

**Analysis of the Effect of Milestone Aviation Accidents on Safety
Policy, Regulation, and Technology**

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ABSTRACT

The centennial of powered flight was celebrated last year, yet the history of significant development of the aviation industry only spans the past 50 years. Aviation professionals can point to significant events in aviation with a relative ease. Many of these events have a direct cause and effect relationship with changes in safety and security regulations, policies and technology. There are also cases of technological development that have resulted in changes in operations, regulations and policies.

Analysis of major events related to aviation safety, such as a specific accident, clearly show the corresponding outcomes across a wide spectrum. Less clear is an in-depth understanding of specific correlations between aviation accidents and their outcomes.

This paper will examine how milestone accidents in aviation safety, from 1988 through 2002, have lead to significant changes in the areas of policy, regulation, industry and technology. The authors hypothesize that outcomes in these areas are characterized by reactive as opposed to proactive solutions.

Methodology includes use of expert interviews and surveys combined with content review of U.S. Congressional record, Federal Aviation Administration regulations, including the code of federal regulations, news articles and trade journals.

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INTRODUCTION

The significant period of U.S. civil aviation industry that has shaped this very large, complex and truly safe system spans over about 50 years. The growth, technological changes and sophistication of the commercial aviation system in the U.S. have been phenomenal and the evolution of this system has been greatly affected by the government policies and regulations. Despite the size and complexity of the U.S. aviation system, it has been the safest in the world in the past decades. The need to allow the industry to develop and deregulation of the airline industry in the 1978 have resulted in aviation accidents having a significant impact on aviation regulation and policies.

This paper serves as the foundational research for a graphical display or *timeline* of milestone aviation events and the resulting outcomes in policy, regulation and technology. The aviation safety timeline is meant to function as an educational tool to succinctly display a great amount of information concerning the processes between an aviation accident and the safety related outcomes that have occurred. Many observations can be drawn from the research and aviation safety timeline. Considering that the United States has the largest air transport environment; the timeline will depict costly and valuable lessons learned that many other countries may find useful for driving the continued development of their own air transport.

To describe the aviation safety timeline, this paper reviews earlier timeline models and research on measuring outcomes. The research methodology to select the milestone aviation accident and the indicators of change in policy, regulation and technology are described next. A review of major aviation accidents resulted in identifying sixteen accidents occurring over the 1988-2002 period. These accidents are then categorized according to safety issues. Critical safety issues are used to guide and frame the discussion of outcomes in policy, regulations and technology. An analysis of all outcomes is completed from which findings and observations are drawn. Appendices provide detailed descriptions of policy, regulation and technology outcomes. For clarity, these terms are defined here.

Policy is defined as the plan of action adopted by an organization. Regulation is defined as a rule or restriction. The authors define technology as an applied system that serves as a solution to a particular safety issue across the entire industry.

LITERATURE REVIEW

The idea for the aviation safety timeline was inspired by a historic disaster time line chart created by Rubin et al, the Terrorism Time Line (TTL): Selected Milestone Events and their U.S. Outcomes (1988-2001)¹. The TTL is a visual outline that depicts major terrorist events and their outcomes in laws, regulations, practices, expert systems, and organizational changes that have evolved during the last two decades. Based on the TTL, its accompanying background research document on the particular events, as well as direct interviews with Rubin, a similar methodology was followed to guide this research paper. Birkland's idea of "focusing events" formed the basis for describing and

determining milestone aviation safety accidents². Focusing events serve as a wake-up call to attract attention to major public problems and lead to searches for solutions³, because they can be used to demonstrate the existence of policy failure. Birkland distinguishes between two types of focusing events: an event that would not have happened or would not have been so severe “if only” something had been done versus focusing events that serve groups that were already warning of the existence of a problem. These are events that clearly show a pattern of existing problems that have been argued as a precursor to an accident. Along with the argument for policy failure comes a search for answers and in particular, an attempt to apply these so-called lessons of an event to mitigate the impacts of future such events⁴.

RESEARCH METHODOLOGY

A. Data Collection

The following criteria were established for gathering a large pool of aviation safety events from which the milestone accidents would be determined: scheduled passenger flights, jet planes, payload capacity more than 7500lbs or/and passenger capacity greater than 30 seats. In order to remain focused on outcomes in the United States, this project only considered accidents by U.S. carriers in domestic or international flights and foreign carriers with flight operations into the U.S. A special note: security events that lead to aircraft crashes were not considered for this research paper, thus the 1988 PanAm 103 bombing or the extraordinary events of September 11th, 2001 are not included in this analysis.

Using the AirClaims database, all accidents that fit these criteria were considered between 1988 and 2002⁵. The initial search resulted in a large pool of 142 accidents complete with a basic level of details. Beyond the basic level of details concerning the accident, the AirClaims database does not designate one accident to be more significant than another. Thus, more information for each of these events was gathered using several internet-based aviation accident search engines (Airdisaster.com and Aviation-Safety.net) to include registration number and flight number^{6,7}.

B. Selection of Milestone Aviation Safety Accidents

With the additional information in place, fourteen experts in aviation safety reviewed the list of 142 events to determine which were considered “milestone” according to the following criterion: aviation safety related accidents which have led to significant outcomes in the areas of policy, regulation, or technology. Six experts who replied designated 26 of the pool of 142 accidents as “milestone”. Accidents were counted if they received at least one mark. Thus, 12 received one mark, 6 received two marks, 2 received three marks, 7 events received four marks, and 3 events received five marks, while only 1 event received six marks.

For each of these accidents, additional information was gathered concerning circumstances of the accident as well as the probable cause of the accident. The

circumstances of the accident were gathered from Airdisaster.com and Aviation-Safety.net. The probable cause was based on the National Transportation Safety Board (NTSB) accident database⁸. Of the 26 accidents, nine were not prominently represented by all three databases, thus these nine accidents were struck from the research project leaving only 17 accidents. The 17th accident, which occurred in November 2001, was struck from this paper, as conclusions have not been finalized. Thus, only 16 accidents were considered for further analysis.

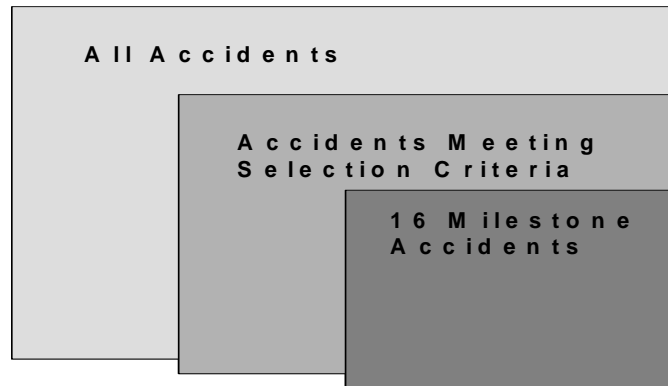


Figure 1 - Milestone aviation accident selection process

CHRONOLOGY OF 16 MILESTONE ACCIDENTS

The following section provides a brief description of each accident, complete with date, number of fatalities and injuries, and probable cause as determined by the NTSB.

1. 1988 – Aloha Airlines Flight 243

On April 28, 1988, a Boeing 737-200, N73711 experienced an explosive decompression and structural failure at 24,000 feet. Approximately 18 feet from the cabin skin and structure aft of the cabin entrance door and above the passenger floor line separated from the airplane during the flight. Of 89 passengers and 6 crewmembers, 7 passengers and 1 flight attendant were seriously injured. The probable cause was identified as failure of the Aloha Airlines maintenance program to detect the presence of significant disbonding and fatigue damage.

2. 1988 – Delta Air Lines Flight 1141

On August 31, 1988, a Boeing 727-232, N473DA crashed shortly after lifting off from runway 18L at the Dallas-Fort Worth International Airport. Twelve passengers and 2 crewmembers were killed, 21 passengers and 5 crewmembers were seriously injured, and 68 passengers sustained minor or no injuries. The probable cause was identified as takeoff without the wing flaps and slats properly configured.

3. 1989 – United Airlines Flight 811

On February 24, 1989, a Boeing 747-122, N4713U experienced an explosive decompression as a result of the in-flight loss of the right forward lower lobe cargo compartment door and a part of the right cabin fuselage. Of 337 passengers and 18 crewmembers, 9 occupants were lost during the decompression, and 1 crewmember, 15 flight attendants, and 22 passengers were injured during the decompression and emergency evacuation. The probable cause was identified as the initial failure of the latches at the bottom of the door, explosive decompression and destruction of the cabin and fuselage structure.

4. 1989 – United Airlines Flight 232

On July 19, 1989, a DC-10-10, N1819U experienced a catastrophic failure of the number two engine during cruise flight and crashed during an attempted landing at Sioux Gateway Airport, Iowa. One flight attendant and 110 passengers were fatally injured. The probable cause was identified as the uncontained disintegration of the number two engine's fan rotor.

5. 1990 – Avianca Airlines Flight 52

On January 25, 1990, a Boeing 707-321B with Colombian registration HK2016 crashed in a wooded residential area in Cove Neck, Long Island, New York. Of the 158 persons aboard, 73 were fatally injured. The probable cause was identified as the failure of the flight crew to adequately manage the airplane's fuel load, and their failure to communicate an emergency fuel situation to air traffic control before fuel exhaustion occurred.

6. 1990 – Northwest Airlines Flight 1482

On December 3, 1990, a McDonnell Douglas DC-9, N3313L collided with Northwest Airlines Flight 299, a Boeing 727 near the intersection of runways 09/27 and 03C21C at Detroit Metropolitan/Wayne County Airport. Of the 40 passengers and 4 crewmembers on board, 7 passengers and 1 crewmember were killed. The probable cause was identified as the lack of proper crew coordination by the DC-9, as well as deficiencies in ATC services, surface marking and cockpit resource management.

7. 1991 – USAir Flight 1493

On February 1, 1991, a Boeing 737-300, N388US collided with Skywest Flight 5569, a Fairchild Metroliner, while landing on runway 24L at Los Angeles International Airport, California. All 10 passengers and 2 crewmembers aboard the Metroliner and 20 passengers and 2 crewmembers aboard B-737 were fatally injured. The probable cause was identified as the failure of the Los Angeles Air Traffic Facility Management to implement procedures that provided redundancy comparable to the requirements contained in the National Operational Position Standards and the failure of the FAA Air Traffic Services to provide adequate policy direction and oversight to its ATC facility managers.

8. 1991 – United Airlines Flight 585

On March 3, 1991, a Boeing 737-291, N999UA crashed while maneuvering to land at Colorado Springs Municipal Airport, Colorado. The airplane was destroyed by impact force and fire; all 25 persons onboard were killed. The probable cause was identified as uncommanded rudder deflection.

9. 1994 – US Airways Flight 427

On September 8, 1994, a Boeing 737-3B7, N513AU crashed while maneuvering to land at Pittsburgh International Airport, Pennsylvania. All 132 persons on board were killed. The probable cause was identified as a loss of control of the airplane resulting from the movement of the rudder surface to its blow down limit. The rudder surface most likely deflected in a direction opposite to that commanded by the pilots as a result of a jam of the main rudder power control unit servo valve secondary slide to the servo valve housing offset from its neutral position and over travel of the primary slide.

10. 1995 – American Airlines Flight 1572

On November 12, 1995, a McDonnell Douglas MD-83, N566AA was substantially damaged when it impacted trees in East Granby, Connecticut. The airplane also impacted an instrument landing system antenna at its landed short of the runway on grassy, even terrain. No fatalities. The probable cause was identified as the flight crew's failure to maintain the required minimum descent altitude until the required visual references identifiable with the runway were in sight.

11. 1995 – American Airlines Flight 965

On December 20, 1995, a Boeing 757-223, N651AA, struck trees and then crashed into the side of a mountain near Buga, Colombia, in night visual meteorological conditions, while descending into the Cali area. The airplane was destroyed, and all but four of the 163 passengers and crew onboard were killed. The probable cause was identified by the Civil Aviation Authority of Colombia as the flight crew's failure to adequately plan and execute the approach to runway 19 at SKCL; failure of the flight crew to discontinue the approach into Cali; the lack of situational awareness of the flight crew regarding vertical navigation; failure of the flight crew to revert to basic radio navigation at the time when the FMS (Flight Management System)-assisted navigation became confusing and demanded an excessive workload in a critical phase of the flight.

12. 1996 – ValuJet Flight 592

On May 11, 1996, a McDonnell Douglas DC-9-32, N904VJ crashed into the Everglades swamp shortly after takeoff from Miami International Airport, Florida. All 110 persons aboard were killed. The probable cause was identified as improperly packed oxygen generators ignited, leading to a fire, which burned through control cables and filled the cabin with smoke.

13. 1996 – TWA Flight 800

On July 17, 1996, a Boeing 747-131, N93119 crashed into Atlantic Ocean about 8 miles south of East Moriches, New York, after taking off from John F. Kennedy International

Airport, New York. All 230 people on board were killed. The probable cause was identified as the explosion of the center fuel tank.

14. 1997 – Korean Air Flight 801

On August 6, 1997, a Boeing 747-3B5B with Korean registration HL7468 crashed at Nimitz Hill Guam. Of the 254 persons on board, 228 were killed; 23 passengers and 3 flight attendants survived the accident with serious injuries. The probable causes were identified as the captain's failure to adequately brief and execute the nonprecision approach and the first officer's and flight engineer's failure to effectively monitor and cross-check the captain's execution of the approach.

15. 1999 – American Airlines Flight 1420

On June 1, 1999, a McDonnell Douglas DC-9-82 N215AA crashed after it overran the end of runway 4R during landing at Little Rock National Airport, Arkansas. Of the 145 people on board, the captain and 10 passengers were killed; the first officer, the flight attendants, and 105 passengers received serious or minor injuries; and 24 passengers were not injured. The probable cause was identified as the flight crew's failure to discontinue the approach when severe thunderstorms and their associated hazards to flight operations had moved into the airport area and the flight crew's failure to ensure that the spoilers had extended after touchdown.

16. 2000 – Alaska Airlines Flight 261

On January 31, 2000, a McDonnell Douglas MD-83, N963AS crashed into the Pacific Ocean about 2.7 miles north of Anacapa Island, California. The 2 pilots, 3 cabin crewmembers, and 83 passengers on board were killed. The probable cause was identified as a loss of airplane pitch control resulting from the in-flight failure of the horizontal stabilizer trim system jackscrew assembly's acme nut threads.

For each of the 16 milestone accidents, the NTSB (or the Civil Aviation Authority of Colombia) aircraft accident report was reviewed for the specific safety issues associated with the accident. Appendix A (16 Milestone Accidents and Their Safety Issues) describes the safety deficiencies related to each accident. *It is the safety deficiencies associated with these accidents that led to their designation as milestone events because they covered a broad area of safety.* The safety issues are the link between these milestone accidents and the larger context of policy, regulation and technology. The larger context is where the significant outcomes have resulted in order to develop improved policy, regulatory, and technology tools to prevent a reoccurrence of the safety issues associated with these milestone accidents.

OUTCOMES – POLICY, REGULATION, AND TECHNOLOGY

U.S. Congressional response concerning aviation safety was the main resource to examine policy outcomes. Indicators of Congressional response include public laws and hearings from the Senate, House and Joint Committees. As Congressional Sessions cover a two-year period, the policy outcomes are grouped accordingly. Appendix B (Detailed

List of Policy Outcomes) describes all of policy outcomes related to the 15-year time period covering the 16 milestone accidents.

For regulation outcomes, NTSB Safety Recommendations to the FAA with FAA responses, in the National Aviation Safety Data Analysis Center website were used. Indicators of FAA regulation response include Airworthiness Directives, Advisory Circulars, and Amendments to the Federal Aviation Regulation (part of the Code of Federal Regulation), Bulletins or Other documents, which includes Orders, Notices, or Revisions to particular manuals. Appendix C (Detailed List of Regulation Outcomes) describes the regulations outcomes in response to specific NTSB recommendations related to the 16 milestone accidents.

To examine technology outcomes, indicators of technology response from the above mentioned Congressional or FAA documents were examined. These documents were used as a starting point to further examine technologies that resulted from an accident or safety issue. A variety of sources, including reports, news and journal articles were used to describe which technologies were developed or implemented as a result of specific milestone accidents.

Categorization of Safety Issues

Appendix A shows that many of the safety issues related to the 16 milestone accidents overlap. As a result of this overlap, nine categories were devised to classify and compile all of the safety issues into broad and inclusive topics. As organized in Table 1, the most prevalent categories of safety issues standing-out with highest recurrence are Systems & Procedures followed by Design, FAA Oversight, and Maintenance. The least prevalent has been Human Error and Weather & Other, Human Factors, Mechanical Failure and finally Aging Aircraft. Contrary to the results of Table 1, analysis of the policy and regulations outcomes shows that four main issues emerged which was not necessarily based on their prevalence in NTSB aircraft accident reports. These four issues are:

1. FAA Oversight
2. Maintenance and Aging Aircraft
3. System and Procedures
4. Human Factors

The inconsistency with Table 1 may be indicative of the effect of Congressional influence and other public policy factors in shaping outcomes. The four issues that emerged are FAA oversight, Maintenance and Aging Aircraft, Systems and Procedures, and Human Factors. While Design was clearly a significant category in terms of how many times it was cited as a safety issue, it was not discussed as much as the four issues. Alternatively, Aging Aircraft was only cited as a safety issue twice, however, as the outcomes from policy and regulation show, it was a very significant issue, especially when considered as part of the safety issue of Maintenance.

Table 1 - Nine Categories of Safety Issues

Accident/Safety Issues	Design	Aging Aircraft	Systems & Procedures	Mechanical Failure	FAA Oversight	Human Error	Maintenance	Weather & Other	Human Factor
1988 – Aloha Airlines FL243		→	→		→		→		→
1988 – Delta Air Lines FL1141			→	→	→	→		→	→
1989 – United Airlines FL811	→		→				→		
1989 – United Airlines FL232	→		→				→		→
1990 – Avianca Airlines FL52			→		→				
1990 – Northwest Airlines FL1482	→		→				→	→	
1991 – USAir FL1493			→		→	→	→		
1991 – United Airlines FL585	→			→				→	
1994 – USAir FL427	→		→	→					
1995 – American Airlines FL1572			→			→		→	
1995 – American Airlines FL965	→		→		→	→			
1996 – ValuJet FL592	→		→		→				→
1996 – Trans World Airlines FL800	→	→					→		
1997 – Korean Air FL801	→		→		→				
1999 – American Airlines FL1420			→		→	→		→	
2000 – Alaska Airlines FL261	→				→		→		

OUTCOMES BASED ON KEY SAFETY ISSUES

1. Federal Aviation Administration Oversight

Policy Response – No public laws were promulgated during the 15-years that directly related to oversight, though several laws did contain elements that required the FAA to address the other three safety issues described below. A number of hearings in the Senate, House and Joint Committees were held concerning the FAA Oversight issue. The years of 1988 and 1989 were characterized by widespread criticism of the FAA’s ability to ensure safety in a rapidly growing air transport industry. Hearings on the matter continued through the 101st Congressional Session (1990-1991). While the number of hearings decreased over time, even up through the 103rd Congressional Session (1994 and 1995), safety and de-regulation of the airline industry was a significant topic of discussion. Eventually, the belief that de-regulation was unsafe, along with criticism of the FAA’s oversight abilities subsided. Figure 2 describes the Congressional Sessions policy response during the 15-year period in terms of the number of public laws and hearings on aviation safety.

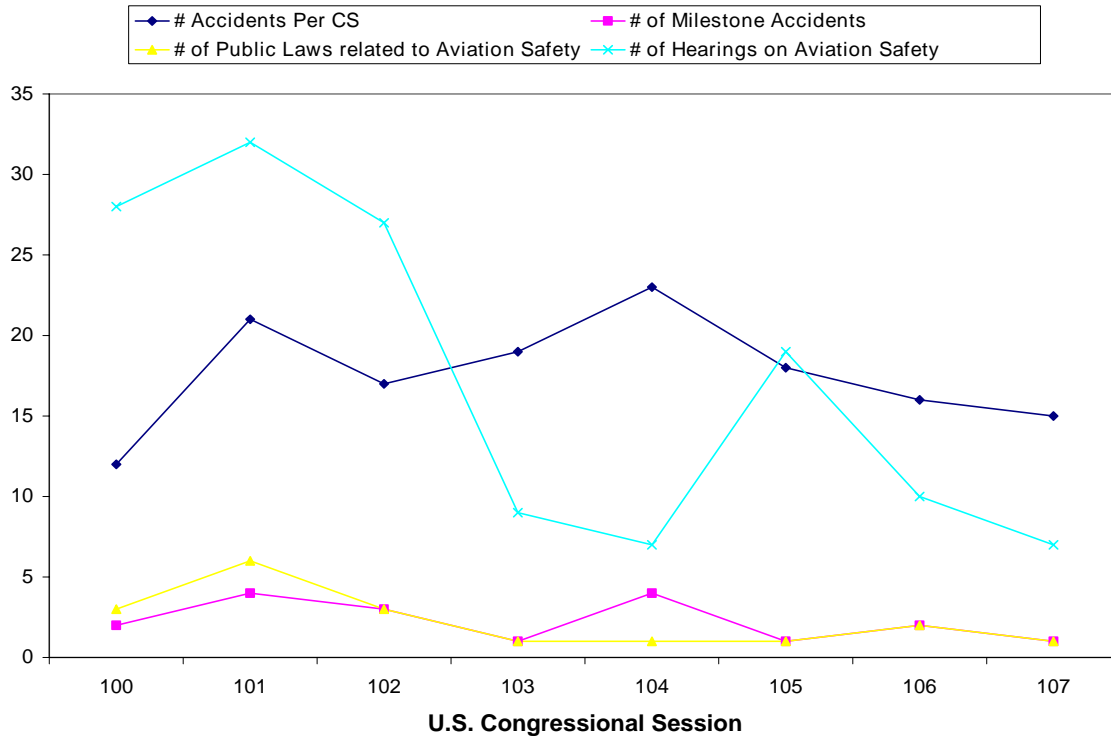


Figure 2 - Number of Public Laws and Congressional Hearing Concerning Aviation Safety
 Note. CS = Congressional Session.

As the rate of accidents has declined so has the number of public laws and hearings. Interestingly, the number of milestone accidents has also declined.

Regulation Response – FAA oversight was mentioned as an important safety issue in more than a half of the NTSB aviation accident reports for the 16 milestones. With the authority to certificate aircraft and other components as airworthy, the FAA is responsible for ensuring effective oversight of the air transport. This puts the FAA in a unique position, which makes it open to public criticism. Thus, FAA oversight has been a consistent concern as the NTSB cited it in 1988 (Aloha flight 243 and Delta flight 1141), 1990 (Avianca flight 52), 1991 (USAir flight 1493), 1995 (American flight 965), 1996 (ValuJet flight 592), 1997 (Korean Air flight 801), 1999 (American flight 1420) and 2000 (Alaska flight 261). Among these accidents, the Aloha flight 243 and ValuJet flight 592 accident brought widespread public criticism (well beyond the industry experts) to FAA oversight. As the authority for safety, FAA has used regulatory tools to respond to safety issues. Figure 3 depicts the FAA regulation responses for each of 16 milestone accidents, in terms of issuing Airworthiness Directives (ADs), Advisory Circulars (ACs), and Amendments to the Federal Aviation Regulations (FARs), and Bulletins.

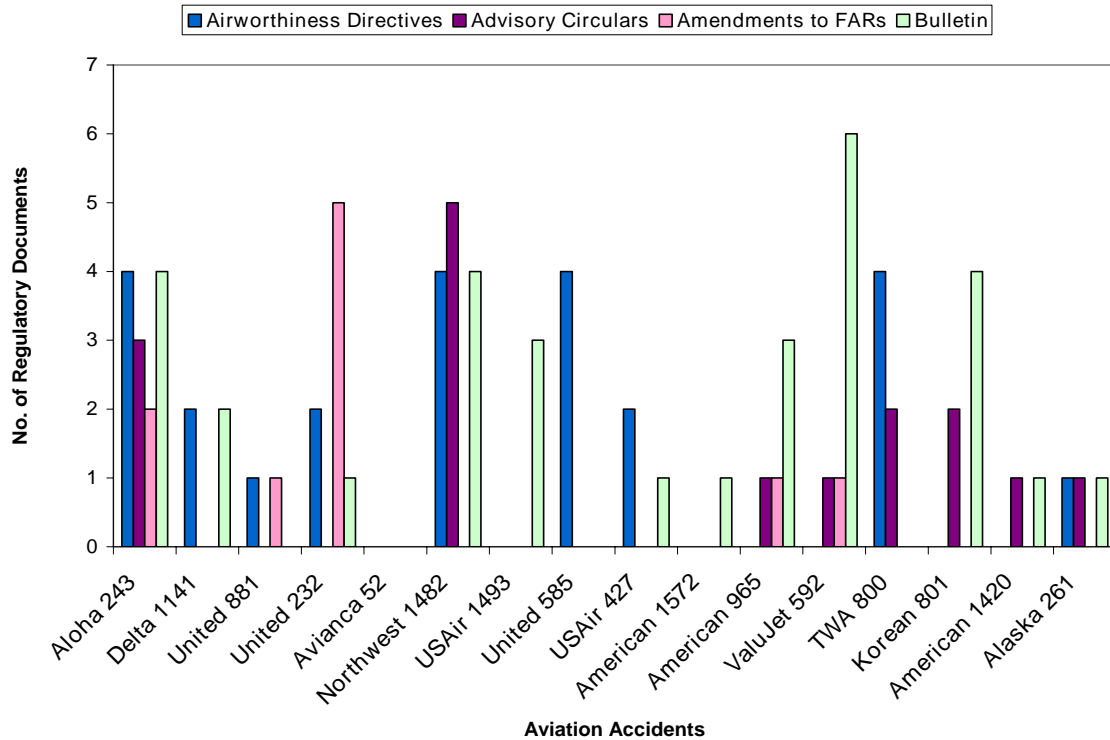


Figure 3 - Numbers of Regulation Responses Related to 16 Milestone Accidents

Technology Response – One of the most significant outcomes was not a particular technology, but the public law, PL100-591 Aviation Safety Research Act of 1988. This directed the FAA to be responsible for long-term research, development and implementation of technological solutions to safety issues raised by all aviation accidents. With this law, the FAA was required to provide an annual report presenting the national aviation research plan for a 15-year period. Interestingly, the law required that the FAA study the relationships between human factors and airline accidents. With the Research Act of 1988 in place, subsequent hearings on technological solutions in general as well as specific technologies were prevalent throughout the 15-years examined by this research project. Hearings were held on technology improvements for aircraft, maintenance and inspection, and air traffic management.

2. Maintenance and Aging Aircraft

Policy Response – While no public laws were promulgated concerning maintenance and aging aircraft, the sheer number of hearings over the 15-year period is indicative of the significance of this safety issue. Nineteen out of a total 138 hearing were dedicated to maintenance and aging aircraft. Seven different hearings on aging aircraft were held beginning in 1988 as a result of the Aloha Airlines flight 243 accident. Additional hearings were held following the explosive decompression accident of United Airlines flight 811. Hearings on maintenance were less than aging aircraft, numbering only five, but consideration of an Aviation Safety Whistleblower Protection Act during the 101st Congressional Session was significant because it indicated a growing concern with maintenance inspections. By the 104th Session, the FAA established in 1997 a Center of

Excellence for Airworthiness Assurance, which included inspection, maintenance and repair as academic and industry research focuses.

Regulation Response – Although maintenance and aging aircraft can be considered as two separate issues, it is clear that the aging aircraft issues have influenced the procedures of maintenance and inspection over the past 15 years. In addition to Aloha flight 243 and TWA flight 800, the NTSB determined maintenance as a safety issue for five additional accidents of the 16 milestones. Although operators and manufacturers already had become concerned with airplanes that were reaching their design life⁹, the Aloha accident in 1988 struck those in civil aviation by surprise. A significant amount of attention focused on the characteristics and causes of structural aging. By 1990 the FAA published “Aging Aircraft Evaluation Trend Report”. A number of changes to regulations were made and many ACs were issued in regard to certification and inspection. As Appendix C shows, many of the new regulation (as ADs and ACs) were issued after 1998—ten years after the Aloha accident. There may be several reasons as to why it took ten years for the FAA to initiate a regulatory response. One reason is the crash of TWA flight 800 in 1996, which again drew attention to the issue of aging aircraft. In December 2002, the FAA published an “interim file rule” mandating age-related inspection and records reviews for multi-engine Part 121, 129 and 135 aircraft¹⁰, which went into effect in December 2003. According to the FAA, this rule establishes adequate and timely maintenance of age-sensitive parts and components to prevent age-related accidents and extend the airworthy life of the airplanes.

Technology Response – Specific technological solutions to address maintenance and aging aircraft include the development of the Fluorescent Penetrate Inspection (FPI) following the uncontained engine failure of United Airlines flight 232 accident. FPI is an inspection technique for surface crack detection in both aircraft and engine components during production, qualification, and in-service assessment.

3. Systems and Procedures

Policy Response – One public law and many hearings have been held concerning collision avoidance as well as weather prediction and reporting. During the 101st Congressional Session, public law PL101-236 Traffic Alert and Collision Avoidance System for Commercial Aircraft was promulgated to address the Northwest Airline flight 1482 (1990) collision related accident. This public law extended the deadline for installing this technology on commercial aircraft of 30 seats or more. The collision related accident USAir flight 1493 (1991) also encouraged a significant policy response. Over the 15-year period, ten hearings have examined the issue and proposed the Traffic Alert and Collision Avoidance System as a solution. In addition to collision avoidance, weather prediction and reporting was another significant systems and procedures safety issue. Up through the 106th Congressional Session, four hearings had been held concerning the improvement of technologies related to weather, including next generation radar and terminal Doppler systems.

Regulation Response - Systems and procedures may be the most critical part when addressing airworthiness. Table 1 shows almost all milestone accidents involved a failure of or lack of systems and procedures. These accidents included collisions with aircraft or ground objects and loss of control in flights. Subsequent improvements in systems and procedures should contribute to mitigating the safety risks and reducing the number of these types of accident. Advanced technology and consideration of human factors are two key components of improving or developing systems and procedures.

Technology Response – Many of these types of accidents accelerated the development or improvement of technologies that enhance aviation safety. Of course technologies themselves do not prevent accidents from happening. Thus, as advanced technologies were developed and discussed at the policy level, ADs and ACs were issued accordingly to mandate the installations and provide proper procedures and training requirements. The advanced technologies included:

- Traffic alert and Collision Avoiding System II (TCAS II) increases cockpit awareness of proximate aircraft and serves as a “last line of defense” for the prevention of mid-air collisions. This system also analyzes the projected flight path of approaching aircraft and issues ‘Resolution Advisories’ to the pilot to resolve potential mid-air collisions. As part of TCAS II, Runway Visual Range (RVR) provides a standardized, instantaneous, and accurate method of measuring visibility along runways.¹¹ (Due to Northwest Airlines Flight 1482, US Air Flight 1493)
- Terrain Awareness Warning System (TAWS) provides the flight crew with sufficient information and alerting to detect a potentially hazardous terrain situation that would permit the flight crew to take effective action to prevent a controlled flight into terrain (CFIT) event.¹³ (Due to American Airlines Flight 965)
- Automatic Dependent Surveillance – Broadcast (ADS-B) allows pilots in the cockpit and air traffic controllers on the ground to "see" aircraft traffic with much more precision than has been possible ever before. (Due to Northwest Airlines Flight 1482)
- Automated Weather Observing System (AWOS) measures, collects and broadcasts weather data to help meteorologists, pilots and flight dispatchers prepare and monitor weather forecasts, plan flight routes, and provide necessary information for correct takeoffs and landings.¹² (Due to United Airlines Flight 585, American airlines Flight 1572, American Airlines Flight 1420)
- Propulsion Control System (PSC), which provides emergency maneuverability, is an advanced propulsion control system designed to prevent future accidents such as United Airlines Flight 232, where the aircraft control system was damaged and the pilot did a heroic job of controlling and crash-landing the airplane by manual operation of the engine controls.

Table 2 shows which milestone accidents have contributed to the development and implementation of specific technological solutions. Northwest Airlines flight 1482 was significant because it contributed to the development of six different technologies shared between the aircraft and airport operating area that address the safety issue of collision. Not included in Table 2 is the Advanced Ground Proximity Warning System (AGPWS) technology (an improvement over the original system, GPWS) that was

developed following the CFIT accidents of American Airlines flight 965 and Korean Airlines flight 801.

Table 2 - Some Technology Outcomes Resulting from Milestone Accidents

Accident/ Technology Outcome	ADS-B	AMASS	ASDE-X	AWOS	EVAS	FPI	ROWS	RVR	TAWS	TCAS II
1988 – Aloha Airlines FL243										
1988 – Delta Air Lines FL1141										
1989 – United Airlines FL811										
1989 – United Airlines FL232						→				
1990 – Avianca Airlines FL52										
1990 – Northwest Airlines FL1482	→	→	→				→	→		→
1991 – USAir FL1493		→	→							→
1991 – United Airlines FL585				→						
1994 – USAir FL427										
1995 – American Airlines FL1572				→						
1995 – American Airlines FL965									→	
1996 – ValuJet FL592					→					
1996 – Trans World Airlines FL800										
1997 – Korean Air FL801										
1999 – American Airlines FL1420				→				→		
2000 – Alaska Airlines FL261										

Note. ADS-B = Automatic Dependent Surveillance Broadcast, AMASS = Airport Movement Area Safety System, ASDE-X = Airport Surface Detection Equipment Model X, AWOS = Automated Weather Observing System, EVAS = Emergency Vision Assurance System, FPI = Fluorescent Penetrate Inspection, ROWS = Runway Obstruction Warning System, RVR = Runway Visual Range, TAWS = Terrain Awareness and Warning System, TCAS II = Traffic alert and Collision Avoiding System II.

4. Human Factors

Policy Response – Human factors has been a concern at the policy level beginning with the 100th Congressional Session. Following the Aloha flight 243 accident, Congress passed the Aviation Safety and Research Act of 1988, which mandated that the FAA augment its human factor research in practically all areas of aviation, including aircraft, cockpit, air traffic system as well as maintenance and inspection. In particular, human factors and its implications for the modernization of the air traffic system has been a focus of many hearings.

Regulation Response – In 1993, the FAA issued the FSIB 93-40A, titled “Human Factors Involved in Inspection and Repair in a Heavy Maintenance Environment”. This Bulletin expired in 1994 and was incorporated into Order 8300.10, as Change 10 in the Airworthiness Inspector’s Handbook. Two years later, ValuJet flight 592 (1996) prompted a second regulatory response about human factors. By 1998, the FAA published, "Human Factors in Aviation Maintenance and Inspection, Strategic Program Plan". In addition to its growing relevance to maintenance and inspection, human factors must also be adequately addressed in design, application of technology, systems, training, and procedures. In 1996, the U.S. General Accounting Office issued a report titled,

“Status of Efforts to Integrate Research on Human Factors into FAA’s Activities.” The report highlighted the importance of the consistent application of human factors. Second, it stated that it is difficult to get agreement on how to achieve the goals of human-centered automation.¹⁴

Technology Response – There is a fine balance to be struck in the human factors area in response to safety deficiencies. While often there are many pressures to address safety deficiencies and accident causes with technological solutions, there are several main issues in human factors area:

- Man-machine interface, “Glass Cockpit” approaches
- Sensory overload
- Crew Resource Management (CRM)

Addition of each new piece of equipment or interface requires a human factor analysis. This is a complicated area of human interface with machines and human psychology in a very unique environment that continues to challenge aviation professionals, policy-makers and regulators.

FINDINGS AND OBSERVATIONS

Without understanding the changes that have occurred in the airline industry during the 15-year period, it may be difficult to grasp how aviation accidents and their outcomes have contributed to ensuring a safer aviation environment. Nevertheless, this paper shows that aviation accidents result in many changes in policies, regulations, and technologies.

The concern for aviation safety has remained consistent even if the number of policy responses has declined over the 15-year period. The number of regulations in response to the milestone accidents and safety issues has fluctuated, but remained consistent over the same period. The number of technological solutions has also remained consistent.

Congressional criticism of the FAA’s ability to conduct effective oversight given the consequences of the deregulated air transport industry was prevalent at the beginning of the 15-year period. Criticism was greatest in 1988 through 1990, which was ten years after the deregulation, and subsided by 1994. As the level of criticism subsided, the total number of accidents per Congressional Session remained the same (at least ten per session) and the number of milestone accidents declined (from a high point of five per session to one during the final session considered). This time period would have corresponded to an increasing amount of air traffic and growing complexity of the air traffic system. These factors may demonstrate that FAA’s oversight improved over the 15-year period.

In addition to the four major aviation safety categories, other human issues emerged during the past 15 years of aviation history. These include a concern for the families of

the victims of aviation accidents as well as children restraint systems. Concern with the families of the victims of aviation accidents grew over time, beginning with public law PL101-604 Aviation Security Improvement Act of 1990 which designated the Department of State to provide for the notification and assistance of families of U.S. victims of aviation disasters abroad. By 1996, a hearing was held to determine that Death on the High Seas Act did not apply to victims of Aviation Incidents (Y1.1/8:105-201). This cleared the way for public law PL 104-264 Aviation Disaster Family Assistance Act of 1996 and the public law PL105-148 Foreign Air Carrier Family Support Act of 1997. The Foreign Air Carrier Family Support Act of 1997 was established in order to properly regulate foreign air carriers that operate in the United States. These Acts are not only examples of interests in human issues, but also examples of how policies and regulations have been responding to the changes in civil aviation at the international level, such as the increase of code-share operations. The issue of caring for families of the victims of aviation disaster was further brought to the attention of the International Civil Aviation Organization (ICAO). As a result, the ICAO issued a circular that urged its member states to establish a similar system to support the families of the victims of aviation accidents and provided the guidelines to how to do so.¹⁵

The children restraint systems were first discussed at the policy level following the United Airlines Flight 232 (1989) and the Avianca Airlines Flight 52 (1990). Since that time, interest has remained consistent over the time period (hearings were held during the 102nd Congressional Session [1991-1992] and the 105th [1997-1998] following the ValuJet flight 592 accident), yet children restraint systems have not become part of Federal Aviation Regulation. Currently, children restraint systems are recommended by the FAA, but not required.

Although this research paper limited its discussion to the 16 milestone aviation accidents that occurred in the U.S. during the past 15-years, it is important to address the aviation safety issues in the international context. The importance is due to the issues of systems and procedures and human factors having become even more complex when considered within the larger, international environment. For example, the midair collision of the DHL Boeing 757 and the Bashkirian Airlines, Tupolov Tu-154, which happened in Europe on July 1, 2002, raised additional complicated issues. According to reports, the DHL pilots followed TCAS commands to descend; however, the Russian pilots did not respond to ACAS (Airborne Collision Avoidance System), the European counterpart of TCAS, commands to climb, instead following the controller's order to descend.¹⁶ This example clearly demonstrates the complexity of the issues of systems and procedures and human factors in the larger, international environment.

The Air Traffic System has received considerable attention at the policy level over the entire 15-year period, especially in terms of modernization, staffing levels, training and human factor. Concern with the Air Traffic System continues today, with a focus on staffing levels given the inevitability of retirement of many current air traffic controllers.

This research paper has demonstrated that response and outcomes to aviation accidents and the safety issues raised by them is a complex environment with many layers of

interaction. With this understanding in mind, future research should focus on gathering more information concerning all three types of outcomes; policy, regulation and technology. This research paper could also benefit from a review of the ten years immediately following deregulation of the air transport industry in 1978. A review of the accidents and safety issues between 1978 and 1988, as well as the growth of the air transport industry, would further enhance a timeline of significant milestones and outcomes in aviation safety. Reviewing and comparing the level of air transport industry growth during the two time periods 1978 to 1988 and 1988 to 2002 could also provide a measure of significance for the outcomes particular to this research paper. Finally, this paper may benefit from a comparison of aviation safety outcomes with other modes of transportation. This may show that aviation is unique among the other modes of transportation due to the great number and breadth of outcomes.

While contrary to popular opinion, it is not large fatality events that always lead to significant outcomes in Congress or the FAA. Aloha Airlines flight 243 clearly shows even an accident with few fatalities can lead to a great amount of Congressional response and regulatory actions regarding a safety issue. In contrast, many less hearings and regulatory responses followed USAir 427 with 132 fatalities.

Without further analysis of U.S. Congressional record and resources outside the bounds of this research paper, a conclusion cannot be made as to whether significant technological changes are driven by user groups (i.e. airline) and consumer safety advocates versus industry pointing to an accident or realizing the need for something based on accident pre-cursors. A good case study may be the EVAS (Emergency Vision Assurance System), which was approved for installation in 1999 by the FAA following the ValuJet flight 592 accident (1996). Two years before the accident (1994), a Senate hearing was held to debate a bill (S.787) directing the U.S. DOT to require that aircraft have ventilations systems and smoke displacement equipment for pilots and flight crew (Y4.C73/7:S.HRG.103-397). Detailed review of the relevant Congressional documents, examining in particular who spoke at a hearing as well as the text of their speech, may reveal the answer. Research may show that more than likely there may not be just one plausible explanation for all of the significant technological outcomes.

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APPENDIX A: 16 Aviation Accidents and Related Safety Issues

1988 – Aloha Airlines Flight 243	Quality of air carrier maintenance programs and FAA surveillance of those programs, Engineering airworthiness of the B-737 with particular emphasis on multiple site fatigue cracking of the fuselage lap joints, Human factors aspects of air carrier maintenance and inspection for the continuing airworthiness of transport category airplanes, to include repair procedures and the training, certification and qualification of mechanics and inspectors
1988 – Delta Air Lines Flight 1141	Flight crew procedures; Wake vortices; Engine performance; Airplane flaps and slats; Takeoff warning system; Cockpit discipline; Aircraft rescue and firefighting; Emergency evacuation; Survival factors
1989 – United Airlines Flight 811	Design and certification of the B-747 cargo doors, Operation and maintenance to assure the continuing airworthiness of the doors, Emergency response
1989 – United Airlines Flight 232	Engine fan rotor assembly design, certification, manufacturing, and inspection; Maintenance and inspection of engine fan rotor assemblies; Hydraulic flight control system design, certification, and protection from uncontained engine debris; Cabin safety, including infant restraint systems; Aircraft rescue and firefighting facilities
1990 – Avianca Airlines Flight 52	Pilot responsibilities and dispatch responsibilities regarding planning, fuel requirements, and flight following during international flights; Pilot-to-controller communications; Air traffic control flow control, procedures; Flight crew coordination and English language proficiency of foreign crews; Oversight of foreign flight operations into the U.S.A.; Crashworthiness with children
1990 – Northwest Airlines Flight 1482	Airport marking and lighting, Cockpit resource management, ATC procedures in low visibility conditions, Flight attendant procedures for evacuation, Design of DC-9 tail cone emergency release system
1991 – USAir Flight 1493	Air traffic management and equipment at airport, Aircraft exterior lighting and conspicuity, Pilot situational awareness during take-off, landing and on airport operating area, Air traffic controller workload, performance, supervision, Accident survivability, evacuation standards and procedures, Interior furnishing flammability standards, Survival devices
1991 – United Airlines Flight 585	Potential meteorological hazards to airplanes in the area of Colorado Springs; 737 rudder malfunctions, including rudder reversals; Design of the main rudder power control unit servo valve
1994 – USAir Flight 427	Boeing 737 rudder malfunctions, including rudder reversals; Adequacy of the 737 rudder system design; Unusual attitude training for air carrier pilots; Flight data recorder parameters
1995 – American Airlines Flight 1572	Tower shutdown procedures, Non-precision approach flight procedures, Precipitous terrain and obstruction identification during approach design, Issuance of altimeter settings by air traffic control, Low level wind shear system maintenance and recertification, Emergency evacuation issues

APPENDIX A: 16 Aviation Accidents and Related Safety Issues

1995 – American Airlines Flight 965	Flight crew procedures, ATC approach controller actions, FAA surveillance of American Airlines (AA) South American operation, Survivability issues, Design of B-757 speed brake, AA's procedures and training in retracting speed brakes during GPWS escape maneuvers
1996 – ValuJet Flight 592	Minimization of the hazards posed by fires in class D cargo compartments; Equipment, training, and procedures for addressing in-flight smoke and fire aboard air carrier airplanes; Guidance for handling of chemical oxygen generators and other hazardous aircraft components; SabreTech's and ValuJet's procedures for handling company materials and hazardous materials; ValuJet's oversight of its contract heavy maintenance facilities; FAA's oversight of ValuJet and ValuJet's contract maintenance facilities; FAA's and the Research and Special Programs Administration's (RSPA) hazardous materials program and undeclared hazardous materials in the U.S. mail; and ValuJet's procedures for boarding and accounting for lap children
1996 – Trans World Airlines Flight 800	Fuel tank flammability, Fuel tank ignition sources, design and certification standards, Maintenance and aging of aircraft systems
1997 – Korean Air Flight 801	Flight crew performance, Approach procedures, and Pilot training; Air traffic control, including controller performance and the inhibition of the minimum safe altitude warning system at Guam; Emergency response; the adequacy of Korean Civil Aviation Bureau and FAA oversight; Flight data recorder documentation
1999 – American Airlines Flight 1420	Flight crew performance, Flight crew decision-making regarding operations in adverse weather, Pilot fatigue, Weather information dissemination, Emergency response, Frangibility of airport structures, and FAA oversight
2000 – Alaska Airlines Flight 261	Lubrication and inspection of the jackscrew assembly, Design and certification of the MD80 horizontal stabilizer trim control system, FAA oversight

APPENDIX B: Detailed List of Policy Outcomes

Congressional Session 100th (1987-1988)

1. 1988 – Aloha Airlines Flight 243
2. 1988 – Delta Air Lines Flight 1141

Public Law:

PL100-457 Department of Transportation and Related Agencies Appropriations Act
PL100-591 Aviation Safety Research Act of 1988
PL100-685 National Aeronautics and Space Administration Authorization Act, Fiscal Year 1989

Hearing:

S181-5.6 DOT and Related Agencies Appropriations, FY88 Y4.Ap6/2:S.HRG.100-354/pt.2
S181-12 FAA FY88 Budget Amendment and Summer Safety Initiatives, FY88, Special Hearing
S261-26 Safety and De-regulation of the Airline Industry Y4.C73/7:S.HRG.100-468
S261-50 Oversight of the FAA Y4.C73/7:S.HRG.100-660/corr.
S261-52 Reports on Aviation Safety Y4.C73/7:S.HRG.100-698
S321-58.9 Nuclear Regulatory Commission Oversight
J841-5 Investment in the Nation's Air Transportation System Y4.EC7:AI7
J952-66 Safe Skies for Tomorrow: Aviation Safety in a Competitive Environment Y3.T22/2:2SA1
H362-10 Threat from Substandard Fasteners: Is America Losing Its Grip? Y4.EN2/3:100-Y
H401-16 Maintenance at Eastern Airlines: FAA Oversight Y4.G74/7:M28/2
H401-36 Eastern Airlines Subcontracting of Passenger Flights to Orion Air Y4.G74/7:EA7
H641-11 Use of Foreign Repair Stations by U.S. Airlines Y4.P96/11:100-24
H641-14 Aviation Safety (Near Midair Collisions and Runway Incursions) Y4.P96/11:100-14
H641-16 Aviation Safety (FAA's Near Midair Collision Reporting System and the Proposed Boeing-747 Over wing Exit Removal) Y4.P96/11:99-65
H641-20.1 Identify airline pilots with drunk driving citations
H641-21 Aviation Safety (The Status of Aircraft Collision Avoidance Technology) Y4.P96/11:99-66
H641-33 Boeing's Proposal To Remove Over wing Exits From 747-Series Aircraft Y4.P96/11:100-40
H641-34 Air Carrier Certification Programs Y4.P96/11:100-45
H641-38 FAA's Safety Enforcement Program Y4.P96/11:100-63
H643-4 Investigation Into the Management of Texas Air Corporation and Eastern Airlines Y1.1/8:100-619
H643-9 Aviation Whistleblower Protection Act of 1988 Y1.1/8:100-883
H701-42 Collision Avoidance Technology Y4.SCI2:100/67
H701-48 Progress in Aviation Weather Prediction and Reporting Y4.SCI2:100/72
H701-75 Controller Performance Research Act; and the Aviation Safety Research Act of 1988 Y4.SCI2:100/109
H703-8 Controller Performance Research Act Y1.1/8:100-893
H703-9 Aviation Safety Research Act of 1988 Y1.1/8:100-894
H703-10 Research and Development on Fatigue and Corrosion in Aging Aircraft Y1.1/8:100-895

Congressional Session 101st (1989-1990)

3. 1989 – United Airlines Flight 811
4. 1989 – United Airlines Flight 232
5. 1990 – Avianca Airlines Flight 52
6. 1990 – Northwest Airlines Flight 1482

Public Law:

PL101-370 FAA Programs
PL101-508 Omnibus Reconciliation of 1990
PL101-604 Aviation Security Improvement Act of 1990
PL101-641 Independent Safety Board Act Amendments of 1990
PL101-164 DOT and Related Agencies Appropriations Act, 1990
PL101-236 Traffic Alert and Collision Avoidance System for Commercial Aircraft

Hearing:

S385-7 Intl Civil Aviation Organization Air Navigation Commission Membership expansion, Intl. convention protocol, Pres message
H181-74 Aircraft structural integrity and safety, NTSB recommendations
H641-2 Airlines foreign repair station, FAA regulatory revision
H641-11 Aircraft Structural Integrity and safe ops, FAA and industry programs oversight
H641-20 Aviation weather forecasting and info programs improvement
H641-26 FAA aviation safety regulatory activities oversight
H643-5 Aircraft structural integrity and safe ops, inspection requirements for aging aircraft established
H263-5, H643-3 Aviation Safety and Capacity Expansion Act
H363-36, H643-6, S263-45 Aircraft CVR info disclosure revision
H701-31, S261-5 DC-10 aircraft safety and design issues
H701-35 FAA air traffic controller and airway technician training programs oversight
H701-41 Airport runway collisions, safety concerns and R&D programs
H701-50 Aircraft Accident Prevention Act, Aircraft systems malfunction prevention, FAA info exchange program established
H703-8 Aircraft systems malfunction prevention, FAA R&D program established
H703-12 FAA engineering and R&D programs, FY91-FY92 authorization
H703-73 Aviation Training Research Act
S181-1 DOT and Related Agencies Appropriations, FY89, Part 1
S261-44 Aging Aircraft Y4.C73/7:S.HRG.101-96
S541-23 Employee Health and Safety Whistleblower Protection Act Y4.L11/4:S.HRG.101-47
H181-70 DOT and Related Agencies Appropriations for 1990 Y4.AP6/1:T68/4/990/pt.6 weather observing systems)
H641-1 Aviation Whistleblower Protection Y4.P96/11:100-54
H641-17 Proposals to Improve the Effectiveness of the FAA Y4.P96/11:100-64
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H641-23 Air Traffic Controller Staffing Standards Y4.P96/11:100-46
H641-29 Airline Maintenance Practice Y4.P96/11:100-84
H641-34 Collision Avoidance System Equipment and Compliance Deadlines Y4.P96/11:101-6
H641-35 FAA Organization, Structure, Management and Effectiveness Y4.P96/11:101-7
H641-38 Flight Attendant Duty Time Limitations Y4.P96/11:101-9
H641-41 Aviation Safety (Status of the U.S. ATC System) Y4.P96/11:101-12
H642-2 Compilation of Selected Aviation Laws Y4.P96/11:100-81 Y4.P96/11:100-81
H701-2 FAA R&D Program Review, NAS Plan, CAMI Mission and Program Plan Y4.SCI2:100/107
H701-66 Oversight on the FAA's FY90 R&D Program Y4.SCI2:101/20

Congressional Session 102nd (1991-1992)

7. 1991 – USAir Flight 1493
8. 1991 – United Airlines Flight 585

Public Law:

PL102-581 Airport and Airway Safety, Capacity, Noise Improvement, and Intermodal Transportation Act of 1992
PL102-345 FAA Civil Penalty Administrative Assessment Act of 1992
PL102-143 DOT and Related Agencies Appropriation Act, 1992

Hearing:

S181-34 DOT and Related Agencies Appropriations, FY93, Part 2. Y4.AP6/2:S.HRG.102-725/pt.2.
S181-40 Field Hearing to Receive Testimony on The Crash of USAir Flight 405, Special Hearing Y4.AP6/2:S.HRG.102-800
H181-76 DOT and Related Agencies Appropriations for 1993, Part 6 Y4.AP6/1:T68/4/993/pt.6
H401-27 Review of FAA Procurement of Airport Surface Detection Equipment, ASDE-3 Y4.G74/7:P94/23
H403-5 Issues in Aircraft Cabin Safety and Crash Survivability: The USAir-Skywest Accident Y1.1/8:102-501
H641-21 Federal Oversight of the Maintenance and Repair of Aging Aircraft Y4.P96/11:102-29
H641-31 To Review the Status of the Airborne Traffic Alert and Collision Avoidance System (TCAS) Y4.P96/11:102-41
H641-35 GAO Report: "Problems Persist in FAA Inspection." Y4.P96/11:102-50

H641-37 FAA Program Reauthorization Y4.P96/11:102-52
H641-47 FAA Civil Penalties Program Y4.P96/11:102-62
H643-3 Airport and Airway Safety, Capacity and Intermodal Transportation Act of 1992 Y1.1/8:102-503
H643-5 FAA Civil Penalty Administrative Assessment Act of 1992 Y1.1/8:102-671
H701-21 FAA's Research, Engineering and Development Programs Y4.SCI2:102/67
H701-78 FY93 FAA R,E&D Authorization Y4.SCI2:102/126
H703-5 FAA Research, Engineering and Development Authorization Act of 1992 Y1.1/8:102-511
H401-67 Tragedy at LAX: Runway Incursions and the Federal Response Y4.G74/7:T67/8
H401-77 Aircraft Cabin safety and Fire Survivability Y4.G74/7:A17/21
H641-3 Child Restraint Systems on Aircraft Y4.P96/11:101-54
H641-5 Aging Aircraft Safety Act Y4.P96/11:101-49
H641-25 FAA's Training Programs for Air Traffic Controllers, Safety Inspectors, and Maintenance Technicians
Y4.P96/11:101-74
H641-33 Pilot/Air Traffic Controllers Communications Issues Y4.P96/11:101-77
H641-41 Ground Collisions and Runway Incursions Y4.P96/11:102-2
H641-43 Flight Attendant Duty Time Limitations Y4.P96/11:102-3
H642-5 Compilation of Selected Aviation Laws Y4.P96/11:102-23
H643-1 Aging Aircraft Safety Act of 1991 Y1.1/8:102-39
H701-40 FAA's Research and Development Program Y4.SCI2:102/7

Congressional Session 103rd (1993-1994)

9. 1994 – USAir Flight 427

Public Law:

PL103-305 Federal Aviation Administration Authorization Act of 1994

Hearing:

S261-28 Aviation Competition and Safety Issues Y4.C73/7:S.HRG.103-397
J952-67 Federal Research and Technology for Aviation Y3.T22/2:2AV5
H641-5 Advanced Aircraft Technology and FAA Aircraft Certification Y4.P96/11:103-38
H701-41 Safer Skies: Aviation Weather Research Y4.SCI2:103/97
S261-64 Relationship between the FAA and NTSB Y4.C73/7:S.HRG.103-228
J952-62 Aviation Evacuation Testing: Research and Technology Issues, Background Paper OTA-BP-SET-121
H401-21 Aviation Safety Issues Y4.G74/7:AV5/8
H641-4 Government and Industry Programs Related to Aircraft Deicing and Other Safety Matters Y4.P96/11:102-70
H642-4 Compilation of Selected Aviation Laws Y4.P96/11:103-5

Congressional Session 104th (1995-1996)

10. 1995 – American Airlines Flight 1572
11. 1995 – American Airlines Flight 965
12. 1996 – ValuJet Flight 592
13. 1996 – TWA Flight 800

Public Law:

PL104-264 Aviation Disaster Family Assistance Act

Hearing:

S261-8 Oversight Hearings on Aviation Safety Y4.C73/7:S.HRG.104-334
H753-19 Aviation Disaster Family Assistance Act of 1996 Y1.1/8:104-793
H753-23 Federal Aviation Authorization Act of 1996 Y1.1/8:104-848
H641-17 FAA's Oversight of Foreign Airline Safety Y4.P96/11:103-73
H701-21 Application of FAA Wake Vortex Research to Safety Y4.SCI2:103/157
H751-2 Ways to Reduce Unfunded Federal Mandates and Regulatory Burdens on the Aviation Industry without affecting the
Safety of the Traveling Public Y4.T68/2:104-4
H752-2 Compilation of Selected Aviation Laws Y4.T68/2:104-6

Congressional Session 105th (1997-1998)

14. 1997 – Korean Air Flight 801

Public Law:

PL105-148 Aircraft Accident Victims Family Assistance Requirements Established

Hearing:

S181-7 Aviation Safety and Security issues, review

S261-7 Aviation Safety Y4.C73/S.HRG.105-271

H181-84 FAA air traffic control computer system design

H261-16 Aircraft accidents, Fed agencies investigation procedures

H701-8 Y4.SCI2:105/22 Role of Research and Development in Improving Civil Air Traffic Management

H701-34 Bolt and fastener testing, aircraft industry requirements

H751-12.2 One Year After ValuJet Crash: FAA Response to HAZMAT and Cargo Fire Protection Issues Y4.T68/2:105-22

H751-30 Airport runway collisions, safety concerns

S261-21 Aviation Safety Treatment of Families After Airlines Accidents Y4.C73/7:S.HRG.104-612

S261-29 Safety Oversight of FAA Y4.C73/7:S.HRG.104-620

S401-7 Aviation Safety: Are FAA Inspectors Adequately Trained, Targeted and Supervised? Y4.G74/9:S.HRG.104-659

H751-7 Aviation Safety: Issues Raised by the Crash of ValuJet Flight 592 Y4.T68/2:104-48

H751-19 H.R. 3187, Aviation Safety Protection Act Y4.T68/2:104-57

H751-21 Aviation Safety: Treatment of Families After Airline Accidents Y4.T68/2:104-61

H751-22 Aviation Disaster Family Assistance Act of 1996 Y4.T68/2:104-64

H751-29 H.R. 1309, Child Safety Restraint Systems Requirement on Commercial Aircraft Y4.T68/2:104-63

H751-44 Proposal to Require TCAS on Cargo Aircraft Y4.T68/2:105-5

H752-6 Compilation of Selected Aviation Laws Y4.T68/2:105-14

H753-7 Nonapplicability of Death on the High Seas Act to Aviation Incidents Y1.1/8:105-201

Congressional Session 106th (1999-2000)

15. 1999 – American Airlines Flight 1420

16. 2000 – Alaska Airlines Flight 261

Public Law:

PL106-528 Airline & Airport Security Improvement Measures

PL106-181 Airlines & Pilots Operating Certificates Emergency Revocation

Hearing:

S521-24 Administrative Oversight of the Investigation of TWA Flight 800 Y4.J89/2:S.HRG.106-534

H181-4 (Appropriations)

H751-9 (Reauthorization of NTSB and issues related to Flight 800 investigation)

H751-23 Aviation Operations During Severe or Rapidly Changing Weather Conditions Y4.T68/2:106-29

H751-30 Pilot Fatigue Y4.T68/2:106-33

H751-31 Aircraft Electrical System Safety Y4.T68/2:106-37

S261-13 S.943 and H.R. 2005, Death on the High Seas Act Y4.C73/7:S.HRG.105-771

H751-14 Problems of Passenger Interference with Flight Crews and A Review of H.R. 3064, The Carry-On Baggage Reduction Act of 1997 Y4.T68/2:105-73

H751-20 H.R. 1846 FAA's Emergency Revocation of FAA Licenses Y4.T68/2:105-80

H753-8 To Clarify the Application of the Act Popularly known as the DOHSA to Aviation Incidents Y1.1/8:106-32

APPENDIX C: Detailed List of Regulation Outcomes

1. 1988 – Aloha Airlines Flight 243

AD: AD 90-NM-131 (1991) – requires a one time inspection of the engine of control cable system.

AD 93-06-01 (1993) – mandated a change to the Supplemental Structural Inspection Documents (SSID) for Boeing 747 series airplanes.

AD 98-11-03 (1998) – deletes the terms “damage obvious” and “malfunction evident” as classifications under the damage tolerance rating system (applicable to Boeing 727 series).

AD 98-11-04 (1998) - deletes the terms “damage obvious” and “malfunction evident” as classifications under the damage tolerance rating system (applicable to Boeing 737-100 and -200 series).

AC: AC 91-56 (1998) – “Supplemental Structural Inspection Program for Large Transport Category Airplanes”

AC 25.571 (revised 1998) – “Continuing Structural Integrity Program for Large Transport Category Airplanes”

AC 65-31 (2001) – “Training Qualification, and Certification of Nondestructive Inspection (NDI) Personnel”

FAR: 14 CFR 25.571 (amended 1998) – “Fatigue Evaluation of Structure”

14 CFR 147 (amended 1992) – “Aviation Maintenance Technician Schools” (Amendment No. 147-5)

Bulletin: ACOB 8-90-2 (1990) – “Airworthiness During Suspected Airframe Damage”

HBAW 96-01 (1996) – “Information and Guidance Pertaining to Structural Maintenance Programs for Aging Large Transport and Other Transport Category Airplanes”

FSIB 93-40A (1993) – “Human Factors Involved in Inspection and Repair in a Heavy Maintenance Environment” (expired 1994 and incorporated in to Order 8300.10, Airworthiness Inspector’s Handbook, Change 10)
HBAW 94-05A (1994) – “Significant Difference Between Flight Cycle and Flight Time Relationship Affecting Airplane Maintenance Programs”

Other: Action Notice 8300.68 – “Request for Aircraft Inspection Program Information”

“Aging Aircraft Evaluation Trend Report” (1990)
Order 8300.12 (1993) – “Corrosion Prevention and Control Programs”

2. 1988 – Delta Air Lines Flight 1141

AD: AD 90-03-18 (1990) – addresses nuisance (false) warning during reduced engine taxi, and requires that the TOCWS be modified into include engine pressure ratio

logic information in series with the existing throttle angle arming logic.

AD 88-22-09 (1988) – mandates that an operational and functional check be performed on the TOCWS at intervals not to exceed 200 flight hours.

AC: None

FAR: None

Bulletin: ACOB 8-90-5 (1990) – “Verification of Flap Position During Stall Recognition and Recovery”

ACOB 8-90-6 (1990) – “Visual Confirmation and Accomplishment of All Operating Checklist Items”

Other: Action Notice 8300.84 (1990) – “Alternate Fueling Methods Accomplished in Accordance with Approved Minimum Equipment Lists (MEL)”

3. 1989 – United Airlines Flight 811

AD: AD 91-22-05 (1991) – requires that stronger latches be installed in oversized storage compartments that formerly held life rafts on all B-747 airplanes.

AC: None

FAR: None

Bulletin: None

4. 1989 – United Airlines Flight 232

AD: AD 89-20-01 (1989) – required that certain CF6-6 engine fan Stage I rotor disks be inspected in accordance with General Electric Aircraft Engines (GEAE) Service Bulletin 72-947.

AD 90-13-07 (1990) - requires modifications to the hydraulic systems on all Douglas DC-10 airplanes.

AC: None

FAR: 14 CFR Part 39 (1991)

14 CFR 91.107, 121.311, 125.211 and 135.128 (1992) – “Miscellaneous Operational Amendments” (Amendment Nos. 91-231, 121-230, 125-17, and 135-44)

Bulletin: ACOB 1-91-1 (1991) – to inform air carrier training departments to review the UAL flight 232 accident scenario, to evaluate their emergency training programs, and to stress the importance of time management in emergency cabin preparation.

Other: Notice N8120.13 1991) – “Verification of Completeness, Accuracy, and Traceability of Manufacturing and Quality Records”

5. 1990 – Avianca Airlines Flight 52

AD: None

AC: None

FAR: None

Bulletin: None

Other: Action Notice 8430.53 (1990) – to notify all principal operations inspectors to advise all domestic and foreign air carriers to emphasize the need for pilots to be thoroughly knowledgeable of the flight operating and pertinent air traffic control rules and procedures.

6. 1990 – Northwest Airlines Flight 1482

AD: Docket No. 91-NM-136-AD (1991) – requires placement or modification of the internal and external tail cone release system cable and handle assemblies for McDonnell Douglas DC-9 series airplanes.

Docket No. 91-NM-137-AD (1991) – requires placement or modification of the internal and external tailbone release system cable and handle assemblies for McDonnell Douglas MD-88 series airplanes.

Docket No. 91-NM-21 AD (1991) – to adopt an airworthiness directive applicable to McDonnell Douglas Model MD80 and MD88 series airplanes.

Docket No. 91-NM-04-AD (1991) – requires repetitive inspections and functional checks of the DC-9 tail cone release system for proper operation. (Amendment 39-6867)

AC: AC 150/5340-18C (1991) – “Standards for Airport Sign Systems”

AC 150/5340-1F (1991) – “Marking of Paved Areas of Airports”

AC 150/5370-10A (revised 1996) – “Standards for Specifying Construction of Airports (Change 9)

AC 120-57 (1992) – “Surface Movement Guidance and Control System”

AC 150/5220-4B – “Water Supply Systems for Aircraft Fire and Rescue Protection”

FAR: None

Bulletin: FSAT 93-04 (1993) – “Low Visibility Taxi Operations”

HBAW 94-05 (1994) – “Low Visibility Taxi Operations”

ACOB 8-76-6 (revised 1992) – “Guidelines for Crewmember Training on Aircraft Tail cones and Approval of Tailbone Training Devices”

ACOB 8-76-46 (revised 1992) – “Crewmember Emergency Training; Use of Mockups”

Other: Order 7110.65H (revised 1994) – “Air Traffic Control”

Notice 8300.86 (1990) – “Tail Cone Emergency Exit Maintenance Programs”

7. 1991 – USAir Flight 1493

AD: None

AC: None

FAR: None

Bulletin: ACOB 1-92-1 (1992) – “Flight Attendant Restraint During a Crash and Emergency Evacuation Second Choice Exit Determination”

ACOB 8-93-2 (1993) – “Monitoring Air Traffic Control Communications for Potential Traffic Conflicts”

FSAW 94-25 (1994) – “Air Carrier Strobe Light Maintenance Programs”

Other: Section 2, Radio Communication Phraseology and Techniques, paragraph 4-31, of the Airman’s Information Manual (revised 1992)

8. 1991 – United Airlines Flight 585

AD: AD 94-01-07 (1994) – requires repetitive inspections of the Boeing 737 main rudder PCU at 750 hours intervals.

AD 96-26-07 (1996) – mandates changes to the Airplane Flight Manual to enable the flight crew to take appropriate action to maintain control of the airplane during an uncommanded yaw or roll condition.

AD 97-14-03 (1997) – mandates design changes to add a rudder limiting device that reduces the rudder authority at flight conditions where full rudder authority is not required and redesigned, more reliable yaw damper system.

AD 97-14-04 (1997) – mandates design changes to the Boeing 737 main rudder PCU to eliminate all known single servo valve failures.

AC: None

FAR: None

Bulletin: None

Other: None

9. 1994 – US Airways Flight 427

AD: AD 96-26-07 (1996) – see UAL 585

AD 97-14-03 (1997) – see UAL 585

AD 97-14-04 (1997) – see UAL 585

AD 2000-22-02 (2000)

AD 2002-20-07 R1 (2002) – mandates installation of a new rudder control system in Boeing 737 aircraft.

AC: None

FAR: None

Bulletin: FSAT 00-16A (2000) – directs all flight standards district offices, certificate management offices, and principal operations inspectors to ensure that all 14 CFR Part 121 air carrier operators of Boeing 737 airplanes provide their flight crews with initial and recurrent flight simulator training in the uncommanded yaw or roll and jammed or restricted rudder procedures contained in Boeing’s 737 Operations Manual.

Other: None

10. 1995 – American Airlines Flight 1572

AD: None

AC: None

FAR: None

Bulletin: FSAW 97-11 (1997) – “McDonnell Douglas Corporation Aircraft Models MD-80 and DC9 Evacuation Slide Rigging Procedures”

Other: Order 8260.3B (1998) – “United States Standards for Terminal Instrument Procedures (TERPS) (Change 17) Order 8260.47 (1998) – “Barometric Vertical Navigation (VNAV) Instrument Procedures Development” Order 7110.65L (revised 1998) - "Air Traffic Control”

11. 1995 – American Airlines Flight 965

AD: None

AC: AC 120-51C (1998) – “Crew Resource Management Training”

FAR: 14 CFR 121.354 (2000) – “Terrain Awareness and Warning System”

Bulletin: FSAT 97-05 (1997) – “Availability and Use of Navigation and Approach Charts”

FSAT 01-08 (2001) – “Navigation Database Information Versus Printed and Electronically-Generated Aeronautical Charts”

HBAT 98-03 (1998) – “Monitoring of Speed brake Position During GPWS Recovery Maneuvers”

Other: None

12. 1996 – ValuJet Flight 592

AD: None

AC: AC 120-16D (2003) – “Continuous Airworthiness Maintenance Programs” (Amendment to 16C)

FAR: 14 CFR 145.219 (2001)

Bulletin: HBAT 97-09 (1997) – “Action to Conserve Data Contained within Cockpit Voice Recorders (CVR) Following an Incident or Accident”

HBAW 96-05C (1997) – “Air Carrier Operations Specifications Authorization to Make Arrangement With Other Organizations to Perform Substantial Maintenance” HBAT 98-04 (1998) – “Emphasis on Load Manifest” HBAT 98-18 (1998) – “Air Carrier Manual Instructions Concerning Minimum Equipment List Conditions and Airworthiness”

HBAW 98-09 (1998) – “Air Carrier Manual Instructions Concerning Minimum Equipment List Conditions and Airworthiness”

HBAW 98-10 (1998) – “Air Carrier Control and Handling of Aircraft Components or Consumable Materials That Contain Hazardous Materials”

Other: "Human Factors in Aviation Maintenance and Inspection, Strategic Program Plan" (1998)

“Evaluation of Aviation Maintenance Working Environments, Fatigue, and Maintenance Error/Accidents” (2000)

Final rule: eliminating Class D compartment (1998) Order 8130-21B (1997) – Procedures for Completion and Use of FAA Form 8130-3

13. 1996 – TWA Flight 800

AD: AD 97-26-07 (1997) – requires a repetitive inspection of Teflon sleeves that protect wiring to the outboard main tank boost pumps on all Boeing 747 series airplanes.

AD-98-20-40 (1998) – addresses this safety recommendation with regard to the Boeing 747-100, -200, -300, -SP and -SR series airplanes

AD 99-03-02 (1999) – requires separation and shielding of the FQIS wires and circuits on those airplanes, similar to the requirement of AD 98-20-40

AD 99-08-02 R1 (revised 1999) - requires inspections and testing to verify that the wiring, tubing, and components inside the CWT are in satisfactory condition and electrically bonded to the airplane structure and inspection of FQIS wiring and replacement of FQIS probes that have knurled surfaces or sharp edges that may damage FQIS wiring.

AC: AC 25.981-1B (2001) – “Fuel Tank Ignition Source Prevention guidelines”

AC 25.981-2 (2001) – “Fuel Tank Flammability Minimization”

FAR: None

Bulletin: None

Other: Final rule: “Transport Airplane Fuel Tank System Design Review, Flammability Reduction and Maintenance and Inspection Requirements” (2001)

"Enhanced Airworthiness Program for Airplane Systems" (2001)

Aging Transport Non-Structural Systems Plan (ATNSSP 1998)

Policy statement: ANM-01-04 (2001) – “System Wiring Policy for Certification”

14. 1997 – Korean Air Flight 801

AD: None

AC: AC 120-71 (2000) – “Standard Operating Procedures for Flight deck Crewmembers”

AC 121.445-1D (being revised 2003)

FAR: None

Bulletin: HBAT 99-08 (1999) – “Vertical Navigation (VNAV) Approach Procedures Using DA(H); OpSpec C073”

FSAT 00-08 (2000) – ” Standard Operating Procedures for Flight deck Crewmembers (AC 120-71), Including Stabilized Approach.

FSAT 00-18 (2000) – “Use of BARO-VNAV for
Published Instrument Approach Procedures; OpSpec C052
Revision”

FSAT 01-05 (2001) – “Approach Preparation: Preparing
for an Instrument Approach as Backup in Night VMC or
Whenever IMC May be Encountered”

Other: Instrument Procedures Instruction Letter 99-014
(1999) – “Adding Descent Angles to Non-precision
Approach Charts”

15. 1999 – American Airlines Flight 1420

AD: None

AC: AC 120-71 (amended 2003) – “Standard Operating
Procedures for Flight deck Crew Members” (Appendix 1)

FAR: None

Bulletin: FSAT 01-12 (2001) – “Approach and Landing
Accident Reduction (ALAR): Recommended Flight crew
Training”

Other: Order 720.3 (added 2003) – “Airport Emergency
Plan” (paragraph 2-1-9)

AIM (new edition 2004) – provides information to pilots
on Low Level Wind Shear Alert System (LLWAS) and
alert data for controllers.

16. 2000 – Alaska Airlines Flight 261

AD: AD 2000-15-15 (2000) – requires removal of
degraded grease at intervals of 650 flight hours.

AC: AC 120-16D (2003) – see ValuJet 592

AC 120-79 (2003) – “Developing and Implementing a
Continuing Analysis and Surveillance System”

FAR: None

Bulletin: FSAW 02-02 (2002) – “The Potential Adverse
Effects of Grease Substitution”

Other: Notice N 8400.66 (2004) – “Dispatch and
Maintenance Support to Pilots Experiencing a Malfunction
Threatening Flight Safety”

Order 8300.10 (revised 2002) – to state that if there is any
doubt as to the soundness of the request, the aviation safety
inspector should coordinate the request with the
appropriate aircraft certification office.