Aviation Safety Improvements: Advancing Safety Through Multiple Means

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**The views expressed in this paper are not those of the Safety Board and are not necessarily endorsed by the Safety Board.*

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After an aircraft accident occurs, safety issues are identified, and safety recommendations are issued to prevent future similar events. These recommendations identify specific actions for the most appropriate organization to take to resolve or mitigate the identified safety issues. As our investigations evolve, so too must our methods in addressing safety issues.

Overview of Aviation Safety Improvements

On September 17, 1908, the first powered airplane passenger fatality occurred. During a test flight for the US Army at Fort Myers, Virginia, a wooden propeller blade split, and pilot Orville Wright was unable to control the airplane (see figure 1). Lt. Thomas Selfridge sustained a skull fracture as a result of the accident and died hours later. Although aviation history has been full of amazing achievements, when accidents occur, industry pauses to investigate the circumstances and learn from these events. After the 1908 accident, US Army pilots were required to wear helmets to prevent

injuries similar to the one sustained by Lt. Selfridge. Even from these early days of aviation, the prevention of similar accidents through safety improvements was of primary importance.

Figure 1. 1908 Fort Myers, Virginia, Airplane Accident (US National Archives)

Title 49 *United States Code* 1131 authorizes the National Transportation Safety Board (NTSB) to investigate transportation accidents and "establish the facts, circumstances, and cause or probable cause." The NTSB may also issue safety recommendations aimed at preventing future similar accidents [1].

Safety recommendations are defined as a formal request issued as a result of investigations or safety studies. Recommendations address a specific issue identified during an investigation or a study and specify actions to correct the issue. Letters containing the recommendations are sent to the most appropriate public or private organization to address the safety issue. By regulation, the Federal Aviation Administration (FAA) is required to respond to NTSB recommendations. Since the NTSB's inception in 1967, the agency has issued 14,434 safety recommendations, with 5,561 aviation-related safety recommendations [2].

Once a response to a recommendation is received, the NTSB corresponds with the recommendation recipient until the recommended action (or an acceptable alternate action) is completed. However, in some cases, the recipient determines that it will not take any actions to address the identified safety issue. When this situation occurs, the NTSB cannot compel the recipient to take action regarding the recommendation because the NTSB is not a regulatory agency. All safety recommendations issued by the

NTSB and the related correspondence and classifications are available on the agency's website [3].

The NTSB typically issues safety recommendations at the conclusion of an investigation, but recommendations are issued sooner when warranted, especially if an urgent safety issue has been identified. Although the NTSB's safety recommendations have been the impetus for extensive aviation safety improvements, a formal recommendation is not always necessary or the most advantageous approach to improve aviation safety, especially if the public and industry call for improvements immediately after an accident. Other tools that the NTSB uses in resolving safety issues and preventing future accidents include safety accomplishments and safety results.

A safety accomplishment is defined as a positive measureable change within the transportation environment that is brought about through some direct action of an NTSB employee. Some safety issues identified during investigations, due to their nature, may be resolved through direct action of the entity involved. Through meetings and correspondence between the investigator and the entity, ideas for resolving the safety issue are identified and then acted on.

A safety result is defined as a positive change within the transportation environment that is brought about simply by the NTSB's investigation of an accident or incident. The investigator does not make a suggestion to improve safety because the affected party acts on its own to resolve the identified safety issue. A summary of each type of safety improvement used by the NTSB is shown in figure 2.

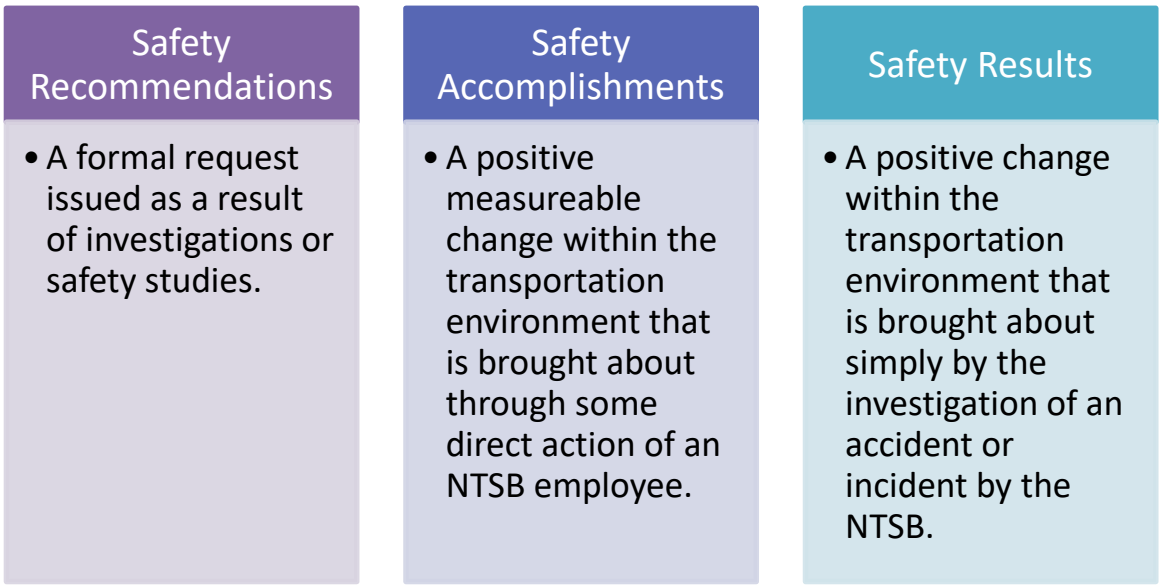

Figure 2. Types of safety improvements

The next section highlights three accidents in which the NTSB issued safety recommendations. These investigations also led to safety accomplishments or safety results.

Case Studies

UPS flight 1354, Birmingham, Alabama

On August 14, 2013, about 0447 central daylight time, UPS flight 1354, an Airbus A300-600, N155UP, crashed short of runway 18 during a localizer nonprecision approach to runway 18 at Birmingham-Shuttlesworth International Airport, Birmingham, Alabama [4]. The captain and the first officer were fatally injured. The airplane was destroyed by impact forces and postcrash fire (see figure 3). The scheduled cargo flight was operating under the provisions of 14 *Code of Federal Regulations* (*CFR*) Part 121 on an instrument flight rules flight plan. Dark night visual flight rules conditions prevailed at the airport, and variable instrument meteorological conditions with a variable ceiling were present north of the airport on the approach course at the time of the accident.

Figure 3. UPS Accident Site

The NTSB determined that the probable cause of the accident was the flight crew's continuation of an unstabilized approach and their failure to monitor the aircraft's altitude during the approach, which led to an inadvertent descent below the minimum approach altitude and subsequently into terrain. Contributing to the accident were (1) the flight crew's failure to properly configure and verify the flight management computer for the profile approach; (2) the captain's failure to communicate his

intentions to the first officer once it became apparent the vertical profile was not captured; (3) the flight crew's expectation that they would break out of the clouds at 1,000 feet above ground level due to incomplete weather information; (4) the first officer's failure to make the required minimums callouts; (5) the captain's performance deficiencies likely due to factors including, but not limited to, fatigue, distraction, or confusion, consistent with performance deficiencies exhibited during training; and (6) the first officer's fatigue due to acute sleep loss resulting from her ineffective off-duty time management and circadian factors.

As a result of the investigation, the NTSB made 15 recommendations to the FAA, 2 recommendations to UPS, 2 recommendations to the Independent Pilots Association, and 1 recommendation to Airbus. The safety recommendations to the FAA addressed areas related to fatigue, dispatcher training, operating procedures and training, the hazards of dive-and-drive approaches, the need to include information from the remarks section of aviation routine weather reports in automatic terminal information system (ATIS) reports, ground proximity warning system software updates, terrain awareness and warning system alerts and responses, and flight management computer programming. The safety recommendations issued to UPS and the Independent Pilots Association addressed fatigue reporting and assessment. The safety recommendation to Airbus addressed the need to provide a direct cue to flight crews when the flight management computer for applicable Airbus models is programmed incorrectly.

In addition to these safety recommendations, safety improvements were made outside of the formal safety recommendation process. The Birmingham airport authority and the Birmingham control tower replaced the emergency phone system and updated procedures to provide timely notification to emergency response personnel. Also, controllers received refresher training about entering remarks data into ATIS reports and updating those reports. Thus, the safety recommendations addressed the broad safety issues identified during the investigation, and the safety results implemented at the Birmingham airport and control tower addressed local procedures and training (see figure 4).

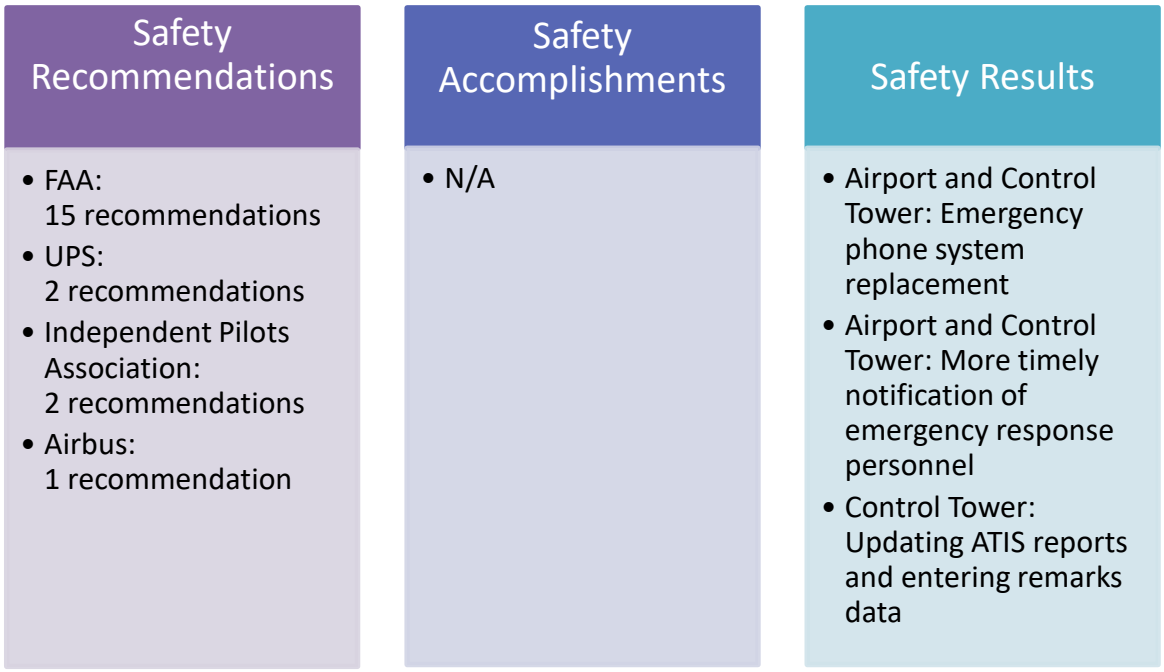

Figure 4. UPS Accident Safety Improvements

Sundance Helicopters, Las Vegas, Nevada

On December 7, 2011, about 1630 Pacific standard time, a Sundance Helicopters, Inc., Eurocopter AS350-B2 helicopter, N37SH, operating as a "twilight tour" sightseeing trip, crashed in mountainous terrain about 14 miles east of Las Vegas, Nevada [5]. The pilot and four passengers were fatally injured. The helicopter was destroyed by impact forces and postcrash fire (see figure 5). The helicopter was registered to and operated by Sundance Helicopters as a scheduled air tour flight under the provisions of 14 *CFR* Part 135. Visual meteorological conditions with good visibility and dusk light prevailed at the time of the accident, and the flight was operated under visual flight rules.

Figure 5. Sundance Helicopters Accident Site

The NTSB determined that the probable cause of the accident was Sundance Helicopters' inadequate maintenance of the helicopter, including (1) the improper reuse of a degraded self-locking nut, (2) the improper or lack of installation of a split pin, and (3) inadequate postmaintenance inspections, which resulted in the in-flight separation of the servo control input rod from the fore/aft servo and rendered the helicopter uncontrollable. Contributing to the improper or lack of installation of the split pin was the mechanic's fatigue and the lack of clearly delineated maintenance task steps to follow. Contributing to the inadequate postmaintenance inspection was the inspector's fatigue and the lack of clearly delineated inspection steps to follow.

As a result of the investigation, the NTSB issued three recommendations to the FAA. These recommendations addressed establishing duty-time regulations for maintenance personnel, implementing best practices for conducting maintenance under 14 *CFR* Parts 135 and 91 Subpart K, and human factors training for maintenance personnel.

During the investigation, several safety improvements were completed. Sundance Helicopters was a member of the Tour Operators Program of Safety (TOPS). Investigators determined that Sundance Helicopters did not meet the TOPS audit requirements but had successfully passed the audit. After discussions with the NTSB, TOPS formed a committee to evaluate its auditing process. TOPS then revised its audit

sampling procedures, added the revised information to its annual auditor training and orientation, and modified its audit-related checklists.

In addition, due to the maintenance errors and issues identified during the investigation, the NTSB worked with the FAA to (1) publish a general aviation maintenance alert on its website to highlight recent helicopter maintenance errors and (2) distribute the information through the FAA Safety Team (FAAST) e-mail registry. The NTSB also provided accident case study data related to maintenance errors that the FAAST included in its inspection authorization renewal training for mechanics.

Although the issues addressed in the safety recommendations could only be required through regulatory change, the safety accomplishments improved, in a timely manner, the TOPS audit for operators and distributed information to mechanics so that the lessons learned from the investigation could be available to a wide audience (see figure 6). Notably, the safety accomplishments had been completed before the NTSB's determination of the probable cause for this accident.

Figure 6. Sundance Helicopters Accident Safety Improvements

Empire Airlines flight 8284, Lubbock, Texas

On January 27, 2009, about 0437 central standard time, an Avions de Transport Régional Aerospatiale Alenia ATR 42-320, N902FX, operating as Empire Airlines flight 8284, crashed short of the runway while on an instrument approach to Lubbock Preston Smith International Airport, Lubbock, Texas [6]. The captain sustained serious injuries, and the first officer sustained minor injuries. The airplane was substantially

damaged (see figure 7). The airplane was registered to FedEx Corporation and was operated by Empire Airlines, Inc., as a 14 *CFR* Part 121 supplemental cargo flight. Instrument meteorological conditions prevailed at the time of the accident, and an instrument flight rules flight plan was filed.

Figure 7. Empire Airlines Accident Site

The NTSB determined that the probable cause of the accident was the flight crew's failure to monitor and maintain a minimum safe airspeed while executing an instrument approach in icing conditions, which resulted in an aerodynamic stall at low altitude. Contributing to the accident were (1) the flight crew's failure to follow published standard operating procedures in response to a flap anomaly, (2) the captain's decision to continue with the unstabilized approach, (3) the flight crew's poor crew resource management, and (4) fatigue due to the time of day during which the accident occurred and a cumulative sleep debt, which likely impaired the captain's performance.

As a result of the investigation, the NTSB issued nine recommendations to the FAA. These recommendations addressed improving first officer assertiveness, prohibiting operations in known freezing rain or freezing drizzle (unless the airplane manufacturer has demonstrated that the airplane model can safely operate in those conditions), flight training on the dangers of operating in freezing precipitation,

improving airport emergency response communications, ensuring airport emergency response access, retrofitting aircraft performance monitoring systems, annunciating flap asymmetries, developing minimum simulator model fidelity requirements for airplane ice accretion, and providing simulator training (once the simulator fidelity requirements are in place) for flight crews of all aircraft certificated for flight in icing conditions.

Numerous safety accomplishments resulted from the work of the investigative team. In the months after the accident, Empire Airlines issued training guidance on flap anomalies, issued flight bulletins addressing airspeed bugs and prohibitions on operating in freezing rain or freezing drizzle, and implemented special emphasis icing training. FedEx held a safety summit to its feeder operators to address the circumstances of this accident and facilitate improved training, developed "no-go" weather items that prohibit takeoff or landing operations in known or reported freezing rain or freezing drizzle, and installed ice evidence probes on all company ATR airplanes without such equipment. Also, in March 2010, the FAA issued Safety Alert for Operators (SAFO) 10006, "In-Flight Icing Operations and Training Recommendations," to encourage all operators to review and, if necessary, amend their flight crewmember and dispatcher training programs to ensure that the programs address supercooled large droplet (SLD) icing conditions.

The safety recommendations resulting from this accident addressed broad operational safety issues affecting all operators and airports, and the safety accomplishments addressed changes made by Empire Airlines and FedEx to prevent future similar events from occurring (see figure 8). Also, with the issuance of the SAFO, the FAA was able to educate and remind operators about SLD icing conditions. Similar to the safety accomplishments associated with the Sundance Helicopters' accident, these safety accomplishments were implemented before the completion of the accident investigation.

Figure 8. Empire Airlines Accident Safety Improvements

Conclusion

Potential safety improvements should be included in team discussions from the beginning of an investigation to ensure that the investigative team can resolve identified safety issues in a timely and an effective manner. This dialogue may also help the team develop unique solutions to complex safety issues and determine the best manner to collaborate with potential recipients on ways in which the safety issues could be addressed.

Documenting and sharing safety improvement information is another important aspect in improving aviation safety. Although official safety recommendations are well documented and tracked, comprehensive documentation of all related safety accomplishments and safety results is also needed. Safety improvement information is typically included in the NTSB's final report of an investigation, similar to the documentation of safety actions by other accident investigation boards. Such documentation provides those outside of the investigation with knowledge of the safety improvements that have occurred so that all interested parties may learn from the event.

Each safety improvement resulting from an investigation is important in preventing future accidents and incidents. Investigative agencies and teams should understand and consider the full array of safety improvement options and, based on the needs of the investigation, choose the most effective method for conveying this information to bring about the desired change. Whether a local change is instituted by an airport manager or a significant regulatory change is made within the industry, each safety improvement implemented is a step forward for aviation safety.

References

1. Safety recommendations are issued by the NTSB in accordance with sections 302 and 304(a)(3) of *Public Law* 93-633, the "Independent Safety Board Act of 1974," 49 *United States Code* 1116.
2. The safety recommendation information was retrieved on July 13, 2016.
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