place more flexible regulations through RSAC and supporting them with new risk assessment techniques;

Sponsoring development of PTC technologies through partnerships with States and railroads;

Helping to provide the basic radionavigation tool, which is NDGPS; and

Supporting retention of the radio frequency spectrum necessary for train control and related functions.

My time today is limited, so I would like to focus today on the progress made toward PTC and the next significant steps we need to take to support implementation of this important technology.

First, where are we?

PTC is both a promise and a reality. Acting under an FRA order, Amtrak and other Northeast Corridor (NEC) railroads are implementing the Advanced Civil Speed Enforcement System (ACSES), which builds on the existing cab signal/automatic train control technology already in place on trains in the NEC. This system now supports train speeds to 150 mph on segments between New Haven and Boston, where all passenger and freight trains are equipped. It also supports 135-mph operations on segments south of New York City, where track arrangements permit "flanking protection" for Acela high-speed trains. New Jersey Transit is implementing a complementary and interoperable system (Advanced Speed Enforcement System or "ASES") for its own lines. Amtrak is currently working on a data-radio component for ACSES which will make it suitable for application to the remaining territories and railroads on the NEC. ACSES and ASES will work together with the existing signal-based technology to provide PTC protections in that very busy electrified territory. They rely on use of transponders placed between the rails to determine position. Because these systems depend upon a relatively dense and costly infrastructure, they do not appear to be appropriate for use outside the NEC. FRA is finalizing a project with the AAR and the freight railroads toward a "Universal Locomotive Operating Platform" to better adapt the NEC systems for freight locomotives that will operate in these territories and must be equipped.

PTC functions are also provided by Amtrak's Incremental Train Control System (ITCS), which is in place on the Amtrak line in Michigan, with the State of Michigan, Amtrak, and FRA as program sponsors. System Supplier GE Transportation Systems Global Signaling (GEIS-GS) has also made significant financial contributions to this effort. ITCS is currently supporting passenger operations to 90 mph and is also installed on freight trains in the territory. It relies on both augmented GPS and existing track circuits to execute its functions. As further experience is gained and more formal safety verification and validation are completed on the system, it will support operations to 110 mph. The system works well, from the point of view of both safety and availability. In its current form, it is designed exclusively as an "add on" to an existing contemporary signal system, thus it utilizes existing signal infrastructure to provide a cost effective communication based train control system with many of the critical safety benefits of PTC. However, the current ITCS project was not configured to provide the business benefits which make such systems attractive to freight railroads. As a result, ITCS provides a new level of confidence that communication-based train control can deliver fail-safe train control systems at a fraction of the cost of the traditional infrastructure based train control technologies; however, more complex technologies are needed to deliver the full range of PTC functions (both safety and business functions) that we believe will prove most beneficial to the freight railroad system.

A project by the Illinois Department of Transportation (IDOT), which is being advanced by the North American Joint PTC (NAJPTC) Program, seeks to break further ground with an ambitious system design that will use data radio links to transfer information between trains and the wayside and between the wayside and the dispatching center and that could accommodate the safe movement of unequipped trains intermingled with equipped trains. The NAJPTC Program is funded by a partnership including the AAR, the State of Illinois, and FRA. Union Pacific Railroad and Amtrak are implementing partners. The system supplier team, including Lockheed-Martin and Wabtech, have made significant financial contributions to this project. NDGPS will provide the basic radionavigation capability, supported by inertial guidance and a track database. The project will also demonstrate the feasibility of "flexible block" operations (where trains are separated based on safe braking requirements rather than arbitrary fixed blocks, adding to effective track capacity). This type of architecture is potentially ideal for extension to the national rail network, since it could serve as the center of an array of Intelligent Railroad Systems useful for a variety of safety and business needs. The IDOT project is targeted to yield a system ready for revenue service by the end of this year. FRA is already reviewing the safety issues involved in this system, using the approach described in our proposed rule on Performance Standards for Processor-Based Signal and Train Control Systems.

Three freight railroads are exploring less complex "overlay" systems that are designed to provide safety improvements while also supporting more efficient operations. The farthest advanced in testing is the Communications Based Train Management (CBTM) System on CSX Transportation. CBTM was initially started as a safety-only pilot project in unsignalized territory, and CSX now plans to enhance its functions for possible broader use. Burlington

Northern Santa Fe has not yet announced its specific intentions, but is expected to begin testing of an "overlay" system in the next few months. The Alaska Railroad, using funds provided by the Congress through FRA, is currently working on a multi-stage program leading to PTC.

Second, where do we need to go?

Certainly there are some obvious things we need to do. First, by the end of this year FRA will issue the final rule on Performance Standards for Processor-Based Signal and Train Control Systems. The RSAC PTC Working Group meets next month to review the final agreements that we need to complete the rule, and we are already drafting the final documents with the anticipation that it will be done.

Second, the railroad industry needs to fulfill its commitment as a part of the NAJPTC program to provide standards for interoperability of PTC systems. Railroads now share locomotives extensively, and most of the cost of PTC will be on-board systems. PTC systems do not have to be identical, but they do need to be compatible so that a lead locomotive that starts in Seattle can communicate with, and be responsive to, the train control systems on the wayside all the way to Jacksonville. The railroad industry has experience doing this, and the industry needs to complete this work now.

Third, the railroads and FRA will need to work through a variety of implementation issues to ensure that these systems will be safe and reliable. Communication-based train control will present a new paradigm requiring that we be both flexible and vigilant. More than ever before, we will be asked to assess risks under circumstances of considerable uncertainty. FRA and the industry are working toward development of this capability.

NDGPS

The Subcommittee has asked that we address not only the broad issue of PTC but also the particular issue of PTC's fundamental radionavigation system, which is NDGPS. NDGPS is a program sponsored by FRA and implemented by the United States Coast Guard. This "nationwide" program is intended to fill in the gaps in the Coast Guard's marine navigation program. Supplementing and correcting GPS satellite data, NDGPS provides integrity-monitored positioning with a typical accuracy of one to three meters, depending upon the distance of the receiver from the differential beacon. Currently, over 80 percent of the territory of the contiguous United States has at least single-beacon coverage. The program objective is to provide dual coverage for redundancy so that continuous, failsafe service will be available in support of surface transportation and other needs. In an excellent example of defense-to-civilian conversion, NDGPS utilizes facilities and equipment of the de-commissioned U.S. Air Force Ground Wave Emergency Network system. Various facilities of that network have also been used to upgrade Coast Guard marine navigation beacons.

NDGPS provides assurance of accuracy and prompt warning of any irregularity in GPS positioning data. In PTC applications, NDGPS is augmented by other means of determining position. I want to emphasize that NDGPS is operational and fully provides all of the promised capabilities for PTC and any other surface use by Federal and State agencies and the general public wherever the installations are completed.

Passenger Equipment Safety

As we look back at recent fatal passenger accidents, PTC very likely could have prevented events such as the collisions at Silver Spring, Maryland, and Secaucus, New Jersey, in 1996, and the Metrolink collision at Placentia, California, just last year. But PTC would have done nothing to prevent the derailments of Amtrak trains at Crescent City, Florida, or Kensington, Maryland, both of which involved alignment of track structure. Nor would PTC as currently conceived have helped prevent most of the crashes that occur at highway-rail crossings, such as the fatal crash at Bourbonnais, Illinois (where the initial impact with a loaded highway trailer caused a secondary collision with standing rail equipment). Furthermore, even when PTC is ready for national implementation, it will take time to implement. Importantly, many lesser-magnitude events that did not make headlines could have been worse had it not been for the durability of North American passenger equipment.

So we continue to look at "passive" safety at the same time we work on "active" safety, and we proceed from a strong foundation. In the United States there has been substantial activity in the last ten years to improve the rail passenger safety record by developing and refining Federal crashworthiness standards for passenger trains.

FRA's passenger equipment crashworthiness standards were developed and refined as part of a comprehensive rulemaking on passenger equipment safety over a five-year period, culminating in the issuance of the Passenger Equipment Safety Standards in 1999. FRA's rule was based on extensive research and consultations with the Nation's intercity passenger and commuter railroads, their employees, industry associations, passenger advocate groups, manufacturers, and States. The rule's crashworthiness standards ensure that a passenger train has features that provide at least a minimum level of protection for passengers and crewmembers in the event of a collision or derailment. In addition to crashworthiness standards for conventional- speed passenger equipment, the rule also addresses areas such as fire safety, emergency systems, power brake and mechanical inspections, and high-speed equipment.

FRA standards for Tier I equipment (speeds to 125 mph) closely follow previous industry standards, with modest enhancements designed to move in the direction of optimizing the safety of existing designs, i.e., making them safer without significantly reducing their cost effectiveness. Standards for Tier II equipment (speeds to 150 mph) incorporate crash energy management concepts of the kind in use internationally, both with respect to certain new rail rolling stock and with regard to automobiles.

Concern has been raised that FRA's crashworthiness standards unreasonably restrict the use in the United States of passenger equipment built to European safety standards. FRA standards, like the private industry standards that preceded them, do require a minimum car body buff (compressive) strength of 800,000 pounds, which is almost twice that required under UIC (International Union of Railways) structural standards generally observed in Europe. However, FRA standards are appropriate given the differences between European and U.S. railroad operating environments.

Discussions of which approach is "better" miss the point. The rail systems in Europe and the U.S. have evolved along much different lines, which has led to somewhat different safety strategies and priorities. European railway systems evolved, very often, as highly uniform (within each country), government-owned passenger systems with relatively few freight operations, using relatively small and light equipment. There has been significant government investment in crash avoidance systems (many rail lines have active train control systems), and considerable public investment in eliminating highway-rail grade crossing risks. Furthermore, there is a significantly greater degree of government regulation in Europe. In many countries, railroads are required to maintain government certification, which entails detailed government review and approval of railroad policies, procedures, and standards; this has contributed to a great deal of uniformity and coordination between passenger and freight operations.

By contrast, the U.S. rail system has evolved as a private freight system with a relatively small amount of publicly owned and operated passenger operations. Passenger operations are almost always in a mixed freight and passenger environment. With relatively little government investment, active collision avoidance systems, such as automatic train control, are a rarity.

U.S. railroads generally have many more grade crossings, averaging one per mile of track or one each 45 seconds for a train traveling 79 mph. A majority of these crossings have no active warning devices. Particularly on Amtrak long-distance routes, many crossings do not have automated warning devices; and even where there are automated warning devices, motorist discipline in this country cannot match that found in most European countries. As highway motorists approach grade crossings in Europe, their behavior tends to be less aggressive than that of typical U.S. drivers. The reason for this behavior is grounded in the fact that in Europe most crossings with lights and gates have gates that are substantially more robust than in the U.S. You would not want to attempt to drive through such gates because they are often steel pipes that would not break away in the manner they do in the U.S. Often these gates also extend across the full width of the road (similar but not exactly like what we refer to in this country as "four quad gates"). In addition many crossings have posted signs that instruct the drivers to turn off their automobile engines if stopped at the crossings. Drivers are used to sometimes long delays at crossings, in particular in the vicinity of train stations in urban areas with busy train traffic. Drivers can often be seen bringing out a book and reading after they are stopped at an active crossing. They calmly wait until the lights go off, and the gates go back up (if gates are present); then they restart their cars and move on. Another factor in European drivers' behavior relates to the fact that, although sometimes stoppage times can be excessive, usually the time they are stopped is not excessive due to the fact that most freight trains are far shorter than those in the U.S. and tend to operate at higher average speeds, thus blocking crossings for significantly less amount time. Finally, European countries have extensive enforcement and high fines that help to deter drivers' risky behavior.

Also, for more than 30 years, freight and passenger rail operations in the U.S. have been almost completely segregated among separate companies. Although passenger and freight trains in the U.S. operate *on* the same railroad lines, they are not operated *by* the same railroad companies. There is generally not the same degree of coordination and uniformity between passenger and freight operations as there is in Europe.

European authorities have provided standards that work reasonably well in their operating environment, where they have placed a greater emphasis on very costly crash avoidance systems and strategies. They are now looking toward enhancements that incorporate crash energy management into new equipment as appropriate for the service.

Likewise, on the North American continent we have sought to provide standards that work well in our more rugged environment, where we have always placed a much greater emphasis on crashworthiness. It is interesting to note that, similar to the more widespread

European practice, FRA's Tier II requirements move us in the direction of crash energy management as an important enhancement to our basic standards.

The historical and structural differences between the U.S. and European railroad networks are responsible for significant differences in railroad operating policies and equipment design standards. In the United States, passenger equipment shares the same tracks with very heavy and long freight trains. In the United States, it is common for a road freight train to be pulled by several six-axle locomotives, each locomotive weighing approximately 400,000 pounds, and it is not unusual for a freight train to exceed 10,000 tons (20 million pounds!). In contrast, freight equipment is smaller and lighter in Europe, and–importantly–passenger trains predominate. It is common for a road freight train in Europe to be pulled by only one four-axle locomotive that weighs approximately 260,000 pounds, and European freight cars are also substantially lighter. Existing American passenger equipment is also heavier and stronger than European passenger equipment. FRA's standards are meant to allow passenger equipment to operate safely in this challenging environment.

Further, much U.S. commuter rail service is provided in the push/pull mode over highway-rail crossings, putting a premium on the crashworthiness of cab cars and electric multiple-unit cars (a special focus of FRA's new standards and the American Public Transportation Association's (APTA) companion private standards). Note that large trucks used in the U.S. are also heavier than typical European vehicles; so the highway-rail crossing comparison involves both a higher likelihood of a crash and greater average severity when a crash occurs.

It is important to emphasize that FRA's crashworthiness standards rely to a great extent on historical U. S. rail industry standards that have contributed to the high level of safety at which passenger rail service is provided in our nation. In fact, in recent years the Nation's passenger railroads, through APTA, have adopted crashworthiness standards that are, on the whole, even stricter than FRA's own standards.

Both U.S. and European authorities continue to pursue improvements in crash survivability for rail passenger equipment, and both approaches will proceed from the premise that new equipment needs to be compatible with equipment already in use in the particular service environment.

Concern has also been raised that FRA's crashworthiness standards favor a particular kind of car construction technology. Our philosophy has been to optimize car designs for safety without defeating their purpose, which is to move people from one place to another under conditions that they find acceptable. So it is true to some extent that specific improvements in crashworthiness have focused on known opportunities derived from current design practice. At the same time, however, we have been building analytical tools which will permit us to evaluate, from a performance standpoint, a wide range of equipment types. This will permit us to open the doors for findings of safety equivalency, provided manufacturers are forthcoming with design details and fabrication practices so that performance can be properly evaluated.

Let me stress that even our current standards offer significant flexibility, however. For instance, any kind of car construction technology using any type of structural material can be used to meet FRA's principal crashworthiness standard–the standard for buff strength–as long as the structure can support the required load. Current car designs use a variety of techniques, and international builders have repeatedly advised us that they can provide equipment meeting our standards.

Recognizing that context is critical, FRA has provided for exceptions from our buff strength and other standards where they are appropriate. Within the Passenger Equipment Safety Standards, an exception is provided for a railroad operating on a dedicated right-of-way with compatible equipment. This exception recognizes the needs of the Port Authority Trans-Hudson, which uses heavy rail transit multiple-unit cars to provide commuter service in New York and New Jersey.

FRA has also recognized that equipment built to different structural standards may provide a level of safety equivalent to that provided by FRA's structural requirements. The Passenger Equipment Safety Standards contain a special approval process for railroads to petition to operate equipment built to such alternate structural standards, with the exception of the buff strength standard–for which a waiver would be required (again, because of the need for basic compatibility).

In implementing the new standards, FRA provided for petitions for grandfathering the usage of passenger equipment placed in service up to six months following the issuance of our rule for equipment not meeting the buff strength standard. FRA has authorized the use of five Talgo trainsets under that provision, and Talgo has made modifications to the trainsets to address FRA concerns, without any compromise in performance. Talgo officers have also stated repeatedly that they intend to offer new equipment fully compliant with the buff strength and other requirements for the North American market.

Further, FRA has issued a policy statement concerning the use of tracks of general system railroads to be shared by light rail and conventional rail equipment under conditions such as "temporal separation." This policy statement has been implemented to facilitate several light rail projects where the different types of equipment are separated by time of day. Some would have us go further and permit intermingling of light rail and conventional rail operations. Yet, in studying the successful European experience in Karlsruhe, Germany, with mixed light rail passenger and freight traffic, where the different types of rail equipment share the same tracks at the same time, FRA learned that safety is largely dependent on a rail system with more integration between–and control of–passenger and freight traffic than found in any comparable system in the United States. This includes equipping all trains with automatic train control that operate in the shared use area.

Much of the interest in European equipment centers around the potential of high-speed rail. FRA's standards address safety needs in a mixed passenger-freight environment to 150 mph. FRA has clearly stated that it will proceed with rules of particular applicability where petitioners seek to use lighter equipment to achieve higher speeds on a dedicated, grade-separated right-of-way. Indeed, in 1997, FRA proposed a rule of particular applicability that would have permitted use of French-built high-speed trains on a dedicated right-of-way for the Florida Overland Express project then underway. The promoters ended that project due to lack of funding just as FRA was close to finalizing that rule, but we have indicated to the Florida Department of Transportation and the Florida High Speed Rail Authority that we continue to be available to work with them as they select technology for the current Florida project.

Within the last month, FRA has asked RSAC to assist FRA in making any necessary improvements to our Passenger Train Emergency Preparedness and Passenger Equipment Safety Standards regulations. In any specific rulemaking, members of RSAC nominate individuals to be members of a specific working group tasked with developing recommendations and regulatory drafts related to the assigned subject matter. These recommendations and regulatory drafts are then presented to the full RSAC for consideration and approval. As in any FRA rulemaking, and in addition to the input from RSAC, FRA will continue to solicit public comment and consider all comments received before any rule is made final.

FRA, with the assistance of the Volpe Center, continues to engage in research to develop design strategies for improving rail equipment crashworthiness. A field study is ongoing to better understand the sequence of events during an accident that leads to train occupant injuries and fatalities. As part of this effort, full-scale crash testing of rail equipment is being conducted at the TTC, and advanced computer models of train accidents have been developed. The results of this research have been shared with the industry in an ongoing manner and have been applied by APTA in its crashworthiness standards. FRA anticipates that the results of this research will also be applied by RSAC to improve upon FRA's own crashworthiness standards.

Advances in Locomotive Crashworthiness

FRA is actively addressing the crashworthiness of not only passenger equipment, but also locomotives. RSAC's Locomotive Crashworthiness Working Group is preparing a notice of proposed rulemaking to enhance crash survivability in locomotive cabs. Participants include the freight and passenger railroads, rail labor organizations, and the major locomotive builders.

The proposed rule will set forth performance standards for locomotives and will incorporate by reference an enhanced version of the current AAR "S-580" standard. The Working Group has determined that S-580 has substantially improved the crashworthiness of locomotives built since 1990 and that additional improvements can be made to optimize locomotive designs from the safety standpoint without affecting utility. Research by the Volpe Center for FRA has provided computer modeling to support development of these standards. The attached criteria are examples from this effort, which have been reported to the RSAC as work in progress.

Conclusion

Thank you for allowing me to provide this brief update on the current safety record of the railroad industry and on the complex, technical areas of PTC, NDGPS, and locomotive and rail passenger equipment safety. I look forward to your comments and questions on these important subjects.

Attachments

List of Attachments
to June 10, 2003, Testimony of Jo Strang,
Deputy Associate Administrator for Railroad Development,
Federal Railroad Administration

1. "Technical Paper on Rail Equipment Crashworthiness" by David Tyrell, Senior Engineer, Volpe National Transportation Systems Center, Research and Special Programs Administration, U.S. Department of Transportation

2. "Passenger Death Rates (a) United States 1997-1999"

3. "Positive Train Control (PTC) and Grade Crossing Safety"

4. Criteria for Front End Structure (Collision Posts and Short Hood)

Attachment 2 to Testimony of Jo Strang, Deputy Associate Administrator for Railroad Development, Federal Railroad Administration: (separate page)

Attachment 3 to Testimony of Jo Strang, Deputy Associate Administrator for Railroad Development, Federal Railroad Administration:

Positive Train Control (PTC) and Grade Crossing Safety

The Incremental Train Control System (ITCS) operating in Michigan today uses the data radio link of the PTC system to "call ahead" to grade crossings, assuring first that adequate warning time is provided for motorists despite the higher approach speed of the oncoming passenger trains, and secondly assuring the oncoming train that the crossing warning circuitry is operating properly. The ITCS computer aboard a train permits the train to proceed through the crossing at high speed (presently 90 mph) only if the crossing warning circuitry affirmatively reports back that it is operating properly. Lower speeds are be enforced according to the reported conditions from the crossing, down to "restricted speed," for example, if the crossing warning systems have been in continuous operation more than five minutes before the train is to arrive. This feature is already in daily use and has warned approaching trains of crossing problems on several occasions. Similar features will be implemented in the Illinois demonstration system. Using radio-based PTC in this way avoids the need to greatly extend existing track circuits for each crossing, which would also lower their operating reliability.

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**Attachment 1 to Testimony of Jo Strang,
Deputy Associate Administrator for Railroad Development,
Federal Railroad Administration:**

**Technical Paper on Rail Equipment Crashworthiness Prepared by David Tyrell,
Senior Engineer, Volpe National Transportation Systems Center**

1. Background

The Federal Railroad Administration (FRA) has been working with the Volpe National Transportation System Center (Volpe Center) to conduct research into rail equipment crashworthiness. The approach in conducting this research has been to propose strategies for improved crashworthiness and to apply analytic tools and testing techniques for evaluating the effectiveness of those strategies. The information from this research has been used to develop the crashworthiness requirements for Amtrak's high-speed trainset, to develop the FRA's Passenger Equipment Safety Standards, and to draft revisions and additions to current FRA locomotive crashworthiness regulations and the Association of American Railroads (AAR) standards. This research was also applied to support the FRA in evaluating Amtrak's request to grandfather Talgo equipment for continued use in the Pacific Northwest. Information from the research is currently being used by the American Public Transportation Association (APTA) to develop further and refine industry standards and recommended practices for rail passenger equipment crashworthiness, and will support FRA efforts to make improvements to its passenger equipment safety standards as well.

The principal activities of the research include technical studies, the documentation and dissemination of the results of these studies, and the application of the study results to standards development. Through the APTA and the AAR, the railroads and suppliers are involved in planning and conducting these studies. The results are also presented to these organizations, and are documented in Government reports and in technical papers written for the American Society of Mechanical Engineers (ASME,) the Transportation Research Board (TRB,) and other technical organizations.

2. Role of Research in Developing Crashworthiness Standards

In the late 1980's high-speed passenger train service, with train speeds up to 200 mph (320 kph), was proposed (and subsequently cancelled) for Texas on a triangular route with San Antonio, Houston, and Dallas/Fort Worth at the corners. In the early 1990's Amtrak demonstrated the German ICE and Swedish X2000 trainsets in the Northeast Corridor. In 1989, in response to growing interest in high-speed passenger rail, the FRA initiated a program of research into the safety aspects of high-speed passenger train systems. Collision safety–the balancing of collision avoidance measures of the system with the crashworthiness features of the train–was part of this program of research. One of the first results of this research was a risk-based approach for assessing collision safety. This approach was used to develop the crashworthiness specifications for Amtrak's high-speed trainset, which is now in service in the Northeast Corridor. Additional studies of alternative crashworthiness approaches and occupant protection measures were also carried out to support the development of the high-speed trainset crashworthiness specifications.

The scope of the crashworthiness research was later broadened to include intercity and commuter rail passenger trains operated at speeds less than 125 mph (200 kph). In 1996, a Rail Equipment Crashworthiness Symposium was held at the Volpe Center, with sessions on collision risk, structural crashworthiness, and occupant protection. Researchers from England and France made presentations, as did researchers from the U.S. This Symposium supported the development of FRA's Passenger Equipment Safety Standards. A number of other studies on occupant protection and structural crashworthiness were also carried out in support of this rulemaking effort.

The results of the research on rail equipment crashworthiness were made available to APTA for development of its Manual of Standards and Recommended Practices, by allowing ex officio representation of FRA and the Volpe Center on the APTA Passenger Rail Equipment Safety Standard (PRESS) Construction/Structural Subcommittee and by conducting several studies requested by APTA. The research shared includes studies of dynamic sled testing of selected interior configurations and full-scale impact tests to evaluate the effectiveness of proposed APTA standards for corner posts.

As part of this research, simulation models of locomotive collisions were developed and used to evaluate the potential effectiveness of structural design modifications, helping to provide technical information for a report to Congress on locomotive cab safety and working conditions, published in 1996. The Locomotive Crashworthiness Working Group of the Railroad Safety Advisory Committee (RSAC), formed in 1998, is currently developing recommendations on locomotive crashworthiness. The information developed for the report to Congress, as well as the results of efforts conducted specifically to support the RSAC Locomotive Crashworthiness Working Group, have been used by the Working Group to draft recommendations.

Research studies on passenger equipment crashworthiness are being carried out to develop the base of information required for taking the next step in passenger equipment safety rulemaking.

Ongoing research into rail equipment crashworthiness ranges from field investigations of the causes of occupant injury and fatality in train accidents, to full-scale testing of existing and modified designs under conditions intended to approximate accident conditions, to investigations of the fundamental mechanics of structural crush.

3. Technical Studies

The overall objective of the rail equipment crashworthiness research is to develop design strategies with improved crashworthiness over existing designs. The rail equipment crashworthiness research strategy is as follows:

1. Define the occupant protection scenarios. For developing crashworthiness, the occupant protection scenarios are the conditions to be survived, if possible. These protection scenarios include the primary accident–a collision or derailment–and the secondary collision–the interaction of the occupant with the interior of the vehicle.
2. Develop information on the features of existing designs that influence crashworthiness. Information on the design details of the equipment–both for the carbody and for the interior arrangement–is developed for use in analytic models and in the fabrication of test articles. Information developed from accidents includes the damage to the carbodies, such as structural failure, and forensic evidence, such as blood, in the interior.

3. Develop options for alternative designs. In some instances, potentially effective changes in either the carbody structure or the interior arrangement can be directly inferred from accident consequences. In other instances, extensive analysis is required to determine potentially effective crashworthiness strategies.

4. Determine the effectiveness of equipment of existing design and alternative design. Post-accident results can show how effective the equipment was in preserving the survival space for the occupants and in maintaining the forces and decelerations imparted to the occupants to survivable levels. There are typically gaps and uncertainties in the information available from accidents; for example, the precise impact speed and initial conditions at impact are rarely, if ever, known in an accident. Analyses and tests are used to fill in the gaps of information available from accidents. Analytic models and tests, similar to those developed and conducted for conventional equipment, are used to evaluate the effectiveness of alternative designs.

5. Compare the crashworthiness of alternative designs with existing designs. For a given occupant protection scenario, comparisons are typically made either in terms of the maximum primary collision speed for which everyone would be expected to survive, or, to support a benefit/cost analysis, in terms of fatalities and injuries as a function of collision speed.

3.1 Protection Scenarios

Passenger train accidents can occur under a wide range of circumstances, but those that can be mitigated by crashworthiness features of the train can be placed into three broad categories:

collisions with another train,

collisions with objects, such as a grade crossing collision, and

single train events, such as a derailment

Further classifications can be made within each of these categories. For example, significant differences may be expected for a locomotive-led train colliding with another locomotive-led train than for a locomotive-led train colliding with a cab car-led train. Track route alignment can also significantly influence the consequences of a collision; the consequences of a head-on collision on tangent track may be expected to be significantly different from an oblique collision at a switch. Similarly, the consequences of a grade crossing collision with a heavy highway truck are significantly different from a grade crossing collision with an automobile. For all accident types, the collision speed can also profoundly influence the consequences of the collision. Placing the accidents into categories allows calculation of the likelihood of occurrence for each collision category as well as the development of strategies for protecting the occupants in each collision category.

Of particular concern are collisions involving cab cars as one or both of the impacting cars. In comparison to locomotives, cab cars are exposed to more risk in collisions. The presence of passengers, the cab car being of lighter weight and weaker strength than the locomotive, and the cab operator being placed at the extreme end of the car, with essentially no structure ahead of him or her, render the car vulnerable. Cab cars are used in all commuter operations in the U.S., either in push-pull operation with a locomotive pushing or in multiple-unit operation, where most of the cars are self-powered.

Some accidents happen under such circumstances–for instance at such great speed--that it is a practical impossibility to survive such collisions. Very high speed collisions require the use of buffer cars or other measures which may not be considered practical.

3.2 Ongoing Efforts

3.2.1 Field Study of Occupant Injury

The FRA, with the cooperation of the National Transportation Safety Board (NTSB), is conducting a field study of occupant injury during train collisions. The objectives of this study are to determine:

- the range of severity of the injuries that occur in train collisions and derailments,
- the types of injuries that occur,
- where these injuries occur on the train, and
- the causal mechanisms for these injuries.

The results of this study will be used to focus the research efforts on occupant protection and to provide information for benefit/cost analyses of potential occupant protection measures. As part of the study, detailed observations are made of the train interior locations where injuries have occurred, and interviews are conducted with accident survivors and medical personnel treating the survivors. Observation of the train interior, with its associated forensic evidence, allows development of the causal mechanisms for casualties.

Six accidents have been investigated as part of this study:

- a passenger train derailment in Lake City, South Carolina on August 21, 2000,
- a passenger train collision with a freight train in Syracuse, New York on February 5, 2001,
- a passenger train derailment in Nodaway, Iowa on March 17, 2001,
- a passenger train derailment in Crescent City, Florida on April 18, 2002,

a passenger train collision with a freight train in Placentia, California on April 23, 2002, and

a passenger train derailment in Kensington, Maryland, July 29, 2002.

Three more accidents will be investigated as part of this study.

3.2.2 Full-scale Testing of Passenger Equipment

Two series of tests have been planned: one based on a head-on collision scenario, in which a cab car-led train collides with a locomotive-led train, and the second based on a grade-crossing collision scenario, in which a cab car-led train collides with a tractor trailer carrying a coil of sheet steel. Conventional and alternative designs are to be tested in both series of test.

The conditions and the sequence of the tests are listed in Table 1. The overall objective of these tests is to demonstrate the effectiveness of improved-crashworthiness design equipment. The first series of four tests defines the crashworthiness of conventional-design equipment in the in-line and grade-crossing collision scenarios. The performance of improved-crashworthiness design equipment will be measured in the second series of four tests. This arrangement of the tests allows comparison of the conventional-design equipment performance with the performance of improved-crashworthiness design equipment. The in-line collision tests are intended to measure the crashworthiness of a single car, then the interactions of two such cars when coupled, and finally the behavior of complete trains, including the interactions of the colliding cars. As part of these tests, interior configurations with forward-facing unrestrained, forward-facing restrained, and rear-facing unrestrained test dummies are being used to measure potential occupant dynamics during a train collision. The grade-crossing collision tests are intended to measure the effectiveness of the car end structure in preventing intrusion during a grade-crossing collision.

Table 1. Sequence of Full-scale Passenger-Equipment Impact Tests

Test Conditions	Conventional-Design Equipment	Improved-Crashworthiness Design Equipment
Single-car impact with fixed barrier	November 16, 1999	September 2003
Two-coupled-car impact with fixed barrier	April 4, 2000	September 2003
Cab car-led train impact with locomotive-led train	January 31, 2002	November 2004
Single-car impact with steel coil	June 4, 2002	June 7, 2002

To date, the first three in-line tests for existing-design equipment and the two grade-crossing tests have been conducted. The single car test and two-car test of improved-crashworthiness design equipment, incorporating crushable end structures, are planned for September 2003.

The results of the grade-crossing tests demonstrate that improved-design corner posts are effective. The conventional design did not withstand the impact of the heavy object, and the coil eliminated the operator's volume and nearly intruded into the passenger compartment. In contrast, the improved-crashworthiness design withstood the impact of the heavy object under similar collision conditions.

The results of the in-line tests of conventional equipment show that the crush is focused on the impacting cab car. Consequently, there is a substantial loss of occupant volume. Computer simulation results show that for the improved-crashworthiness design equipment, there is no loss of volume for the passengers. There is potentially a loss of volume for the operator. However, means of protecting the operator, such as an operator's cage that is pushed back into a utility closet in the event of a collision, are being investigated.

While the principal objective of these tests is to determine effective strategies for improved structural crashworthiness and improved occupant protection, a secondary objective is to validate and improve the computer models that have been developed as part of the rail vehicle crashworthiness research. As part of the planning of these tests, detailed computer simulations are performed prior to the tests. The results of the simulations are used to determine the impact speed as well as other details of the test such as accelerometer size and location. After the test, the simulation results are compared with the test measurement, and the analyses are refined as necessary. After the first test, the test measurements indicated that the simulation captured the underlying mechanics of the response of the car structure during the test, but that a number of refinements could be made to the simulation. After the most recent test, there was very close agreement between the pre-test simulation results and the test measurements, so that no refinements were made of the simulation.

3.2.3 Other Selected Studies

In addition to the field study of occupant injury and the full-scale tests and associated analyses, a number of other efforts are currently underway. Crush zone designs are being developed for the full-scale in-line tests of improved-crashworthiness design equipment. This development has included destructive substructure tests. Previous efforts included the development of a two-position intercity passenger seat design incorporating seatbelts; there is an ongoing effort to develop a three-position commuter seat design incorporating seatbelts. Efforts are underway to simulate the casualties seen in the field study; these simulations will be used to evaluate the potential effectiveness of alternative occupant protection strategies. An effort is underway to advance the state of the art in analyzing material failure. Because rail equipment is manufactured with higher-strength steels and crush distances can easily exceed three feet in a collision, accurate characterization of material failure is required to predict the mode of crush and the force/crush characteristic for rail equipment.

3.3 Support from Researchers in Other Modes

Both the National Highway Transportation Safety Administration (NHTSA) and the Federal Aviation Administration (FAA) have provided assistance to the rail equipment crashworthiness research. The FAA made available all the results of its research on aircraft crashworthiness and discussions have been held on alternative approaches to analyzing and testing impacts. In particular, the results of FAA research were helpful in formulating the technical basis for the following sections of the Passenger Equipment Safety Standards: 49 CFR § 238.233, "Interior fittings and surfaces," and 49 CFR § 238.435, "Interior fittings and surfaces." Similarly, the NHTSA has made the results of its research available, and has also been helpful by loaning test equipment. Instrumented test dummies have been borrowed from NHTSA for dynamic sled testing of interior configurations as well as for use in full-scale impact tests.

3.4 Interactions with Foreign Researchers

The FRA's research into rail equipment crashworthiness has made use of the results of European and Asian research, and the FRA has reciprocated by making the results of its research available to European and Asian researchers. In 1996, at the start of the effort to develop the FRA's Passenger Equipment Safety Standards, a symposium on rail equipment crashworthiness research was held at the Volpe Center, where researchers from France and England presented their results. Discussions have been most active with counterparts in the United Kingdom recently. Several researchers from the UK traveled to the Volpe Center in September 2002 and May 2003 to learn the latest results of the FRA's crashworthiness research. Representatives from the US visited the UK in March 2003 to learn the latest results of the UK research. Results from the FRA's crashworthiness research have regularly been presented at the International Symposium on Passive Safety of Rail Vehicles, held annually in Europe.

3.5 Documentation of Technical Study Results

The results of the rail equipment crashworthiness research have been documented as the research has been conducted. For example, the results of the studies conducted in support of the specification for Amtrak's high-speed trainset were documented in one Government report and three technical papers. This documentation helped form the basis for the FRA's current high-speed passenger train crashworthiness regulations and for conventional-speed passenger train occupant protection regulations. In all, more than 50 Government reports and technical papers resulting from the rail equipment crashworthiness research have been published since 1998. The principal purpose in documenting the research is to assure that the latest technical information is available to all of the parties involved in development of regulations and standards.

4. Interactions with the Industry

Interactions with the industry occur during regulation and standards development, but also during workshops conducted by the FRA, presentation of the results of the research at conferences held by technical societies, and through direct interactions between FRA and Volpe staff and the staffs of the railroads and suppliers. The FRA, in conjunction with the FTA, has periodically conducted Research Needs Workshops. The results of the research and plans for future research have been discussed at these workshops.

Both the in-line and grade-crossing full-scale tests have been conducted in close coordination with the Construction/Structural Subcommittee of APTA's PRESS Committee. This coordination includes development of the overall test approach, review of the details of the test implementation and presentation of the test results.

The industry has supported this research and has donated a substantial amount of equipment. Amtrak has donated two retired locomotives, which have been used in the full-scale impact tests. Both the Long Island Rail Road and the South East Pennsylvania Transportation Authority have donated retired passenger equipment, which has also been used in the full-scale tests. General Motors/ElectroMotive Division, General Electric Transportation Systems, and Bombardier have provided design drawings. Information from these drawings has been used as input to the computer simulation models. The AAR and APTA have been very effective in organizing the support from the industry.

5. Closing

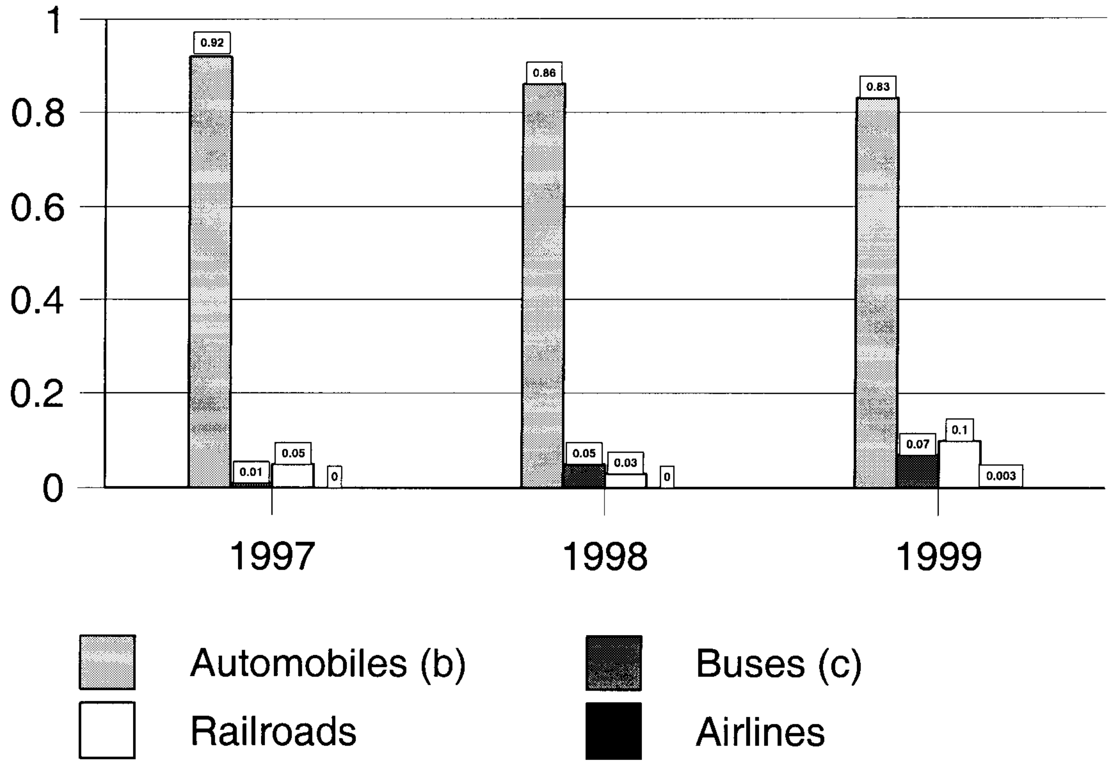
The application of modern engineering has allowed considerable changes to rail equipment crashworthiness practice, which, until recently, had remained substantially unchanged for nearly 50 years. Modern computers and computer-aided engineering tools have allowed the evaluation of the effectiveness of concepts proposed to increase rail equipment crashworthiness and the development of potentially effective concepts. Destructive testing for such concepts, as is commonly done in the automotive industry, is expensive for rail equipment, which can cost up to

$2 million per car. These engineering tools have reduced the need for testing, and have also increased the utility of more economical testing such as component and substructure tests. While significant advances have been made to date, there are continued opportunities for application of modern engineering tools for increased rail equipment crashworthiness. A bibliography of reports and papers on rail equipment collision safety research by FRA during the period March 1993 through May 2003 is available upon request.

Attachment 2 to Testimony of Jo Strang, Federal Railroad Administration

PASSENGER DEATH RATES (a)

United States 1997-1999



(a) Deaths per 100 million passenger miles.

(b) Drivers of passenger automobiles are considered passengers.

(c) Figures do not include school buses.

Source: National Safety Council, *Injury Facts, 2001 Edition.*

Attachment

The following criteria are examples from the effort by the RSAC Locomotive Crashworthiness Working Group, which have been reported to the RSAC as work in progress:

(a) Front end structure (collision posts).

(1) *Objective.* The front end structure of the locomotive must withstand a frontal impact with a proxy object which is intended to simulate lading carried by a heavy highway vehicle (see figure 1).

(2) *Proxy object characteristics and orientation.* The proxy object must have the following characteristics: cylindrical shape; 48-inch diameter; 126 inches in length; 65,000 pounds in weight; and uniform density. The longitudinal axis of the proxy object must be oriented perpendicular to the longitudinal axis of the locomotive.

(3) *Impact and result.* The front end structure of the locomotive must withstand a 30-mph impact resulting in no more than 24 inches of crush along the longitudinal axis of the locomotive, measured from the foremost point on the collision post. The center of impact must be 30 inches above the top of the locomotive underframe along the longitudinal centerline of the locomotive.

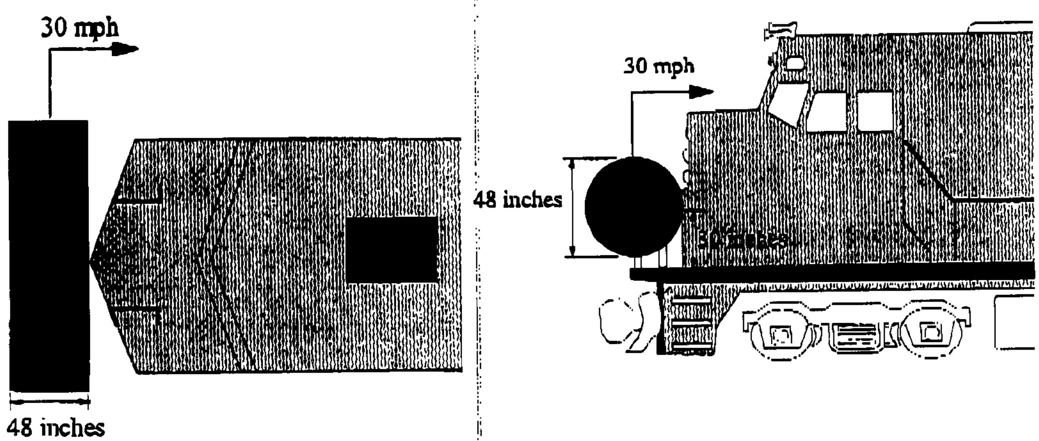


Figure 1. Schematic of Front End Structure (Collision Posts) Impact

(b) Front end structure (short hood).

(1) *Objective.* The front end structure of the locomotive must withstand an oblique impact with a proxy object intended to simulate an intermodal container offset from a freight car on an adjacent parallel track (see figure 2).

(2) *Proxy object characteristics and orientation.* The proxy object must have the following characteristics: block shape; 36-inch width; 60-inch height; 108 inches in length; corners having 3-inch radii; 65,000 pounds in weight; and uniform density. The longitudinal axis of the proxy object must be oriented parallel to the longitudinal axis of the locomotive. At impact, the proxy object must be oriented such that there is 12 inches of lateral overlap and 30

inches from the bottom of the proxy object to the top of the locomotive underframe.

(3) *Impact and results*. The front end structure of the locomotive must withstand impact at 30 mph with no more than 60 inches of crush along the longitudinal axis of the locomotive, measured from the first point of contact on the short hood.

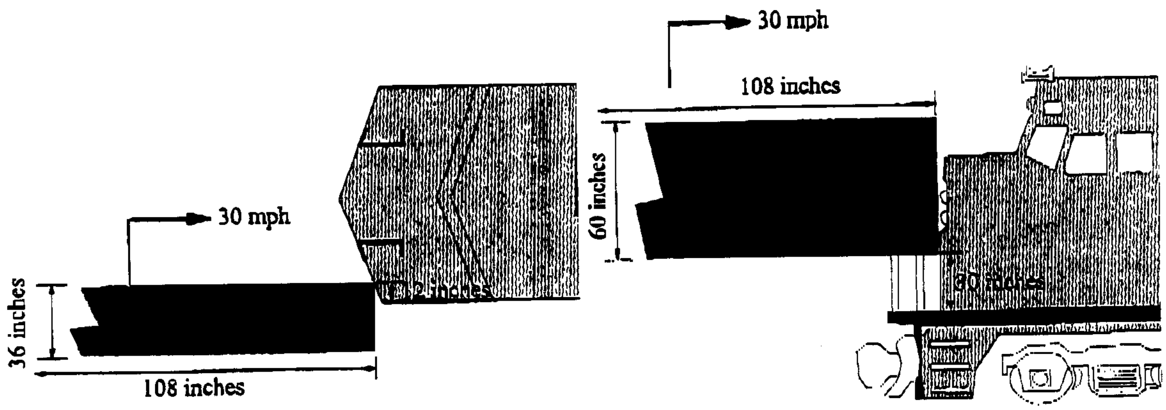


Figure 2. Schematic of Front End Structure (Short Hood) Offset Impact