National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: May 16, 1995

In reply refer to: A-95-40 through -51

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On July 2, 1994, about 1843 eastern daylight time, a Douglas DC-9-31, N954VJ, operated by USAir, Inc., as flight 1016, collided with trees and a private residence near the Charlotte/Douglas International Airport, Charlotte, North Carolina, shortly after the flightcrew executed a missed approach from the instrument landing system (ILS) approach to runway 18R. The captain, first officer, one flight attendant, and one passenger received minor injuries. Two flight attendants and 14 passengers sustained serious injuries. The remaining 37 passengers received fatal injuries. The airplane was destroyed by impact forces and a postcrash fire. Instrument meteorological conditions prevailed at the time of the accident, and an instrument flight rules flight plan had been filed. Flight 1016 was being conducted under 14 Code of Federal Regulations (CFR) Part 121 as a regularly scheduled passenger flight from Columbia, South Carolina, to Charlotte.[1]

The National Transportation Safety Board has determined that the probable causes of this accident were: 1) the flightcrew's decision to continue an approach into severe convective activity that was conducive to a microburst; 2) the flightcrew's failure to recognize a windshear situation in a timely manner; 3) the flightcrew's failure to establish and maintain the proper airplane attitude and thrust

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[1]For more detailed information, read Aircraft Accident Report -- "Flight Into Terrain During Missed Approach, USAir Flight 1016, DC-9-31, N954VJ, Charlotte/Douglas International Airport, Charlotte, North Carolina, July 2, 1994" (NTSB/AAR-95/03)

setting necessary to escape the windshear; and 4) the lack of real-time adverse weather and windshear hazard information dissemination from air traffic control (ATC), all of which led to an encounter with and failure to escape from a microburst-induced windshear that was produced by a rapidly developing thunderstorm located at the approach end of runway 18R.

Contributing to the accident were: 1) the lack of air traffic control procedures that would have required the controller to display and issue airport surveillance radar (ASR-9) weather information to the pilots of flight 1016; 2) the Charlotte tower supervisor's failure to properly advise and ensure that all controllers were aware of and reporting the reduction in visibility and the runway visual range (RVR) value information, and the low level windshear alerts that had occurred in multiple quadrants; 3) the inadequate remedial actions by USAir to ensure adherence to standard operating procedures; and 4) the inadequate software logic in the airplane's windshear warning system that did not provide an alert upon entry into the windshear.

The primary ATC issue that the Safety Board examined in this accident was the failure of controllers to disseminate pertinent weather information to the flightcrew of flight 1016. The radar and tower controllers had indications that the weather was deteriorating when the airplane was 16 miles from the runway, on the downwind leg of the visual approach. The Safety Board believes that the combination of ATC procedures and a breakdown in communications within the Charlotte ATC tower prevented the flightcrew from being provided critical information about adverse weather that developed over the airport and along the approach path to the runway. The Safety Board also believes that if the flightcrew had been provided information regarding the severe weather in the terminal area, they might have abandoned the approach to runway 18R sooner or they might not have initiated the approach.

In addition, the Safety Board believes that the Center Weather Service Unit (CWSU) meteorologist was attentive to the significant weather conditions in the Atlanta airspace on the afternoon and evening of the accident, and that he made the appropriate weather issuances to Federal Aviation Administration (FAA) facilities. However, the Safety Board believes that he may have been at a disadvantage in his efforts to monitor the northern area of the Atlanta airspace because of the unavailability of data for the Charlotte area from the Columbia, South Carolina, (CAE) Doppler weather surveillance radar (WSR-88D), also known as NEXRAD, Next Generation Radar. If the meteorologist had been able to access the CAE

WSR-88D data, it would have provided a high resolution depiction of the weather conditions in the Charlotte area. Further, it would have shown the development of the weather cell near the airport about 19 minutes before the accident, and that information could have been transmitted to the Charlotte terminal radar approach control (TRACON), ATC tower, and flightcrews.

Testimony by the Charlotte tower supervisor at the Safety Board's public hearing on this accident indicated that verbal issuances regarding thunderstorms received from the Atlanta CWSU meteorologist are typically forwarded to pilots on the automatic terminal information service (ATIS). The Safety Board is concerned that there are no requirements for controllers to provide CWSU information directly to pilots. Although it is impossible for the Safety Board to know what actions the flightcrew of USAir 1016 would have taken if they had been given an advisory of a Video Integrator Processor (VIP) level 3, 5 or 6 echo near the airport, the Safety Board believes that this critical weather information might have influenced the flightcrew's decision regarding the approach at Charlotte.

The Safety Board believes that the CWSU is a valuable program and a necessary part of the National Airspace System. The Safety Board is concerned that in the case of the Atlanta CWSU meteorologist, it may not be possible for one person to monitor 100,000 square miles of airspace for significant weather phenomena and to make timely issuances to the affected ATC facilities. The CWSU meteorologist is required to make the appropriate advisories whenever a thunderstorm, as defined by the National Weather Service (NWS), is detected. Thunderstorms imply severe or greater turbulence, severe icing, and low level windshear. Thus, every thunderstorm can be considered potentially hazardous. The Safety Board believes that the constant attention necessary to monitor a very severe thunderstorm could possibly overwhelm the CWSU meteorologist, especially on days when numerous thunderstorms are occurring in the airspace. As the CWSU meteorologist stated at the Safety Board's public hearing on this accident, "it's more than one person can handle." Therefore, based on the circumstances of this accident, the Safety Board also believes that the FAA and NWS must reevaluate the total program to improve the reporting system.

The crew of this flight 1016 received ATIS "Yankee" and so advised ATC when they checked in on the frequency. However, ATC had changed the ATIS to "Zulu," but did not update the flightcrew of the change. Given the circumstances, the Safety Board believes that the ATIS procedures should be changed to ensure that broadcasts are promptly updated whenever any conditions conducive to thunderstorms are observed. These conditions should include, but not be limited

to, windshear, lightning, and rain. Additionally, the Safety Board believes that controllers should issue these items until the information is broadcast on the ATIS and the pilots have acknowledged receipt of the information.

The investigation revealed that the TRACON final radar west controller (FRW) did not provide the flightcrew with critical information about precipitation that was identified and depicted on the ASR-9 radar. The FRW controller stated in his testimony at the Safety Board's public hearing that the ASR-9 depicted precipitation at a level 3 intensity, which the NWS classifies as "heavy precipitation." At 1836:59, the controller advised the flightcrew that they, "may get some rain just south of the field, might be a little bit comin' off north." This simple statement was the controller's interpretation of precipitation that was depicted as a VIP level 3 and was not issued using the proper phraseology, as contained in the ATC Handbook.

In his testimony, the manager of the Advanced System Branch of the FAA stated that controllers in general are "absolutely not" taught to interpret information detected by the ASR-9 radar. The Safety Board is concerned that controllers are not required either to display precipitation or to issue to flightcrews the precipitation levels depicted on their radar.

In 1989, the General Accounting Office (GAO) conducted a study of the FAA's use of new radar and identified a lack of formal procedures for the issuance of ASR-9 weather information to pilots. In 1994, the manager of Air Traffic Investigations stated, in part:

> FAA policy regarding ATC issuance of weather information is contained in Order 7110.65...when weather information is issued pursuant to the guidance...ATC specialist should use certain pre-established phraseology...Significantly, the recommendation that weather information be issued and the use of certain prescribed phraseology does not make the issuance of weather information mandatory.

The FRW controller stated that his workload was "light" and the complexity was "light to none." He also stated that because of the light workload he was able to perform additional duties, including the issuance of weather information. The guidance provided in the ATC Handbook for the issuance of the weather information specifically states that certain phraseology will be used. An example of

this phraseology is as follows: "Level five weather echo between eleven o'clock and one o'clock, one zero miles...."

The Safety Board is concerned over the subjective nature of the guidance to controllers regarding the issuance of weather information, especially when that information is generated from the ASR-9 radar.

The Safety Board believes that the use of the words "some rain" by the FRW controller might have, despite the controller's intentions, been interpreted by the flightcrew as a description of the amount or intensity of the rainfall. This characterization may have led the flightcrew to believe that the rainfall was insignificant and did not pose a threat to the flight. The recommended phraseology was intended to standardize weather condition reports to pilots and to make pilots aware of the location and intensity of precipitation depicted on radar.

During the investigation, the Safety Board found that the tower supervisor did not correctly perform his duties when he determined that the prevailing visibility had decreased to 1 mile, and he did not relay this information to the other controllers. Also, he did not activate the RVR equipment or ensure that the controllers issued RVR information to pilots.

The tower supervisor is responsible for providing general supervision in the ATC facility. Although he does not directly control traffic, he must ensure the safe and efficient operation of the facility. This is accomplished by a multitude of tasks, including the assignment of controller positions, ensuring that the appropriate equipment is activated and operational, and determining the prevailing visibility. The supervisor must also oversee control positions to monitor the quality of controller performance and to ensure that they receive all available information.

The supervisor testified at the public hearing that he was aware of the requirement to notify each controller individually of the prevailing visibility, and that notification by means of a "blanket broadcast" was not acceptable. Although it was later determined that this procedure was not in effect at the time of the accident, it still remains the responsibility of the supervisor to ensure that, like pilots, the controllers have all available information regardless of standard operating procedures.

The ATC Handbook provides specific guidance that any time the prevailing visibility is determined to be 1 mile or less; or when the RVR indicates a reportable

value of 6,000 feet or less, regardless of visibility, this information will be reported to pilots. The supervisor determined that the prevailing visibility had decreased to 1 mile; however, he did not ensure that all of the equipment necessary to determine RVR was activated. At 1840, the RVR indicated a reportable value of 2,400 feet, which was the USAir minimum value permissible to execute the ILS approach. The RVR value was not reported to the crew of flight 1016 because the RVR display located in the tower cab was not activated. Currently, there are no standardized procedures to ensure that controllers are aware of a reportable RVR value when the system is not in an operational mode in the tower.

In conclusion, the Safety Board believes that the failure of the controllers to report ASR-9 radar data, as well as other pertinent weather information to the crew of flight 1016, and the supervisor's failure to ensure that each controller was aware of the decreased visibility and that all necessary RVR equipment was activated and displaying reportable information, were contributing factors to the accident. As a result of these findings, the Safety Board believes that the FAA should amend the ATC Handbook and take other actions to correct the deficiencies identified in this accident.

The Safety Board's examination of USAir's windshear training program found that the program was comparable to the industry standards contained in the *Windshear Training Aid*, and that the flightcrew of flight 1016 had received the training.

The program's curriculum discussed the necessity of avoiding windshear and emphasized that crewmembers should be able to recognize cues that either indicate the possibility of a windshear or an actual encounter. Crewmembers were provided with a table of microburst windshear probabilities based on different cues. These cues included (1) precipitation depicted as red on airborne weather radar has a high probability of microburst activity; (2) an LLWAS alert of less than 20 knots has a medium probability; and (3) an airspeed gain of greater than 15 knots has a high probability of microburst activity. These guidelines applied to operations in the airport vicinity, within 5 miles of the point of takeoff or landing along the intended flightpath and below 1,000 feet above ground level. The cues were considered cumulative, and, if more than one was observed, the probability weighing was to be increased.

The Safety Board believes that the crew of flight 1016 was exposed to at least three windshear probability cues, two of which were rated as high. They were the

convective weather conditions that existed at the airport; the flightcrew's visual observations and decision to make the missed approach to the right; and the subsequent intracockpit discussions about the location of the rain. Finally, the flightpath that would have resulted from following the prescribed ILS approach procedure offered a strong likelihood of an encounter with microburst windshear activity.

The observation of the microburst cues was further validated by the cockpit voice recorder (CVR) when the captain commented about 4 minutes before the accident that the rain activity, "looks like it's sitting right on the [unintelligible]," to which the first officer replied, "yep, [the edge of the rain is] laying right there this side of the airport, isn't it." This information, combined with the previous knowledge gained from the airborne weather radar about the weather cell, should have been a clear indication that a microburst was very possible.

Based on the guidance and training provided by USAir to this crew, the Safety Board believes that there were sufficient microburst windshear cues presented to the flightcrew that warranted abandoning the approach earlier. However, perhaps because of incomplete or misleading weather information from other sources ("smooth ride" report from another flight and visual contact with the runway), the flightcrew's perception of the weather was interpreted as nonthreatening. Thus, they continued the approach beyond the final approach fix. Nonetheless, based upon their simulator training, the Safety Board believes that after the flightcrew observed the increased airspeed upon entry into the rain, they should have recognized that a windshear condition existed and executed a windshear escape maneuver.

The Safety Board is concerned that the windshear training conducted in the simulator may not be totally effective because flightcrews, through repetition, have become accustomed to performing required routine tasks in the training and checking process. These tasks result in: 1) the pilot having a good knowledge of the type of maneuver or abnormal condition that will be simulated; 2) knowledge of the time period that the abnormal condition may be simulated; 3) crew reliance in identifying windshear on the aircraft windshear alert system; and 4) rote knowledge of the "routine" procedure necessary to successfully satisfy the simulated condition. This was found to be evident in the USAir windshear training program to the extent that, typically, the windshear cues always provided to the flightcrews in the simulator occurred in the form of either turbulence immediately before the windshear and/or a fluctuation in airspeed.

The Safety Board believes that the use of repetitive windshear cues, such as turbulence and/or airspeed fluctuation in USAir's windshear training conducted in the simulator, might have led the pilots to associate windshear with those cues. As was evident in this accident, there was no turbulence associated with the entry into the microburst wind field at Charlotte. The lack of turbulence could have contributed to the crew's failure to identify the microburst activity because it was dissimilar to the cues they had been trained to recognize in the simulator.

The Safety Board concludes that although the flightcrew had received the requisite windshear training at USAir, they did not apply the principles of this training adequately during the accident flight. Therefore, the Safety Board believes that the FAA should reexamine the circumstances and findings of this accident as a basis for a review and revision, as necessary of the airline industry windshear training programs.

On another issue in this accident, the Safety Board examined the performance capabilities of the low level windshear alert system (LLWAS) at Charlotte and the possible effect it had on the accident. The Safety Board recognizes that the system's configuration at the time of the accident might have been susceptible to degraded performance due to the sheltering of the LLWAS wind sensors by obstructions. However, the Safety Board believes that there was no degradation in the performance during the windshear event on the day of the accident. Nonetheless, because of the siting problems identified in this accident, the Safety Board believes that the FAA should review all LLWAS installations to ensure that wind sensors are located in areas that allow optimum performance.

At the public hearing on this accident, the FAA's principal operations inspector (POI) for USAir testified that there was a recognized trend in pilot noncompliance regarding standard operating procedures at USAir.

Over the years, the Safety Board has investigated a number of catastrophic accidents in which standard operating procedures were either overlooked or discounted. For example, on May 10, 1988, the Safety Board determined that the probable cause of the accident involving Northwest Airlines flight 255, which crashed shortly after takeoff from Detroit Metropolitan/Wayne County Airport, Romulus, Michigan, killing 156 people, was the flightcrew's failure to use the taxi checklist to ensure that the flaps and slats were extended for takeoff.[2] As a result of

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[2]See Aircraft Accident Report -- "Northwest Airlines, Inc., McDonnell Douglas DC-9-82, N312RC, Detroit Metropolitan/Wayne County Airport, Romulus, Michigan, August 16, 1987" (NTSB/AAR-88/05)

that accident, the Safety Board issued Safety Recommendation A-88-067 urging the FAA to:

> Require that all Part 121 and 135 operators and principal operations inspectors emphasize the importance of disciplined application of standard operating procedures and, in particular, emphasize rigorous adherence to prescribed checklist procedures.

On December 20, 1990, the FAA provided a response to this Safety Board recommendation, indicating that:

> The FAA ensures that all 14 CFR Parts 121 and 135 Operators and Principal Operations Inspectors emphasize the importance of disciplined application of standard operating procedures and the rigorous adherence to checklist procedures. On December 30, 1988, in response to this safety recommendation, the FAA issued Action Notice A8400.2 Normal Checklist Review, Parts 121 and 135 Operators, which required Principal Operations Inspectors to review the adequacy of checklists and the implementing procedures used by all 14 CFR Parts 121 and 135 operators. On February 22, 1988, the FAA published an NPRM to promulgate an SFAR that would improve air carrier training, evaluation, certification, and qualification requirements for appropriate evaluation. The SFAR was published on October 2, 1990.

On March 25, 1991, the FAA responded again to the safety recommendation, and referenced the Advanced Qualification Program (AQP) that was published on October 2, 1990. This AQP SFAR 58 (Special Federal Aviation Regulation) established an alternative method of traditional training programs and permitted certificate holders that were subject to the training requirements of 14 CFR Parts 121 and 135 to develop innovative training programs that incorporate most recent advances in training methods and techniques. The SFAR also established training programs for meeting the training, evaluation, certification, and qualification requirements for flight crewmembers, flight attendants, aircraft dispatchers, instructors, evaluators, and other operations personnel subject to the training requirements of 14 CFR Parts 121 and 135.

On March 27, 1992, the Safety Board classified Safety Recommendation A-88-067 "Closed--Acceptable Action."

Based on the circumstances of this accident, the Safety Board believes that the FAA should reiterate to its POIs the necessity for air carriers to adhere to standard operating procedures, placing particular emphasis on the importance of rigorous compliance with prescribed checklist procedures.

In addition, the Safety Board's investigation revealed that the 9-month-old in-lap infant who was held by her mother in seat 21C sustained fatal injuries during the impact sequence. The child's mother was unable to maintain a secure hold on the child during the impact sequence, and the child struck several seats. The Safety Board believes that if the child had been properly restrained in a child restraint system, she might not have sustained fatal injuries.

Following the DC-10 accident in Sioux City, Iowa, on July 19, 1989, the Safety Board issued Safety Recommendation A-90-78 to the FAA to revise 14 CFR Parts 91, 121, and 135 to require that all occupants be restrained during takeoff, landing, and turbulent conditions and that all infants and small children below the weight of 40 pounds and under the height of 40 inches be restrained in an approved child restraint system appropriate to their height and weight.[3] Additionally, the Safety Board issued Safety Recommendation A-90-79 urging the FAA to conduct research to determine the adequacy of aircraft seat belts to restrain children.

The FAA has conducted research into child restraint devices. In September 1994, the FAA's Office of Aviation Medicine, Civil Aeromedical Institute (CAMI) released a report entitled "The Performance of Child Restraint Devices in Transport Airplane Passenger Seats," It states, in part, that children 2 years of age, and currently required to be restrained by an adult lap belt, are not provided an adequate level of protection because the lap belt tension is not considered to be a snug fit when the belt is adjusted to its maximum length. The report also states that test results indicated that an anthropomorphic test dummy, representing a child 3 years of age and restrained by a lap belt, would be afforded adequate protection.

Further, CAMI conducted a series of dynamic tests on various types of child restraint systems, including booster seats, forward-facing carriers, aft-facing

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[3]See Aircraft Accident Report -- "United Airlines Flight 232, McDonnell Douglas DC-10-10, Sioux Gateway Airport, Sioux City, Iowa, July 19, 1989" (NTSB/AAR-90/06)

carriers, harness systems, belly belts, and normal seat belts. The report concluded that some of the child restraint systems "may not meet the expected levels of performance in an accident."

The Safety Board is satisfied with the FAA's action regarding the study of child restraint systems; thus, Safety Recommendation A-90-79 is classified "Closed--Acceptable Action." Also, because CAMI found that normal lap belts can provide acceptable restraints for 3-year-old children, the Safety Board finds that the 40 pounds, 40 inches standard used in Safety Recommendation A-90-78 has been superseded by the findings of the CAMI report. Since the FAA has not taken steps to require that all occupants be restrained during takeoff, the Safety Board now classifies Safety Recommendation A-90-78 as "Closed--Unacceptable Action/Superseded."

The Safety Board is disappointed with the FAA's inadequate actions regarding the required use of child restraint systems on transport category, air carrier flights. The Safety Board notes the increased use of integrated child restraint systems in automobiles, as well as the probable introduction of ISOFIX [standard child restraint system attachments that will be incorporated into the designs of automobiles]. Therefore, the Safety Board is concerned about possible future problems for parents who may not have the appropriate child restraint systems for aircraft use. Accordingly, the Safety Board believes that the FAA should develop standards for forward-facing, integrated child restraint systems to be used in aircraft. The Safety Board believes that the development of forward-facing, integrated child restraint systems for aircraft could correct some of the problems identified in the CAMI testing. The Safety Board also believes that small children traveling on aircraft should be provided crashworthiness protection that is at least equivalent to that provided to other passengers.

Therefore, as a result of its investigation of this accident, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Amend FAA Order, 7110.65, Air Traffic Control, Chapter 2, General Control, Section 9, Automatic Terminal Information Service (ATIS) Procedures, paragraph 2-141, Operating Procedures, to ensure that broadcasts are promptly updated whenever any conditions conducive to thunderstorms are observed. These conditions would include, but not be limited to, windshear, lightning, and rain. Additionally, require that controllers issue these

items until the information is broadcast on the ATIS and the pilots have acknowledged receipt of the information. (Class II, Priority Action) (A-95-40)

Amend FAA Order 7110.65, Air Traffic Control, Chapter 2, General Control, Section 6, Weather Information, paragraph 2-115, Reporting Weather Conditions, to require the tower supervisor to notify tower and radar approach control facility personnel, in addition to the National Weather Service observer, of the deterioration of prevailing visibility to less than 3 miles. Additionally, require the controllers to issue the visibility value to pilots until the information is broadcast on the ATIS and the pilots have acknowledged receipt of the information. (Class II, Priority Action) (A-95-41)

Amend FAA Order 7110.65, Chapter 2, Section 6, paragraph 2-113, to require radar and tower controllers to display (including on BRITE) the highest levels of precipitation, whether it is VIP level 1 or level 6, as depicted by ASR-9 radar, and issue the information to flightcrews. (Class II, Priority Action) (A-95-42)

Provide clear guidance to all air traffic controllers and supervisors that "blanket broadcasts" in the tower cab without receiving acknowledgments are unacceptable methods of communicating information, and require that all advisories, coordination, and pertinent information disseminated to controllers are acknowledged by the individual controller to ensure receipt of the information. (Class II, Priority Action) (A-95-43)

Require that the FAA record the precipitation levels detected by the ASR-9 radar system, and retain the information for use in the reconstruction of events during incident/accident investigations. (Class II, Priority Action) (A-95-44)

Develop and disseminate guidance and definitive standards to FAA inspectors to ensure a clearly identified system of checks and balances for FAA programs, such as "compliance through partnership," and provide the necessary training to ensure the

understanding of such programs. (Class II, Priority Action) (A-95-45)

Require that Principal Operations Inspectors (POIs) ensure that their respective air carrier(s) adhere to the company's operating procedures, and emphasize rigorous compliance to checklist procedures. (Class II, Priority Action) (A-95-46)

Review all low level windshear alert system (LLWAS) installations to identify possible deficiencies in performance, similar to those identified by the sheltered wind sensors at the Charlotte/Douglas International Airport, and correct such deficiencies to ensure optimum performance of the LLWAS. (Class II, Priority Action) (A-95-47)

In cooperation with the National Weather Service, re-evaluate the Central Weather Service Unit (CWSU) program and develop procedures to enable meteorologists to disseminate information about rapidly developing hazardous weather conditions, such as thunderstorms and low altitude windshear, to FAA TRACONs and tower facilities immediately upon detection. (Class II, Priority Action) (A-95-48)

Reevaluate the *Windshear Training Aid* based on the facts, conditions, and circumstances of this accident, with the view toward incorporating additional simulator training cues, such as scenarios in which no turbulence is encountered, before the onset of the actual windshear, and to include procedures for using the windshear escape maneuver, in lieu of a missed approach procedure, when the airplane is in the final approach phase (below 1,000 feet) and conditions conducive to windshear are present, regardless of whether the pilot encounters airspeed fluctuations or precipitation. (Class II, Priority Action) (A-95-49)

Develop standards for forward-facing, integrated child safety seats for transport category aircraft. (Class II, Priority Action) (A-95-50)

Revise 14 Code of Federal Regulations Parts 91, 135, and 121 to require that all occupants be restrained during takeoff, landing, and

turbulent conditions, and that all infants and small children be restrained in a manner appropriate to their size. (Class II, Priority Action) (A-95-51)

Also, the Safety Board issued Safety Recommendation A-95-52 to the National Weather Service, and A-95-53 through A-95-56 to USAir.

Chairman HALL, Vice Chairman FRANCIS, and Member HAMMERSCHMIDT concurred in these recommendations.

By: Jim Hall
Chairman