

WE ARE ALL SAFER

NTSB-Inspired Improvements in Transportation Safety



ATTENTION

National Transportation Safety Board
Washington, D.C. 20594



Dear Readers:

More than 90 years ago, philosopher George Santayana said, "Those who cannot remember the past are condemned to repeat it." I like to say it this way: We can't afford to let future generations forget the safety lessons we have learned from more than 30 years of transportation accident investigations.

It is in that spirit that the National Transportation Safety Board investigates accidents and offers recommendations aimed at preventing similar accidents. It is the Safety Board's responsibility to make transportation safer for each new generation — to take all that we have learned from past mistakes and apply those experiences to shaping transportation in the future. Only then does each tragic accident become an investment in safety.

This publication records some of the major lessons learned and the changes that have been made to prevent future accidents. It documents how we have taken charge of our destiny and provided new generations with a safer transportation system. The Safety Board will continue to build on this history and is committed to ensuring that we do not forget our past, or worse, repeat it.

A handwritten signature in black ink that reads "Jim Hall". The signature is written in a cursive style.

Jim Hall, Chairman
National Transportation Safety Board

We Are All Safer

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Introduction



"It gives me great pride to reflect on the advances we've made in transportation safety over the past few decades because of the Safety Board's work. The public's trust in our transportation system depends on continuing efforts to improve safety."

**Vice Chairman
Robert T. Francis II**



"Every time you get on an airplane, a school bus, a train, a marine vessel or even in your automobile, you are protected by safety features recommended by the Safety Board. And we're not finished because the Board is committed to an ever safer transportation system."

**Board Member
John Hammerschmidt**

The National Transportation Safety Board (NTSB) was established by Congress in 1967 to investigate and determine the causes of accidents in all modes of transportation. Since then, the Safety Board has investigated more than 110,000 aviation accidents and thousands of railroad, marine, highway, and pipeline accidents. The Board is recognized as one of the world's premier independent accident investigation agencies because of the expertise it has accumulated in more than three decades of experience. It is a lean agency of about 400 employees nationwide that costs each citizen only about 18 cents a year to fund.

On call 24 hours a day, 365 days a year, Safety Board investigators travel to every corner of the world to investigate accidents. The Board's 24-hour communications center coordinates the logistics of accident launches and enables investigators to get to accident sites quickly. The center provides simultaneous communications among investigators on the way to accidents or already on scene and technical experts at headquarters and regional offices.

The Safety Board also provides assistance to families affected by aviation and other transportation disasters. After an accident, the duty of notifying next of kin, making arrangements for transporting family members to a location near the accident site, and returning victims' remains are the responsibilities of the carrier. The local community responds with emergency services, and volunteers provide grief counseling and food services. The Safety Board is responsible for improving and coordinating services to victims' families, particularly regarding the initial notification of the accident, recovery and identification of victims, disposition of unidentifiable remains, return of personal effects, and access to information.

At the accident site investigators gather a wide range of information concerning the circumstances of the accident. Investigators and technical experts analyze this information, along with many other facts pertaining to the event, to determine the probable cause of the accident and to develop safety recommendations aimed at preventing similar accidents.

The Safety Board has issued 11,000 safety recommendations in all transportation modes to more than 1,300 recipients in government, industry, and associations. Since 1990, the Board has highlighted many significant issues on its list of “Most Wanted Transportation Safety Improvements.” Although the Board has no regulatory or enforcement powers, its reputation for impartiality, insightfulness, and thoroughness has helped it reach a recommendation implementation rate of more than 82 percent.

Transportation safety is a team effort, achieved when all elements of the transportation system cooperate and fulfill their responsibilities. The U.S. Department of Transportation (DOT) and state authorities issue safety regulations and enforce them. Transportation companies and manufacturers ensure the safety of their operations and products. And travelers take responsibility for their own safety by becoming familiar with the operational and safety features of the vehicle being used. In this mix has been placed an independent watch dog—the National Transportation Safety Board—to determine what led to an accident and what can be done to prevent a recurrence.

Every time you travel in an airplane, a school bus, a train, a boat, and even your own automobile, you are protected by safety measures resulting from Safety Board recommendations. This publication summarizes many of these Safety Board-inspired improvements.



“It is not enough to find the cause of accidents. The Safety Board’s most important products are recommendations that actually result in correcting the problem that led to the accident in the first place. Innumerable lives have been saved because of accidents that were prevented by Safety Board recommendations.”

**Board Member
John Goglia**



“The work of the Board goes far beyond domestic safety. Its products and expertise are instrumental in improving transportation safety around the globe. We will continue to work with our counterparts worldwide to advance safety.”

**Board Member
George Black**

Aviation



The National Transportation Safety Board is in charge of investigating all civil aviation accidents in the United States, including public-use aircraft, except for those operated by military and intelligence agencies. Under international treaty, the Safety Board provides U.S.-accredited representatives and investigators to foreign investigations involving U.S.-registered, -certified, or -operated aircraft and aircraft whose airframe, engines, or other major components are manufactured or designed in the United States. Because of our nation's large aviation manufacturing industry, our investigative authority covers a significant portion of transport-category aircraft worldwide. Civil aviation is a rapidly growing global system.

The importance of aviation to the nation's economy is enormous, and forecasters predict steady growth in the industry through the year 2009. For example, the total number of passengers boarding scheduled commercial airlines in the United States rose from 580 million in 1995 to 630 million in 1997. That number is expected to top 985 million by the year 2009. Air traffic continues to climb with an estimated 63 million takeoffs and landings at the nation's airports with control towers in 1997. That number is expected to exceed 75 million by the year 2009.

Major transportation accidents exact a significant emotional and monetary toll on society. The human cost to victims, survivors, and their families is immeasurable. The direct cost of just one fatal commercial aviation accident can total hundreds of millions of dollars.

Safety Board recommendations to improve aviation safety have addressed problems in operations, cabin safety, weather, and aircraft design.

Ground Proximity Warning Systems

On December 29, 1972, an Eastern Air Lines Lockheed L-1011 crashed into the Florida Everglades while on approach to Miami International Airport. Almost two years later, on December 1, 1974, a TWA Boeing 727 crashed into a mountain while on approach to Washington Dulles International Airport in Virginia. One hundred ninety-one persons died in the two tragedies. There was one common factor: no mechanical malfunctions contributed to either accident.

The Safety Board concluded that these accidents – termed “controlled flight into terrain,” or “CFIT” for short – could have been prevented by a terrain warning system in the cockpit.

The Board’s first recommendation calling for the development of an onboard warning system was issued after a nonfatal accident in 1971 involving a DC-9 that struck antennas as it was landing in Gulfport, Mississippi. In 1975, after further Board recommendations following accidents in the Florida Everglades and Virginia, the Federal Aviation Administration (FAA) began to require large passenger aircraft to be equipped with a ground proximity warning system (GPWS). This device warns flightcrews if their aircraft is approaching terrain, descending too quickly, or improperly configured for landing, usually with an aural warning like “Pull Up, Pull Up,” or “Terrain.” This requirement has dramatically lowered the frequency of CFIT accidents involving transport-category aircraft in U.S. airspace. By contrast, CFIT accidents continue to occur overseas in countries where such devices are not required, and a special International Civil Aviation Organization task force is working on preventing such accidents.

In 1986, based on a series of accidents involving commuter aircraft, the Safety Board recommended that the requirement for GPWS be extended to smaller passenger airliners. Following subsequent commuter CFIT accidents, the Board added the issue to its



“Most Wanted” list. Since April 1, 1994, commuter aircraft having 10 or more seats must be equipped with GPWS. This requirement should greatly increase the safety of commuter flights, especially during approach to landing in instrument meteorological conditions.

Another CFIT accident prompted the Safety Board to recommend that the FAA require aircraft to be equipped with the next generation of “enhanced” GPWS, which gives flightcrews significantly more advance warning. The recommendation grew out of the December 20, 1995, crash of an American Airlines Boeing 757 on approach to Cali, Colombia, killing all but four of the 163 persons on board. During the descent, with the speedbrakes extended, the pilots failed to clear the mountain following a ground proximity warning. Based upon the Board’s investigation and recommendations, action by the FAA includes an automatic speedbrake retraction design review, amendments to the crew resource management training advisory circular, and standardization of navigational aid identifiers on printed charts and electronic charts displayed on aircraft computers.

The FAA is working on an advanced terrain avoidance warning system regulation with a proposed rule expected in late 1998, followed by a final rule in 1999. A major aviation association and numerous air carriers announced in early 1998 that they had begun to voluntarily install the new advanced devices.

Fire Safety

Cabin fires, although extremely rare in passenger airliners, can be devastating. In July 1973, the Safety Board assisted French authorities in their investigation of the crash landing of a Varig Boeing 707 near Paris after a fire in a rear lavatory. Two months later, the Board asked the FAA to require smoke detectors or frequent in-flight checks of lavatories by flight attendants for early detection of fires. Another in-flight fire, this time involving a Pan American Boeing 707 cargo flight, occurred in November 1973. And in the summer of 1974, two more airliner lavatory fires, both nonfatal, prompted the Board to recommend specifically that the FAA require installation of automatic-discharge fire extinguishers in lavatory waste paper containers in all airliners. The FAA required airlines to prohibit smoking in lavatories. The agency also urged routine flight attendant inspections of lavatories before takeoff and periodic inspections during flight.

On June 2, 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. When the plane finally stopped, only half of the 46 persons aboard were able to escape the burning aircraft before becoming overcome by smoke and fumes. As a result, the Safety Board made a number of safety recommendations to both reduce the likelihood of an in-flight fire and to slow the progress of a developing fire. Most of the Board's recommendations were implemented, and have resulted in the following fire safety improvements on U.S. airliners:

- Smoke detectors and automatic-discharge fire extinguishers in lavatories. Stiff fines are also imposed when anyone attempts to disable a smoke detector;
- Floor-level escape lighting along aisles that guide passengers toward an exit should visibility be reduced by smoke; and
- Fire-blocking cabin and seat materials, which are required on all airliners built after August 19, 1990. Older aircraft receive the new materials when they undergo a complete refurbishment. Safety Board investigators credited fire-blocking seat materials with saving lives following a takeoff accident and fire aboard a Delta Air Lines Boeing 727 at Dallas/Fort Worth in August 31, 1988. A study showed that fire-blocking materials gave passengers additional time to exit the aircraft.

Another concern related to fire safety is the heat-resistant capability of material on evacuation slides. Based on Safety Board recommendations issued after a runway overrun accident involving a Continental Airlines DC-10 in Los Angeles in 1978, evacuation slides on aircraft are now coated with a material to resist heat from postcrash fires. In the accident, which killed two people, 40 of the 200 occupants were forced to jump to the ground while another 15 persons used the escape rope in the cockpit. Heat from the intense fire caused several evacuation slides to deflate and melt. There were 31 serious injuries.

Cargo compartment fires are another fire safety concern. In 1981, a Saudi Arabian Airlines Lockheed L-1011 experienced an in-flight fire after departure from Riyadh for Jeddah. Although the



airplane returned and landed at Riyadh, all 301 persons aboard perished in the ensuing cabin fire, which was later determined to have started in the aft Class C cargo compartment. The investigation revealed that the design of Class C compartments did not meet the intent of regulations that required Class C compartments to smother a fire. Safety recommendations issued by the Board after this accident led to major modifications to all widebody airplane Class C cargo compartments aimed at preventing a fire from spreading.

On November 28, 1987, a South African Airways Boeing 747 “combi” (combined cargo and passenger service) experienced an in-flight fire over the Indian Ocean en route from Taiwan to Johannesburg. The airplane crashed into the Indian Ocean, with the loss of all 160 on board. The investigation of that accident was expensive and complex because portions of the wreckage had to be recovered from 15,000 feet under water. The investigation determined that a fire started in the main deck cargo compartment, located just behind the passenger cabin. As the result of Safety Board recommendations, major modifications were required for all “combi” airplanes, and regulations were revised to ensure more rigorous standards of fire suppression and detection on passenger aircraft.

On February 2, 1988, an American Airlines DC-9 safely landed in Nashville with a fire burning in the cargo compartment. The fire was traced to an improperly packaged and prohibited chemical shipment. As a result of its investigation of this incident, the Safety Board recommended that fire detection and suppression equipment be required in cargo areas that were previously thought to be so airtight that a fire could not be sustained. No regulations were issued, and on May 11, 1996, a ValuJet DC-9 crashed in Miami after a fire erupted in a cargo compartment. The Safety Board investigation concluded that activation of one or more chemical oxygen generators in the forward Class D cargo compartment initiated the fire. In early 1998, the FAA issued a rule requiring fire detection and suppression systems in all the cargo holds of 3,700 aircraft by 2001.

Windshear

Since 1968, the Safety Board has issued more than 60 safety recommendations addressing windshear and related weather issues. Major recommendations were issued following the 1975 crash of an Eastern Air Lines Boeing 727 in New York, and several others that followed.

On August 2, 1985, a Delta Air Lines Lockheed L-1011 crashed while landing at Dallas/Fort Worth International Airport during a thunderstorm, killing 135 persons. The Safety Board's investigation revealed it to be the seventh fatal transport-category aircraft accident since 1970 and the 18th overall attributable to the weather phenomenon now known as windshear.

As a result of the Safety Board's recommendations, research efforts were launched that greatly increased our knowledge and understanding of the windshear phenomenon. Among the safety improvements developed as a result of these recommendations were enhanced windshear training for pilots and low-level windshear alert systems installed at all major airports. The Board also recommended the installation of Terminal Doppler Weather Radar (TDWR), an integral part of these alert systems, to provide pilots with more timely and more accurate weather information.

Because of these improvements, there has been only one windshear-related accident involving a transport-category aircraft in the United States in the last 13 years—the July 1994 DC-9 accident in Charlotte, North Carolina. A TDWR had not yet been installed at Charlotte. The Safety Board believes that the enhanced radar would have given controllers the opportunity to issue timely information to the flightcrew about the severity of the weather and may have prevented the accident. As of mid-1998, 37 TDWR facilities had been commissioned in airports throughout the country and the FAA is developing an advanced onboard weather detection system.



Windshear detector radar.

Icing

Since the beginning of powered flight, aviators have contended with the effects of ice on their aircraft. In fact, aviation safety pioneer Jerome Lederer noted in 1939, “Strange as it may seem, a very light coating of snow or ice, light enough to be hardly visible, will have a tremendous effect on reducing the performance of a modern airplane.”

Almost 60 years later, the commercial aviation industry is still not able to avoid the tragic consequences of this phenomenon. Nine icing-related commercial aviation crashes have occurred since 1982 in the United States alone, involving transport-category aircraft and commercial passenger aircraft.



Beginning in 1975, the Safety Board issued numerous safety recommendations addressing the measurement, forecasting, avoidance, and protection of aircraft against such icing conditions. In response to recommendations issued by the Board after its investigation of a USAir Fokker F-28 crash at LaGuardia Airport on March 22,

1992, that killed 27 people, the FAA significantly upgraded the deicing/anti-icing requirements for major air carriers and commuters.

Following a fatal accident involving a United Express Jetstream 31 at Pasco, Washington, on December 26, 1989, and a subsequent, nonfatal USAir Express Jetstream 31 accident at Beckley, West Virginia, on January 30, 1991, the Safety Board issued recommendations that led to the modification of all Jetstream 31 airplanes to prevent aerodynamic stall because of ice accretion. The investigation revealed that ice built up during certain phases of flight and caused subsequent stall and loss of control of the airplane.

In late 1994, the Safety Board recommended that ATR-42 and ATR-72 passenger aircraft not be allowed to fly into known or forecasted icing conditions while it continued to investigate the crash of an American Eagle ATR-72 in Roselawn, Indiana, that killed

all 68 persons aboard. After imposing flight restrictions on ATRs, the FAA approved a design modification to the ATR deicing system that was in place on all ATRs in the United States by the 1995-1996 icing season. As a result of these actions, flight operations in icing conditions have become considerably safer.

Midair Collisions

As air traffic continues its rapid growth, the airspace used by aircraft does not expand. With more aircraft flying more often in this finite airspace, advances in collision avoidance technology are critical to maintaining adequate separation of aircraft.

Since 1967, the Safety Board has recommended 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, transport-category aircraft have been equipped with traffic alert and collision avoidance systems (TCAS). General aviation aircraft operating in controlled airspace near major airports are now required to be equipped with Mode C transponders, which give air traffic controllers altitude information. Mode C transponders provide several major benefits: they permit radar to automatically display the altitudes of aircraft equipped with them; they provide air traffic control computers with route and altitude information that sound alarms when imminent collision hazards are detected. This technology has greatly enhanced the prevention of midair collisions and near-collisions.

All air traffic controllers now receive annual TCAS training as a result of Safety Board recommendations. This training explains the operation of TCAS and the roles and responsibilities of flightcrews in responding to TCAS alerts.

Thanks, at least in part, to the installation of anticollision equipment and the improved air traffic controller training, several midair collisions involving transport-category aircraft have been avoided in the United States.

Rejected Takeoffs

On May 21, 1988, an American Airlines DC-10, operating near maximum gross weight, was damaged beyond economical repair during a rejected takeoff at Dallas/Fort Worth International Airport. During the rejected takeoff, the airplane decelerated normally for five to six seconds, and then did not continue to adequately decelerate, resulting in the airplane running off the end of the runway at a ground speed of about 97 knots. Only two of the 255 occupants were injured.

Evidence showed that the airplane's brakes failed during the rejected takeoff. If the brakes had not failed, the airplane could have stopped on the runway. Examination of the airplane's wheel brake system revealed that eight of the 10 brakes totally failed when the brake friction material depleted. Before the rejected takeoff, the brakes were near the established replacement limit of 0.7 inch.



Certification flight test data showed that new brakes, which have about 2.7 inches of material available, wear, on average, about 1.5 inches during a rejected takeoff. With brake material allowed to wear down to 0.7 inch before replacement, the replacement limit was clearly unacceptable. The limits had been established to ensure that the brakes would not be damaged during normal friction material wear, not necessarily to survive a rejected takeoff.

The Safety Board determined that this oversight evolved from the FAA's acceptance of inadequate certification testing procedures, including using new brakes instead of worn brakes; testing during a landing rather than a rejected takeoff; and inadequate dynamometer testing. At the Board's urging, the FAA issued airworthiness directives improving allowable brake wear limits on transport-category airplanes.

The Safety Board also conducted a special investigation on the safety of rejected takeoffs and found serious shortcomings in pilot training concerning possible rejected takeoff hazards. In response, Boeing, working together with segments of the aviation industry, developed a rejected takeoff training aid to improve pilot training in this important area. This training aid has since become an FAA advisory circular and is widely used throughout the industry.

Runway Overruns

Aircraft occasionally overrun the end of a runway on landing or during rejected takeoffs. There were major accidents in 1989 and 1994 at New York's LaGuardia Airport. Two people died in one of the accidents. Although the FAA requires a 1,000-foot safety area at the end of newly constructed runways, some runways built before that standard was enacted are adjacent to wetlands, waterways, or sharp terrain drop-offs that do not allow the minimum safety area. Consequently, another method is needed to protect aircraft on these runways.



In 1984, following its safety study on airport certification, the Safety Board recommended that the FAA "initiate research and development activities to establish the feasibility of soft-ground aircraft arresting systems and promulgate a design standard, if the systems are found to be practical." Soft-ground systems use material that will deform readily and reliably when an aircraft traverses it. As the tires crush the material, the drag forces decelerate the aircraft.

The extensive research that followed this recommendation [resulted in the development of a cellular concrete](#) system that was tested at the FAA's Technical Center in Atlantic City. In November 1996, the Port Authority of New York and New Jersey installed a 400-foot-long arrestor bed for runway 4R at JFK International Airport. Arrestor beds for runways 13 and 22 at LaGuardia are planned for 1998. This is a major step in mitigating the effects of potentially dangerous runway overruns at airports in the United States and around the world.

Alcohol and Aviation

Since 1984, the Safety Board has asked the FAA to use the National Driver Register (NDR) to help identify airmen whose driver's licenses have been suspended for alcohol-related offenses. Such pilots may have alcohol dependencies that could affect their ability to safely operate an aircraft.

After an alcohol-related aviation accident in 1986, the Safety Board issued safety recommendations that underscored the potential benefits of an NDR search. A Beech G-18S airplane, which was on an unscheduled air cargo flight from Milwaukee to Atlanta, crashed near Copperhill, Tennessee. The airplane was destroyed, killing the pilot. The Board determined that the pilot's blood alcohol concentration (BAC) at the time of his death was 0.158 percent, well above the limit of 0.10 used in most states to cite drivers for driving while intoxicated (DWI).

The investigation disclosed that the pilot had been convicted of seven DWI offenses during the previous four years and that he had been alcohol-dependent during that period. The NDR recorded seven driver's license revocations as a result of the pilot's DWI convictions. Although the pilot had been examined regularly by designated aviation medical examiners, the FAA did not detect his alcohol abuse and dependency.

In November 1988, the FAA issued regulations to identify pilots involved in alcohol- or drug-related motor vehicle offenses resulting in convictions or administrative actions. The new regulations, which went into effect in 1990, require pilots to report any alcohol- or drug-related driving conviction or administrative action within 60 days. Pilots applying for a medical certificate must consent to the release of NDR information. To detect pilots with DWI convictions, the FAA is systematically matching the names of those holding aviation medical certificates with the NDR and law enforcement records.

Out of the first 170,000 records processed by the FAA during its initial search, about 4,000 driving records were identified as questionable and 84 were earmarked for enforcement action against the pilots. The FAA reviews the NDR for approximately 300,000 pilots yearly.

Airlines are now required to perform preemployment, random, and postaccident drug testing for the presence of certain illicit drugs in persons employed in safety-sensitive positions. The requirement has been expanded to include postaccident testing for alcohol.

The Safety Board has never determined alcohol use to be a cause or factor in a fatal accident involving a U.S. airliner. The Board also learned, through its safety study on alcohol use by general aviation pilots between 1983 and 1988, that the percentage of fatally injured pilots who tested positive for alcohol was 6.7 percent, down from about 10 percent in the mid-1970s.

Parachuting Safety

On April 22, 1992, a de Havilland Twin Otter crashed during takeoff at Perris Valley, California, after an engine lost power. The Safety Board determined that the accident was caused by contaminated fuel from the airfield's fuel tanks and the pilot's improper actions after the power loss, as well as other factors. Although the aircraft never rose above 50 feet, 14 jumpers and the two pilots were killed.

The Safety Board conducted an in-depth study of drop zone operations following that accident. It found that sport parachute operations have unique procedures not found in any other aviation operation. Operators of sport parachute flights control their fuel handling, maintenance, and other procedures with more limited resources than other aviation operations involving passengers.

On September 7, 1992, a Beech C-45 being used for a sport parachute flight crashed near Hinckley, Illinois, after one of the engines malfunctioned. The pilot was maneuvering to land when the aircraft went out of control close to the ground. All 12 aboard died.

In both of these accidents, the Safety Board found that the parachutists were not properly secured by seatbelts or restraints. Had the jumpers been wearing proper restraints, lives



might have been saved because impact forces were survivable, particularly at Perris Valley. The Board made recommendations to the FAA and to the U.S. Parachute Association (USPA). The recommendations urged the FAA to add drop zone oversight to their national work plan, require mandatory use of seatbelts by parachutists, and develop better safety restraint systems and seating for parachutists.

The USPA and drop zone operators are aggressively pursuing these issues, particularly by changing the behavior of jumpers to insist that seatbelt usage be mandatory. Now, parachutists and drop zone operators are paying more attention to aircraft safety issues. Since the Safety Board's recommendations were issued, investigators believe many lives have been saved by the proper use of seatbelts and other new safety practices in survivable sport parachute aircraft accidents.

Aircraft Seats

For years the Safety Board has recommended that the FAA establish higher crashworthiness standards for passenger and crew seats to better prevent seat failures and protect persons in accidents. In minor-to-moderate aircraft crashes, the occupants often are thrown about or ejected because of seat failure. The Board also has testified numerous times before Congress and joint FAA-industry groups on the need for improved seats.

The Safety Board's concern about seat integrity was underscored during its investigation of the November 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. If stronger seats had been installed, the severity of the occupants' injuries might have been reduced, and more passengers might have survived.

In May 1988, the FAA published its final rule upgrading the crashworthiness of seats on newly certificated transport-category aircraft from 9 Gs to 16 Gs and, for the first time, requiring that seats be tested dynamically for their strength in addition to the current requirement for static testing.

During its investigation of a 1989 crash of a Grand Canyon Airlines DHC-6, serious deficiencies were found with the

crashworthiness of the passenger seats. The steel hollow-tube seatframes had been chrome-plated for cosmetic reasons, an action that had not been approved by the FAA. As a result of the improper chrome-plating, the Board found multiple seatframe separations at welds that were made during manufacture, and corrosion of seatframes to the extent that some frame tubes had no wall thickness beneath the chrome-plating. A Board inspection of 21 other Grand Canyon Airlines and Scenic Airlines, which owned Grand Canyon, airplanes found similar problems. Based on the Board's findings, the FAA ordered the airlines to replace any defective seats. The airlines subsequently equipped their aircraft with new seats which will enhance survivability of passengers in case of an accident.

Seatbelt Integrity

In its investigation of a 1988 turbulence incident, the Safety Board learned that three seatbelts detached from their shackles, resulting in minor injuries to the three passengers using those seatbelts. The seatbelts were typical of those commonly used in air carrier, air taxi, and commuter airplanes. Tests conducted under the Board's direction revealed that, under certain conditions, the seatbelts could become detached from their fittings, thereby rendering them useless.

As a result of its findings, the Safety Board recommended that the FAA issue a maintenance alert to inspect seatbelts and make the proper repairs. The FAA issued the alert, which resulted in the inspections of 27,000 seatbelts in commercial air carrier, military, and general aviation aircraft, thus increasing the survivability of persons wearing those seatbelts during an emergency.

Regional and Commuter Airlines

The regional and commuter airline industry has grown immensely since the Airline Deregulation Act of 1978. In 1992, they carried 45 million passengers to hundreds of communities. That number rose to 62 million in 1997 and is expected to almost double to 117 million by the year 2009.

Commuter airlines, those using aircraft with 30 or fewer passenger seats, historically had a higher accident rate than



airlines with larger planes, which flew under more stringent safety regulations. Part of the reason for the higher accident rates may have been that commuter airline accident statistics include bush operations in Alaska, which pose more risks than the average commuter airline flight in the lower 48 states. However, some of the disparity in accident rates may have been the result of less stringent regulations, especially those governing pilot training and qualifications.

The Safety Board issued numerous safety recommendations advocating “one level of safety” to bring commuter airline regulations more in line with stricter regulations governing the operation of larger aircraft, which call for the installation of safety devices like altitude encoding transponders, ground proximity warning systems, and cockpit voice recorders.

In 1994, the Safety Board addressed the larger issue of why regional and commuter operations were subjected to a separate level of regulation, and determined that to the extent possible, commuter airlines should operate under the same regulations as scheduled airlines operating larger planes. In particular, the Board recommended that FAA surveillance and commuter regulations concerning pilot training, scheduling, dispatch services, airport certification, airline management oversight, be aligned as much as possible with requirements for the larger airlines.

In December 1995, the FAA issued a final rule that brought commuter airline flights in aircraft having 10 or more passenger seats under the safety standards of the large air carrier rules. Under this rule commuter airlines were certified under the more stringent safety regulations in 1997.

Crew Resource Management

In a number of airline accidents investigated by the Safety Board in the 1960s and 1970s, the Board detected a culture and work environment in the cockpit that, rather than facilitating safe transportation, may have contributed to the accidents. The Board found that some captains treated their fellow cockpit crewmembers as underlings who should speak only when spoken to. This intimidating atmosphere actually led to accidents when critical information was not communicated among cockpit crewmembers. A highly publicized accident in 1978 provided the impetus to change this situation.

On December 28, 1978, as a result of a relatively minor landing gear problem, a United Airlines DC-8 was in a holding pattern while awaiting landing at 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.

As a result of this accident and others, the concept of cockpit resource management, now called crew resource management (CRM), was born. Following pioneering work by the National Aeronautics and Space Administration (NASA), the Safety Board issued recommendations to the FAA and the airline industry to adopt methods that encourage teamwork, with the captain as the leader who relies on the other crewmembers for vital safety-of-flight tasks and also shares duties and solicits information and help from other crewmembers. United Airlines was one of the first airlines to adopt this concept, which is endorsed by pilot unions and is now almost universally used by the major airlines (as well as in other modes of transportation). The Board has also recommended and the FAA has acted to implement CRM for regional and commuter airlines.



The value of CRM was demonstrated on July 19, 1989, when a United Airlines 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 deadheading captain who was 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 survived a situation for which no pilots in the world had ever been trained.

Aircraft Design

Safety Board investigations have resulted in findings of inadequate design or certification of particular aircraft components. For example, on April 5, 1991, an Atlantic Southeast Airlines EMB-120 crashed near Brunswick, Georgia, killing all 23 persons aboard.

The Safety Board found that severe wear of a component in the propeller control unit on the airplane's left engine resulted in asymmetrical lift and thrust, rendering the aircraft uncontrollable. During its investigation, the Board learned of three previous occasions when operators found that a propeller would not operate properly during ground tests. Based on Board recommendations, the FAA required additional inspections of propeller control units and the installation of a fail-safe feature to prevent the propeller blade angle from rotating below the flight idle position while in flight.

In August 1995, an Atlantic Southeast Airlines EMB-120 turbopropeller engine-powered airplane crashed near Carrollton, Georgia, following a propeller blade separation and secondary in-flight damage to the airplane. The Safety Board's investigation determined that the imbalance caused by the failed propeller blade displaced the engine from its mounts, resulting in drag. The drag resulted in a loss of control in an attempted forced landing. The Safety Board's investigation revealed that the failed propeller blade had been recently removed and returned to service following an inspection that had detected indications of the crack. However, that inspection by the manufacturer's repair station did not detect the crack that led to the in-flight failure. It had been masked by an improper repair procedure which eliminated the crack indication. The Safety Board subsequently recommended the removal from service within five days of all blades that had similar inspection indications and repairs. The Safety Board's investigation also brought about improvements in ultrasonic inspection techniques, blade repair procedures, technician training, and corporate policies on flight safety critical components.

Changes recommended by the Board as a result of one tragedy can prevent another. Almost 25 years ago, on March 3, 1974, a Turkish Airlines DC-10 crashed near Paris, France, when the lower aft cargo door separated in flight during climbout. The resultant explosive decompression caused the cabin floor to buckle downward

and jam the flight control cables. All 346 persons aboard perished. Safety Board recommendations that stemmed from that investigation led to the installation of blowout pressure relief panels in the cabin floors of all widebody airplanes.

On February 24, 1989, a United Airlines Boeing 747 en route from Honolulu, Hawaii, to New Zealand with 355 persons aboard lost the forward lower lobe cargo door during climbout. Although nine occupants were killed in the accident, the catastrophic loss of the entire airplane and its occupants was prevented by the opening of the pressure relief doors in the cabin floor. While the cabin floor was damaged, the control cables remained functional because of the modifications required after the Turkish Airlines accident.

Another widebody airliner had a different problem that has since been corrected following Safety Board recommendations. On April 6, 1993, during a flight from Shanghai, China, to Los Angeles, a China Eastern Airlines MD-11 experienced an inadvertent deployment of all leading-edge wing slats while at 33,000 feet over the Pacific Ocean. The resulting severe pitch oscillations led to two fatalities and 160 injuries. Based on results of the Safety Board investigation, McDonnell Douglas worked with the FAA and aircraft operators to redesign the MD-11 flap/slat handle, and reduce the potential for inadvertent slat operation. In addition, the Board identified that flightcrews needed additional training related to the high-altitude handling qualities of the MD-11 and DC-10 aircraft.

On May 5, 1991, a Lauda Air Boeing 767-300ER experienced an uncommanded in-flight deployment of the number one engine thrust reverser, while climbing through 24,700 feet, approximately 16 minutes after takeoff from Bangkok, Thailand. The pilots lost control, the airplane entered a steep dive, exceeded the maximum velocity and 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. Design changes to engine reverser systems that have been introduced and mandated as a result of this accident have greatly reduced the possibility of an in-flight thrust reverser deployment in the 767 and many other air carrier aircraft models.

There are many other examples of specific aircraft design problems discovered by the Safety Board. Here are some of them:

- On December 29, 1991, a China Airlines Boeing 747 freighter crashed about five minutes after takeoff near Taipei, Taiwan, and on April 10, 1992, an El Al Boeing 747-200 freighter crashed into two nine-story apartment buildings while returning to land after takeoff from Amsterdam, Netherlands. The investigations of both accidents revealed that during climb, the No. 3 engine and pylon had separated from the wing, collided with the No. 4 engine and caused the separation of that engine. The combined effects of asymmetrical weight, thrust, and drag caused the pilots to lose control. The investigations revealed that the failed fuse pins in the pylon-to-wing attachment fittings had cracks stemming from corrosion pits. As a result of the Safety Board's involvement in the Taiwanese and Dutch investigations, inspection procedures were modified and an improved fuse pin was designed and installed in all Boeing 747s reducing the likelihood of a repeat of such accidents.
- Following the Board's investigation of a 1990 runway collision in Detroit that killed a flight attendant and seven passengers, redesigned emergency tailcone release handles are now required on all commercial and military DC-9s and MD-80s to assure the availability of this exit in the event of an emergency.
- During the Safety Board's exhaustive investigation of the crash of a USAir Boeing 737 near Pittsburgh on September 8, 1994,

that claimed 132 lives, investigators found that rudder anomalies could be produced in laboratory tests. In October 1996, the Board recommended numerous rudder design changes to older 737s. The FAA and Boeing agreed in 1996 to retrofit older 737s with a new rudder system design.



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- In May 1997, a Skywest Airlines EMB-120 had an in-flight fire in the No. 2 engine after takeoff from San Diego, California. The Safety Board's investigation determined that a missing drain plug in the Pratt & Whitney Canada PW100 engine may have allowed fuel to drain into the hot engine compartment and caused the fire. During the investigation, the Safety Board, Embraer, Pratt & Whitney Canada, and the operators of EMB-120 airplanes coordinated an inspection of the worldwide fleet and discovered many other airplanes with missing drain plugs that were subsequently capped, eliminating a fire hazard.
 - In general aviation, a Safety Board recommendation led to an FAA airworthiness directive in 1993 to repair corrosion and cracking in the wing front spar fuselage attachment assembly on Piper PA-25 airplanes. Left uncorrected, the problem could have led to in-flight wing separations. More than 1,200 aircraft were affected by the directive.

Structural Fatigue and Corrosion

On April 28, 1988, an Aloha Airlines Boeing 737-200 airplane experienced a structural failure and explosive decompression at 24,000 feet while en route from Hilo to Honolulu, Hawaii. Approximately 18 feet of fuselage skin and structure, above the passenger floor and aft of the main cabin entrance door, separated from the airplane in flight. One flight attendant was swept out of the plane during the decompression and killed. Although power from one engine was lost and there were control difficulties, the flightcrew performed an emergency descent and landing at Kahului Airport, on Maui, without further incident.

The Safety Board's investigation revealed that the fuselage failure was caused by disbonding of the fuselage lap joints and multi-site fatigue cracking. As a result of the investigation, the Safety Board issued over 20 recommendations that addressed shortcomings in the maintenance and repair of the aircraft's structure. These recommendations and the Board's accident investigation greatly increased the industry's understanding of aging aircraft structural issues. As a result, the FAA requires increased fatigue testing on newly certified airplanes. Older aircraft are subjected to periodic reviews, inspections, and modifications to eliminate corrosion and metal fatigue.

Uncontained Failures of Titanium Engine Components

On July 19, 1989, a United Airlines DC-10 airplane equipped with General Electric CF6-6 engines crashed during an emergency landing at the Sioux City Municipal Airport, Sioux City, Iowa, following an uncontained failure of the center engine's front compressor fan disk. Of the 286 persons on board, 111 were killed in the crash landing. The Safety Board's investigation discovered that the ejected engine



fragments damaged all three hydraulic systems and crippled the pilots' ability to control the airplane. The pilots could not operate the hydraulically powered control systems but manipulated the throttles to control the airplane and turning movements.

The investigation revealed that the failure stemmed from a crack that originated from a hard nugget or inclusion in the disk that was originally about the size of a grain of sand. The inclusion had been formed during the titanium melting process and the crack had been missed during several inspections of the fan disk. This accident and others that followed it resulted in a much greater industry understanding of the titanium melt and manufacturing process and improvements in airlines' in-service inspection process which were adopted throughout the industry.

In July 1996, a Delta Air Lines McDonnell Douglas MD-88 airplane, powered by Pratt & Whitney JT8D-200 series engines, experienced an uncontained front compressor fan hub failure in an engine during the takeoff roll at Pensacola, Florida. The Safety Board's investigation determined that the titanium hub failed from a fatigue crack that originated in a tierod hole at the time of manufacture. The hardened surface that became the origin of the crack origin was not detected by the inspection process used during

manufacture. The detectable enlarged crack was also missed during a fluorescent penetrant inspection of the hub in service.

In April 1995, an Egypt Air Airbus A-300 airplane, equipped with General Electric CF6-50 series engines, experienced an uncontained failure of a high-pressure compressor engine spool during takeoff at Cairo, Egypt. The Safety Board assisted the Egyptian aviation authorities and determined that a stage of the spool had failed from a fatigue crack that originated from an inclusion. This investigation revealed that the crack existed at the time of the last inspection and that the spool was difficult to thoroughly inspect.

In September 1997, a Canadian Airlines Boeing 767 experienced an uncontained failure of a General Electric spool during takeoff at Beijing, China. The Safety Board's investigation revealed that a crack originated from an oxygen-rich area in a highly stressed region of the titanium spool. The investigation also revealed that a water leak during the titanium melt process caused the oxygen-enriched area.

As a result of the Sioux City, Pensacola, Cairo, and Beijing investigations, the Safety Board has made many recommendations regarding titanium engine parts that addressed shortcomings in the titanium melting, disk manufacturer's inspection, and the engine overhauler's inspection processes. The actions taken by the aviation community have resulted in an increased awareness of the titanium melting, machining, and inspection processes and brought about many changes to ensure higher manufacturing quality, better in-service inspections, and higher reliability of these parts.

Off-wing Escape Slides

On April 5, 1993, a TACA International Airlines (El Salvador) Boeing 767-200 crashed while landing at La Aurora International Airport in Guatemala City, Guatemala. All of the 224 occupants safely evacuated the airplane, and only minor injuries were reported. During the evacuation, as the left overwing emergency exit door was opened, the off-wing escape slide compartment door did not open, and the slide did not deploy. Consequently, several passengers jumped from the wing to the ground.

The Safety Board assisted Guatemalan aviation authorities and determined that the slide door could not open because one of three latches was installed upside down and had moved to the closed

position rather than to the open position. The Safety Board issued recommendations that addressed shortcomings in the latching mechanism design, installation procedures, and inspection procedures. These corrective actions resulted in the discovery of other improperly installed latches. The correction of these deficiencies has reduced the likelihood that off-wing slides might be unavailable in future emergency aircraft evacuations.

Pitot-Static System Blockages

On February 6, 1996, a Birgenair Boeing 757-200 crashed into the Atlantic Ocean after climbing through 7,300 feet after takeoff from the Puerto Plata International Airport, Dominican Republic. On October 2, 1996, an Aero Peru Boeing 757-200 crashed into the Pacific Ocean about 30 miles off the coast of Lima, Peru. All 189 people on board the Birgenair flight and all 70 people on board the Aero Peru flight were killed, and both airplanes were destroyed.



During the Safety Board's participation in the investigations of these accidents, it was discovered that the pitot tube had become blocked on the Birgenair airplane and the three left static ports on the Aero Peru airplane were blocked by masking tape during ground maintenance that preceded the flight. These obstructions in the pitot-static systems of the airplanes caused erroneous airspeed and altitude readings and confusion in the cockpit that led to the accidents. The Safety Board issued recommendations that addressed shortcomings in the Boeing 757/767 cockpit crew alerting systems, pilot training, operations, and maintenance procedures. Industry action in response to these recommendations should reduce the likelihood of such accidents in the future.

Helicopter Safety

In 1996, the Safety Board concluded a special investigation of Robinson Helicopter Company R22 helicopters following 31 R22 and three R44 accidents in which there was an in-flight loss of main rotor control that resulted in the main rotor contacting the tailboom or fuselage in flight. In all of these accidents, the occupants of the helicopters were killed. The Safety Board did not find any evidence of an initiating airframe or engine component malfunction; flight into adverse weather, such as low visibility or cloud ceilings, was not

indicated in any of the accidents. The Board found that the R22, which has a lightweight, highly responsive, low rotor inertia design, was involved more frequently in loss of main rotor control accidents than other helicopters studied.

During the investigation, the Safety Board issued safety recommendations that resulted in research by both the FAA and the manufacturer that led to product improvements including the mandatory introduction of an engine governor and a larger optional engine. The recommendations also required in special awareness training that addressed loss of rotor control events and pilot proficiency, and restrictions on operating in certain wind conditions. The Board's investigation and the actions taken by the FAA and the manufacturer in response to the investigation have been very effective; there were no R22 or R44 loss of main rotor control accidents in the world for more than two years following the accidents addressed in the report.

Fuel Tank Explosions

On July 17, 1996, a Trans World Airlines Boeing 747-100 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. The extensive investigation and recommendations have resulted in safety improvements made in coordination with Boeing and the FAA. This has led to greater industry understanding of the hazards posed by fuel vapor at elevated temperatures in fuel tank ullage, flammability and ignition energies of Jet A fuels, shortcomings in fuel tank electrostatic and lightning protection, electrical surge protection for fuel quantity indication systems, improved fuel pump safety, and understanding of aging wiring issues.

With respect to the 747 fleet, the Safety Board's recommendations have resulted in fuel system product improvements, service bulletins, notices of proposed rulemaking, and airworthiness directives to correct issues that have been uncovered. As the investigation progresses, the industry is more aggressively addressing aging wiring issues to eliminate ignition sources in other aircraft models in the air carrier fleet.

Turbopropeller Airplane Safety

On February 1, 1994, an American Eagle SAAB 340 made a forced landing into the False River Airport, in New Roads, Louisiana. The Safety Board determined that the captain placed the engine power levers below the flight idle stop which rotated the propeller blades into the reverse thrust range. As a result, the engines experienced an overspeed condition and both power turbines were destroyed. The investigation revealed that the captain had bypassed mechanical limits to move the power levers into reverse (beta) pitch to reduce speed and increase the descent. The Safety Board's investigation revealed similar incidents of inappropriate use of the in-flight beta and recommended mechanical lockouts to physically prevent pilots from selecting beta in-flight. As a result of these accidents and the safety recommendations, the FAA has mandated changes in a variety of turbopropeller-powered airplanes to greatly reduce the possibility of propellers operating in the beta range while in flight.

Flight Safety in Alaska

Because of its geography, Alaska is extraordinarily dependent on aviation to meet the transportation needs of a far-flung population. Also, Alaska's environment, from adverse weather to rough terrain



to active volcanoes, is extremely challenging to safe flight operations. Concerned about historically greater fatal accident rates for the commuter airline and air taxi segments of the commercial aviation industry in Alaska (relative to these same industry segments in the remainder of the United States), the Safety Board conducted a safety study of aviation operations in Alaska in 1995.

The Safety Board found that some of the risks of flying in Alaska could be controlled if the state received enhanced aviation

facilities with improved communications, instrument approach procedures, weather reporting, and airport field condition reporting. Specifically, these improvements were targeted at the most common type of fatal accident in Alaska: continued visual flight into adverse weather.

In response to safety recommendations issued by the Safety Board, the FAA has begun to test a system for instrument flight operations in Alaska that uses satellite-based navigation and communication technologies, and approved instrument flight operations for passenger-carrying commercial flights using single-engine airplanes. It also implemented a new system for disseminating information about runway conditions to Alaska pilots. The National Weather Service has expanded the information that weather observers can manually enter into automated weather observations and has improved the dissemination of weather charts and satellite images to pilots in the state. Also, 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.

Space

The Safety Board's expertise is also applied to the nation's efforts to explore space and improve the safety of space flight. After the shuttle Challenger was destroyed during its launch in 1986, NASA requested assistance from the Safety Board. The Board's reconstruction efforts were critical to NASA's determination of the failure sequence. Following that investigation, NASA requested Board assistance in determining the crashworthiness and survivability of the orbiter and the effects of explosions on space shuttle payloads. It also requested long-term commitment of Board resources in two areas: providing expertise in any future space transportation accidents and training NASA staff and astronauts in wreckage reconstruction and analysis techniques.

During the Challenger investigation, the U.S. Air Force requested Safety Board participation in the investigation of a Titan 34D military launch vehicle explosion that occurred seconds after liftoff at Vandenberg Air Force Base. Board investigators located the cause of the failure, and the flaw was repaired before a sister vehicle was launched.



Following the creation of the Office of Commercial Space Transportation within the DOT, the Safety Board and DOT signed an agreement for the Board to investigate selected mishaps that occur during launches of commercial space vehicles. In February 1993, the Board investigated its first incident under this agreement when a Pegasus SCD-1 vehicle was launched from the wing of a B-52 after an abort command was given. Although the launch was successful, the Board found unsafe launch conditions and recommended changes.



Railroad



The railroad industry transported more than \$32 billion in freight in 1997, amassed more than 1.36 trillion revenue ton miles, and employs about 256,000 people. Amtrak carries about 21 million intercity passengers a year, and rail rapid transit systems – a major source of urban transportation – carry almost two billion passengers annually.

Safety Board recommendations in the rail mode have addressed problems in both passenger service and freight transportation.

Passenger Rail Car Safety

Safety Board accident investigations have resulted in a large number of safety improvements in rail passenger car equipment and design, injury reduction and prevention, train collision avoidance, and operations. More than 150 Safety Board recommendations for safety improvements covering a wide spectrum of rail passenger issues have resulted in:

- Seats, seat cushions, and appliances that are now secure from movement;
- Windows that are impact resistant and available as emergency exits;
- Mirrors that are shatterproof;
- Overhead luggage racks that have effective retention devices; and
- Interior surfaces that are rounded and/or padded.

Other Safety Board recommendations have resulted in improvements in flammability standards, safety feature information, and emergency egress such as:

- Replacement of materials to meet current flammability, smoke emission, and toxicity standards;
- Installation of smoke detectors with guards to prevent unauthorized removal;

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- Passenger emergency briefing cards and placards, including how to use emergency extrication tools;
 - Conspicuous markers and levers to facilitate operation of doors and emergency windows;
 - Portable lighting in the form of chemical emergency light sticks that can be used by passengers to find their way out of cars and their way along tracks in the dark;
 - Relocated, reliable, and long-lasting batteries for interior emergency lights; and
 - Additional emergency exit windows.

The Safety Board has recognized that community involvement and on-board service crew training and education are necessary to better cope with emergencies. Safety Board recommendations resulted in:

- Development of procedures for emergency passenger car evacuation that ensure the safety of passengers;
- Comprehensive training and re-training programs for on-board service employees in emergency procedures including the demonstrated operation of emergency exits; and
- Coordination and training of local track-side communities for emergency rescue familiarization.



The railroad industry has also acted on other Safety Board recommendations to increase railroad passenger safety. The industry is eliminating rim-stamped straight-plate wheels on passenger cars which were failing and causing accidents. Railroad tunnels used by commuter and intercity passenger trains have been inspected and equipped with fire hydrant stand pipes, emergency communication stations and hookups, and improved lighting as a result of Safety Board investigations and recommendations.

Supervision of passenger train crews and the management of train movements have also been the topics of Safety Board recommendations which have resulted in:

- 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.

Two Safety Board investigations of passenger train accidents in 1996 at Secaucus, New Jersey, and Silver Spring, Maryland, have led to significant recommendations on the physical testing for qualification of train crews and signal system design. In January near Secaucus, 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 one of the train engineer’s failure to correctly perceive 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 February Silver Spring accident, three crew members and eight passengers on a Maryland commuter train were killed when it ignored a signal and 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’ failures to conduct analyses on the human factors impact of signal modifications on that rail line.

As a result of years of rail passenger safety recommendations from the Safety Board, the Federal Railroad Administration (FRA) is enacting regulations regarding passenger equipment safety standards and passenger train emergency preparedness. These regulations will implement many of the recommendations the Safety Board has made to the FRA and the railroad industry to improve the crashworthiness of rail passenger cars and locomotives.

Rail Rapid Transit

The Safety Board has long been concerned about rail rapid transit safety. Almost two billion passengers a year commute on rail rapid transit systems, and a 1991 Safety Board study showed that state and local governments have the primary responsibility for the safety of these systems. During peak operating hours, a single rail rapid transit train can carry as many as 1,500 passengers. Safety oversight varies by system.

Investigations of accidents on rail rapid transit systems have led to improvements through Safety Board recommendations. Accidents on the New York City Transit system led to improvements regarding:

- Braking distance standardization and testing;
- Installation of speedometers and realistic speed control signage;
- Fail-safe operating standards and systems; and
- Operator qualifications and fitness for duty standards.

Numerous recommendations were made and related actions taken after the January 1996 collision of a Washington Metro subway train at Shady Grove, Maryland. The train overshot an aboveground station during poor weather and hit a standing, unoccupied subway train. The train engineer was killed. The accident investigation resulted in a reevaluation of the system's management oversight, and actions were taken to improve and correct deficiencies in the following areas:

- Braking performance, speed control, and the automatic train control system;
- Operating rules and policies;
- Communication practices; and
- Emergency service response.

The Safety Board investigation of a 1991 collision involving Greater Cleveland Regional Transit Authority (GCRTA) trains revealed that a train operator had disconnected the automatic cab signal system, thus eliminating one means of collision prevention. Coded track circuits in the GCRTA's train control system transmit speed commands to the on-board train control equipment.



To avoid the speed limitation, the operator in this accident cut out the cab signal, thus deactivating the automatic train control system. In response to subsequent Board recommendations, the GCRTA implemented procedures for recording the use of cab-signal cutouts to prevent unauthorized operations.

Alcohol and Drug Use

After a dozen years of recommendations by the Safety Board, the FRA instituted the first mandatory drug/alcohol testing rule for any mode of transportation in 1986. The January 1987 accident in Chase, Maryland, that killed 16 people on an Amtrak train was the first major accident where required testing showed that drugs were a factor.

The rule appears to be having its intended effect. Postaccident tests (tests required after serious railroad accidents) indicate that the number of employees with positive test results for alcohol or other drugs has fallen from 5.5 percent in 1987 to less than 1 percent in 1995. Random drug testing results (testing at random required by federal regulations) have also shown a decline in employees testing positive for drugs from 1.04 percent in 1990 to 0.9 percent in 1995.

Locomotive Fuel Tank Integrity

During the course of its railroad accident investigations, the Safety Board has documented many instances of locomotive fuel tanks that ruptured during collisions. In the Sugar Valley, Georgia, and Corona, California, accidents five of the six fatally injured crewmembers suffered extensive burns and smoke inhalation. In the 29 locomotive derailments investigated by the Board in 1991, diesel fuel spills occurred in 56 percent of the accidents. Based on Board recommendations, the FRA, the Association of American Railroads, and locomotive manufacturers met in 1993 to establish a program to collect data on fuel tank damage and fuel spills. Manufacturers have begun to design locomotives with a better protected fuel tank.

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 occurred in either of the accidents, despite serious track damage. Historically, severe track damage has resulted in damage and rupture to more conventional frame-suspended fuel tanks.

Tourist and Historic Railroads

There are over 330 tourist railroads, museums, dinner trains and special excursion trains in the United States. These organizations have as many as 40,000 volunteers and employees who operate 140 steam locomotives, 1,000 diesel-electric locomotives, and 1,200 passenger cars. Three hundred of the passenger cars are certified to run on Amtrak trains. Approximately 1,225 miles of railroad are used for regular tourist and excursion service. According to the tourist industry, almost five million people visit these operations annually.



The Safety Board has investigated several tourist railroad accidents and made related recommendations to improve their safety. The most significant tourist railroad accident occurred in June 1995 near Gettysburg, Pennsylvania, when a steam locomotive 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. Actions that resulted from the accident that have affected the steam tourist industry include:

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- Addition of a redundant water monitoring system for steam engines;
 - A required boiler water monitoring device;
 - 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.

Improved Emergency Braking Capabilities

As the result of an investigation involving the derailment of a runaway freight train in Cajon Pass, California, the Safety Board determined that an important safety device, a two-way end-of-train device (ETD) that could be activated in an emergency to assist in stopping the train, was not properly armed and ready for service. At the time of the accident, there were no comprehensive industry guidelines for the implementation and use of two-way ETD equipment with the capability of initiating an emergency brake application at the rear of the train. In the past, ETDs did not have

such an important safety feature and emergency braking could only be initiated by an engineer from the controlling locomotive at the front of a train.



A two-way ETD allows a train crew to initiate an emergency brake application from the rear of a train, as well as from the front. During the investigation, the Safety Board found that the railroad was not properly repairing, inspecting, and testing the two-way feature of the ETD on trains operating over

mountain grade territories. As a result of Safety Board recommendations, federal regulators now require heavy trains operating over mountainous terrain to be properly equipped with a two-way ETD.



Marine



Much of this nation's commerce travels between U.S. ports and points overseas, and on the tens of thousands of miles of inland waterways. Water transport moves about 790 billion ton-miles a year and employs almost 200,000 persons. There are about 78 million recreational boaters in the United States and 118,000 commercial fishing vessels. Cruise ships board about five million passengers a year from U.S. ports. Ferryboats, most prominently in New York City and Seattle, carry more than 270 million passenger miles a year.

Safety Board marine recommendations have addressed problems in vessel safety standards, recreational boater education, and commercial fishing vessel safety.

Passenger Vessel Safety

Large passenger ships carry millions of people on excursion trips and pleasure cruises from U.S. ports every year. Passenger ships operating from U.S. ports may be registered either in the United



States or in foreign countries.

U.S.-registered passenger ships operating from one U.S. port to another must meet U.S. safety standards, while foreign-registered ships must meet international safety standards established by the International Maritime Organization (IMO), a United Nations agency. There are only a handful of U.S.-registered passenger ships: two operating in the cruise trade in the Pacific, and a few large

excursion boats that operate on rivers. There are about 140 foreign-registered passenger ships operating from U.S. ports, carrying about four million passengers annually.

Since 1979, the Safety Board has investigated 24 accidents on board foreign-registered passenger ships that regularly operated from U.S. ports. These accidents caused 11 deaths, 186 injuries, and more than \$140 million in property damage. In a 1989 safety study and again in a 1993 special investigation report on passenger vessels, the Board identified serious shortcomings in passenger ship safety and issued recommendations to improve the 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.

As a result of the Safety Board's recommendations, the U.S. Coast Guard obtained international agreement to require fire safety improvements on all passenger ships. The international fire safety requirements for passenger ships have been virtually rewritten, and for the first time, all of the new requirements will be applied to existing ships as well as to new ships. Automatic sprinklers, fire detection and alarm systems, and emergency lighting are compulsory on all ships able to carry 36 or more passengers that were delivered after October 1994.

Another vessel safety issue is the installation of voyage data recorders (VDRs), which are similar to flight data recorders on aircraft. Since the 1970s, the Safety Board has promoted the use of such recorders on various types of vessels and other modes of transportation. Automatic data recording devices are useful for management oversight, and they also provide crucial, factual information for accident investigation and have played a key role in identifying and addressing accident causes. The 1995 grounding in an Alaskan canal of the *Star Princess*, which was fitted with a VDR, is an excellent example of the usefulness of these devices in accident reconstruction and in improving management oversight. In this case, the Safety Board found 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. The Safety Board currently is working closely with the Coast Guard to develop carriage requirements and technical standards for VDRs with a subcommittee of the IMO.

Recreational Boating Safety

As recreational boat use increases, so too does the potential for more accidents, injuries, and fatalities. An estimated 12 million state-registered recreational boats and as many as 78 million people participate in this activity. Recreational boating activities are conducted on 50 million acres of lakes, 633,000 miles of rivers, and along 88,633 miles of coastline. The use of alcohol in this environment compounds the possibility for tragedy.

While the Coast Guard and state boating law authorities suspect alcohol use to be a major factor in the high number of recreational boating fatalities (about 600 to 800 a year), creditable national statistics are not available. There are no uniform reporting requirements or guidelines for collecting this information. As a result of a safety study conducted during the early 1980s, the Safety Board urged the adoption of a clearly defined blood alcohol concentration (BAC) for intoxication, such as is applied to highway vehicle operators. In response, the National Association of State Boating Law Administrators drafted state guidelines in 1984 that include specific prohibitions against operating a boat while intoxicated. By 1997, every state had a law concerning boating while intoxicated, 48 states have a specific BAC definition, and 38 states have implied consent provisions.



In 1993, the Safety Board issued recommendations to the states to require mandatory education, operator licenses, and use of personal flotation devices (PFDs) for children. Since that date, 16 states have passed laws requiring PFD use for children, 18 require mandatory education, and one – Alabama – requires a boat operator's license.

Of the many organizations that the Safety Board supports in improving recreational boating safety, one of the newest is the National Recreational Boating Safety Coalition. This coalition was formed with the Safety Board's assistance in 1995. The primary mission of this organization is 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.

Vessel Traffic Services

The 1989 *Exxon Valdez* oil tanker accident in Alaska focused national attention on the need for a viable vessel traffic service (VTS) system to prevent marine accidents. Even before that environmental disaster, however, the Safety Board had been in the forefront of efforts to improve VTS in U.S. ports.

After the *Exxon Valdez* accident investigation, the Safety Board recommended that the Coast Guard increase the staffing level at the Valdez, Alaska, VTS. The Coast Guard complied with this recommendation and also upgraded its vessel plotting system at Valdez to an electronic charting display that automatically records the position of vessels with a satellite-aided tracking system.

After the Coast Guard closed its VTS operations in New York City and New Orleans in 1988, the Safety Board recommended that the DOT reestablish those offices. An act of Congress led to the reopening of the New York VTS in 1990.

The Coast Guard has issued final rules that will require mandatory participation in the VTS systems in the United States as required by the Oil Pollution Act of 1990. Many of the Safety Board's recommendations in its *Exxon Valdez* report were contained in the 1990 act.

Commercial Fishing Vessels

In September 1987, the Safety Board issued a safety study on uninspected commercial fishing vessels, which, along with a number of individual Board accident reports, identified critical safety problems throughout the commercial fishing vessel industry. At that time, commercial fishing had the worst safety record of all U.S. industries. Coast Guard accident data showed that, between 1981 and 1984, an average of 75 lives and nearly 250 documented U.S. commercial fishing vessels per year were lost in accidents.

As a result of the Safety Board's study and public interest, Congress passed the Commercial Fishing Industry Vessel Safety Act of 1988. As a further result of the Board's study and subsequent accident investigations, the Coast Guard published final rules in August 1991 to improve the safety of commercial fishing vessels.

These regulations for the first time required commercial fishing vessels to carry specific lifesaving devices, including liferafts, survival suits, and emergency position indicating radio beacons (EPIRBs).

These improvements are having a dramatic impact on the safety of commercial fishing vessel operations. According to 17th District Coast Guard data for Alaska, in 1991 and 1992, the average



number of fishermen who lost their lives was about 25 annually; from 1993 through 1996 that number has declined to an average of about 10 annually. Additionally, the Safety Board sought to improve the fire construction standards on fishing vessels carrying more than 16 persons. Specifically, the Safety Board asked that the Coast Guard and the National Fire Protection Association (NFPA) to cooperatively develop a national marine fire safety

standard on the safe use of rigid polyurethane foam and other combustible insulation used in refrigerated holds on board commercial fishing industry vessels. Both the Coast Guard and the NFPA have responded favorably to the Safety Board's recommendation and are working toward its accomplishment.

Emergency Position Indicating Radio Beacons

In October 1988, Congress passed a law requiring each manned uninspected vessel operating on the high seas or beyond three nautical miles from the coastline of the Great Lakes to be equipped with alerting equipment, including emergency position indicating radio beacons (EPIRBs). Safety Board accident investigation findings provided the factual basis needed to support this action.

Recommendations were issued in the early 1980s following investigations of the sinkings of uninspected vessels. The Safety Board pointed out at the time that the cost of EPIRBs on vessels would not approach the cost of even one massive air and sea

search. For example, the search for the fishing vessel *Amazing Grace* off the mid-Atlantic coast in December 1984 cost about \$12 million.

In 1986, the Safety Board recognized the need for requiring EPIRBs on uninspected vessels when it investigated the capsizing and sinking of the *Pride of Baltimore*, a sailing vessel owned by Maryland. The vessel sank so quickly that the manually operated EPIRB was not released or activated. Survivors were not located until four days after the vessel sank. Had the vessel been equipped with an automatic EPIRB, the survivors might have been found sooner during the massive air and sea search that followed the sinking.

As technology improved, a satellite EPIRB that transmitted data on 406 MHz frequency became available. When a 406 MHz distress signal from a stricken vessel is received by geostationary satellites, the EPIRB registration database provides vessel information for an appropriate search and rescue response. Accuracy of satellite EPIRB positions are to within 1.4 nautical miles. The next-generation 406 MHz EPIRBs equipped with integral satellite technology will transmit distress position data accurate to within 100 meters.



The Safety Board began making recommendations to replace the old, less accurate EPIRB with the new 406 MHz EPIRB in 1989. As a result of the Safety Board's efforts, federal regulations now require uninspected commercial vessels, ocean-going ships, and other vessels to be equipped with 406 MHz EPIRBs. These EPIRBs will enable search and rescue units to locate a vessel in distress much quicker and with greater precision, resulting in improved survival rates and reduced search costs.

In a related matter, search and rescue operations on the Great Lakes have also been improved during severe weather periods because of Safety Board recommendations. Three new Coast Guard stations were commissioned and more ship coverage is provided during November, the stormiest month on the lakes.

Towing Vessel Safety

After the investigation of towing vessel accidents involving the U.S. towboats *Fremont*, and *Mauvilla*, and the U.S. tugboat *Morris J. Berman*, the Safety Board issued recommendations to the DOT, Coast Guard, and the industry to improve navigation safety on inland waterways and towline safety for offshore towing operations.

In the first accident, the barge being towed by the *Fremont* was struck and sank, spilling all of its cargo of molten sulfur into the waterway. 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. In the second accident, a towboat operator became lost and disoriented in dense fog because of his inability to interpret his radar presentation, and his vessel collided with an unprotected railroad bridge. The railroad track was displaced and Amtrak Train No. 2, traveling at about 70 mph, derailed on the bridge and plunged into the Bayou Canot resulting in the loss of 47 lives and 111 injuries. In the third accident, the vessel's towline parted resulting in the grounding of

the tank barge and the loss of about one million gallons of fuel oil contaminating the beaches and shoreline of Puerto Rico.



As a result of Safety Board recommendations stemming from these accidents, 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.

After the *Mauvilla* accident, the DOT convened an intermodal (marine, highway, and railroad) bridge information system task force to compile information on bridges vulnerable to impact from marine traffic. Approximately 5,450 bridges were identified: about 3,900

highway bridges and 1,550 railroad bridges. The task force validated information about bridge contacts and ownership and distributed this information to state and federal agencies. Now in the event a bridge is struck by a marine vessel, the bridge owner and local emergency response agencies are notified to stop vehicular traffic (highway and railroad) until inspectors determine that the bridge is safe for transportation.

These safety improvements will not only make towing vessel operations safer, but also will greatly improve the safety of highway and railroad traffic using bridges that span navigable waterways.

Highway



More than 196 million registered vehicles and 176 million licensed drivers are on record in the United States. According to the National Highway Traffic Safety Administration (NHTSA), more than 90 percent of fatalities and 99 percent of injuries in transportation are the result of motor vehicle crashes. Traffic crashes cost the nation every year over 40,000 lives; over 3.5 million injuries; and \$150 billion in medical costs, lost productivity, and property damage. Safety Board recommendations for highway safety range from human performance concerns such as driver fatigue, alcohol and drug use to engineering problems like school bus construction, seatbelt usage, air bag concerns, and highway design.

Drunk Driving

In May 1988, a pickup truck driving on the wrong side of an interstate highway near Carrollton, Kentucky, slammed into an activity bus (a former school bus) bringing children and parents back

from a day at an amusement park. The subsequent fire killed 27 bus passengers, making it the worst drunk driving accident in U.S. history. The driver of the pickup had a blood alcohol concentration (BAC) of 0.26 percent an hour and a half after the accident – more than two times the legal limit in most states at that time.



The overall number of deaths attributed to alcohol-impaired driving has been declining in recent years, due in part to

Safety Board anti-alcohol and anti-drug initiatives. Alcohol-related traffic fatalities have decreased from over 25,000 in 1982 to just over 17,000 in 1996.

All 50 states have set 21 as the minimum drinking age, after a Safety Board study found that teenagers were overrepresented in the population of drunk driver accidents. The Board's 1982 recommendations began the national debate that led to universal adoption of the standard. It is estimated that the age-21 laws have saved about 16,500 lives since their enactment.

In 1984, the Safety Board issued a study showing the benefits of two deterrent programs: sobriety checkpoints and administrative license revocation (ALR). ALR allows law enforcement officers to immediately revoke a driver's license if the driver fails an alcohol test or refuses to take one. The revocation is subject to subsequent judicial review. When the study was completed, 21 states employed sobriety checkpoints and 21 states and the District of Columbia had ALR. Since issuance of the study, 19 additional states have employed sobriety checkpoints, and 19 more states have adopted ALR laws. Studies have shown that jurisdictions that adopt ALR laws register a nine percent drop in alcohol-related nighttime driving fatalities. When all jurisdictions adopt ALR, it is estimated that 2,000 lives will be saved every year.

Despite the progress gained by the age-21 laws, underage drivers continue to be overrepresented in both alcohol-related fatal crashes and total fatal crashes. In 1993, the Safety Board issued nine safety recommendations to the states calling for a review of drinking age laws and asked the states to vigorously enforce youth drinking and driving laws and to enact comprehensive laws that prohibit drivers under the age of 21 from driving with a measurable BAC. When these recommendations were issued, 15 states had some form of low-BAC legislation for young drivers. In less than five years after the Board issued the zero tolerance recommendations, all states have enacted zero alcohol tolerance laws for drivers under age 21. These measures are major steps in combatting one of the single most deadly threats in America – the alcohol-impaired driver.

Reporting Drunk Drivers

On September 9, 1982, the Safety Board issued recommendations to the 50 states and the District of Columbia to implement a citizen awareness and drunk driver reporting program similar to the REDDI-type programs used in Colorado, Maryland, Nebraska, Utah, and Washington.

REDDI stands for “Report Every Drunk Driver Immediately.” In the 1980s, states and citizens embraced the opportunity to report impaired drivers as hazards on the road. They did so despite the difficulty of locating a telephone and calling the correct number. Technological changes in the 1990s have led to the use of cellular telephones to report highway crashes and hazards. Calls to emergency numbers (usually 911) are now so frequent that states have developed alternatives such as #77 for reporting non-emergency (not life-threatening) hazardous situations. State police agencies have also developed specific numbers for high-density locations. Rural states such as Wyoming have reported nearly 10,000 arrests from 104,000 calls in the 15 years of its program.

School Bus Safety

School buses carry 23.5 million passengers daily. Safety Board initiatives from tougher bus construction to better driver training have helped make school buses one of the safest forms of transportation in the country.

In April 1977, following a series of Safety Board recommendations, the DOT 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 improvements.



In a 1987 study on the performance of buses built to the new standards, the Safety Board found that the new standards had significantly improved the safety of school bus transportation, and recommended rapid retirement of all prestandard buses in the fleet. As of 1994, 14 states had virtually eliminated the use of prestandard buses for pupil transportation: 20 had two percent or less of the buses in operation; and the remaining 16 states had developed phase-out programs.

In a related 1989 study, the Safety Board found that occupants of small buses built to the 1977 federal standards

generally fared well in the accidents investigated. However, the study found that almost a third of lapbelted passengers were wearing their belts improperly. Sometimes, the belts had been improperly modified by employees of the school district or the bus contractor. The prompt action of school transportation associations in response to this study alerted school districts to the dangers of improper installation and use of restraints in small school buses. School bus manufacturers also responded to the Safety Board's recommendations urging better emergency door latches to prevent them from opening during an overturn accident.

An additional safety advance followed the Safety Board's investigation of an accident near Snow Hill, North Carolina, in 1985, and one near Bronson, Florida, in 1987. In 1988, the manufacturer of the buses involved in the accidents announced it would comply with a Board recommendation to strengthen floor joints with additional rivets, thus exceeding the strength requirement in federal standards.

As a result of Safety Board investigations of a school bus accident in Carrollton, Kentucky, that involved fire, and one in Alton, Texas, that involved a submersion, recommendations were issued to NHTSA to improve school bus egress. These recommendations addressed the total surface area for egress, the size of school bus side windows, and the need for exit doors to remain open during emergencies. NHTSA issued new standards addressing these problems in November 1992.

Another safety problem that the Safety Board has eliminated is the use of 16- and 17-year-old school bus drivers. The Board sought this action because these drivers were statistically overrepresented in school bus accidents when compared to older bus drivers. States that permitted younger drivers required them to get a U.S. Department of Labor waiver. The Board provided the Labor Department with accident data, prompting a study. As of June 1988, the Labor Department no longer allowed states to employ 16- and 17-year-old school bus drivers.



Seatbelts

The safety benefits of seatbelt use in automobiles was proved long ago. Every day, people are saved and injuries are prevented by properly worn seatbelts. Seatbelt use has increased from 15 percent in 1982, to 68 percent in 1996, saving more than 85,000 lives in that time.

A major safety improvement resulted from a Safety Board recommendation concerning the performance of seatbelts in rear seats of automobiles. In June 1989, NHTSA issued a final rule requiring rear-seat lap/shoulder belts in new cars. The federal requirement was extended to light trucks, multipurpose vehicles, and convertibles manufactured after September 1991.

These actions resulted from Safety Board recommendations that lap/shoulder belts be installed at all outboard seating positions and that manufacturers develop an aggressive 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.

A subsequent Safety Board study documented the benefits of properly worn lap/shoulder belts, and also helped educate the public by highlighting the degraded crash protection when improperly worn. Children, as well as adults, have benefited from the Board's findings. Before the release of this study, parents were routinely advised by safety organizations and NHTSA to misroute the shoulder portion of the three-point belt around the child's body if, in the parent's opinion, the shoulder strap came too close to the child's face or neck. Children were thus restrained by a lap-only belt, with its degraded crash protection and potential for injury. Since the Board's study, organizations that promote child safety now advocate using the lap/shoulder belt as designed, giving children better crash protection.

Air Bags and Child Passenger Safety

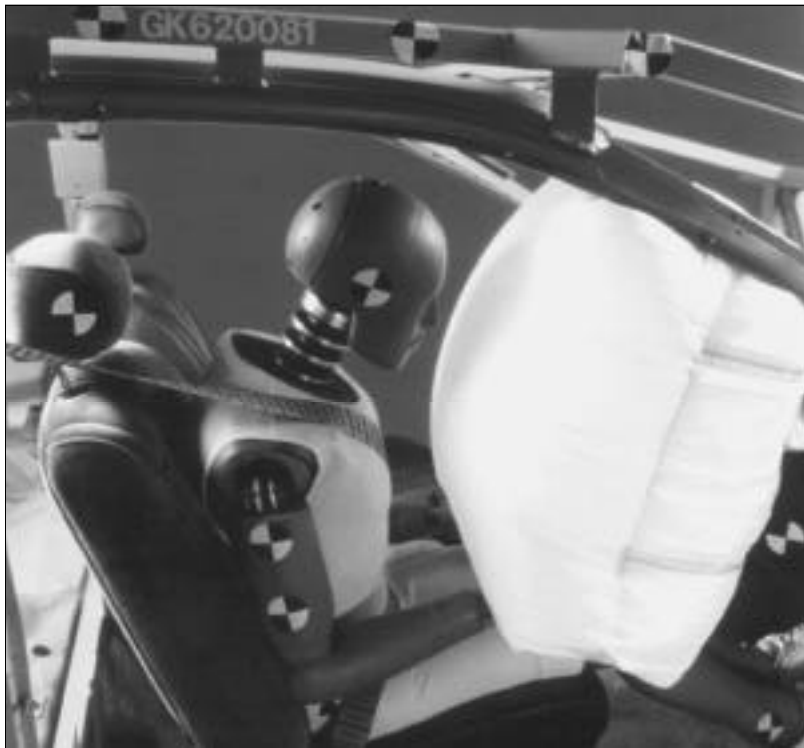
When occupants properly use seatbelts, air bags increase the chances of survival in severe frontal crashes. But air bags may pose dangers for some occupants in certain situations. About 35 million cars currently on the road are equipped with passenger-side air bags and each month approximately one million new cars equipped with air bags are manufactured.

Between 1993 and mid-1998, 61 children died because they were struck by an air bag in what would have otherwise been a survivable crash. These occupants were in the danger zone when the air bag inflated. Forty-four adults were also killed by their air bags in crashes they could have survived.

In 1996, the Safety Board completed a study on the performance and use of child restraint systems, seatbelts, and air bags for children in passenger vehicles. The study analyzed data from 120 vehicle crashes that occurred between 1994 and 1996. Vehicle occupants included

207 children under age 11. Of these 120 accidents, air bags deployed in 13 accidents in which a child was seated in the front passenger seat. The study focused on the dangers that passenger-side air bags pose to children; factors affecting injury severity; adequacy of federal standards regarding the design and installation of child restraint systems; need to improve seatbelt fit for children; adequacy of public information and education on child passenger protection; and adequacy of state child restraint use laws.

The Safety Board also convened a public forum in March 1997 to discuss concerns related to the effectiveness of air bags and ways to increase seatbelt and child restraint use. Other issues discussed included air bag-induced injuries; role of air bags as a primary or secondary restraint system; deployment thresholds;



complexity of implementing depowered air bags, switches, and suppression devices; advanced air bag technology; experience with air bags in other countries; evaluating the effectiveness of air bags; enforcement of restraint laws; design of child-friendly back seats; and design of child restraints.

NHTSA participated in the forum, along with representatives from Australia, Canada, and Europe; the automobile industry; air bag suppliers; insurance, safety and consumer groups; and family members involved in crashes in which air bags deployed.

As a result of its study and public forum, the Safety Board issued a series of recommendations to improve the effectiveness of air bags. Action taken as a result of those recommendations include:

- The automobile industry sent letters and warning labels to owners of 60 million cars currently on the road that are equipped with air bags advising the owners about the dangers that air bags pose to children;
- NHTSA required highly visible and permanent warning labels in all newly manufactured air bag-equipped vehicles and on child restraint systems, effective February 1997;
- NHTSA and the automobile and insurance industries initiated an air bag safety campaign in May 1996. The multi-million dollar effort is dedicated to educating the public about the importance of putting children in the back seats of vehicles with air bags, buckling their seatbelts, and strengthening state seatbelt use laws and increasing their enforcement.
- To make automobiles more child-friendly, many automobile manufacturers provide built-in child restraints, center rear seat lap/shoulder belts, and adjustable upper shoulder belt anchorages in the back seats of passenger vehicles, and;
- Since May 1997, automobile manufacturers have been permitted to install depowered air bags in newly manufactured vehicles. These air bags reduce the risk of air bag-induced injuries to short-statured and senior citizen occupants.
- Certain at-risk occupants now can apply for permission from NHTSA to install on-off switches for one or both front airbags.
- Education and legislative efforts have begun to have children ride in the safer back seat.

Child Safety Seats

Between 1980 and 1984, more than 3,000 children under five years old were killed in motor vehicle accidents and more than 250,000 were injured. This toll exceeded that of all common childhood diseases combined for the same period. Studies indicated 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. After the enactment of a pioneering child safety seat law in Tennessee in 1977, other states began to pass similar laws. By late 1982, such laws had been enacted in 19 states, but most of the nation's young remained unprotected.

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 Board investigated 53 accidents and found dramatic differences in the injuries to infants and small children who did and did not have safety seat protection. In December 1982, the Safety Board recommended legislative action in the remaining 31 states and the District of Columbia. This effort was followed up a year later by the results of hearings and further investigations.

Now all 50 states and the District of Columbia have child passenger protection laws. Between 1982 and 1996, child safety seats in automobiles have saved the lives of more than 3,200 young children, according to NHTSA.

Commercial Driver's Licenses

There are about 2.6 million truck drivers in the United States. Safety Board investigations of major truck crashes repeatedly demonstrated the need for improved driver performance. In 1980 and 1986, the Board conducted evaluations of truck driver performance and identified ways to alleviate shortcomings in the systems for detecting and controlling unsafe drivers. The Board's 1986 study endorsed a national license for commercial truck drivers to help bar unqualified drivers from operating trucks. The Board also recommended a special license or endorsement for drivers transporting hazardous materials.

Since publication of the study, Congress has enacted a law requiring the commercial driver's license (CDL), which requires most truck and bus drivers to obtain a CDL and prohibits them from having more than one driver's license. An alcohol/drug testing program is also included under the CDL program. From 1986 to 1996, fatal tractor-semitrailer crashes declined 30 percent, according to DOT data.

Heavy Truck Brakes

In 1992, the Safety Board released a safety study on the performance of heavy vehicle air brakes. In more than 1,500 roadside inspections of big trucks conducted with the cooperation of state police agencies, the 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.

Safety Board recommendations have addressed uniform brake maintenance policies; performance standards related to stability, control, and stopping distances; and hardware changes that emphasize automatic adjusters, improved maintenance, and antilock brake systems.



In early 1995, DOT removed a design restriction that discouraged the use of long stroke chambers, which allow brakes to stay in adjustment longer. This action was taken in direct response to a Safety Board recommendation. Also in 1995, DOT issued final rules requiring antilock brake systems on all large trucks and buses by

the end of the decade. DOT estimated that the rule would save 500 lives a year and more than \$3 billion annually in accident costs.

Reduced Visibility

Thousands of people have been killed on U.S. highways in limited visibility conditions, including fog, smoke, and dust. The Safety Board investigated six limited visibility crashes since December 1990 that killed 40 people and involved more than 450 vehicles. Recommendations were issued to federal and state governments calling for development of a comprehensive solution to the problem.

Tennessee, Louisiana, and California, three of the states in which these crashes occurred, have implemented comprehensive detection systems and response plans that include the detection of traffic flow disruptions and procedures for uniform driver response through the reduced visibility area. A Safety Board public hearing on the issue resulted in information that was distributed to all states, and the Transportation Research Board compiled and published preferred practices in this area. The Board has further addressed this issue by focusing recent recommendations on intelligent transportation systems, especially in crash avoidance countermeasures.

Grade Crossing Safety

In 1996, 472 people died in highway-railroad grade crossing accidents. The year before, 579 people were killed. On average, 1,800 individuals are injured annually. The Safety Board has been a longtime supporter of Operation Lifesaver, a national voluntary safety program that addresses grade crossing safety through programs in education, enforcement, and engineering. Grade crossing accidents have been declining since 1977, but the number of fatalities is still too high.

In October 1995, a school bus and commuter train collided at a suburban Chicago grade crossing, killing seven high school students and seriously injuring 24 others. A quick



response by all states, in less than 15 months, to Safety Board recommendations resulted in the first nationwide database to track, monitor, and inspect about 3,500 highway-railroad crossings that have interconnected road signals and rail warning lights. All states quickly inspected and made safety adjustments to these intersections. For the first time, this information is available to state transportation and education departments and school safety officials to help them plan and monitor local school bus routes and train drivers to avoid potential grade crossing hazards.

In addition, 24 states have responded positively to a Board recommendation that grade crossings with passenger or commuter train activity be given high priority for the installation of active warning devices. Additionally, in response to the concerns addressed in a Board report on the poor visibility aspects at many grade crossings, some states are seeking legislative action to reduce highway sight-distance problems. All states now have programs, encouraged by Safety Board recommendations, to educate the public about the dangers of highway-railroad grade crossings.

In 1996, the Safety Board issued recommendations to all Class 1 railroads urging them to implement 24-hour, toll-free emergency notification systems to permit the public to promptly report emergencies at all active and passive crossings. Many railroads have initiated such systems. In April 1998, one Class 1 railroad completed the installation of emergency signs at all crossings throughout its system.

Center High-Mounted Stop Lights

As early as 1975, the Safety Board recommended 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. Center high-mounted stop lights have been required on all new passenger cars sold in the United States since the 1986 model year and all new light trucks since the 1994 model year.

In March 1998, NHTSA issued a report on their effectiveness. The study concluded that center brake lights prevent 92,000 to 137,000 police-reported crashes, 58,000 to 70,000 nonfatal

injuries, and \$655 million in property damage a year. It also estimates that the lamps save \$3.18 in property damage for every dollar they cost.

Highway Bridge Safety

In 1967, a highway bridge spanning the Ohio River between Ohio and West Virginia collapsed, killing 46 motorists. Since then, the Safety Board has investigated 12 highway bridge collapses which resulted primarily from erosion, corrosion, collisions by vessels and trucks, poor design, and inadequate inspection practices. The Board's recommendations regarding bridge safety have led to vastly improved national bridge inspection and management programs.



The Safety Board's investigation into bridge collapses caused by erosion included a 1987 collapse of a New York State Thruway bridge near Amsterdam, New York, and a 1989 collapse near Covington, Tennessee. In 1997 as a result of a Safety Board recommendation, an ambitious nationwide underwater highway bridge inspection program was completed by federal and state highway agencies. More than 22,000 highway bridges received underwater inspections for scouring and deterioration. Now all bridges over water are on underwater inspection schedules of five years or less.

Earthquake Preparedness

When a 1971 earthquake in San Fernando, California, caused catastrophic damage to transportation facilities, the Safety Board investigated this event. The Safety Board recommended that the DOT and the states develop programs to retrofit bridges to make them less vulnerable to collapse from earthquakes and to reduce the potential for loss of life. Also, the Safety Board recommended that new bridges be designed to better resist seismic forces.

California continues to retrofit many of its bridges. The retrofits and new bridge designs have been effective in limiting damage from earthquakes in the last 10 years. The Golden Gate Bridge, the world's tallest suspension bridge, is undergoing a seismic retrofit to withstand a 90-second earthquake that measures 8.3 on the Richter scale.

The seismic program is not limited to California. New York, for example, has a program to determine the vulnerability of its bridges from seismic forces and to retrofit bridges vulnerable to earthquakes and other extreme events such as vessel and vehicle collisions and scour. The design for extreme events has now become part of bridge codes throughout the United States.



Pipeline



Pipelines carry more hazardous materials in the United States than any other form of transportation. Annually, almost 600 billion ton-miles are carried in 177,000 miles of pipe, and more than 21 billion cubic feet of natural gas are delivered through 1.2 million miles of pipe. The oil and gas pipeline industries employ 120,000 people.

The Safety Board has played a vital role in helping to reduce accidents and injuries attributable to liquid and gas pipeline accidents. In the years 1984 through 1996, the number of pipeline accidents fell 23 percent and injuries 10 percent. Safety Board [recommendations in the pipeline mode have addressed](#) problems in safety standards, excavation damage prevention, pipeline failure detection, and service line shutoff.

Pipe Replacement Programs

In the 1980s, the Safety Board investigated numerous accidents involving failures of cast-iron pipe, many of which had been used for a century. The Board recommended in 1991 that each gas operator implement a program to identify and replace in a timely manner cast-iron piping that may threaten public safety. The DOT issued two alert notices as a result of that recommendation, and required operators to establish surveillance and rehabilitation programs.

Operating Standards

As a result of an investigation of a pipeline accident at Fort Benjamin Harrison in Indiana in 1990 that killed two people, the Safety Board found that the Department of Defense did not have adequate standards to ensure the safe operation of gas pipelines on military bases. In response to Board recommendations, the U.S. Army Corps of Engineers adopted federal standards for pipeline safety at all military bases.

Risk Management

In 1972, the Safety Board recognized the benefits of pipeline operators using risk management principles to identify hazardous conditions and to make system modifications to minimize threats to public safety. The Board recommended the incorporation of risk management programs by operators and by regulators into pipeline safety operations. The DOT Office of Pipeline Safety now has a program allowing pipeline operators to implement risk management programs that will enhance the safety of those who live and work near pipelines.

Excavation Damage Prevention

Excavation damage prevention programs were almost unknown in 1970 when the Safety Board first identified excavation damage as the largest single cause of pipeline accidents and of deaths and injuries resulting from pipeline accidents. Board investigations, safety studies, and safety promotion activities have been instrumental in convincing federal and state agencies, and 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 damages to gas lines and other buried facilities. As a result, there are one-call notification centers in all states and the District of Columbia and excavation damage prevention laws in 48 states and the District of Columbia. Similar programs have been implemented in five other countries. In the 1970s,



excavation damage to pipelines was estimated to cause 50 to 60 percent of all pipeline accidents. While still the largest single cause of pipeline accidents and damage to other buried facilities, excavation damage now accounts for only 25 percent of all pipeline accidents.

Liquid Pipeline Failure Detection

The failure to identify and promptly shut down failed liquid pipelines can result in significant damage to the environment. 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. Many pipeline operators have been convinced by Safety Board reports over the last 30 years to install more effective systems for monitoring pipeline operations and to install remote and automatic valves so operators will be promptly alerted to failures and be able to rapidly isolate those areas. Moreover, many more operators are using internal inspection devices to identify and remove deteriorated segments from their pipeline systems. For systems not designed to accommodate conventional internal inspection devices, researchers are seeking ways to modify inspection tools for use in all pipelines. New pipelines are designed to accommodate internal inspection devices to detect system weakness before an accident occurs.

Rapid Shutoff of Damaged Service Lines

Many gas distribution systems recognized more than 30 years ago that the major cause of accidents involving service lines was excavation damage. Those operators called on their equipment suppliers to develop a simple device capable of shutting off the flow of gas in service lines that experienced an abnormal flow increase.



Excess flow valve.

The device developed, an excess flow valve (EFV), could be installed in the service line near the gas main at a cost of \$30 to \$50. Safety Board investigations of accidents confirmed the effectiveness of these devices and the Safety Board began calling for their installation in new and renewed high-pressure gas service lines.

In the 25 years that the Safety Board has advocated

EFVs, several gas distribution operators have voluntarily installed more than one million EFVs. Regulations now require that gas distribution operators install an EFV on new and renewed high-pressure gas service lines when a customer requests one and agrees to pay the cost. Today, these valves cost about \$10 to \$20, about the same as a quality home smoke detector.

Hazardous Materials Transportation



The safe transportation of hazardous materials has been a continuing concern of the Safety Board. Safety Board hazardous materials investigations have resulted in safety improvements in all modes of transportation.

Railroad Tank Car Safety

Among the Safety Board's achievements has been the adoption of requirements for headshield protection and top and bottom shelf couplers on tank cars carrying hazardous materials. On July 19, 1974, in a railroad yard in Decatur, Illinois, a tank car was



Shelf coupler.

punctured by a box car coupler, allowing liquefied isobutane (a flammable gas) to escape and vaporize. About 10 minutes later, the tank car exploded, killing seven yard employees and injuring 349 other persons. Property damage was estimated at \$18 million. The Board recommended that the FRA determine the capabilities of top and bottom shelf couplers and headshields to protect tank cars transporting hazardous materials. Shelf couplers keep

cars together during a derailment. Headshields protect tank cars from being punctured at the ends of the tank car, the most vulnerable area for such occurrences.

On September 15, 1977, the DOT issued regulations that required top and bottom shelf couplers and headshield protection to be included in the design of new tank cars of a certain DOT specification used to transport flammable gases and ammonia;

existing cars of that specification had to be retrofitted. However, in the six months following issuance of these regulations, three derailments involving the release of hazardous materials from tank cars killed 26 persons, injured 205 persons, and resulted in \$3.5 million in property damage. Following a 1978 public hearing on the issue, the Safety Board recommended that the requirement for shelf couplers and headshields be extended to all tank cars designed for the transportation of flammable gases and ammonia.

As a result of other accident investigations, Safety Board recommendations led to new regulations issued in 1981 and 1984 that expanded the types of DOT specification tank cars that had to be equipped with these safety features. On September 21, 1995, the DOT published new regulations that require better protected tank cars, including headshield and thermal protection, for the transportation of a wider variety of hazardous materials, including designated environmentally harmful materials. Enhanced puncture protection is also required for tank cars constructed of nickel and aluminum.

The use of shelf couplers, headshields, and thermal protection on tank cars has dramatically decreased the incidence of violent tank car explosions and ruptures. Yet the danger still exists, and accidents still occur.

In a 1991 safety study, the Safety Board investigated 45 railroad accidents that occurred during a one-year period, and reviewed reports of its past major accident investigations and safety studies, to quantify the safety of transporting hazardous materials by rail. In 1989, about 1.52 million carloads of hazardous materials moved by rail, and the Board found that in the five-year period from 1985 through 1989, 2,121 railroad accidents involved hazardous materials, resulting in the evacuation of more than 100,000 people. The study concluded that hazardous materials that are highly flammable or toxic, or that pose a threat to the environment, are frequently transported in tank cars that provide inadequate protection even though better protected tank cars are available. The Safety Board asked the DOT to conduct a risk assessment and asked the industry to establish a list of the more dangerous materials.

Based on Safety Board recommendations issued from the safety study, the Chemical Manufacturers Association now requires each of its members to have an ongoing chemical distribution risk



management program to evaluate such risks and implement risk reduction methods that are appropriate for the level of risk. In at least 21 of the 45 cases investigated for the study, the Safety Board found that local emergency response incident commanders did not have a hazardous materials emergency response plan to follow, and in 19 of the 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.

Nine major railroad systems have responded positively to the Safety Board's recommendations for improved coordination with communities adjacent to railroad yards and along hazardous materials routes; likewise, these railroad systems are taking action to establish hazardous materials training programs and evaluation systems for their employees. The American Short Line Railroad Association notified its members of the need to meet the intent of the Board's recommendations. DOT's Research and Special Programs Administration (RSPA), with the assistance of the FRA, published new regulations in 1992 that established training and testing requirements for any employee who performs any functions associated with the transportation of hazardous materials. Under these regulations, rail carriers are required to train and test train crews about hazardous materials emergency response procedures before they operate a train. These actions will help mitigate the effects of an accident involving hazardous materials rail cars.

An urgent safety recommendation was issued to the FRA following 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 January 1992. A white vapor cloud filled the area and ignited into a fireball. The tank car was of a dual-diameter design, manufactured in 1965. The tank had a larger diameter at its midsection than at its end sections, and angled transition sections joined the larger and smaller sections. 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.

The Safety Board found that an estimated 6,000 to 7,000 dual-diameter tank cars were in the rail tank car fleet and that these cars were used to transport such volatile materials as liquefied petroleum gases, vinyl chloride, and anhydrous ammonia.

Based on Board recommendations, the FRA issued an emergency order requiring dual-diameter tank car owners to immediately implement a sampling inspection program. Because 40 cars were found to have cracks, the Safety Board initiated a special investigation on periodic inspection and testing requirements for all tank cars used in the transportation of hazardous materials.

The Safety Board found that DOT requirements were not effective for the detection of structural defects. The FRA and RSPA published new regulations in September 1995 that require nondestructive testing of tank cars. Industry associations have supported the Safety Board's recommendations for improved inspections and testing requirements for tank cars, and are continuing work with the FRA and RSPA to refine testing techniques and protocols.

Emergency Response

As a result of several accident investigations in recent years, the Safety Board has issued a number of safety recommendations to railroads, carriers, shippers, and emergency response agencies regarding communication and coordination in hazardous materials accidents and incidents.

Following the derailment of nine tank cars filled with butane in Akron, Ohio, in 1989, emergency response personnel had difficulties identifying the hazardous materials on the CSX Transportation, Inc. (CSXT) train. In response to Safety Board recommendations, CSXT implemented a training program for operating crews and supervisors concerning responders immediately following a hazardous materials incident or accident. CSXT also established procedures to work more closely with emergency response agencies during wreckage clearing operations and to require train crews to maintain up-to-date listings showing the position of hazardous materials cars in their trains.

As a result of a freight train derailment in Freeland, Michigan, in 1989, a tank car containing a chlorosilane mixture was punctured, causing the cargo to ignite. Because the chlorosilane manufacturer's material safety data sheet had conflicting information and did not provide effective firefighting procedures, emergency responders attempted various techniques over a five-day period before they were

able to extinguish the blaze. In response to a Safety Board recommendation, the manufacturer corrected the material safety data sheet.

The Safety Board found in its investigation of the release and ignition of butadiene from a tank car in New Orleans in 1987 that emergency responders were unable to obtain product-specific information promptly. In response to the Board's recommendations, the shipper now includes an emergency 24-hour telephone number on its shipping papers which contains detailed information on the characteristics of the material.

Shipping and Handling

The Safety Board issued six urgent recommendations to the DOT within 20 days of the 1996 crash of ValuJet Flight 592 in the Florida Everglades. Two of these recommendations urged the FAA to evaluate the programs for all air carriers for accepting passenger baggage and freight and identifying undeclared hazardous materials



shipments, and then, based on these evaluations, to require that air carriers revise their practices and training programs as necessary. The additional four recommendations, to both FAA and RSPA, urged a permanent prohibition on the transport of chemical oxygen generators as cargo on board any passenger or cargo aircraft when the generators have passed expiration dates and the chemical core has not been depleted. The recommendation also urged prohibiting transport

of oxidizers and oxidizing materials in cargo compartments that do not contain fire or smoke detection systems.

These recommendations were issued after preliminary evidence from the investigation indicated that five cardboard boxes containing as many as 144 chemical oxygen generators had been loaded on the aircraft shortly before its departure from Miami International

Airport. When transported as cargo, these generators are classified as oxidizers under the DOT hazardous materials regulations and must be properly packaged, labeled, and identified. The boxes containing these generators were shipped as company materials and were not identified as hazardous materials.

In response, the FAA initiated the evaluation recommended by the Safety Board and developed a hazardous materials education and enforcement program that focuses on freight forwarders. In August 1996 the FAA also issued new regulations that require all shippers and freight forwarders to certify that all packages being shipped do not contain unauthorized explosives, destructive devices, or hazardous materials. Additionally, in early 1998, the FAA published a final rule that requires improved fire standards for baggage and cargo compartments in transport category aircraft.

Conclusion



Transportation safety cannot be accomplished through the efforts of one person, a group, or a government agency. It is a shared responsibility among people who travel, the companies that provide transport, and the agencies that regulate travel. Investigative agencies all over the world have provided valuable contributions to our knowledge of transportation safety. Those companies that have enacted the improvements voluntarily and those agencies that have mandated them through regulatory action can take credit for doing their part in improving the quality of our travel.

In many instances, however, these improvements would not have occurred without the Safety Board's impetus. Board recommendations begin the process that eventually saves lives and property. There are numerous other safety enhancements contained in current Board recommendations that the Board continues to pursue. And there are global issues, such as human fatigue and an organization's ingrained philosophy or "corporate culture," that cross all modes of transportation and that are the focus of much of the Board's work.

There is no way to accurately identify the accident that did not happen or the life that was not forever altered through the efforts of the Safety Board. But the men and women of the agency take pride in these safety enhancements that statistics show contribute to the United States having one of the safest transportation systems in the world.

For more information on the National Transportation Safety Board, please contact the Board's Public Affairs Office at (202) 314-6100, or write NTSB, Public Affairs Office, Washington, DC 20594; or access the Board's web page at www.nts.gov.

