National Transportation Safety Board

Lessons Learned and Lives Saved

Transportation safety improvements from the National Transportation Safety Board, an independent agency whose mission saves lives via accident investigations, safety recommendations, and advocacy.

AirVenture Oshkosh
2006 Edition

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NTSB/SR-06/01
PB2006-917002

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We Are All Safer

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National Transportation Safety Board. 2006. *We Are All Safer: Lessons Learned and Lives Saved, AirVenture Oshkosh 2006 Edition. 4th ed.* Safety Report/SR-06/01. Washington D.C.

Abstract: This report highlights some of the thousands of transportation safety improvements that have resulted from NTSB accident investigations and recommendations. Accidents have been prevented, lives saved and injuries reduced because of NTSB-inspired safety advances in all modes of transportation: aviation, highway, marine, railroad and pipeline. This reports also gives a brief history of the Safety Board, its responsibilities, and the legislation that created it, that strengthened its independence, and that has expanded its safety role over the years. This report includes information on the "Most Wanted List." The list focuses n additional safety advances the Safety Board strongly believes are needed to further increase transportation safety.

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NTSB safety recommendations have prevented numerous accidents and saved countless lives.

Mark V. Rosenker

Dear Fellow Aviation Enthusiasts:

The National Transportation Safety Board welcomes you to our exhibit at the Experimental Aircraft Association's AirVenture Oshkosh 2006. We thank you for your commitment to safety and urge you to continue to be vigilant.

I hope you can take the time to read this publication. It contains many significant safety accomplishments in aviation and other modes of transportation—highway, rail, marine, and pipeline. These are the positive actions taken as a result of NTSB safety recommendations. We have been successful, we believe, because of the NTSB's independence, and the professional and thorough analyses that result in accident reports that are recognized worldwide for their objectivity and credibility.

But we can do even better. We encourage pilots with all levels of experience to *be alert* to dangers of even the smallest amounts of ice on upper wing surfaces, *pay attention* to other aircraft and vehicles on airport runways—especially at uncontrolled airports—and always *be rested and ready* for your flights.

I also urge you to check out the Most Wanted list section of this publication. In addition to your commitment to a safe general aviation environment, we ask you to support the NTSB's efforts to make the nation's aviation system even safer for passengers and crews by:

- Reducing dangers to aircraft flying in icing conditions.
- Eliminating flammable fuel/air vapors on fuel tanks in transport category aircraft.
- Stopping runway incursions and ground collisions of aircraft.

- Improving audio and data recorders and requiring video recorders on passenger aircraft.

- Requiring restraint systems for children under age 2 on passenger aircraft.

- Eliminating the dangers of human fatigue by using scientific data to set rest and duty hours for flight crews and aviation safety personnel.

Since the NTSB was launched in 1967, we have issued more than 12,480 safety recommendations; with more than an 82 percent acceptance rate. More than 4,600 of those recommendations, or about 37 percent, have dealt with aviation safety issues. Over the years they have prevented numerous accidents and saved countless lives, not only in aviation but also in all other modes of transportation.

The Safety Board wants to make sure that we all remember the lessons learned from past accidents, and never repeat them.

Mark V. Rosenker
Acting Chairman

National Transportation Safety Board

July 2006

On call 24 hours a day, 365 days a year, the NTSB investigates hundreds of accidents a year including these: a fire aboard a small passenger vessel in Port Richey, Florida in 2004 (top), and an airport runway overrun accident in Chicago that claimed one life in 2005.

Federal Law Gives Safety Board a Unique Mandate

Since 1967, a series of Federal laws created and shaped the National Transportation Safety Board into an organization that uses an aggressive approach to prevent and reduce the severity of future transportation accidents. It independently addresses real-world safety problems, allows full government and industry participation in its investigations, issues safety recommendations and works hard to get them implemented, and disseminates its reports and findings to as wide an audience as possible.

The Safety Board also provides oversight of transportation regulatory agencies, and is the eyes and ears of millions of Americans traveling through our nation's skies; traveling on our roads, rails, and waterways each day; and living and working near pipelines. The Safety Board does not regulate transportation equipment, personnel, or operations, and it does not initiate enforcement action.

Lean Independent Agency

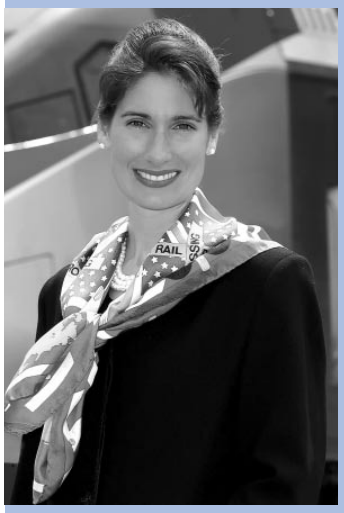
The Safety Board has investigated more than 120,000 aviation accidents and over 10,000 surface transportation accidents—becoming the world's premier transportation accident investigation agency. On call 24 hours a day, 365 days a year, investigators travel throughout the country and to every corner of the world to investigate significant accidents and develop factual records and safety recommendations. As a small and lean organization with only about 400 employees, the Safety Board reacts quickly to changes in the transportation environment. The Safety Board strives to restore and maintain the public's confidence in the safety of the nation's transportation systems following accidents and serious incidents in aviation, rail, highway, marine, pipeline, and hazardous materials.

Aggressive Safety Mission

The Safety Board gets involved when there is a breakdown in a transportation system such as an accident or serious incident. It investigates these events, determining the probable cause, and makes recommendations to prevent them from happening again. It takes the "lessons learned" from real-world accidents and uses them as catalysts to prevent future transportation deaths, injuries, and property damage. In addition to individual accident investigations, the Safety Board often consolidates a series of accident and incident investigations on specific safety issues and publishes safety studies or sponsors industry conferences and workshops on recurring safety issues such as human fatigue, corporate safety culture, and transportation recording devices. These studies often spur action by industry and government agencies to improve safety. This proactive focus, along with the agency's authority, independence, objectivity, technical competence, and worldwide reputation, has been the cornerstone of the Safety Board's success.

In 2003, the NTSB Academy opened its door as the agency's first comprehensive training and learning facility. The Academy trains and teaches its own employees and transportation industry personnel from throughout the United States and the world. It designs its courses to further the Academy's motto: "Independence, integrity, and innovation in transportation accident investigation."

"The NTSB enjoys broad bipartisan support because of our independence, the quality and dedication of our staff and the significant contributions we have made to transportation safety in the United States and around the world."



Deborah A. P. Hersman, Member

"Over the years, important responsibilities have been added to the NTSB's mission of accident investigation. This year marks the 10th anniversary of legislation that gave us the lead in coordinating assistance for families of the victims of major aviation accidents. Since then, our efforts have led us to provide assistance in all modes of transportation when called upon. Our Transportation Disaster Assistance program is now the model used by other federal agencies, the transportation community, the non-profit sector and other accident and disaster assistance agencies worldwide."

Kathryn O'Leary Higgins, Member

Safety recommendations have three straightforward goals: to prevent accidents, to save lives, and to reduce injuries.

Public Trust

The public relies on and trusts the information provided by the Safety Board, whose work results in widely disseminated public documents so that the lessons learned from one accident or incident can be used to prevent future tragedies. During investigations, the Safety Board regularly provides factual briefings to the media and families of victims to ensure that accurate information is provided to the public in a timely and informative manner. This tradition of openness and independence has gained the trust of the American people.

Independent and Unbiased

The Safety Board provides independent oversight of the nation's transportation system by monitoring the effectiveness of regulatory bodies at the Federal, State, and local levels. These investigations help regulatory organizations recognize and acknowledge when their safety regulations or programs are ineffective and improve them, sometimes after repeated accidents. The public has consistently shown strong support for the Safety Board's independent, unbiased assessment of the cause of accidents and needed safety improvements.

Recommendations: Implementation is Key

Since the Safety Board began its work, more than 12,480 safety recommendations have been issued with three straightforward goals: to prevent accidents, to save lives, and to reduce injuries. Safety Recommendations are the primary tool used by the Safety Board to pursue safety improvements and prevent future accidents. Its reputation for careful and deliberate examination of the facts and circumstances, impartiality, technical competence, and thoroughness has enabled the Safety Board to achieve an 82-percent-plus acceptance rate on recommendations. Contributing to this high success rate is the practice of including industry and regulatory agencies as participants in the investigation. This practice quickly alerts these entities to accident findings, and they are more amenable to recommended changes because of their participation on the technical investigative team. The Safety Board believes that every one of its recommendations is important, and when implemented, all of them will improve safety.

The Safety Board also has a "Most Wanted List"—a series of safety recommendations selected for intensive follow-up and heightened awareness because they will impact or enhance the safety of the national transportation system, have a high level of public visibility or interest, and are recommendations that would benefit from more attention. A major change was instituted in 2003 to the list: a new classification and timeliness system using red, yellow, and green color-coding. Red indicates that action in the issue area is unacceptable. Yellow is assigned to those issues with an acceptable overall status, but where implementation is progressing slowly. Green indicates acceptable status and timely progression.

Leveraging Resources

The Safety Board has a long history of partnering with industry and other agencies to accomplish its mission. It multiplies its resources several times over by allowing technical experts from industry and other government entities to assist us in our accident investigations. This "party system" enables operators, manufacturers, labor organizations, and regulators full participation in the fact-finding phase of accident investigations. Parties do not participate in the Safety Board's analysis. In addition, the Safety Board further leverages its resources by inviting corporate executives, safety officers, and experts from industry and academia to symposia and workshops on safety topics that often affect the whole industry.

Statutory Authority

Congress has charged the Safety Board with investigating every civil aviation accident in the United States and significant accidents in the other modes of transportation—railroad, highway, marine, and pipeline—and issuing safety recommendations aimed at preventing future accidents. The rules are spelled out in Chapter VIII, Title 49 of the *Code of Federal Regulations*.

Through a series of laws since the 1960s, Congress has mandated the Safety Board's independence and expanded its safety and disaster assistance responsibilities.

Under these mandates, the Safety Board determines the probable cause of all U.S. civil aviation accidents and certain public-use aircraft accidents; selected railroad, highway, marine, and pipeline accidents; and releases of hazardous materials in all forms of transportation. The Safety Board is responsible for maintaining the government's database of U.S. civil aviation accidents and provides investigators to serve as U.S. Accredited Representatives as specified in international treaties for aviation accidents overseas involving U.S.-registered aircraft, or involving aircraft or major components of U.S. manufacture.

The Safety Board opened its doors on April 1, 1967. Although independent, it relied on the U.S. Department of Transportation (DOT) for funding and administrative support. On April 1, 1975, under the Independent Safety Board Act, all organizational ties to DOT were severed. The Safety Board is not part of DOT, or affiliated with any of its modal agencies.

In 1996, the President and the Congress gave the Safety Board the additional responsibility of coordinating the Federal effort for the families of the victims of major aviation accidents. The Board has a Transportation Disaster Assistance staff that has implemented a family assistance plan and reviews air carriers' family assistance plans. In 1997, legislation was enacted to extend the Family Assistance Act to foreign carriers flying into and out of the United States. Following the Safety Board's lead, many other countries are establishing similar policies and procedures for improving how families will be treated following a transportation accident.

The Safety Board and the Law

Laws enacted by Congress give the Safety Board the mandate to determine the probable cause of the following:

NTSB investigators are on call 24 hours a day, 365 days a year and travel to accident sites in the United States and throughout the world.

- All U.S. civil aviation accidents and certain public-use aircraft accidents
- Selected highway accidents
- Railroad accidents involving passenger trains or any train accident that results in at least one fatality or in major property damage
- Major marine accidents and marine accidents involving a public and a nonpublic vessel
- Pipeline accidents involving a fatality, substantial property damage, or significant injury to the environment
- Releases of hazardous materials in all forms of transportation
- Selected transportation accidents that involve problems of a recurring nature

These laws also give the Safety Board the authority to do the following:

- Conduct special studies on safety problems
- Maintain official U.S. census of aviation accidents
- Evaluate the effectiveness of government agencies involved in transportation safety
- Evaluate the safeguards used in the transportation of hazardous materials
- Review appeals from airmen and merchant seamen whose certificates have been revoked or suspended
- Review appeals from airmen, mechanics, and repairmen who have been assessed penalties by the FAA
- Lead U.S. teams on foreign airline accident investigations to assist foreign authorities under provisions of the International Civil Aviation Organization agreements
- Evaluate the effectiveness of emergency responses to hazardous materials accidents
- Coordinate Federal support services for functions of victims of major transportation accidents

NTSB-Inspired Safety Advances

Since the National Transportation Safety Board gained its total independence from the U.S. Department of Transportation in 1975, thousands of safety improvements have been inspired by Safety Board recommendations.

Many of the advances have had a major impact on transportation safety, and all of them—big and small—have saved lives. They range from improving communications among aircraft, rail, and ship crews, to complete redesigns of structural and electronic systems, to envisioning new technologies and seeing them through until they become standard equipment on transportation vehicles.

Presented here are some examples of those improvements—some from a single recommendation and others the result of numerous recommendations. Many examples include information and lessons learned from specific accidents and incidents that inspired Safety Board investigators to push for changes.

Aircraft Icing Prevention

Education and training. A major information and training campaign by NASA and the Federal Aviation Administration educates aircraft manufacturers, operators, and pilots of air carriers and general aviation propeller-driven aircraft to the hazards of thin and often imperceptible rough ice accumulations; the importance of activating deicing devices; and the need to maintain minimum speeds in icing conditions.

The Safety Board's investigation report of a Comair Embraer-120 that crashed in Monroe, Michigan, in 1997 pointed to a lack of requirements to maintain adequate minimum airspeeds in icing conditions. Control of the aircraft was lost, the Safety Board said, when the airplane accumulated a thin, rough accretion of ice.

Modifications to aircraft. Modifications were made to Jetstream 31 airplanes to prevent early aerodynamic stall due to ice accretion, and expanded deicing boots were installed on the wings of the ATR-42 and -72 regional aircraft.

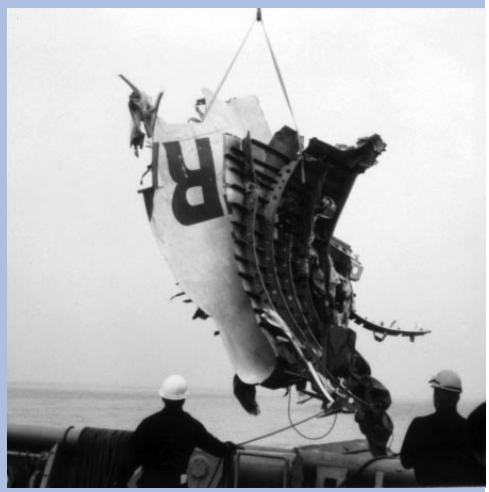
The improvements were made following a fatal accident involving a United Express Jetstream 31 at Pasco, Washington, in 1989, a nonfatal USAir Express Jetstream 31 accident at Beckley, West Virginia, in 1991, and the 1994 crash of an American Eagle ATR-72 in Roselawn, Indiana. Safety Board investigations revealed that ice buildup during certain phases of flight caused subsequent loss of roll control of the airplane.

On-board detection. Deicing and anti-icing requirements for major air carriers and commuters have been significantly upgraded, and the Federal Aviation Administration and the aviation industry have developed on-board ice detection systems capable of alerting crews when an aircraft encounters freezing drizzle and freezing rain—types of previously under-researched and dangerous precipitation.

A series of icing-related accidents, investigated by the Safety Board, resulted in a wide range of icing-prevention improvements. Icing

Aircraft wreckage is strewn across a field in Roselawn, Indiana, after the 1994 crash of an ATR-72. NTSB's investigation led to upgrades in the aircraft's deicing design.

The 1982 crash of a 737 in the Potomac River claimed 78 lives. It was one of several major accidents that focused attention on the need for icing technology and deicing equipment improvements.



A fuel-air vapor explosion in the center wing tank of a 747 brought down the plane in 1996, killing all 230 on board.

was a major factor in the 1994 American Eagle ATR-72 crash in Indiana that claimed the lives of all 68 onboard, a USAir Fokker F-28 crash at LaGuardia Airport in 1992 that killed 27 people, and the 1997 Comair EMB-120 crash that killed 29 people.

An earlier accident was the 1982 crash of an Air Florida 737 in Washington, D.C., killing 69 of the 74 passengers and crew and 4 motorists on the bridge. The Safety Board said ice buildup on the wings and engine pressure probes, a long period between deicing, and limited crew experience in winter weather conditions led to the accident.

Airplane Maintenance and Inspection

Gas turbine disks. More frequent eddy current inspections of disks in gas-turbine engines were mandated along with new service bulletins to inspectors and airline engine repair technicians outlining inspection procedures and specific repair tools and techniques to be used on high-rotating components.

A series of non-fatal incidents alerted the Safety Board. In one incident, an engine failure and fire occurred while mechanics were repairing and testing an engine on a US Airways 767 in Philadelphia. Similar incidents that were investigated involved engines on Thai Airways and Gulf Air aircraft, and an uncontained engine failure on a Varig Brasil Airlines 767 in Sao Paulo, Brazil, in June 2000.

Fire protection. Airlines operating MD-80, MD-90, and DC-9 series airplanes are required to inspect primary and alternate static port heaters for evidence of electrical arcing or thermal damage and to replace damaged heaters.

In 1999, a Delta Air Lines MD-88 experienced a fire in the forward cargo compartment, traced to a static port heater, shortly after takeoff from Northern Kentucky International Airport.

Fuel tank hazards. Major advances have been made by the industry and the Federal Aviation Administration in evaluating and researching the hazards posed by fuel vapor when it reaches elevated temperatures in fuel tanks, flammability and ignition energies of Jet A fuels, shortcomings in fuel tank electrostatic and lightning protection, and electrical surge protection for fuel quantity indication systems. Improvements have also been made to fuel pumps and fuel tank wiring.

In 1996, a TWA 747 experienced an in-flight explosion of its center wing fuel tank near East Moriches, New York, shortly after takeoff from JFK International Airport, New York. All 230 on board died.

Landing gear upgrades. Improvements have been made to large aircraft landing gear design, inspection techniques, and maintenance procedures.

Several changes resulted from investigations in the U.S and abroad. One was in 1993, when a USAir Fokker F-28 experienced a collapsed main landing gear during landing at the Pittsburgh, Pennsylvania,

airport. The Safety Board's investigation discovered improper assembly of the main landing gear torque link, and shimmy damper assembly, as well as shortcomings in the maintenance procedures and manual.

Parts lubrication. Lubricant applications procedures, used for critical aircraft systems, have been tightened. Airlines are required to give the Federal Aviation Administration performance results and test data to make sure that any changes in lubricants or their use does not pose a potential hazard. Principal inspectors and aircraft certification offices must grant approval.

These changes stem from the crash of an Alaska Airlines MD-83 into the Pacific Ocean off the coast of California in 2000, killing all 88 on board. The Safety Board said the accident was the result of an in-flight failure of the nut threads on the jackscrew assembly for the horizontal stabilizer trim system. The failure was caused by excessive wear because of the airline's insufficient lubrication of the jackscrew assembly, its extended lubrication interval, and the government's approval of the extension.

Rotating engine parts. Major improvements have been made in inspection techniques, practices, and requirements and more stringent regulations have been established for both Federal Aviation Administration inspectors and mechanics who work on and repair high-energy rotating parts of gas turbine engines that power large aircraft. This includes revised training courses for FAA inspectors to better analyze an airline's performance in correctly inspecting and repairing engines.

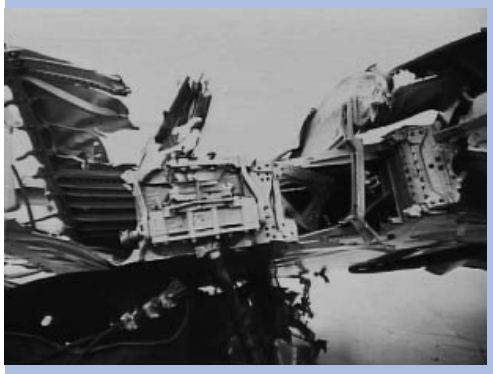
In Pensacola, Florida, two passengers were killed in 1996 when a Delta Air Lines MD-88's left engine failed during takeoff, sending debris into the aircraft cabin. The Safety Board's final report said the engine's front compressor fan hub had failed because the airline's inspection process did not detect the metal fatigue crack.

Structural fatigue and corrosion. Older aircraft are subjected to periodic reviews, inspections, and modifications to eliminate corrosion and metal fatigue and the Federal Aviation Administration requires increased fatigue testing on newly certified airplanes—all part of a comprehensive program to prevent structural failure.

In 1988, an Aloha Airlines 737 experienced a structural failure and explosive decompression en route from Hilo to Honolulu, Hawaii. A section of fuselage skin and structure separated from the airplane in flight. One flight attendant was killed. The Safety Board's investigation revealed that the fuselage failure was caused by disbonding of the fuselage lap joints and multi-site fatigue cracking.

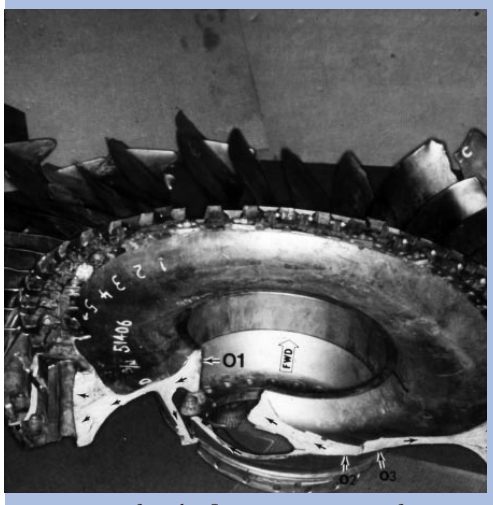
Titanium engine components. Tighter controls and scrutiny of the titanium melt, and manufacturing process for aircraft engines and improvements in the airline industry's inspection process have been mandated.

In 1989, a United Airlines DC-10 equipped with General Electric engines crashed during an emergency landing in Sioux City, Iowa, following an uncontained failure of an engine front compressor fan disk. Of the 286 persons on board, 111 were killed in the crash landing. The investigation revealed that the failure stemmed from a crack that originated from a tiny "hard nugget" or inclusion. It had been formed

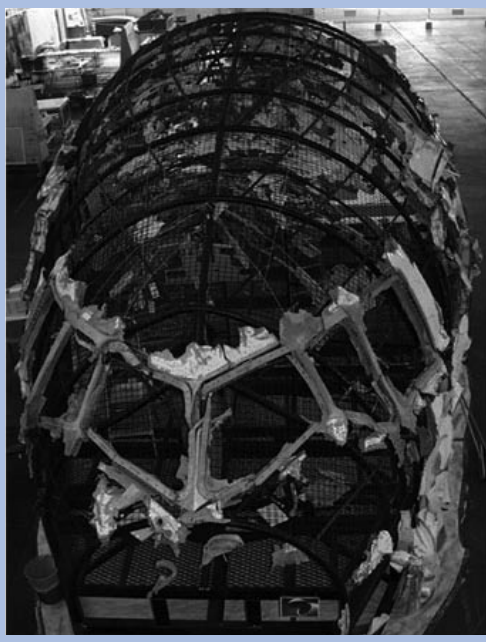


The jackscrew assembly of a MD-83 is recovered from the Pacific Ocean in 2000.

Debris from an engine that failed during takeoff punctured the cabin of a MD-88 in 1996, killing two passengers. Improvements in engine inspection and training resulted from the accident.



Investigators found a flaw into a titanium fan compressor disk that failed in flight, causing major damage to the flight controls of a DC-10 that crashed in 1989.



Investigators reconstructed part of the cockpit to a MD-11 to help find the cause of a 1998 accident.

The worst drunk driving accident in U.S. history prompted stricter drinking and driving laws. Twenty-seven students and parents died in this fiery crash in 1988, caused by a drunk driver.

during the titanium melting process and the crack had been missed during several inspections.

Wiring and insulation. The inspection, repair, and replacement of wiring, insulation, and circuit breakers in the cockpit and cabin of MD-11 aircraft was ordered by the Federal Aviation Administration after the crash of a Swissair MD-11 in the North Atlantic near Nova Scotia, Canada, following an inflight fire.

All 229 on board died in the 1998 crash. The Canadian report concluded that the fire most likely started from a wire arcing event; flammable insulation materials propagated a fire above the ceiling in the cockpit; and the type of circuit breakers used in the aircraft were not capable of protecting against all types of wire arcing events. The Safety Board assisted the Canadian Safety Board in the investigation.

Alcohol and Drugs in Transportation

On highways. States undertook comprehensive reviews of their driving-under-the-influence legislation and how the laws are implemented following the Safety Board's accident report on the worst drunk driving accident in the nation's history.

A pickup truck, driven by a drunk driver on the wrong side of an interstate highway, struck a school activity bus, killing 27 children and parents in Carrollton, Kentucky, in 1988. The driver of the pickup had a blood alcohol concentration of more than two times the legal limit in most States in 1988.

Young drivers. States have set 21 as the minimum drinking age and have tougher and more vigorous enforcement of minimum drinking age laws that include stricter penalties. These include license actions taken against underage purchasers and the vendors who sell to persons under the minimum age — major steps in combating one of the single most deadly threats: the alcohol-impaired driver.

Numerous investigations of alcohol-related crashes and a Safety Board study found that teenagers were over-represented in the population of drunk driver accidents.

Truck drivers. States adopted tougher driving under the influence of alcohol laws for commercial motor vehicle drivers, in part because of a 1990 Safety Board study on fatigue, alcohol, and drug use that analyzed 182 accident investigations involving 186 heavy trucks in 8 States.

On waterways. States have enacted laws dealing with boating while intoxicated, and most have specific blood alcohol concentration limits. The National Association of State Boating Law Administrators issued State guidelines that include specific prohibitions against operating a boat while intoxicated.

In a boating accident study conducted during the 1980s, the Safety Board urged the adoption of clearly defined blood alcohol concentration limits for intoxication similar to that applied to highway vehicle operators.

On the rails. The first mandatory drug and alcohol-testing rule for any mode of transportation was adopted by the Federal Railroad

Administration following a series of deadly train accidents investigated by the Safety Board in the 1980s.

One of the most serious was the 1987 collision between an Amtrak passenger train and a Conrail freight train in Chase, Maryland, in which 16 people were killed and more than 170 others were injured. The Safety Board's report said a marijuana-impaired freight train engineer failed to heed a signal and stop the train. Another notable accident was the collision of two freight trains in Possum Grape, Arkansas, in 1982. An alcohol-impaired engineer relinquished control of one of the trains to a brakeman who was unqualified to run the train, causing the accident.

In the skies. Airlines are required to perform pre-employment, random, and post-accident drug and alcohol testing for the presence of certain illicit drugs in persons employed in safety-sensitive positions. The Federal Aviation Administration also has regulations to identify pilots involved in alcohol- or drug-related motor vehicle offenses by requiring them to report an alcohol- or drug-related driving conviction or administrative action.

Alcohol-related aviation accidents prompted the Safety Board to issue safety recommendations that underscore benefits of a National Driver Registry search. In one accident, a Beech G-18S airplane on an unscheduled air cargo flight from Milwaukee to Atlanta crashed near Copperhill, Tennessee. The airplane was destroyed, and the pilot was killed. The Safety Board determined that the pilot's blood alcohol concentration was well above the limit allowed by most States at the time and that the pilot had been convicted of seven drunk-driving offenses during the previous 4½ years.

Forty-seven lives were lost when an passenger train derailed on a bridge and plunged into a bayou in 1993. Barges had previously hit the railroad bridge displacing the track.

Bridge Safety

Bridge allisions, protection and response. An intermodal— marine, highway, and railroad—task force on bridge information systems compiled ownership and contact information on more than 5,000 bridges vulnerable to impact from marine traffic. If a bridge is struck by a marine vessel, the bridge owner and local emergency response agencies are notified to stop highway and railroad traffic until inspectors determine that the bridge is safe for transportation.

One of the Safety Board's accident investigations that prompted these improvements occurred in 1993 when a towboat operator became lost and disoriented in dense fog because of his inability to interpret his radar presentation. The barges struck an unprotected railroad bridge, displacing the railroad track. An Amtrak passenger train derailed on the bridge and plunged into the Big Bayou Canot, near Mobile, Alabama, resulting in the loss of 47 lives and causing 111 injuries.

Inspections. States are required to conduct recurring underwater inspections of bridges and their footings for scouring and damage from the movement of debris and changes in the streambed material composition.

The Safety Board's investigation into bridge collapses caused by erosion included the 1987 collapse of a New York State Thruway bridge near Amsterdam, New York, which sent four automobiles and

Ten people died when a New York State Thruway bridge collapsed in 1987. This was one of several NTSB-investigated accidents that resulted in improved underwater inspections of bridges and their footings.

a tractor semitrailer 80 feet to the creek below and killed 10 people; the 1989 collapse near Covington, Tennessee; and the 1967 collapse of a highway bridge spanning the Ohio River between Ohio and West Virginia, which killed 46 motorists.

Commercial Motor Vehicles

Better truck brakes. Automatic slack adjusters are required by the National Highway Traffic Safety Administration on all new trucks equipped with air-mechanical brake systems.

Numerous accident investigations involving heavy truck brakes and a 1989 safety study uncovered systemic deficiencies with heavy truck and bus braking systems.

Antilock brake systems. Federal regulations require new commercial motor vehicles over 10,000 pounds gross weight—large trucks and buses—to be equipped with antilock brake systems. Recommended practices to assess tire performance were developed and include tests on free-rolling cornering, straight line braking, and combined cornering and braking.

Safety Board recommendations have reduced accidents and improved trucking safety through commercial driver's licensing, better braking systems, and more driver training.

The changes stem from numerous accident investigations and a safety study on the performance of heavy vehicle brakes. In 1,500 roadside inspections of big trucks conducted with the cooperation of the States, the Safety Board reported that 46 percent of the trucks were placed out of service because of improperly adjusted brakes. Another 10 percent were placed out of service for other brake problems.

Commercial driver's licenses. Congress enacted a law mandating a national commercial driver's license, which requires most truck and bus drivers to obtain this license and prohibits such drivers from having more than one driver's license. An alcohol/drug testing program is also included under the program, and the Federal Highway Administration revised motor carrier regulations to require that motor carriers check a driver's record, initially and at least annually, with State licensing agencies; and to require motor carriers to update their records when they move or change their names.

In 1980 and 1986, the Safety Board evaluated truck driver performance and identified ways to alleviate shortcomings in detecting and controlling unsafe drivers. The Safety Board's 1986 study endorsed a national license for commercial truck drivers to help bar unqualified drivers from operating trucks.

Aircraft accidents in the 1960s and 1970s alerted investigators to the need for teamwork, sharing of information, and safety duties among crew members.

Driver training. An information program was developed by the National Safety Council for those considering a career in commercial truck driving to explain the duties and responsibilities of the vocation, the value of formal training, and factors to consider in selecting a truck driver training school, including which schools meet Federal minimum standards. Heavy trucking associations and unions encouraged the development and use of simulator-based training for heavy truck operators.

The importance of proper technical and safety training were cited in numerous Safety Board investigations, including a 1984 crash in which a tractor semitrailer hit a police car traveling in the opposite direction, killing

all four officers in the car, and a 1982 crash in which a tractor semitrailer hit a church van head on, killing 10 of the van's 11 occupants.

Truck maintenance. The American Trucking Associations developed and distributed brake maintenance materials that established inspection techniques and encouraged their dissemination to all truck mechanics. The National Highway Traffic Safety Administration and the Federal Highway Administration developed such hardware as the roller dynamometer, which is capable of measuring the braking capability of a heavy vehicle at roadside inspection stations.

A 1989 Safety Board study examined the effectiveness of air brake systems on heavy trucks and buses and concluded that there was a serious problem with out-of-adjustment brakes, a major contributor to crashes.

Commuter Airline Safety

Stricter safety standards. Commuter airline flights in aircraft with 10 or more passenger seats were brought under the more stringent safety standards that apply to large air carriers in 1997. This included the installation of safety devices like altitude encoding transponders, ground proximity warning systems, and cockpit voice recorders. Federal Aviation Administration surveillance and commuter regulations concerning pilot training, scheduling, dispatch services, airport certification, and airline management oversight were aligned with requirements for the larger airlines.

Safety Board studies of commuter airlines in 1980 and 1994 called for "sweeping" action to improve safety, advocating "one level of safety" to bring commuter airline regulations in line with stricter regulations governing the operation of larger aircraft.

Crew Communications

On airplanes. Crew resource management, formerly called cockpit resource management, encourages teamwork on large airlines and on regional and commuter airlines. Crew resource management requires the captain to serve as a crew leader who relies on other crewmembers for vital safety-of-flight tasks, and requires the captain to share duties with, and solicit information and help from, other crewmembers.

In several airline accidents investigated by the Safety Board in the 1960s and 1970s, the Safety Board detected a culture and work environment in the cockpit that, rather than facilitating safe transportation, may have contributed to accidents.

In 1978, as a result of a landing gear problem, a United Airlines DC-8 was in a holding pattern while waiting to land in Portland, Oregon. Although the first officer knew the aircraft was low on fuel, he failed to express his concerns convincingly to the captain. The plane ran out of fuel and crashed, killing 10.

On ships. Ship bridge resource management training and certification for masters and mates operating on vessels in ocean and near-ocean service is required by the U.S. Coast Guard. The Coast Guard also

Lesson Learned

The value of crew resource management was demonstrated in 1989, when a DC-10 experienced a catastrophic engine failure over Iowa that destroyed the aircraft's hydraulic systems, rendering it virtually uncontrollable. The cockpit crew and a off-duty captain who was flying as a passenger worked as a team to bring the aircraft down to a crash landing at Sioux City. Although more than 100 people perished, almost 200 others survived.

An uncontained failure in the engine on the tail of a DC-10 resulted in the loss of hydraulics and aircraft control.

requires documentation that those trained can effectively apply teamwork to maintain a safe navigational watch. Bridge resource management focuses on such bridge officer skills as teamwork, teambuilding, communication, leadership, and decision-making, and addresses stress, attitudes, and risk. It begins before the voyage with the passage plan and continues through the end of the voyage with the passage debrief.

The Safety Board promoted this teamwork approach after it investigated the 1989 grounding of the *World Prodigy* on a reef in Rhode Island Sound. The damaged ship spilled 7,000 barrels of diesel oil. The Safety Board concluded that the master's impaired judgment from acute fatigue and poor decision-making, coupled with a lack of bridge management techniques, left the vessel without a qualified watch officer several minutes before the grounding.

Another accident was the 1992 grounding of the *QE2* in Vineyard Sound, Massachusetts, which was the result of the failure by the pilot, master, and watch officers to discuss and agree on a navigational plan for departing Vineyard Sound and to maintain situational awareness after an unplanned course change.

On trains. A comprehensive crew resource management training program has been implemented in the rail industry through the cooperation of the Federal Railroad Administration, the Association of American Railroads, rail unions, and major railroads. The training consists of video presentations and workbooks that cover four areas: crewmember proficiency, situational awareness, effective communications and teamwork, and strategies for appropriately challenging and questioning authority and resolving conflicts.

The need for train crew resource management was highlighted in numerous Safety Board investigations including the 1998 collision of Norfolk Southern and Contrail freight trains in Butler, Indiana, which resulted in one death and two injuries. The report pointed to a lack of crew resource management including the failure of the engineer and conductor to observe and confirm signal aspects and their failure to continuously and directly supervise a student engineer.

NTSB investigators probed the 1998 fire aboard a cruise ship that heavily damaged the ship shortly after it left the Port of Miami.

Cruise Ship Safety

Fire safety inspections. As part of their compliance with the International Safety Management Code, major cruise lines are required to routinely inspect laundry ventilation systems for combustible material and clean the ducts to prevent fires. Several cruise lines improved their ventilation and dust systems in laundry rooms to prevent the spread of fire to other parts of the ships.

These changes are the result of the Safety Board's investigation into the 1998 fire aboard the *Ecstasy* cruise ship shortly after it left Miami and lost propulsion with more than 3,400 on board. There were no fatalities; however, 22 crewmembers and passengers were injured. The Safety Board said unauthorized welding by crewmembers in the main laundry ignited a large accumulation of lint in the ventilation system, and the ship's crew failed to maintain the laundry exhaust ducts in a fire-safe condition.

Locating ship passengers. International maritime regulations require passenger ships to have procedures for locating and rescuing trapped passengers and crewmembers, and specific crew assigned and trained for this task. These regulations also require that mock search and rescues of passengers be conducted during required abandon-ship drills.

The changes stem from Safety Board investigations of cruise ship fires. In one of the investigations, in 1996, fire broke out on the *Universe Explorer* near Juneau, Alaska, killing 5 crew and injuring more than 50 others. The Safety Board pointed to numerous inadequacies in crew communications and passenger preparedness to deal with the onboard fire.

Sprinklers and alarm systems. The U.S. Coast Guard obtained international agreement to require tougher fire safety improvements on all passenger ships, and the new requirements were applied to existing ships as well as to new ships. Recommendations resulted in improved standards for structural fire protection, sprinkler installations, low-level emergency lighting, smoke/fire detection systems, crew qualifications, emergency drills, and crew language requirements to ensure the safety of passengers on foreign-registered vessels operating from U.S. ports.

In a 1989 safety study, a 1993 special investigation report on passenger vessels, and investigations of fires aboard several cruise ships, including the 1984 fire on the *Scandinavian Star* that killed two people, the Safety Board identified serious shortcomings in cruise ship safety.

Improved procedures to locate and rescue cruise ship passengers, along with the installation of sprinkler systems and other fire and smoke detection upgrades, stem from numerous NTSB investigations and recommendations.

Data Reporting and Recorders

Air bag research. Passenger side air bags have been evaluated and the National Highway Traffic Safety Administration established performance requirements for them based on actual accidents. It also evaluated the design of child restraint systems to simplify the placement of a child in a restraint system, and revised safety standards to provide for secure and uniform installation of child restraint systems. Federal highway safety regulators developed crash standards using biologically representative child dummies and a crash investigation to evaluate the long- and short-term variations in air bag designs and advanced air bag technologies.

These additional changes resulted from the Safety Board's 1996 safety study on the performance and use of child restraints, seatbelts, and airbags.

Highway vehicle event recorders. Federal highway safety regulators now routinely gather information from previously untapped sources of data-collecting sensors and event recorders already installed in vehicles. This information plays a major role in understanding the dynamics of a crash and its injury-causing impacts and enables researchers and engineers to design safer vehicles.

Use of these information sources was partly prompted by a 1996 Safety Board study that examined the performance and use of child restraints, seatbelts, and airbags in highway accidents. The data showed that 38 children and 23 adults were killed when air bags

Safety Board recommendations in the 1990s led to more airbag research, changes in airbag design, and a public education program.

Lesson Learned

The 1995 grounding in an Alaskan canal of the *Star Princess*, which was fitted with a voyage data recorder, showed the usefulness of these devices in accident reconstruction and in improving management oversight. In this case, the recorder helped Safety Board investigators determine that the pilot and the watchstanders failed to use equipment available to properly monitor the progress of the cruise ship's course. Had this been done, the pilot's navigation error might have been detected in time to avoid the accident.

Voyage data recorders are now required on ships like this one in San Francisco Bay.

One of the longest and most complex accident investigations in the Safety Board's history involved the crash of a 737 in 1994 on approach to Pittsburgh. A redesigned rudder system and pilot training to handle unusual aircraft upsets were the result of the Safety Board's investigation and recommednations.

deployed during crash impacts investigated during a 3-year period. These accidents pointed to the need for more information available for crash investigators to pinpoint causes and seek safety remedies.

Voyage recorders. All passenger lines and new cargo vessels are required to have voyage data recorders similar to flight data recorders on aircraft, and many cargo lines operating older vessels have voluntarily installed them. Automatic data recording devices are useful for management oversight and provide crucial, factual information for accident investigation; they have played a key role in identifying and addressing accident causes.

Since the 1970s, the Safety Board has promoted the use of recorders on various types of vessels and other modes of transportation.

Design and Technology Advances

Aircraft rudders. Upgraded rudder control systems were mandated by the Federal Aviation Administration on all new Boeing 737 aircraft and rudder system retrofits on older 737 aircraft, the world's most popular aircraft. The system includes redesigned actuators and control rods and a system that alerts the cockpit crew to rudder system failures. Flight simulators for 737s have been updated to more accurately reflect aerodynamics associated with the aircraft's roll and yaw characteristics. Specific training was developed for cockpit crews to better prepare them to react more effectively to unusual situations.

These improvements stem from one of the Safety Board's most complicated and lengthy investigations and a reexamination of an earlier crash of a United Airlines 737 in 1991 in Colorado Springs that killed all 25 on board. The lengthiest investigation involved a USAir 737 that crashed on approach to Pittsburgh in 1994, killing all 132 on board. The Safety Board report said the aircraft's loss of control was attributed to a deflection of the rudder surface in a direction opposite to that commanded by the pilots because of a jam of a rudder control component.

Anti-collision devices on cargo planes. The Federal Aviation Administration mandated installation of a sophisticated anti-collision system on all large cargo planes flying in the U.S.—the same requirement that was previously applied to passenger-carrying aircraft. Called TCAS (traffic collision avoidance system), the system alerts flight crews when they are too close to another aircraft during flight and gives the crew evasive options.

The improvements stem from the near mid-air collisions of an Air Canada passenger Airbus A-320 and a FedEx cargo MD-10 over Lincoln, Nebraska, in 1999. The cargo plane was not required to have a TCAS on board.

This improvement is the latest step in a long history of implemented Safety Board recommendations since the late 1960s that called for and supported the development of an airborne collision avoidance system that would be independent of the ground-based air traffic control system to provide pilots with an additional source of information on potential conflicts in flight. Since 1993, the use of TCAS

has been expanded to include installation in more aircraft, and air traffic controllers now receive annual training in the operation of TCAS and the roles and responsibilities of flightcrews in responding to TCAS alerts.

Automatic flight controls. The Federal Aviation Administration required modifications to the automatic flight control systems of Airbus A-310 and A-300-600 models, and testing of the modifications. The autopilot was redesigned to disengage when an aircraft is in go-around mode at low altitudes or when pilots exert manual force on the control column, giving pilots better control in certain conditions.

The changes were the result of a 1994 China Airlines A-300 that crashed on approach to Nagoya, Japan, killing 264 of the 271 on board; and the 1991 in-flight upset of a Interflugen A-310 on approach to Moscow, Russia. That aircraft landed safely. Investigations showed that the pilot's ability to gain manual control of the airplane was hindered by the electronic system. The Safety Board assisted in the investigations.

Center high-mounted stop lights. Center high-mounted stop lights have been required on all new passenger cars since the 1986 model year and on all new light trucks since the 1994 model year.

As early as 1975, Safety Board investigations resulted in a recommendation that automobile brake lights be mounted high enough to separate the function of brake lights from tail lights so that a following driver could see the lights of at least two vehicles directly ahead. A 1998 study concluded that center brake lights prevent 92,000 to 137,000 police-reported crashes and 58,000 to 70,000 nonfatal injuries.

Fail-safe thrust reversers. Design changes were mandated for large aircraft engine reverser systems. An additional lock was added to prevent thrust reversers from deploying in flight.

In 1991, a Lauda Air 767 experienced an uncommanded in-flight deployment of an engine thrust reverser after takeoff from Bangkok, Thailand. The pilots lost control and the airplane crashed, killing all 223 people aboard. The investigation by the Thai airworthiness authorities and the Safety Board revealed the possibility of an in-flight thrust reverser deployment, shortcomings in the fail-safe thrust reverser design requirement on 767 airplanes, and lack of flightcrew operational procedures to address such an anomaly.

Ground proximity warnings. U.S.-registered turbine-powered airplanes with six or more seats are required to be installed with an improved version of ground proximity warning equipment. Called the terrain awareness and warning system, the device gives flightcrews earlier alerts to possible collisions with mountains or the ground.

The recommendation for the technological upgrade in ground proximity warning devices came after an American Airlines 757 crashed in Cali, Colombia, in 1995. It hit a mountaintop on its approach to the airport, killing 160 of the 164 on board. Investigators believed that a more sophisticated warning device would have given the flightcrew an earlier warning, adding a few seconds of time to take actions to avoid the crash.

Today's passenger aircraft are equipped with devices that help prevent accidents and save lives, including ground proximity and anti-airborne collision warnings.

New air bag standards and reducing the risk of air bags to children and short-statured persons stem from Safety Board accident investigations.

The 1989 oil spill in Alaska resulted in better use of vessel traffic services to curb marine accidents.

Developing, upgrading and requiring terrain collision warning systems on passenger aircraft had been promoted by the Safety Board since the early 1970s when it first called for the development of an onboard warning system after a nonfatal accident in 1971 involving a DC-9 that struck antennas as it was landing in Gulfport, Mississippi.

Improved emergency braking capabilities. Federal regulations require heavy trains operating over mountainous terrain to be properly equipped with a two-way end-of-train device. A two-way end-of-train device allows a train crew to initiate an emergency brake application from the rear of a train, as well as from the front.

As the result of an investigation involving the derailment of a runaway freight train in Cajon Pass, California, in 1994, the Safety Board determined that an important safety device, a two-way end-of-train device that could be activated in an emergency to assist in stopping the train, was not properly armed and ready for service.

Mode C transponders. General aviation aircraft operating in controlled airspace near major airports are required to be equipped with Mode C transponders, which give air traffic controllers altitude information. Mode C transponders permit radar to automatically display the altitudes of aircraft equipped with them, and they provide air traffic control computers with route and altitude information that sound alarms when imminent collision hazards are detected.

Safer air bags. The National Highway Traffic Safety Administration permits automobile manufacturers to depower air bags to reduce the risk of air bag-induced injuries to children and to short-statured and senior-citizen occupants. Standards were issued for establishing procedures to permit air bag on/off switches for adults and children at risk and for next-generation air bags that can tailor the deployment of the air bag according to the crash severity, size, and posture of the occupant; seatbelt use or non-use; and the occupant's proximity to the air bag.

These additional changes resulted from the Safety Board's 1996 study on the performance and use of child restraints, seatbelts, and airbags.

Waterway navigation upgrades. The U.S. Coast Guard requires mandatory participation in the Vessel Traffic Services system that tracks ships in waterways systems in the United States as spelled out in the Oil Pollution Act of 1990.

Many of the Safety Board's recommendations from its *Exxon Valdez* report were contained in the 1990 act. The 1989 *Exxon Valdez* oil tanker accident in Alaska focused national attention on the need for a viable vessel traffic service system to prevent marine accidents. Eight tanks ruptured and about 258,000 barrels of crude oil spilled, causing catastrophic damage to the environment.

Emergency Evacuations

Aircraft evacuation slides. Evacuation slides on aircraft are coated with a material to resist heat from postcrash fires because of Safety Board recommendations issued after a runway overrun accident involving a Continental Airlines DC-10 in Los Angeles in 1978.

In the accident, which killed two people, 40 occupants were forced to jump to the ground while another 15 persons used the escape rope in the cockpit. There were 31 serious injuries. Heat from the intense fire caused several evacuation slides to deflate and melt.

Aircraft exits. Redesigned emergency tailcone release handles are required on all commercial and military DC-9s and MD-80s to assure the availability of this exit in the event of an emergency, following the Safety Board's investigation of a 1990 runway accident in Detroit, Michigan.

Two Northwest Airlines jets, a DC-9 and 727, collided, killing a flight attendant and seven passengers. The DC-9's tailcone release mechanism failed.

Fire blocking materials and escape lighting. Fire-blocking cabin and seat materials have been required on all airliners built since 1990. Floor-level escape lighting along aisles that guide passengers toward an exit during reduced visibility because of smoke is the result of Safety Board investigations and recommendations.

Safety Board investigators credited fire-blocking seat materials with saving lives following a takeoff accident and fire aboard a Delta Air Lines 727 at Dallas/Fort Worth in 1988. A study showed that fire-blocking materials gave passengers additional time to exit the aircraft.

Moored vessels. Permanently moored vessels are required to be protected from waterborne and current-related risks. Owners must complete risk assessments including risks associated with the location of the vessel on a waterway, vessel traffic, and environmental factors before permits will be issued. Periodic reviews are required by the U.S. Army Corps of Engineers.

These changes were prompted by an 1998 accident on the Mississippi River at St. Louis, when 14 towed barges struck the center pier of a bridge. Eight barges broke away and three drifting barges struck a moored casino vessel, *President Casino on the Admiral*. The accident caused no deaths, but did cause several million dollars in damage. The Safety Board's analysis showed that authorities had not adequately protected the permanently moored vessel from waterborne and current-related risks, and the failure to conduct emergency drills and a chaotic evacuation jeopardized the lives of the 2,000 on board.

Rail car exits. Rail passenger cars are required to have easily accessible, interior, quick-release mechanisms adjacent to doors to allow passengers to open exterior doors and exit the train in an emergency. Rules require doors to be wider and emergency instructions to be clearly marked.

Eight Job Corps students and three train crewmembers were killed in the collision of an Amtrak and commuter passenger train in 1996 in Silver Spring, Maryland. A fire ensued, and some passengers were unable to escape because of a cumbersome emergency device that thwarted easy opening. More than 25 passengers on both trains were injured.

Smoke detectors. Smoke detectors and automatic-discharge fire extinguishers are required in airliner lavatories. Stiff fines are also

Aircraft evacuation slides have been upgraded to better resist heat from post-crash fires.

Fire aboard a DC-9 in 1983 led to smoke detectors in lavatories and floor-level escape lighting.

imposed when anyone attempts to disable a smoke detector, and the Federal Aviation Administration requires airlines to prohibit smoking in lavatories. The agency also urges routine flight attendant inspections of lavatories before takeoff and periodic inspections during flight.

In 1983, an Air Canada DC-9 flying between Dallas and Toronto developed smoke in the cabin while the airplane was cruising at 33,000 feet. The fire is thought to have started in a lavatory, probably when a motor overheated. The crew declared an emergency, but it took about 20 minutes before they could land at the closest large airport, near Cincinnati, Ohio. When the plane finally stopped, only half of the 46 persons aboard were able to escape the burning aircraft before being overcome by smoke and fumes.

Fire and rescue response following aircraft incidents and accidents has improved because of NTSB investigations.

Emergency Response to Accidents

Airport emergencies. A designated radio frequency has been set up to allow for direct communications between airport fire and rescue and flight crews in the event of an emergency, and standardized hand signals have been established for use in emergency situations when radio communications fail.

Airport fire and rescue response have been factors in numerous Safety Board investigations, including the 1997 incident when an American Airlines MD-82 sustained a contained engine failure and tail pipe fire during the takeoff initial climb from Tucson, Arizona. The aircraft returned to Tucson for a successful landing. There were no injuries to the 123 passengers and crew onboard, but a miscommunication resulted in some passengers exiting the same side of the aircraft where the fire was being extinguished.

The Safety Board report said that the crew experienced difficulty in establishing radio contact with the airport vehicles, and there was a problem hearing the captain's evacuation on the public address system. A flight attendant depended on a "thumbs up" hand signal from one of the rescuers to stop the evacuation because verbal communications failed.

The New Orleans Riverwalk suffered extensive damage when it was struck by a bulk carrier vessel in 1996.

Emergency position indicating radio beacons. Manned, uninspected vessels operating on the high seas or more than 3 nautical miles from the coastline of the Great Lakes are required to be equipped with alerting equipment, including emergency-position-indicating radio beacons.

In the 1980s, the Safety Board pushed for requiring automatic radio beacons on uninspected vessels after investigating several accidents, including the disappearance of the fishing vessel *Amazing Grace* off Cape Henlopen, Delaware, in 1984. A 16-day U.S. Coast Guard search found an empty life raft and none of the estimated seven crewmembers on board. If the vessel had been equipped with a radio beacon, the Safety Board report said, the search area could have been narrowed substantially, saving the time, cost, and possibly, lives.

Marine distress calls. The U.S. Coast Guard upgraded and installed new recording devices in its group communications centers, enabling them to easily record and replay radio transmissions.

The upgrades were the result of the Safety Board investigation of an accident involving a recreational sailboat, the *Morning Dew*, which stuck a jetty and sank in the Charleston, South Carolina, harbor. All four on board, members of the same family, drowned in the 1997 accident. The accident report showed a major failure in communications that delayed search and rescue efforts by more than 9 hours after the first radio transmission to the Coast Guard from the sailing vessel.

Lower Mississippi River alerts. The Port of New Orleans improved its communications system and upgraded its river alert network to inform moored vessels and nearby shore side businesses of potential hazards from large vessels on the Mississippi River. Revised regulations require that pilothouses of passenger vessels be continuously staffed, and that pilots monitor river activities and maintain emergency and working radio frequencies to find out about emergencies in that part of the river. The regulations also require that harbor police use public address systems to alert people of an emergency and that evacuation procedures for vessels moored or docked in the area be revised.

In 1996, the bulk carrier *Bright Field* lost propulsion power in the lower Mississippi River and struck a wharf adjacent to a shopping mall and hotel. Although the accident caused no fatalities, more than 60 people were injured during evacuations of a gaming vessel and an excursion vessel located near the impact area. The Safety Board report said emergency preparedness and evacuation plans of vessels moored in the wharf area were inadequate.

Excavation Damage Prevention

Call 911. Pipeline best-practices guidelines urge excavators to immediately notify 911 and pipeline owners and operators when gas or fuel escapes and endangers lives and property. This was one of several issues that received extra emphasis on the Safety Board's Most Wanted List of Safety Improvements but were later removed because of the progress made to prevent these accidents.

In 1998, in St. Cloud, Minnesota, a communications network installation crew struck and ruptured an underground gas service pipeline. More than a half hour later, an explosion occurred, killing four people, injuring another, and destroying six buildings. The Safety Board investigation report said the accident was more severe because of the cable contractor's delay in notifying proper authorities.

One-call systems. Safety Board investigations, safety studies, and safety promotion activities have been instrumental in convincing Federal and State agencies, pipeline industry organizations, and pipeline operators to develop one-call notification systems, State laws, and public education programs aimed at reversing the increasing trend of excavation-caused damage to gas lines and other buried facilities. There are one-call notification centers in all States and the District of Columbia, and excavation damage prevention laws in most States and the District of Columbia.

In the 1970s, excavation damage to pipelines was estimated to cause 50 to 60 percent of all pipeline accidents.

Lesson Learned

Immediately notifying authorities of gas leaks and pipeline ruptures is critical to saving lives and reducing property damages—one of the many lessons learned through NTSB pipeline accident investigations. Federal and State agencies, and the pipeline industry were convinced to set up "one-call" notification systems in all States and the District of Columbia.

Preventing ruptures. A "Common Ground Study," which listed best practices in preventing ruptures due to excavation, including pipeline design and planning, location, and safe excavation practices, was distributed by the Research and Special Programs Administration. In addition, a public education campaign, "Dig Safely," includes a manual on how to effectively use these materials: print ads for newsletters, public service announcements, brochures, and bill inserts.

These actions stem from the Safety Board's investigation into a natural gas transmission line rupture and fire in a residential area of Indianapolis, Indiana, that killed one resident, destroyed 6 homes, and damaged 65 others. The pipe was damaged by a drilling operation to install an adjacent pipeline.

Fatigue in Transportation

NTSB accident investigations pointed to the need to reduce overcrowding at truck parking areas along the nation's highways.

Highway rest areas. The Federal Highway Administration and the Federal Motor Carrier Safety Administration compiled and published guides for long-haul truck drivers to alert them to public and private rest areas and parking spaces along their route and their availability. The guide is electronically available on the FMCSA Website.

This was a major safety issue in numerous accident investigations and a series of Safety Board public hearings in 1999 on truck and bus safety issues. The recommendation's aim is to reduce the incidents of overcrowding at parking areas—a safety hazard.

Mariner awareness. Marine pilot associations instruct their members to be aware of the hazards of human fatigue and sleep apnea when operating a vessel. Merchant marine physical exam reports have been revised to fully explain the duties of a mariner to the examining physician. Reports must indicate any and all medications taken, the dosage, possible side effects, and the medical condition for which the medication is being taken.

The Safety Board investigated the 1995 grounding of the passenger vessel *Star Princess* on Poundstone Rock in Lynn Canal, northwest of Juneau, Alaska. The Safety Board report pointed to the pilot's poor performance, which may have been exacerbated by chronic fatigue caused by sleep apnea. In addition, the third mate failed to properly maneuver the vessel because of fatigue and excessive workload, the master failed to provide proper navigation watch because of alcohol impairment, and the shipping company failed to provide a fit and rested crew.

On the tracks. Major railroad unions and major freight railroads developed work/rest guidelines to combat human fatigue, a factor in transportation accidents in all modes, and numerous rail accidents.

In 1990, two Atchison, Topeka and Santa Fe Railway freight trains collided head-on in Corona, California, killing four crewmembers and injuring another. The Safety Board's investigation showed that an engineer who was asleep had failed to heed a stop signal. A 1988 head-on collision of two Conrail freight trains in Thompsontown, Pennsylvania, killed the engineers and brakemen on both trains. The Safety Board said

the sleep-deprived condition of the engineer and several crew of one of the trains contributed to their failure to stay alert and comply with a signal. None of the crewmembers had more than 2 hours of sleep during the previous 24 hours.

Transit fatigue course. The Federal Transit Administration has incorporated a human fatigue awareness course offered at the Transportation Safety Institute and has aimed the course at employees and supervisors involved in safety-sensitive jobs.

Human fatigue has been uncovered as a factor in numerous Safety Board investigations, including a 1995 accident in which a New York City Transit subway car struck another train on a bridge, killing the operator and injuring scores of passengers. The train operator was asleep and failed to stop at a signal.

Trucking hours-of-service. Revised truck driver hours-of-service regulations were issued by the U.S. Department of Transportation, the first major rewrite in 60 years. The regulations provide commercial truck drivers a work and rest schedule that is more in line with a person's circadian rhythm—a change aimed at reducing driver fatigue and accidents.

A 1990 Safety Board study of fatal-to-the-truck-driver accidents found that the most frequently cited probable cause was fatigue. The Board said the 31 percent incidence of fatigue in fatal-to-the-truck-driver accidents represented a valid estimate of the portion of fatal-to-the-driver heavy truck accidents that were fatigue-related. A 1995 Safety Board study of truck driver fatigue found that the top factors affecting fatigue were the number of hours slept in the past 24 hours in the most recent sleep period, and whether the sleep was obtained at one time or in split sleep periods.

Lesson Learned

After 60 years, revised truck driver hours-of-service rules have been issued by the Federal government. The rules aim to provide truck drivers with a work schedule more in line with sleep and human fatigue research. The goal is to reduce driver fatigue and accidents.

Commercial Fishing Vessel and Towing Safety

Fishing vessel safety devices. Congress passed the Commercial Fishing Industry Vessel Safety Act of 1988 and several years later the U.S. Coast Guard published final rules to improve the safety of commercial fishing vessels. These regulations for the first time required commercial fishing vessels to carry specific lifesaving devices, including life rafts, survival suits, and emergency-position-indicating radio beacons.

In 1987, the Safety Board issued a safety study on uninspected commercial fishing vessels that, along with a number of individual Safety Board accident reports, identified critical safety problems throughout the commercial fishing vessel industry.

Towing vessel safety. Regulations were issued to improve navigation safety by requiring towline and towing equipment inspections and maintenance; the addition of towing vessel equipment such as charts, marine publications, compass, or swing meters, radar, and vessel position finding devices; and training of towboat operators in radar use.

These changes followed investigations of several towing vessel accidents involving U.S. towboats, including the *Fremont*. The 1992 collision with a containership occurred in the Houston ship channel. The barge being

Lifesaving devices and emergency position radio beacons are a few of the improvements made to commercial fishing vessels following numerous NTSB safety recommendations.

towed by the *Fremont* was struck in fog and sank, spilling all of its cargo of molten sulfur. The lack of a compass on the towing vessel resulted in the operator's inability to evaluate the vessel's movement into the navigation channel and into the path of a containership.

NTSB recommendations have consistently pushed for better grade-crossing safety through driver education, engineering solutions at crossings, and enforcement of laws.

Grade Crossing Safety

Emergencies on the tracks. Major railroads have instituted a 24-hour toll free emergency notification telephone system that can be used by the public to report emergencies to the railroads' communications centers, such as struck or broken-down vehicles at rail/highway grade crossings. This system includes signs at grade crossings that post the number to call to reach the railroad.

This change was the result of dozens of Safety Board investigations involving accidents at grade crossings when trains were unable to stop in time after seeing vehicles blocking the tracks. One was the 1995 accident in Sycamore, South Carolina, where a tractor semitrailer was stuck on the tracks for more than a half hour before it was hit by an Amtrak passenger train. Two locomotives and 14 passenger cars derailed, and the truck was heavily damaged.

Highway intersection safety. A nationwide database was set up to track, monitor, and inspect about 3,500 highway-railroad crossings with interconnected road signals and rail warning lights. All States quickly inspected and made safety adjustments to these intersections. This database helps State and local school safety officials plan and monitor school bus routes, and is available to train drivers to use in avoiding potential grade crossing hazards.

Grade crossing accidents involving school buses are rare, but can be deadly, prompting the Safety Board to add school bus and grade crossing safety to its Most Wanted List of safety recommendations in 2004. Accident investigations have pointed to the need for several improvements, including enhanced bus driver education and evaluation, and installing stop signs at passive crossings.

This improvement was the result of a 1995 accident in which a school bus and commuter train collided at a grade crossing in Fox River Grove, Illinois, killing 7 high school students and seriously injuring 24 others. One of the major factors cited by the Safety Board was a timing problem with an interconnected signal system.

Stop, look and listen. States have programs, encouraged by Safety Board investigations and recommendations, to educate the public about the dangers of highway-railroad grade crossings.

The Safety Board pushed for a strong "Operation Lifesaver" education program in the late 1970s. The program became an independent operation and widened its coverage during the 1980s. Working with individual States, Operation Lifesaver provided a three-pronged attack on the problem of grade-crossing safety: education of drivers, engineering solutions to high-accident crossings, and enforcement of grade-crossing laws.

Hazardous Materials

Community coordination. Major railroads improved coordination with communities adjacent to railroad yards and along hazardous materials routes, and established hazardous materials training programs and evaluation systems for their employees. New Federal regulations established training and testing requirements for employees

involved with the transportation of hazardous materials. Rail carriers are required to train and test train crews about hazardous materials emergency response procedures before they operate a train.

Chemicals on the rails. The American Chemistry Council requires its members to have an ongoing chemical distribution risk management program to evaluate risks of transporting chemicals by rail and to implement risk reduction methods.

In almost half of cases investigated for a safety study, the Safety Board found that local emergency response incident commanders did not have a hazardous materials emergency response plan to follow. In many cases, incident commanders and railroad personnel had not been in contact with each other to develop a plan of action in the event of a train accident involving hazardous materials.

Safer cargo compartments. Fire safety standards and requirements for baggage and cargo compartments in large passenger aircraft were upgraded by the Federal Aviation Administration. The Research and Special Programs Administration prohibits airlines from carrying chemical oxygen generators in cargo and baggage compartments of passenger aircraft and instituted tougher packaging standards for those shipped in cargo planes. The FAA also strengthened its oversight, became more proactive in enforcing rules and penalizing violators, and revised training requirements for airline employees and shippers who handle cargo to recognize undeclared or unauthorized hazardous materials.

The changes were the result of several Safety Board investigations, including the crash of a ValuJet DC-9 in the Florida Everglades in 1996. All 110 on board died after an undetected fire in the cargo hold, ignited by oxidizers the aircraft was carrying, spread to the passenger cabin, burned through aircraft controls, and disabled the flight crew.

Shipping and handling. The Federal Aviation Administration developed a hazardous materials education and enforcement program that focuses on freight forwarders. The FAA also issued new regulations that require all shippers and freight forwarders to certify that packages being shipped do not contain unauthorized explosives, destructive devices, or hazardous materials.

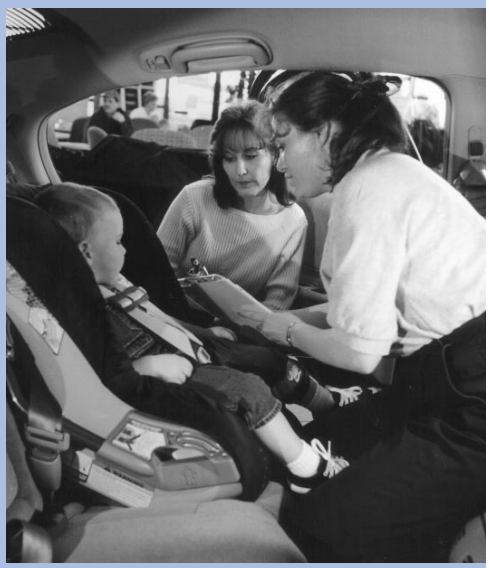
Reconstruction of the forward cargo hold of a DC-9 that crashed in 1996, killing all 110 on board, helped investigators determine the probable cause of the crash and make numerous recommendations that have been implemented to upgrade fire safety standards and hazardous materials rules and enforcement.

Helicopter Safety

Research by both the Federal Aviation Administration and the manufacturer led to product improvements including the mandatory introduction of an engine governor and a larger optional engine in Robinson helicopters. Special awareness training was instituted that addressed loss of rotor control events and pilot proficiency, and restrictions on operating in certain wind conditions.

In 1996, the Safety Board concluded a special investigation of Robinson Helicopter Company R22 helicopters following 34 accidents in which an in-flight loss of main rotor control resulted in the main rotor contacting the tail boom or fuselage in flight. In all of these accidents, the occupants of the helicopters were killed.

Air bag warning labels are required on all vehicles in the United States, thanks in part to numerous NTSB accident investigations and a series of public forums and meetings on air bag safety in the 1990s.



Parents and guardians get help at child restraint "fitting stations"—locations in all States where trained technicians make sure appropriate seats are used and installed correctly.

Passenger and Occupant Protection

Adjustable upper anchorages. Major car manufacturers provide adjustable upper anchorages for the shoulder portion of seatbelts in front seats, and many manufacturers also provide them in the rear seat.

In its 1988 safety study on seatbelt performance, the Safety Board found that properly worn and routed seatbelts reduced injuries in 80 percent of the crashes examined. One of the methods of encouraging proper seatbelt use is to improve the shoulder fit of the belts by providing occupants with a way to adjust the shoulder strap upper-attachment point, the Safety Board said.

Air bag warning labels. The automobile industry sent letters and warning labels to owners of 60 million cars on the road that are equipped with air bags, advising the owners about the dangers that air bags pose to children. The National Highway Traffic Safety Administration requires these highly visible and permanent warning labels on all new vehicles.

These additional changes resulted from the Safety Board's 1996 study on the performance and use of child restraints, seatbelts, and airbags.

Aircraft seats. The Federal Aviation Administration required upgraded G force crashworthiness of seats on newly certificated transport-category aircraft and that seats be tested dynamically for their strength in addition to the requirement for static testing.

The Safety Board's concern about seat integrity was underscored during its investigation of the 1987 crash of a Ryan Air Beech 1900 in Homer, Alaska, that killed 18 of the 21 persons aboard. The crash induced high vertical G forces, and the seats failed.

Child restraint "fitting stations." "Fitting stations" exist in all States. Fitting stations are locations operated by auto manufacturers and dealers, law enforcement and first responders, private safety advocacy organizations, and government agencies that help parents and guardians check for correct child safety seat anchoring and harness configurations. Staff at these stations also point out errors in the use of child restraints and demonstrate the proper use of such seats.

A 1996 Safety Board study on the performance and use of child restraint systems examined 120 accidents and found that in 62 percent of the cases, the child safety seat was improperly secured in the vehicle, the child was improperly secured in the safety seat, or both. Some of the problems uncovered were seatbelts misrouted or worn too loosely, child restraints facing the wrong direction, locking clips not used when needed, and harnesses too loose or inappropriately threaded through the wrong slots.

Getting the word out about air bags. The automobile and insurance industries and the National Highway Traffic Safety Administration initiated an air bag safety campaign in 1996. The multi-million-dollar effort aimed to educate the public about the importance of putting children in the back seats of vehicles with air bags, buckling seatbelts, strengthening State seatbelt use laws, and increasing

enforcement. This effort included a mail campaign to all parents who recently had children based on hospital records.

These additional changes resulted from the Safety Board's 1996 study on the performance and use of child restraints, seatbelts, and airbags.

Passenger rail car safety. Dozens of safety improvements have been made in rail passenger cars. These include securely attached seats, seat cushions, and appliances; impact-resistant windows that can be used as emergency exits; and retention devices on overhead luggage racks. Flammability standards have been upgraded and smoke detectors installed. Additions include passenger emergency briefing cards and placards; conspicuous markers and levers to facilitate operation of doors and emergency windows; emergency light sticks that can be used by passengers to find their way out of cars and their way along tracks in the dark; more reliable interior emergency lights; and additional emergency exit windows.

Rear seatbelts. Rear-seat lap/shoulder belts are required in newly manufactured cars, light trucks, multipurpose vehicles, and convertibles; and manufacturers developed a program to install lap/shoulder belt retrofit kits in existing models.

A 1986 Board study concluded that lap belts provide a significantly lower level of protection than lap/shoulder belts and, in the crashes investigated, sometimes induced serious or fatal injuries that probably would not have occurred had lap/shoulder belts been used.

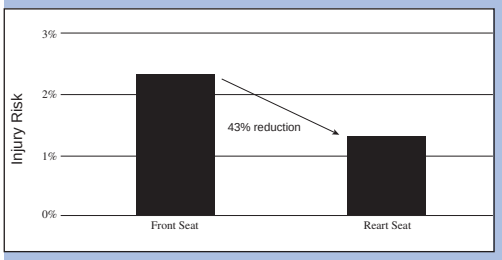
Water safety for youngsters. Many States have passed laws requiring personal flotation device use by children and require recreational boating education. The National Recreational Boating Safety Coalition, formed with the Safety Board's assistance, seeks to reduce deaths, injuries, and property damage associated with the use of recreational boats. The coalition, composed of numerous insurance trade associations and other safety organizations, serves as a forum for the exchange of information about State and Federal legislative activities and education programs.

In 1993, the Safety Board issued recommendations to the States to require education, operator licenses, and use of personal flotation devices by children.

Young children in cars. States passed and strengthened child passenger protection laws. Between 1980 and 1984, more than 3,000 children under 5 years of age were killed in motor vehicle accidents and more than 250,000 were injured. Studies indicate that between 45 and 70 percent of the fatalities and up to half of the injuries could have been prevented by the proper use of a child safety seat.

In 1982, the Safety Board launched a special investigation that demonstrated that children secured in safety seats remained unharmed in motor vehicle crashes that killed or severely injured their parents. The Safety Board investigated 53 accidents and found dramatic differences in injuries to infants and small children who did and did not have safety seat protection.

Injury to Children 0 to 12 Years Old



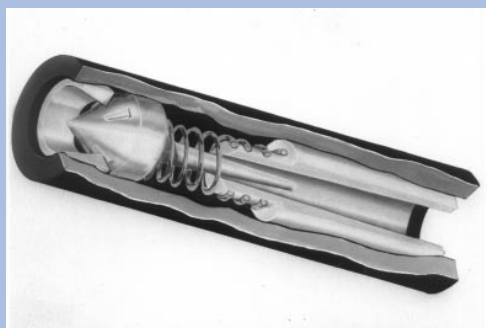
A child's risk of injury is reduced by 43% when moved from the front seat to the rear seat.

Source: Partners for Child Passenger Safety

Safety of the millions of recreational boaters has been an NTSB goal, with numerous States requiring that children use personal flotation devices.

Child safety seats, properly used, substantially reduce deaths and injuries from highway crashes.

NTSB safety recommendations have resulted in periodic pipeline inspections, higher toughness and corrosion standards, and better liquid pipeline failure detection.



This device, an excess flow valve, increases pipeline safety by shutting off the flow of gas in service lines in emergency situations.

Pipeline Safety

Periodic inspections. All hazardous liquid and gas transmission lines must be periodically tested to assess their integrity. Operators must follow a pipeline management program for areas in which a pipeline accident would result in high monetary costs, damage to the environment, and deaths and injuries. Operators are required to test, identify, and remedy corrosion damage; to validate maximum safe operating pressures; to set up frequency assessments; and to address other risks to pipeline safety.

Several pipeline accidents prompted the Safety Board to push for mandatory inspection requirements including a natural gas explosion and fire in Beaumont, Kentucky, in 1985 that killed five, and a 1986 pipeline rupture and fire at Mounds View, Minnesota, that killed two.

Assessing pipeline safety. The Research and Special Programs Administration improved its safety assessment of State pipeline regulators and operators by revising the guidance and evaluation criteria used by Federal inspectors. The changes are designed to accurately assess pipeline operational safety, identify problems, and take action to correct them, and provide more timely communications to pipeline operators about violations.

This improvement stems from a 1996 propane gas leak that caused an explosion in a commercial building in San Juan, Puerto Rico. In the worst pipeline disaster investigated by the Safety Board, 33 people were killed and 69 were injured; the building was destroyed and several others were heavily damaged. The accident report cited numerous oversight and safety evaluation failures by State and Federal regulators that allowed lax safety and training at the local gas company.

Corrosion standards. External corrosion standards for hazardous liquid and carbon dioxide pipeline operators were upgraded, requiring them to inspect the condition of protective pipe coating whenever a pipeline is exposed and to take corrective action when degradation is found. Also upgraded were compliance standards for cathodic protection for underground and submerged metallic pipelines.

In 1996, a steel pipeline transporting liquid butane ruptured near Lively, Texas, sending a butane vapor cloud into a surrounding residential area. The butane vapor ignited as two residents in a pickup truck drove into the vapor cloud and died of thermal injuries. A Safety Board investigation concluded that the accident resulted from the failure to adequately protect the pipeline from corrosion. For a pipeline, the coating is the primary protection against corrosion, but all coatings have damaged or defective areas at which corrosion can occur. Cathodic protection is a technique for preventing corrosion of an underground or submerged pipeline by applying DC electrical current to the pipe surface from an external source.

Liquid pipeline failure detection. Many pipeline operators are using internal inspection devices to identify and remove deteriorated segments from their pipeline systems, and new pipelines are designed to accommodate internal inspection devices to detect system weakness before an accident occurs. Pipeline operators have installed more

effective systems for monitoring pipeline operations, as well as remote and automatic valves, so that operators will be promptly alerted to failures and can rapidly isolate those areas.

Safety Board investigations have continually identified the need for improved monitoring systems, improved means to rapidly shut off failed pipe segments, and improved methods for periodically analyzing the condition of the pipe system.

Rapid shutoff of damaged service lines. Regulations require gas distribution operators to install an excess flow valve on new and renewed high-pressure gas service lines when a customer requests one and agrees to pay the cost. An excess flow valve is a device capable of shutting off the flow of gas in service lines that experience an abnormal flow increase. The Safety Board investigated numerous pipeline accidents caused by excavation damage that could have been minimized by excess flow valves.

Toughness standards. Federal regulations require minimum toughness standards, improved quality assurance, more stringent chemical composition, and higher yield and tensile strength for various types of gas and hazardous liquid pipelines.

A natural gas pipeline rupture in Edison, New Jersey, in 1994 resulted in an explosion and fire that ignited several buildings in an apartment complex. About 1,500 residents were evacuated. There were several minor injuries but no deaths. The Safety Board's investigation found that excavation damage to the pipe had been compounded by the pipe's brittleness—two major factors in its rupture.

Railroad Tank Car Safety

Tank car testing. The Federal Railroad Administration and the Research and Special Programs Administration published new regulations that require nondestructive testing of tank cars. The FRA also issued an emergency order requiring dual-diameter tank car owners to implement a sampling inspection program.

These improved standards were prompted, in part, by the Safety Board's on-scene investigation of the catastrophic failure of a pressure tank car filled with 32,000 gallons of liquid propane in Dragon, Mississippi, in 1992. A white vapor cloud filled the area and ignited into a fireball. Examination revealed a preexisting crack of about 21 inches. Five additional tank cars of similar design were examined, and three of them had cracks ranging from two to 30 inches.

Tank car protection. The U.S. Department of Transportation issued regulations that require top and bottom shelf couplers and headshields, thermal and puncture protection to be included in the design of several types of new tank cars used to transport flammable gases, ammonia, and a wide variety of hazardous material. Existing cars of that specification had to be retrofitted. Headshields protect tank cars from being punctured at the ends of the tank car, the most vulnerable area for punctures.

The nation's railroad tank cars are stronger and safer because of Safety Board investigations and recommendations that resulted in tank car head shields, and thermal and puncture protection.

Tank car couplers were upgraded to prevent tank punctures. Couplers also help hold cars together during derailments.

Tank car protection upgrades stems from several accident investigations. In 1974, in a railroad yard in Decatur, Illinois, a tank car was punctured by a box car coupler, allowing a flammable gas to escape and vaporize. About 10 minutes later, the tank car exploded, killing 7 yard employees and injuring 349 other persons. In a 1991 safety study, the Safety Board investigated 45 railroad accidents and concluded that hazardous materials that are highly flammable or toxic, or that pose a threat to the environment, were frequently transported in tank cars that provided inadequate protection.

Recreational Boating

Personal watercraft. States, the U.S. Coast Guard, and safe boating associations have implemented a series of safety guidelines for those who rent and use personal watercraft, such as jet skis and other small, propelled water vehicles. Safeguards include a checklist for boat rental businesses to help evaluate a person's ability to operate a personal watercraft. Boating courses offered by the Coast Guard Auxiliary, U.S. Power Squadrons, Boat/US, and nationwide associations representing boating administrators and boating law administrators include information on the safe operation of personal watercraft. Off-throttle steering improvements are being added to personal watercraft, and States are encouraged to conduct alcohol testing of boat operators involved in fatal accidents.

In a 1998 Safety Board study, investigators analyzed hundreds of reported personal watercraft accidents in 1996 and 1997. The analysis showed major deficiencies in protection for personal watercraft riders from injury, operator experience and training, and boating safety standards.

This cargo jet was stopped from running off the runway at New York's LaGuardia airport in 2003. It was stopped by an "arrestor bed"—a cellular concrete structure at the end of the runway that slows the aircraft.

Runway Safety

Aircraft overruns. The Port Authority of New York and New Jersey installed "arrestor beds" at the end of runways at JFK International and LaGuardia airports. Arrestor beds are cellular concrete systems that deform readily and reliably when an aircraft traverses it. As tires crush the material, the drag forces decelerate the aircraft.

The Safety Board investigated two major runway overrun accidents in 1989 and 1994 at New York's LaGuardia Airport. Two people died in one of the accidents when the aircraft ran off the runway and crashed into the bay.

In 2003, a landing Gemini Air Cargo MD-11 overshot the runway and came to a stop in the arrestor bed. Four years earlier, arrestor bed technology also safely stopped an American Eagle commuter plane that overran a runway at the airport.

Airport ground collisions. The Federal Aviation Administration issued air traffic bulletins to controllers in airport towers, emphasizing the higher risk of collision to aircraft and ground vehicles on airports when aircraft are maneuvering near runway intersections. Controllers are advised to use more caution and to state the runway intersection when authorizing an aircraft to taxi into position to hold or when clearing an aircraft for takeoff from an intersection.

These bulletins were prompted by the collision of two Cessna aircraft on the Sarasota, Florida, airport runway in 2000, killing both general aviation pilots.

Safety in Alaska's Skies

Harsh flying environment. Major upgrades to air taxi aircraft safety have been made by the Federal Aviation Administration in Alaska, a particularly harsh flying environment with a history of aircraft accidents above the rate in the lower 48 States. These improvements were targeted at the most common type of fatal accident in Alaska: continued visual flight into adverse weather.

Improvements include wider use of the Global Positioning System, upgraded equipment and policies for communicating and gathering weather information, advanced avionics in aircraft, improved navigational aids, more published approaches, and a new system for disseminating information about runway conditions to pilots. The State of Alaska has stepped up its inspections of airport conditions and obtained funding for equipment and training for its airport employees to communicate with pilots about safe conditions for landing.

These changes resulted from the Safety Board's numerous aircraft accident investigations and recommendations and from a safety study of Alaska's unique flying hazards.

School Bus Safety

Easier exits. The National Highway Traffic Safety Administration issued school bus standards for improving total surface area for egress, including standards for the size of school bus side windows and roof hatches, and requiring that exit doors remain open during emergencies.

Safety Board investigations of numerous school bus accidents in the 1970s and 1980s pointed to the need for more ways to exit buses and better designs for emergency doors, windows, and roof hatches.

One of the most horrific accidents was the collision of a pickup truck and church bus in 1988 in Carrollton, Kentucky. The church bus fuel tank was punctured and fire engulfed the entire bus. The bus driver and 26 bus passengers were killed. Contributing to the severity of the accident was the partial blockage by the rear bench seats of the area leading to the rear emergency exit, which impeded rapid passenger egress.

Another accident occurred in 1989 when a truck and school bus collided in Alton, Texas. The bus fell into an excavation pit partially filled with water. The bus front boarding door was jammed shut, but the rear emergency exit door was operable. The bus had no other emergency exits. Nineteen students died at the accident scene, and two died later in the hospital. The fatalities were the result of drowning or complications related to the submersion. Contributing to the severity of the accident, the Safety Board said, was the lack of a sufficient number of emergency exits on the school bus to accommodate the rapid egress of all students.

Debris from a small aircraft litters a runway after a fatal runway collision in 2000. NTSB's investigation and recommendations improved the flow of runway status information between pilots and controllers.

Lesson Learned

Alaska's harsh flying environment is a challenge to NTSB investigators and aviation safety proponents. NTSB investigations have resulted in a series of safety improvements in Alaska involving upgraded pilot education, and airport, aircraft and navigation aid improvements.

Today's school buses are designed and built with dozens of safety improvements including tougher construction standards, greater joint strength, roof rollover protection, energy absorbing seats, better emergency exits, and upgraded fuel protection.

School bus design. The U.S. Department of Transportation enacted tougher construction standards for school buses that required greater body joint strength, roof rollover protection, redesigned energy-absorbing seats, and emergency exit and fuel system protection improvements.

In a 1987 study on the performance of buses built to the new standards, the Safety Board found that the standards had significantly improved the safety of school bus transportation and recommended rapid retirement of all prestandard buses in the fleet. In a 1999 study of bus crashworthiness, the Safety Board determined that occupant protection could be improved for side impact collisions and rollovers.

School bus drivers. The U.S. Labor Department no longer allows States to employ 16- and 17-year-old school bus drivers. The Safety Board sought this action because its investigations showed that these drivers were statistically over-represented in school bus accidents when compared to older bus drivers.

Upgraded school bus inspections. States upgraded the quality of school bus inspection and repair by revising the qualifications and training for inspectors and mechanics. Quality control procedures have been instituted to determine whether needed repairs have been performed adequately and whether major repairs are required.

One of the dozens of school bus accidents investigated by the Safety Board occurred in 1983. A school bus accident near Newport, Arkansas, killed the driver, 4 teachers, and 4 students, and injured 2 teachers and 27 students. The investigation determined that the school bus was in poor mechanical condition and a post-accident inspection indicated major repairs were needed.

Teen Drivers

One of the Safety Board's goals is to improve safety for young novice drivers. Many States have instituted NTSB-backed graduated driver licensing, or provisional license systems. They include restrictions on the number of allowed passengers, mandatory seat belt use, limited driving times, and violation-free driving records before drivers are ready for a full license.

Protecting young drivers. States have enacted laws providing for a provisional license system, called graduated driver licensing, for young novice drivers—a significant change in the way teen drivers are licensed. These laws include a three-stage system for these drivers (learners permit, intermediate phase, and full unrestricted license). They require young novice drivers to wear seatbelts and remain violation free during the intermediate phase in order to obtain the unrestricted license. Some States also restrict nighttime driving and the number of passengers teen drivers can carry under an intermediate phase license.

Safety Board investigations consistently confirmed these grim facts: teen drivers represent less than 7 percent of the driving population but account for more than 14 percent of the drivers involved in deadly crashes; more than 22 percent of all highway fatalities occur in crashes that involve teenage drivers; the risk of a crash increases greatly with each additional teen passenger riding with a younger teen driver; and two-thirds of passengers who were killed in teen crashes were teenagers themselves, between the ages of 15 and 19.

Train and Mass Transit Safety

Locomotive fuel tank integrity. Manufacturers have designed the fuel tanks of locomotives to better withstand derailments and grade crossing accidents. Upgrades include reinforced tank skin, bulkheads with heavier steel, and tanks that are integrated into the locomotive frame.

The Safety Board's investigations documented many instances when locomotive fuel tanks ruptured during collisions. In the 29 locomotive derailments investigated by the Board in 1991 alone, diesel fuel spills occurred in more than half of the accidents.

In 1997, the Safety Board investigated two Amtrak passenger train derailments involving locomotives equipped with "integrally situated" fuel tanks. This type of fuel tank is located within the locomotive frame structure and was found to clearly outperform frame-suspended fuel tanks. Integrally situated fuel tanks provide a higher ground clearance than conventional designs. As a result, less fuel tank damage and no significant spillage or subsequent fire occurred in either of the accidents, despite serious track damage.

Stronger train bodies. Light rail and transit car safety standards have been toughened to require stronger car body corner post structures in self-propelled passenger cars and control cab locomotives.

The actions by the Federal Railroad Administration and Federal Transit Administration followed the Safety Board's investigation into a 1993 commuter train crash in Gary, Indiana. One train failed to heed a stop signal and collided with another train, with the major damage to the left corners of the lead cars of both trains. Seven passengers died and 95 were injured.

Train brakes. Freight train braking rules were strengthened to require the ability for emergency application of air brakes when train equipment is left unattended.

In 1997, the Safety Board investigated an accident involving an Apache Railway freight train in Holbrook, Arizona. The crew was removing one car from the train when the remainder of the train rolled down a descending grade and derailed several cars, including a tank car that spilled its entire contents of hydrogen oxide. A fire ignited and a nearby residential area was evacuated.

Train safety supervision. Supervision of passenger train crews and the management of train movements have improved because of Safety Board investigations and recommendations. Improvements include expanded supervision and management of train operations on the Northeast Corridor, including mandatory speed and signal compliance checks; regular crew fitness-for-duty checks at reporting points; written notification of speed restrictions; special permission procedures for trains entering out-of-service track sections; and a reporting system for Amtrak crew efficiency, rule compliance, and toxicology tests while Amtrak trains are using non-Amtrak or "host" railroad tracks.

Steam Locomotives: Learning Safety Lessons from History

Steam locomotives were built long before the Safety Board was on the job, but that didn't stop investigators from figuring out ways to make them safer.

In fact, the Safety Board has investigated several tourist railroad accidents and issued recommendations to improve their safety. Riding steam locomotives is a popular tourist attraction with more than 360 in operation.

A significant tourist railroad accident occurred in 1995 near Gettysburg, Pennsylvania, when a steam locomotive, built in 1948, failed and released steam through the firebox door and into the locomotive cab, seriously burning the engineer and the two firemen. Investigators found that the train crew had allowed the water in the locomotive boiler to drop to an insufficient level and the boiler and its associated equipment had not been properly maintained.

The Federal Railroad Administration revised and updated regulations regarding steam locomotive safety. Actions that resulted from the accident include the addition of a redundant water-monitoring system for steam engines; certification of steam locomotive operators and repairers; updated and expanded Federal regulations for steam locomotives; and increased compliance for employees and volunteers with the Hours-of-Service Act to minimize fatigue hazards.

Lesson Learned

Dozens of hazardous materials accidents investigated by the NTSB have resulted in improved communications, coordination and training among local emergency responders and jurisdictions, railroads and shippers; better 24-hour emergency contact information; and more accurate hazardous materials manifests on trains and planes.

In 2003, the NTSB Academy opened its doors in Ashburn, Virginia, and is the Safety Board's first comprehensive training and learning facility.

Training

Hazardous materials training. Major railroads, carriers, shippers, and emergency response agencies have improved their communication and coordination during hazardous materials accidents and incidents. Training programs for operating crews and supervisors have been implemented that spell out steps to take immediately following a hazardous materials incident or accident, including procedures for working more closely with emergency response agencies during wreckage-clearing operations and requirements for train crews to maintain up-to-date listings showing the position of hazardous materials cars in their trains. Shippers also include an emergency 24-hour telephone number on their shipping papers that allows access to detailed information on the characteristics of the material.

Dozens of hazardous materials accidents investigated by the Safety Board led to improvements. They include a freight train derailment in Freeland, Michigan, in 1989, when a tank car containing a chlorosilane mixture was punctured, causing the cargo to ignite. The manufacturer's material safety data sheet contained conflicting information and did not provide effective firefighting procedures; emergency responders attempted various techniques over a 5-day period before they were able to extinguish the blaze.

Recurrent training. Amtrak improved its initial and recurrent emergency training for all crews including on-board service personnel for passenger safety and instituted a database to monitor compliance with training requirements.

Lack of consistent emergency training was an issue uncovered in an Amtrak passenger train accident in Kingman, Arizona, in 1997. The train derailed in the dark after it crossed a small bridge that was damaged by a flash flood. Ten Amtrak employees and more than 170 passengers were injured.

Train crew qualifications. Two Safety Board investigations of passenger train accidents in 1996 at Secaucus, New Jersey, and Silver Spring, Maryland, have led to improvements in the physical testing and physical qualifications of train crews and signal system design. In the Secaucus accident, two New Jersey Transit commuter trains collided head on, killing the engineers on both trains and one passenger. The Safety Board determined that the probable cause of the accident was that one of the train engineers failed in correctly perceiving a red signal because of an eye disease and color vision deficiency, which he failed to report to New Jersey transit during annual medical exams. In the Maryland accident, three crew members and eight passengers on a Maryland commuter train were killed when the engineer failed to respond to a signal and the train collided with an Amtrak passenger train. The Safety Board said the engineer and crew failed to obey signals because of multiple distractions, and Federal and State regulators failed to conduct analyses on the human factors impact of signal modifications on that rail line.

Training guidelines. The U.S. Coast Guard revised its enforcement guidelines so that its inspectors can better assess crew training on sophisticated integrated bridge systems on ships and the crew's ability to recognize system failures, especially in high-tech navigation equipment.

In 1995, the *Royal Majesty* passenger ship with more than 1,500 on board ran aground near Nantucket Island, Massachusetts. The Safety Board investigation said the cruise line company failed to adequately train watch officers in the automated features of the ship's integrated bridge system and global positioning system. The ship's navigation system failed, the ship veered off course, and the crew failed to take corrective action.

Weather and Visibility Hazards

Airport windshear alerts. Numerous improvements have been made to low-level wind shear alert systems and Doppler weather radars at large airports nationwide to increase their effectiveness, including the addition of new technology, better placement near airports, increased area coverage, and improved compatibility with other systems at airports. These alert systems provide pilots with faster and more accurate weather information, and a complete windshear training program is available to pilots.

These upgrades were prompted by numerous Safety Board investigations, including that of a USAir DC-9 that collided with trees and crashed in Charlotte, North Carolina, in 1994, killing 37. During severe weather, the aircraft missed its approach. Two other windshear accidents that prompted improvements were the 1975 crash of an Eastern Air Lines 727 in New York, and the 1985 crash of a Delta Air Lines L-1011 while landing at Dallas/Fort Worth during a thunderstorm, killing 135 persons.

Eyes on the skies. The National Weather Service has improved the monitoring of its meteorologists located at government air traffic control center weather service units to ensure adequate staffing when significant adverse weather is forecast.

The improvements stem from the American Airlines DC-9 crash in Little Rock, Arkansas, in 1999. The aircraft ran off the runway in adverse weather, killing 11 and injuring 110 of the 145 on board. Weather information dissemination was a major issue in the investigation report.

Lights on for safety. The National Safety Council and other safety organizations encouraged motorists, through public information, to drive with their low-beam headlights on during the day. Daytime headlight use increases vehicle visibility and more quickly alerts pedestrians and other drivers to impending hazards and crashes.

Reduced visibility. Several States have implemented comprehensive detection systems and response plans that include the detection of traffic flow disruptions and procedures for uniform driver response through reduced visibility areas, especially fog-prone areas and areas affected by smoke and dust. The Transportation Research Board compiled and published preferred practices, and a Safety Board public hearing on the issue resulted in information that was distributed to all States.

Aviation accidents involving windshear and severe weather conditions have led to major improvements in windshear detection education, advances in technology, and improved weather monitoring. They include the 1985 crash of an L-1011 that claimed 135 lives (top photo), and a DC-9 accident in 1999 that killed 11.

Driving with headlights on during the day improves vehicle visibility and safety.

Preventing multi-car pileups is the goal of the NTSB after it investigated six limited visibility crashes in the 1990s.

The potential for work zone accidents on the nation's highway has been reduced thanks to safety improvements following several work zone accident investigations.

The changes stem from the Safety Board investigation of six limited visibility crashes since 1990 that killed 40 people and involved more than 450 vehicles.

Work Zone Safety

Highway construction. The nationwide *Manual of Uniform Traffic Control Devices* was strengthened by the Federal Highway Administration to require that work zone flaggers be stationed far enough ahead of work zone workers and that they use audible warning devices, such as horns, to alert highway workers to the approach of erratic vehicles.

These changes stem from several work zone accident investigations, including a 1990 tragedy when 10 people died and two were injured in a chain reaction crash that occurred in a highway work zone in Sutton, West Virginia. A vehicle transporter carrying eight cars entered a highway repair work area reduced to one lane and struck the rear of a vehicle. A chain reaction resulted and five vehicles were burned and destroyed, including three West Virginia highway department vehicles.

NTSB Most Wanted List

'Most Wanted List' Highlights Needs for More Safety Advances

This publication highlights many of the safety recommendations that have been implemented; however the Safety Board's work is far from finished. In virtually every accident investigation, the Safety Board identifies areas for improvement. Many are given higher priority by placing them on NTSB's "Most Wanted List of Safety Improvements." Fully implementing these recommendations, the Board believes, will save many more lives in the future.

The Most Wanted List was introduced in 1990. It has proven successful in giving extra emphasis to more than 260 recommendations —most of them very tough to implement. Half of them have been implemented to the Safety Board's satisfaction, and many more are nearing implementation.

The current Most Wanted List focuses government, industry, and public attention on 55 recommendations that the Safety Board strongly believes should be acted on quickly. These recommendations advocate a wide range of safety upgrades in all modes of transportation —all uncovered during dozens of accident investigations. Significant progress has been made on many of these issues, but progress on some lags behind and is long overdue. The Safety Board will continue to aggressively push for these safety advances.

Accident investigations that inspired these recommendations include 10 major aviation crashes, dozens of passenger train and freight train derailments and collisions, multiple highway crashes, catastrophic pipeline ruptures and oil spills, and numerous ship collisions in the past decade. They also stem from NTSB safety studies, special reports, and forums focusing on personal watercraft, recreational boating, commuter airlines, hardcore drinking drivers, air bags, seatbelts and child passenger safety, bus crashworthiness, and human fatigue in transportation.

The list is divided into two sections: Actions needed by Federal agencies and actions needed by the States.

Actions needed by Federal Agencies

Aviation

The Federal Aviation Administration should act to:

Reduce Dangers to Aircraft Flying in Icing Conditions

- Use current research on freezing rain and large water droplets to revise the way aircraft are designed and approved for flight in icing conditions.

Deicing aircraft is a critical step in reducing the dangers of flying in icing conditions.

NTSB's goal to eliminate airliner fuel tank explosions is on the agency's Most Wanted List. Smoke rises from a fuel tank explosion in an aircraft parked at a gate in Bangkok, in 2001 (top photo). A tragic accident, attributed to an explosion of a fuel air mixture in center wing tank occurred on 1996 when a 747 crashed into the Atlantic Ocean, and claimed 230 lives. Reconstructing a portion of the downed plane aided NTSB investigators in finding the accident's probable cause. The reconstruction is housed at the NTSB Academy and is used as a training tool for investigators.

- Conduct additional research with NASA to identify realistic ice accumulation and incorporate new information into aircraft certification and pilot training requirements.

The 1994 in-flight icing encounter, subsequent loss of control, and crash of a commuter airliner in Roselawn, Indiana, which took 68 lives, prompted the Safety Board to examine the issue of airframe structural icing and conclude that the icing certification process has been inadequate. The certification process has not required manufacturers to demonstrate the airplane's flight handling and stall characteristics under a realistic range of adverse ice accretion/flight-handling conditions. The Federal Aviation Administration has not adopted a systematic and proactive approach to the certification and operational issues of turbine-engine driven transport category airplane icing.

The consequences of operating an airplane in icing conditions without first having thoroughly demonstrated adequate handling/controllability characteristics in those conditions are sufficiently severe that they warrant a thorough certification test program, including application of revised standards to airplanes currently certificated for flight in icing conditions.

Eliminate Flammable Fuel/Air Vapors in Fuel Tanks on Transport Category Aircraft

- Implement design changes to eliminate the vulnerabilities of flammable fuel/air vapors in all transport category aircraft.

Center wing fuel tank explosions have resulted in 346 fatalities. Operating transport-category airplanes with flammable fuel/air vapors in fuel tanks presents an avoidable risk of explosion. A fuel tank design and certification philosophy that relies solely on the elimination of all ignition sources, while accepting the existence of fuel tank flammability, is fundamentally flawed because experience has demonstrated that all possible ignition sources cannot be predicted and reliably eliminated. As a result of the TWA 800 accident that occurred in July 1996, the Safety Board asked the Federal Aviation Administration to address both long-term and short-term solutions to the fuel tank issue.

Stop Runway Incursions/Ground Collisions of Aircraft

- Give immediate warnings of probable collisions/incursions directly to flight crews in the cockpit.

In the late 1980s, an inordinate number of runway incursions and ground collision accidents resulted in substantial loss of life, and the Safety Board issued numerous safety recommendations addressing the issue. The Federal Aviation Administration completed action on a number of important objectives to make the ground operation of aircraft safer. However, these incidents continue to occur with alarming frequency.

The system the FAA currently deploys to prevent runway collisions requires a controller to do the following: Determine the nature of the problem, determine the location of the aircraft, identify the aircraft involved, determine what action to take, and issue appropriate warnings or instruction The flight crew must then respond to the situation and take action.

Simulations of the FAA's airport movement area safety system performance using data from actual incursions show that alerts may occur as little as 8 to 11 seconds before a potential collision. Until there is a system in place to positively control ground movements of all aircraft, with direct warning to pilots, the potential for this type of disaster will continue to be high.

Improve Audio and Data Recorders/Require Video Recorders

- Require cockpit voice recorders to retain at least 2 hours of audio.
- Require back-up power sources so cockpit voice recorders collect an extra 10 minutes of data when an aircraft's main power fails.
- Install video recorders in cockpits to give investigators more information to identify the causes of complex accidents.

In order to rapidly, effectively, and efficiently determine the factors related to an aircraft accident, the Safety Board's investigators must have as much information as possible. Automatic information recording devices, such as cockpit voice recorders and flight data recorders have proven to be very useful in gathering pure factual information. The fact that this information is recorded immediately prior to and during the accident sequence often gives investigators the ability to quickly determine and correct a problem. This knowledge results in the development of timely, more precise safety recommendations that are likely to reduce future similar accidents.

Require Restraint Systems for Children Under Age 2

- Require restraints for infants and small children during takeoff, landing, and in turbulent conditions to provide them the same level of safety as other passengers.

Infants and young children deserve the same protection that is provided to other aircraft passengers. During take-off, landing, and turbulence, adults are required to be buckled up, baggage and coffee pots are stowed, and computers are turned off and put away, yet infants and toddlers need not be restrained.

Railroad

The Federal Railroad Administration should act to:

Implement Positive Train Control Systems

- Prevent train collisions and overspeed accidents by requiring automatic control systems to override mistakes by human operators.

Over the last three decades, the Safety Board has investigated a long list of accidents in which crewmembers failed to operate their trains effectively and in accordance with operating rules for a variety of reasons, including fatigue, sleeping disorders, use of medications, or distractions within the operating cab. Because of these human performance

The deadliest runway accident in the United States was a collision between a 737 and a commuter at Los Angeles in 1991, killing 34. The Safety Board wants immediate warnings of probable collisions and incursions to be sent directly to flight crews.

In 2003, the government reported 145 railroad head-on, rear-end, and side collisions with 91percent attributed to human factor causes. Implementing positive train control systems would have a major impact on reducing these types of accidents.

deficiencies, the Safety Board has advocated the implementation of a system that compensates for human error and that incorporates collision avoidance to prevent train collisions. The Safety Board believes that this system, known in the industry as positive train control, is particularly important where passenger trains and freight trains operate.

Highway

The Federal Motor Carrier Safety Administration should act to:

Improve the Safety of Motor Carrier Operations

- Prevent motor carriers from operating if that puts vehicles with mechanical problems on the road or unqualified drivers behind the wheel.

The two most important factors in safe motor carrier operations are the operational status of the trucks and the performance of the individuals who drive them. If significant problems exist with trucks and/or the qualifications or fitness for duty of the drivers, the carrier should be rated by the Federal Motor Carrier Safety Administration as unsatisfactory, forcing corrections of the problems identified within a specified time period, along with greater FMCSA oversight because problems in either of these areas could result in severe consequences for safety. If the problems persist, the motor carrier should have its license to operate revoked. The Safety Board has called on the FMCSA to implement such a system.

Prevent Medically Unqualified Drivers from Operating Commercial Vehicles

- Establish a comprehensive medical oversight program for interstate commercial drivers.
- Ensure that examiners are qualified and know what to look for.
- Track all medical certificate applications.
- Enhance oversight and enforcement of invalid certificates.
- Provide mechanisms for reporting medical conditions.

Based on its investigations of accidents involving drivers with serious medical conditions, the Safety Board has determined that serious flaws exist in the medical certification process for commercial vehicle drivers. Such flaws can lead to increased highway fatalities and injuries for commercial vehicle drivers, their passengers, and the motoring public.

Many drivers whose occupations and serious medical conditions are known to their employers, health care providers, and others are never reported to the appropriate motor vehicle licensing authorities, thereby potentially endangering the drivers themselves and others.

Enforcement authorities cannot, in most instances, determine the validity of a medical certificate during safety inspections and routine stops because of the absence of procedures or information sources to validate the medical certificate. The inability to authenticate the information on a medical certificate hampers enforcement authorities in their ability to identify unfit drivers and place them out of service.

Improving motor carrier safety is an important issue on the Most Wanted List. The NTSB's goal is to prevent unqualified drivers from getting behind the wheel, and getting vehicles with mechanical problems off the road.

In the absence of a mechanism to track all medical certification examinations, a commercial driver with a serious medical condition who is denied a medical certificate by one examiner may be able to obtain a certificate from another examiner, thus subverting the purpose of the medical certification process.

The National Highway Traffic Safety Administration and the U.S. Department of Transportation should act to:

Enhance Protection for Bus Passengers

- Redesign motor coach window emergency exits so passengers can easily open them.
- Issue standards for stronger bus roofs and require them in new motor coaches.
- Devise new standards to protect motor coach passengers from being thrown out of their seats or ejected when a bus sustains a front, side, or rear impact or rolls over.
- Develop standard definitions and classifications for each of the different bus body types.

One of the primary causes of passenger injury in motorcoach buses occurs when passengers are thrown from their seating area during an accident. In its 1999 special investigation report on bus crashworthiness, the Safety Board concluded that the overall injury risk to occupants in motorcoach accidents involving rollover and ejection may be reduced significantly by retaining the occupant in the seating compartment throughout the collision.

The Safety Board asked the National Highway Traffic Safety Administration to require new motorcoach bus occupant protection systems that retain passengers in their seating area. In addition, stronger bus roofs and easy-to-open bus window emergency exits are needed to enhance safety. Furthermore, to ensure consistent application of safety standards, the various Federal agencies responsible for bus safety should use a consistent definition for "bus."

This bus accident in New Orleans in 1999 claimed 22 lives and prompted the NTSB to issue recommendations aimed at preventing medically unqualified drivers from operating motor vehicles.

Marine

The U.S. Coast Guard should act to:

Improve Drug and Alcohol Testing of Crews After Accidents

- Strengthen and clarify regulations to require that drug and alcohol testing be conducted quickly after serious marine accidents.

In accidents involving human error, the Safety Board must first determine whether toxicological issues can be excluded as causal to the accident. If drugs and alcohol cannot be excluded, the Board may jeopardize its assessment of other critical issues, such as fatigue. Therefore, post-accident toxicological testing is extremely important to accident investigations. The potential effects of alcohol or drug use as

a causal factor in major marine accidents frequently cannot be ruled out because testing is not done at all, or is often not done correctly and in a timely manner. This is usually attributable to lack of knowledge of the testing requirements for alcohol because U.S. Coast Guard regulations for post-accident alcohol and drug testing are unclear. The Safety Board's recommendations, issued to the Coast Guard in 1998, call for a series of improvements related to alcohol and drug testing.

Intermodal

The U.S. Department of Transportation, Federal Aviation Administration, U.S. Coast Guard, and Pipeline and Hazardous Materials Safety Administration should act to:

Update Hours-of-Service Regulations in Aviation, Marine, and Pipeline Industries

- Set working hour limits for flight crews, aviation mechanics, pipeline controllers, mariners, and other transportation operators, and provide predictable work and rest schedules based on current fatigue research, circadian rhythms, and sleep and rest requirements.

The Safety Board first addressed the issue of operator fatigue in transportation in 1989 in three recommendations that were issued to the Secretary of Transportation calling for research, education, and revisions to existing regulations. The Safety Board's 1999 safety study of U.S. DOT efforts to address operator fatigue continued to show that this problem was widespread. Operating a vehicle without the operator's having adequate rest, in any mode of transportation, presents an unnecessary risk to the traveling public. The laws, rules, and regulations governing this aspect of transportation safety are archaic in many cases and are not adequate to address the problem.

Despite the acknowledgment by the U.S. DOT that fatigue is a significant factor in transportation accidents, little progress, with the exception of a final rule by the Federal Motor Carrier Safety Administration, has been made to revise the hours-of-service regulations to incorporate the results of the latest research on fatigue and sleep issues.

Action needed by the States

Highway

Improve Child Occupant Protection

- Enact State laws requiring booster seats for young children.

In the decade of the 1990s, almost 17,000 children under age 10 died in motor vehicle crashes—6 out of 10 were not buckled up. The vast majority of children under age 8 who are buckled up are improperly restrained in a seatbelt that was designed for adults, rather than in a booster seat. The booster seat aids in the proper positioning of the vehicle's existing lap/shoulder belt. Ten times more children ride in the

front seat of the car than need to, even though an available back seat is safer than the front seat. Furthermore, vehicles should be equipped with lap/shoulder belts at all seating positions, including the center rear seat.

Enact Primary Seatbelt Enforcement Laws

- Increase the number of people who wear seatbelts through stronger enforcement laws.

Lap/shoulder belts, when used, reduce the risk of fatal injury to front seat passenger car occupants by 45 percent and the risk of moderate-to-critical injury by 50 percent. When adults are buckled up, 87 percent of children are buckled up, but when adults are not buckled up, only 24 percent of children are buckled up. States with primary enforcement have about 10-15 percent higher seatbelt use compared to States with secondary enforcement. It is estimated that more than 21,000 lives could have been saved in 2001 if all passenger vehicle occupants over age 4 used seatbelts.

Promote Teen Highway Safety

- Enact graduated driver licensing legislation.
- Prohibit nighttime driving by young novice drivers.
- Prohibit use of wireless communications devices by young novice drivers.

Motor vehicle crashes remain the leading cause of death for 15 to 20 year olds. In the decade of the 1990s, 63,000 youth aged 15 to 20 died in traffic crashes, more than 120 each week. In 2001, 3,608 drivers 15 to 20 years old were killed, and an additional 337,000 were injured in motor vehicle crashes. In 2000, teen drivers constituted about 7 percent of licensed drivers, but were involved in 14 percent of all highway fatalities. About 20 percent of teen driving occurs at night, but about 50 percent of teen fatalities (those occurring with a teenager at the wheel) occur during the hours of darkness. The risk of a crash involving a teenage driver increases with each additional teen passenger in the vehicle, and crash severity increasdistractions including the use of wireless communications devices.

Reduce Hard Core Drinking Driving

Enact State legislation and take other actions that are proven to reduce crashes involving those who repeatedly drink large amounts of alcohol and drive, including:

- Frequent, statewide sobriety checkpoints.
- Legislation to create stricter sanctions for those arrested for the first time with a high blood alcohol concentration.
- Zero blood alcohol requirement for convicted DWI offenders when they get their licenses back.
- Administrative rather than court-based license revocation for refusing to take or failing the sobriety test.
- Vehicle sanctions for DWI offenders.

Boosting the proper use and installation of car booster seats is a goal of a broad coalition of highway safety advocates, including the NTSB.

Because the NTSB believes that enacting graduated driver licensing laws in every State is critical to the safety of young novice drivers, the issue is on the Most Wanted List. Strictly adhering to driving laws, speed limits, and limiting driving times and the number of passengers are elements of an effective graduated licensing program.

Most Wanted Goal

A Most Wanted List goal is to reduce the number of highway crashes involving hard core drinking drivers—those who repeatedly drink large amounts of alcohol and drive. The problem is a serious one. Although hard core drinking drivers represented less than 1 percent of all drivers on the road, they constituted 27 percent of drivers in fatal crashes during a recent survey period.

School bus grade crossing accidents are infrequent, but the results can be deadly when they occur. In this school bus accident in Tennessee in 2000, three students were killed and several others were injured.

- Eliminate plea-bargaining DWI offenses and programs that divert offenders and purge the offense record.
- Retain DWI offense records (to identify and prosecute repeat offenders) for at least 10 years.
- Develop and operate special sanction (court-based) programs for hardcore DWI offenders.

Hard core drinking drivers (repeat offender-drinking drivers with a prior driving-while-intoxicated arrest or conviction within the past 10 years or offenders with a blood alcohol concentration of 0.15 percent or greater) pose an increased risk of crashes, injuries, and fatalities.

Hard core drinking drivers are overrepresented in fatal crashes. Although hard core drinking drivers constituted only 0.8 percent of all drivers on the road in the National Roadside Survey, they constituted 27 percent of drivers in fatal crashes during the same time period in 1996. In 1998 alone, hardcore drinking drivers were involved in a minimum of 6,370 highway fatalities.

Improve School Bus/Grade Crossing Safety

- Install stop signs at passive crossings.
- Prioritize for upgrade to lights and gates, crossings that school buses traverse that now only have warning signs.
- Install noise-reducing switches on new buses.
- Enhance bus driver training and evaluation.
- Include grade crossing questions on commercial driver license exams.

While school bus grade crossing accidents are infrequent occurrences, the results can be catastrophic when they do occur. School buses often carry large numbers of children, and exposing them to the risk of collision at a grade crossing poses grave danger. Passive grade crossings are particularly dangerous because there are no active warning devices to signal that a train is approaching. Ensuring that drivers "stop, look, and listen" at all grade crossings will help ensure the safety of the nation's school children.

In 2004, the States and railroads reported 245,729 grade crossings; 44 percent were passive crossings. Over 86,000 of the passive crossings are public crossings (as opposed to those on private property). About 42 percent of the fatalities from all grade crossing accidents in 2003 were at passive crossings.

Marine

Enhance Recreational Boating Safety

- Require mandatory education of boat operators.
- Require use of lifejackets for children.
- Require safety instruction prior to personal watercraft rental.

Unlike general aviation and motor vehicle operations, an operator of a recreational boat is not required to demonstrate an understanding of the rules of the road or an ability to operate the vessel. A Safety Board study found that as few as 7 percent and no more than 22 percent of first-time boat operators take some type of voluntary boating safety course, and many of those courses do not require persons to demonstrate an ability to operate the vessel. The study also indicated that 85 percent of those who drowned in a boating accident were not wearing personal flotation devices. Operators of rented personal watercraft had less experience than did operators of privately owned personal watercraft. Only one out of three renters included in the Safety Board's accident analysis indicated that the rental agent had required them to demonstrate personal watercraft riding ability.

For updates on the Most Wanted List, visit the NTSB Web site at <http://www.ntsb.gov> and click on the Most Wanted List box on the front page.

The NTSB strongly believes that recreational boating safety can be enhanced and accidents reduced by requiring boat operators to take safety training courses.

Requiring personal flotation devices for children on recreational boats is one of the NTSB's goals to enhance safety. NTSB safety studies show that far too many people who drown in boating accidents were not wearing personal flotation devices.

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