Testimony of

Ms. Dana Schulze
Acting Director, Office of Aviation Safety
National Transportation Safety Board

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— On —

Status of Aviation Safety

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NTSB | National Transportation Safety Board

An Independent Federal Agency

Good morning, Chairman Larsen, Ranking Member Graves, and Members of the Subcommittee. Thank you for inviting the National Transportation Safety Board (NTSB) to testify before you today. I am the Acting Director of the Office of Aviation Safety within the NTSB.

The NTSB is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant accidents in other modes of transportation – highway, rail, marine, and pipeline. We determine the probable cause of the accidents we investigate, and we issue safety recommendations aimed at preventing future accidents. In addition, we conduct special transportation safety studies and special investigations and coordinate the resources of the federal government and other organizations to assist victims and their family members who have been impacted by major transportation disasters. The NTSB is not a regulatory agency – we do not promulgate operating standards nor do we certificate organizations and individuals. The goal of our work is to foster safety improvements, through formal and informal safety recommendations, for the traveling public.

We investigate all civil domestic air carrier, commuter, and air taxi accidents; general aviation accidents; and certain public-use aircraft accidents, amounting to approximately 1,400 investigations of accidents and incidents annually. We also participate in investigations of airline accidents and incidents in foreign countries that involve US carriers, US-manufactured or -designed equipment, or US-registered aircraft.

I would like to thank the committee for being a continued partner in safety. Last year, you addressed multiple NTSB safety recommendations in the *FAA Reauthorization Act of 2018*. Based on our investigations, the NTSB recommended applying second-class medical requirements to commercial balloon operators, requiring all rotorcraft to meet certain minimum crashworthiness requirements to protect fuel systems, and sufficiently marking and maintaining in a database all meteorological evaluation towers.[1] When Congress passed the *FAA Reauthorization Act of 2018* you required the Federal Aviation Administration (FAA) to close these safety gaps.[2]

This testimony will address the state of aviation safety from the NTSB's perspective and is based on our investigations. It will include a description of safety issues we have identified and recommendations we have made, and will conclude with a description of the work we are doing with emerging transportation technologies in aviation.

For the last decade, the US aviation system has experienced a record level of safety, and the number of US-registered civil aviation accidents has declined overall.[3] Deaths associated with US civil aviation accidents decreased from 539 in 2009 to preliminarily 401 in 2018. Nearly 92 percent of aviation fatalities in 2018 occurred in general aviation and non-commercial accidents, with the remainder primarily in Title 14 *Code of Federal Regulations* (*CFR*) Part 135 operations, which include charters, air taxis, and air medical services flights. Until 2018, there had been no passenger fatalities as a result of accidents involving US air carriers operating under the provisions

[1] National Transportation Safety Board, Safety Recommendations A-17-034, A-15-012, A-13-016, and A-13-017.
[2] Public Law 115-254.
[3] National Transportation Safety Board, 2017 preliminary aviation statistics. Accident data for calendar year 2018 are still being validated and have not yet been released.

of 14 *CFR* Part 121 since the crash of Colgan Air flight 3407 in 2009.[4] This unprecedented period of safety came to an end on April 17, 2018, when the Southwest Airlines Flight 1380 accident involving an uncontained engine failure resulted in a first passenger.[5] Over the last several decades, significant advances in technology, important legislative and regulatory changes, and more comprehensive crew training have contributed to the current level of aviation safety. However, we continue to see accidents and incidents that remind us of the need to be ever vigilant.

On February 4, 2019, we announced our Most Wanted List of Transportation Safety Improvements for 2019–2020.[6] This list identifies 10 focus areas for transportation safety improvements based on issues identified through our investigations. Many of the issues on the Most Wanted List address multimodal challenges for improving safety, including many that have been identified in some of our aviation accident investigations, such as alcohol and other drug impairment, distraction, occupant protection, fatigue, medical fitness, and safe shipment of hazardous materials.

Most Wanted List – Improve the Safety of Part 135 Flight Operations

On the Most Wanted List, one issue area is specific to aviation: improving the safety of Part 135 flight operations. Regardless of the purpose of the flight or the type of aircraft, all passenger-carrying flights should be safe. However, currently, air medical service, air taxi, charter, and on-demand operators are not required to meet some of the same safety requirements that have proven effective at enhancing the safety of commercial airline operations. On March 12, 2019, the NTSB issued three new safety recommendations and reiterated six previous safety recommendations to the FAA as a result of the investigation of an accident that occurred on May 15, 2017, in Teterboro, New Jersey.[7] In this accident, a Learjet 35A, operated by a Part 135 operator, Trans-Pacific Air Charter, departed controlled flight while on a circling approach to Teterboro Airport and impacted a commercial building and parking lot. The pilot-in-command and the second-in-command died; there were no passengers on the aircraft and no one on the ground was injured. While the aircraft was operating as a Part 91 positioning flight at the time of the accident, the accident raised concerns about the safety of Part 135 operations and the need for effective flight data monitoring (FDM) programs, safety management systems (SMS), procedures to identify pilots who do not comply with standard operating procedures, programs to address pilots with performance deficiencies, and the need for enhanced guidance for crew resource management training and leadership training for upgrading captains.

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[4] National Transportation Safety Board, *Loss of Control on Approach, Colgan Air, Inc., Operating as Continental Connection Flight 3407, Bombardier DHC 8 400, N200WQ*, Rpt. No. AAR-10/01 (Washington, DC: NTSB, 2012). In 2013, there were two fatal accidents involving nonscheduled cargo flights operating under Part 121—National Air Cargo crash after takeoff at Bagram Air Base, Afghanistan, and United Parcel Service flight 1354 crash during approach in Birmingham, Alabama.

[5] The Southwest Airlines flight 1380 investigation is ongoing. An investigative hearing was conducted on November 14, 2018.

[6] National Transportation Safety Board, *2019–2020 Most Wanted List*.

[7] National Transportation Safety Board, *Departure From Controlled Flight, Trans-Pacific Air Charter, LLC, Learjet 35A, N452DA, Teterboro, New Jersey (Abstract)*, Rpt. No. AAR-19/02 (Washington, DC: NTSB, 2019).

The safety issues identified in the Teterboro accident were not new; the NTSB had previously identified these issues and made recommendations to address FDM equipment and programs and SMS as a result of the investigation of the November 10, 2015, crash of Execuflight flight 1526 in Akron, Ohio.[8] The recommendations were reiterated following the October 26, 2016, crash of Ravn Connect flight 3153 in Togiak, Alaska, and again following the Teterboro accident.[9]

Since completing the investigation in Teterboro, New Jersey and issuing safety recommendations, the NTSB has initiated another 13 investigations into Part 135 accidents and incidents, of which five were fatal crashes – including the May 13 midair collision between two aircraft on sightseeing flights in Ketchikan, Alaska.[10] Further, there are cases of paying passengers aboard aircraft where the operation is exempt from Part 135, such as the June 21 crash of an Oahu Parachute Center skydiving flight in Mokuleia, Hawaii, where all 10 passengers and one crewmember were fatally injured, and the March 11, 2018, crash of a FlyNYON sightseeing flight in New York City where five passengers were fatally injured. Both flights were operating under Part 91.

A list of the safety recommendations we have made regarding Part 135 operations is appended to this testimony. Implementation of these and other recommendations could prevent or mitigate many of the Part 135 crashes that the NTSB investigates, and that is why "Improve the Safety of Part 135 Aircraft Operations" is included on the Most Wanted List.

Most Wanted List – Reduce Fatigue-Related Accidents

Fatigue is a pervasive problem in transportation that degrades a person's ability to stay awake, alert, and attentive to the demands of safely controlling a vehicle, vessel, aircraft, or train. By including "Reduce Fatigue-Related Accidents" on our Most Wanted List, we are calling for a comprehensive approach to combatting fatigue in transportation, focusing on research, education, and training; technology; sleep disorder treatment; hours-of-service regulations; and on- and off-duty scheduling policies and practices.

Over the last 20 years, the NTSB has investigated many air carrier accidents involving fatigued flight crews, including Colgan Air flight 3407. As a result of that investigation, we recommended that the FAA require operators to address fatigue risks associated with commuting.[11] The FAA's final rule for Fatigue Risk Management Plans for Part 121 Air Carriers did not address this recommendation. In 2006, we issued a safety recommendation to the FAA as a result of our investigation of the October 19, 2004, crash of Corporate Airlines Flight 5966 in Kirksville, Missouri, to "modify and simplify the flight crew hours-of-service regulations to take into consideration factors such as length of duty day, starting time, workload and other factors shown by recent research, scientific evidence, and current industry experience to affect crew

[8] National Transportation Safety Board, *Crash During Nonprecision Instrument Approach to Landing, Execuflight Flight 1526, British Aerospace HS 125-700A, N237WR*, Rpt. No. AAR 16/02 (Washington, DC: NTSB 2016).
[9] National Transportation Safety Board, *Collision with Terrain, Hageland Aviation Services, Inc., dba Ravn Connect Flight 3153, Cessna 208B, N208SD*, Rpt. No. AAR 18/02 (Washington, DC: NTSB 2018).
[10] See Appendix for list of open Part 135 investigations.
[11] National Transportation Safety Board, Safety Recommendation A-10-016.

alertness."[12] On January 4, 2012, the FAA published a final rule that prescribed new flight- and duty-time regulations for all flight crewmembers and certificate holders conducting passenger operations under Part 121, but excluded operators who conduct cargo operations.[13] The NTSB disagrees with this exclusion, as many of the fatigue-related accidents that we have investigated over the years involved cargo operators. We also believe that, because of the time of day that cargo operations typically occur, such operations are in greater need of these requirements. The NTSB believes that the FAA should include all Part 121 operations, including cargo operations, under these requirements.

Most Wanted List – Strengthen Occupant Protection

Seat belts and restraints reduce the risk of injury and death to pilots and passengers in the event of an accident. To minimize deaths and injuries, we must increase the use of existing restraint systems, otherwise preventable deaths will continue to occur. In 2011, we conducted a study on airbag performance in general aviation, which supported the idea that shoulder harnesses can reduce injury in an accident.[14] As a result of that study, we recommended that the FAA require that all general aviation airplanes be retrofitted with shoulder harnesses if they don't already have them. In 2013, the FAA reported that, because the economic burden on the general aviation community would outweigh any potential benefit, the agency would not mandate that aircraft manufactured before December 12, 1986, be retrofitted with shoulder harnesses or with a two-point inflatable lap restraint. The recommendation has been classified as "Closed – Unacceptable Action."[15]

This week marks the 30th anniversary of the United Airlines flight 232 crash in Sioux City, Iowa.[16] Of the 296 people on board the aircraft, 110 passengers and 1 flight attendant were fatally injured, and another 172 sustained varying degrees of injury. On this flight, there were four infant passengers; all were being held by adults, as instructed during preparation for the emergency landing. All the infants were injured, one fatally. Following this crash and another in 1994 in Charlotte, North Carolina, the NTSB recommended the FAA remove the exemption that allows for children to be lap-held on commercial aviation flights.[17] We issued similar recommendations again in 2010. These recommendations are all classified as "Closed – Unacceptable Action."[18] Children are safest when they are properly secured in a child safety seat in their own seat when flying.

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[12] National Transportation Safety Board, *Collision with Trees and Crash Short of the Runway, Corporate Airlines Flight 5966 BAE Systems BAE-J3201, N875JX Kirksville, Missouri*, Rpt. No. AAR-06/01 (Washington, DC: NTSB, 2006). National Transportation Safety Board, Safety Recommendation A-06-010.

[13] Federal Aviation Administration, *Flightcrew Member Duty and Rest Requirements*, 14 CFR Parts 117, 119, and 121.

[14] National Transportation Safety Board, *Airbag Performance in General Aviation Restraint Systems*, Rpt. No. SS-11/01 (Washington, DC: NTSB, 2011).

[15] National Transportation Safety Board, Safety Recommendation A-11-004.

[16] National Transportation Safety Board, *United Airlines Flight 232 McDonnell Douglas DC-10-10*, Rpt. No. AAR-90/06 (Washington, DC: NTSB, 1990).

[17] National Transportation Safety Board, *Flight into Terrain during Missed Approach USAir 1016, DC-9-31, N954VJ*, Rpt. No. AAR-95/03 (Washington, DC: NTSB 1995).

[18] National Transportation Safety Board, Safety Recommendation A-90-078, A-95-051, A-10-121, A-10-122, and A-10-123.

Airplane Evacuations

Additionally, even when occupants use appropriate restraints, deaths and injuries may still occur because of inadequate evacuation procedures. In many cases, otherwise survivable crashes turn fatal because occupants cannot evacuate before a postcrash fire consumes the aircraft. On October 28, 2016, American Airlines flight 383, bound for Miami, Florida, experienced a right engine uncontained failure and subsequent fire during takeoff at Chicago O'Hare International Airport.[19] The flight crew aborted the takeoff and stopped the aircraft on the runway, and an emergency evacuation was conducted. Of the 161 passengers and 9 crewmembers onboard, one passenger was seriously injured during the evacuation. A turbine disk in the right engine fractured into at least four pieces, with one piece going through the inboard section of the right wing, over the fuselage, and into a warehouse facility a half mile away. The airplane was substantially damaged by the fire, which was caused by a fuel leak from the right wing fuel tank that resulted in a pool of fire under the right wing.

We held a Board meeting on January 30, 2018, to determine the probable cause of the Chicago accident and to issue relevant safety recommendations. The Board determined that the failure was caused by an internal defect in a turbine disk, which was likely undetectable when the disk was manufactured in 1997 and during subsequent inspections. The investigation also found numerous problems with the evacuation, including a lack of communication between the flight deck and cabin crew, deviation by a flight attendant from emergency evacuation procedures, and the crew's lack of coordination following the evacuation. The Board adopted nine new recommendations – seven to the FAA and one each to Boeing and to American Airlines – and reiterated two recommendations to the FAA.

One of the recommendations to the FAA addresses passengers evacuating airplanes with carry-on baggage, which has been a recurring concern. Flight attendants are trained to instruct passengers not to evacuate with carry-on baggage because doing so could potentially slow the egress of passengers during an evacuation and block an exit during an emergency. In June 2000, we released a safety study on emergency evacuations of commercial airplanes, which found that passengers exiting with carry-on baggage were "the most frequently cited obstruction to evacuation."[20]

Video taken during the Chicago evacuation and postaccident interviews with flight attendants indicated that some passengers evacuated from all three usable exits with carry-on baggage. In one case, a flight attendant tried to take a bag away from a passenger who did not follow the instruction to evacuate without baggage, but the flight attendant realized that the struggle over the bag was prolonging the evacuation and allowed the passenger to take the bag. In another case, a passenger came to the left overwing exit with a bag and evacuated with it despite being instructed to leave the bag behind. In addition, videos from an evacuation due to a fire on a British Airways aircraft in Las Vegas on September 8, 2015, and a Dynamic International Airways

[19] National Transportation Safety Board, *Uncontained Engine Failure and Subsequent Fire, American Airlines Flight 383, Boeing 767-323, N345AN*, Rpt. No. AAR -18/01 (Washington, DC: NTSB 2018).
[20] National Transportation Safety Board, *Emergency Evacuation of Commercial Airplanes*, Rpt. No. SS-00/01, (Washington, DC: NTSB 2000).

aircraft in Fort Lauderdale on October 29, 2015, showed passengers evacuating with carry-on baggage despite the standard instruction to leave their baggage and similar items behind in the event of an emergency.[21]

Evidence of passengers retrieving carry-on baggage during recent emergency evacuations demonstrates that previous actions to mitigate this potential safety hazard have not been effective. As a result of the Chicago investigation, we recommended that the FAA (1) measure the potential delays associated with passengers retrieving and carrying baggage during an emergency evacuation and (2) determine the appropriate countermeasures to mitigate any related potential safety risks.[22]

We have also seen positive outcomes from implementing NTSB safety recommendations and successfully evacuating an aircraft post-accident. On March 8, 2017, a Boeing MD-83 overran a runway during a rejected takeoff in Ypsilanti, Michigan. Seconds after reaching the takeoff decision airspeed of 158 mph at about 5,000 feet down a 7,500-foot runway, the captain's attempt to raise the nose and get the plane airborne was unsuccessful due to an undetected mechanical malfunction of an elevator. The pilot called "abort." The airplane decelerated following the rejected takeoff but was traveling too fast to be stopped on the remaining runway. It departed the end of the runway at about 115 mph, traveled 950 feet across a runway safety area (RSA), struck an airport fence and came to rest after crossing a paved road. An evacuation was ordered. Flight attendants described that during the evacuation the passengers were incredibly calm and responsive, followed flight attendant directions, and did not take or attempt to take luggage or personal belongings with them. The 110 passengers and 6 flight crewmembers evacuated the airplane via emergency escape slides without any serious injuries.[23]

In Ypsilanti, the RSA likely contributed to the lack of serious injuries. In response to an NTSB recommendation, the FAA in 1999 began a national program to add RSAs to many commercial airports.[24] However, there are additional gaps in runway safety.

Additional Safety Issues

Runway safety

Around midnight on July 7, 2017, Air Canada flight 759 was cleared to land on runway 28R at San Francisco International Airport (SFO), but instead lined up on a parallel taxiway where four air carrier airplanes were awaiting takeoff clearance. Flight 759 descended below 100 feet above the ground, and the flight crew initiated a go-around about the time it overflew the first

[21] National Transportation Safety Board, Aviation Accident Final Report for accident number DCA15FA185.
[22] National Transportation Safety Board, Safety Recommendation A-18-009. Classified "Open – Acceptable Response."
[23] National Transportation Safety Board, *Runway Overrun During Rejected Takeoff Ameristar Air Cargo, Inc. dba Ameristar Charters, flight 9363 Boeing MD-83, N786TW Ypsilanti, Michigan March 8, 2017*, Rpt. No. AAR-19/01 (Washington, DC: NTSB 2001).
[24] National Transportation Safety Board, Safety Recommendation A-03-011. Classified "Closed – Acceptable Action."

airplane on the taxiway. The airplane reached a minimum altitude of about 60 feet and overflew the second airplane on the taxiway before starting to climb.[25]

We held a Board meeting on September 25, 2018, to determine the probable cause of the SFO incident and to issue relevant safety recommendations. The Board determined that the flight crew misidentified a taxiway as the intended landing runway, which resulted from the crewmembers' lack of awareness of the parallel runway closure due to their ineffective review of notice to airmen (NOTAM) information before the flight and during the approach briefing. Contributing to the incident were (1) the flight crew's failure to tune the instrument landing system frequency for backup lateral guidance, expectation bias, fatigue due to circadian disruption and length of continued wakefulness, and breakdowns in crew resource management, and (2) Air Canada's ineffective presentation of approach procedure and NOTAM information. The Board adopted six new recommendations to the FAA. These recommendations include developing and requiring technology to alert pilots and air traffic controllers when an airplane is not aligned with a runway surface.[26]

Lithium-ion Batteries

On July 28, 2011, a scheduled cargo flight from Incheon, Republic of Korea, to Shanghai, China, crashed into international waters. The Korean Aviation and Railway Accident Investigation Board (ARAIB) completed its investigation on July 24, 2015 and determined that the cause of this accident was a fire that developed on or near two pallets containing dangerous goods packages, including hybrid-electric vehicle lithium ion batteries and flammable liquids. The NTSB aided the ARAIB's investigation. Based on our participation, on February 9, 2016, we issued two recommendations to the Pipeline and Hazardous Materials Safety Administration (PHMSA) to (1) require the physical segregation of lithium batteries from flammable liquid cargo and (2) establish the maximum loading density of lithium batteries on board an aircraft. Both of these recommendations are classified as "Open – Acceptable Response."[27]

On June 3, 2016, a FedEx delivery truck was making its final delivery of four large, custom-designed, lithium-ion batteries to a Brampton, Ontario, Canada, address. The driver discovered that one of the large battery shipments contained a smoking package and, shortly after the discovery, the package burst into flames. The fire spread to the remaining packages in the cargo area and eventually destroyed the truck. The driver was not injured. The four batteries were designed and packaged by Braille Battery, Inc., and transported from their Florida facility on two FedEx cargo flights. They were then loaded onto the FedEx truck for final delivery when the incident occurred, 10 hours after they were offloaded from the second aircraft.

Although this fire occurred in Canada, we are investigating this incident because the shipment involved a US air carrier and included lithium-ion batteries that were presumably shipped in a configuration that would ensure safe shipment and containment of any battery failure. We

[25] National Transportation Safety Board, *Taxiway Overflight, Air Canada Flight 759, Airbus A320-211, C-FKCK, San Francisco, California, July 7, 2017*, Rpt. No. AIR-18/01, (Washington, DC: NTSB 2018).
[26] National Transportation Safety Board, Safety Recommendations A-18-025, A-18-026, and A-18-027.
[27] National Transportation Safety Board, Safety Recommendations A-16-001, A-16-002.

believe our investigative findings may have significant implications on current regulations addressing the safe transportation of lithium batteries.

International Aviation Accident Investigations

The NTSB participates in the investigation of aviation accidents and serious incidents outside the United States in accordance with the Chicago Convention of the International Civil Aviation Organization (ICAO) and the Standards and Recommended Practices (SARPS) provided in Annex 13 to the Convention.[28] If an accident or serious incident occurs in a foreign state involving a US-registered civil aircraft, US operator, or US-designed or -manufactured aircraft, and the foreign state is a signatory to the ICAO Convention, that state is responsible for the investigation and controls the release of all information regarding the investigation.[29]

In accordance with the ICAO Annex 13 SARPS, upon receiving a formal notification of the accident or serious incident that may involve significant issues, the NTSB may designate a US Accredited Representative and appoint technical advisors to assist the foreign investigation and facilitate the sharing of safety information. The advisors may include NTSB investigators with subject matter expertise, as well as others from US manufacturers, operators, and the FAA.

The following are the key objectives of our participation in international aviation accident investigations:

- Identify safety deficiencies affecting US aviation interests
- Capture safety lessons learned to prevent accidents in the US
- Facilitate credible and comprehensive accident investigations where US interests are concerned

Given the international nature of air transportation and the leading role the United States plays in developing aviation technology, our participation in foreign investigations is essential to enhancing aviation safety worldwide. In 2018, we appointed accredited representatives to 328 international investigations, and traveled to support work on 18 of those investigations.[30]

Boeing 737 MAX Investigations – Jakarta, Indonesia, and Addis Ababa, Ethiopia

On October 29, 2018, a Boeing 737 MAX 8, operated by Lion Air, crashed into the Java Sea shortly after takeoff from Soekarno-Hatta International Airport, in Jakarta, Indonesia, killing all 189 passengers and crew on board. The Komite Nasional Keselamatan Transportasi (KNKT) of Indonesia, who is leading the investigation, released a preliminary report on the accident on

[28] ICAO is a UN specialized agency that manages the administration and governance of the Convention on International Civil Aviation (Chicago Convention), (https://www.icao.int/about-icao/Pages/default.aspx).
[29] There are 193 Member States of ICAO, including both Indonesia and Ethiopia, (https://www.icao.int/MemberStates/Member%20States.English.pdf).
[30] The NTSB appointed an accredited representative to 206 accidents, 98 incidents, and 24 other safety-related occurrences in 2018. NTSB traveled in support of 9 of these accidents and 9 of the incidents.

November 27, 2018.[31] On March 10, 2019, a Boeing 737 MAX 8, operated by Ethiopian Airlines, crashed after takeoff from Addis Ababa Bole International Airport in Ethiopia, killing all 157 passengers and crew, including 8 American citizens. The investigation is being led by the Ethiopia Accident Investigation Bureau (AIB), which released a preliminary report on April 4, 2019.[32]

Because the MAX 8 was designed and manufactured in the United States, in accordance with ICAO Annex 13, the United States is afforded the right to participate in both investigations. Accordingly, the NTSB appointed accredited representatives to assist in both ongoing investigations.

Following last year's Lion Air crash, the NTSB immediately dispatched investigators to Indonesia to participate in the Indonesian government's investigation. An NTSB investigator was stationed onboard one of the search vessels during the search for the critical "black boxes" – the flight data recorder (FDR) and cockpit voice recorder (CVR). When the CVR was recovered on January 14, 2019, the NTSB recalled four investigators from furlough (due to the partial government shutdown) to assist with properly transcribing the recorder's content.[33]

In response to the Ethiopian Airlines crash, an NTSB team of investigators was dispatched to Ethiopia. Once the recovered recorders were sent to the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile, we sent recorder, flight crew operations, and human factors investigators to France to assist with downloading and reading out the recorders' contents.

In accordance with ICAO Annex 13, technical advisors from the FAA, Boeing, and General Electric have accompanied NTSB investigators to the Lion Air and Ethiopian Airlines accident sites to provide their specialized technical knowledge regarding the aircraft and its systems.

Although the NTSB is actively involved in these investigations, ICAO Annex 13 requires that, as the states of occurrence, Indonesia and Ethiopia are responsible for leading their respective investigations. As such, they control the release of all investigative information to the public related to those accidents. Annex 13 provides for other involved states to gain timely access to investigative information for the purposes of continued operational safety. As a result, NTSB participation in foreign accident investigations enables safety deficiencies to be promptly addressed by the FAA, the manufacturer, or the operator, as well as others deemed appropriate, and through NTSB safety recommendations, when needed. Because the United States is the state of design and certification of the aircraft involved in these accidents, we are examining relevant factors in the US design certification process to ensure any deficiencies are captured and addressed, including by NTSB safety recommendations, if necessary.

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[31] Komite Nasional Keselamatan Transportasi, Preliminary Report No. KNKT.18.10.35.04.

[32] Ethiopia Accident Investigation Bureau, Report No. AI-01/19.

[33] Due to a lapse of appropriations from December 22, 2018, through January 25, 2019, the NTSB furloughed all investigative staff. In accordance with the provisions of the Anti-Deficiency Act (including sections 1341(a)(1)(B) and 1342 of Title 31, *United States Code*), allowable agency functions were limited to those where "failure to perform those functions would result in an imminent threat to the safety of human life or the protection of property." Due to the potential safety issues associated with the Lion Air crash, the NTSB responded by recalling four investigative staff from furlough to participate in the CVR readout.

Emerging Transportation Technologies

Advances in technology are transforming transportation and hold promise for improving transportation safety, but they also pose new challenges. Among those advancing technologies are commercial space transportation and unmanned aircraft systems (UASs).

Commercial Space

We have been involved in commercial space accident investigations for over 25 years, since leading the investigation of a procedural anomaly associated with the launch of an Orbital Sciences Corporation Pegasus expendable launch vehicle in 1993.[34] Most recently, we led the investigation of the fatal in-flight breakup of SpaceShipTwo in October 2014.[35] Foremost among the safety issues identified in the 2014 accident was the need to consider and protect against human error for safe manned spaceflight, which is the responsibility of designers, operators, and regulators. We made recommendations to the FAA and the commercial spaceflight industry to establish human factors guidance for commercial space operators and to strengthen the FAA's evaluation process for experimental permit applications by promoting stronger collaboration between FAA technical staff and commercial space vehicle operators.

Our work in commercial space transportation supports our broader mission of improving transportation safety through investigating accidents and serious incidents, collaborating with others to conduct outreach and education related to commercial space vehicles, and developing and disseminating accident investigation techniques in commercial space within the international community. To develop and maintain the necessary investigative expertise and tools in this emerging segment of transportation, we are focused on training for NTSB staff and continuing outreach with commercial space stakeholders.

Unmanned Aircraft Systems

The growing number of UASs and reports of near-collisions with manned aircraft have raised safety concerns regarding UAS integration into the national airspace system. In August 2010, we revised our 14 *CFR* Part 830 regulations to indicate that accident and incident notification requirements also apply to unmanned aircraft.[36] An advisory to operators was released in July 2016 clarifying the reporting requirements (i.e., if there is death or serious injury, the aircraft weighs more than 300 pounds and sustains substantial damage, or other specific serious incidents occur).[37]

On September 21, 2017, the pilot of a US Army UH-60 helicopter reported an in-flight collision with a small UAS just east of Midland Beach, Staten Island, New York. The helicopter sustained damage to its main rotor blade, window frame, and transmission deck. We determined

[34] National Transportation Safety Board, *Commercial Space Launch Incident, Launch Procedure Anomaly, Orbital Sciences Corporation, Pegaus/SCD-1*, Rpt. No. SIR 93/02 (Washington, DC: NTSB 1993).
[35] National Transportation Safety Board. *In-Flight Breakup During Test Flight, Scaled Composites SpaceShipTwo, N339SS, Near Koehn Dry Lake, California, October 31, 2014*, Rpt. No. AAR 15/02 (Washington, DC: NTSB 2015).
[36] 49 CFR § 830.2 (2010).
[37] National Transportation Safety Board, *Advisory to Operators of Civil Unmanned Aircraft Systems in the United States*, July 29, 2016.

that the probable cause of the incident was the failure of the UAS pilot to see and avoid the helicopter due to his intentional flight beyond visual line of sight. Contributing to the incident was the UAS pilot's incomplete knowledge of regulations and safe operating practices.[38] As the number and complexity of UAS operations continues to grow, it is inevitable that the number of NTSB UAS investigations will also increase.

We are also using UASs as an accident investigation tool in all modes. The NTSB appreciates this Committee's and Congress' support of a provision in our 2018 reauthorization that authorized the agency to acquire small UASs for investigative purposes.[39] UASs are rapidly becoming a standard tool in the domestic and international accident investigation community. Small UASs can be very rapidly deployed, which allows wreckage fields to be documented quickly and thoroughly when the accident area must be cleared expeditiously for safety or operational purposes. In addition, small UASs can access unique points of view useful to the investigator as well as areas otherwise inaccessible. Data collected is shared immediately within the investigative process, allowing investigators, managers, and support staff in distant locations instant access to accident site information in order to help focus the investigation on critical aspects of the accident.

Conclusion

Over the last decade, general aviation safety has improved and commercial aviation accidents have become exceedingly rare. However, while accidents and incidents still occur, there will always be room for improvement. The NTSB and staff stand ready to work with the Committee to continue improving the safety of our nation's aviation system for all users.

Thank you again for the opportunity to be here today to discuss the work that the NTSB is doing to make transportation safer. I am happy to answer any questions.

[38] National Transportation Safety Board, Inflight collision of UAS and helicopter, Staten Island, NY.
[39] 49 USC § 1113(b)(1)(J) (2018).

Appendix to NTSB's Testimony Concerning Aviation Safety

Ongoing Major Part 121 Investigations (as of July 8, 2019)

- Southwest Flight 1380 engine failure, Philadelphia, Pennsylvania, April 17, 2018, one fatality, eight injuries
- Atlas Air Flight 3591 crash, Baytown, Texas, February 23, 2019, three fatalities
- Miami Air Flight 293 departed runway, Jacksonville, Florida, May 3, 2019, no serious injuries
- United Airlines Flight 4933 missed runway, Presque Isle, Maine, March 4, 2019, three minor injuries

Ongoing Major Part 135 investigations (as of July 8, 2019)

- Taquan Air scheduled commuter flight crash, Metlakatla, Alaska, May 20, 2019, two fatalities
- Mid-air collision of sightseeing flights, Ketchikan, Alaska, May 13, 2019, six fatalities and nine serious injuries
- Novictor Aviation sightseeing flight crash, Kailua, Hawaii, April 29, 2019, three fatalities
- K2 Aviation sightseeing flight crash, Talkeetna, Alaska, August 4, 2018, five fatalities

Ongoing Major Part 91 investigations with paying passengers (as of July 8, 2019*)*

- Oahu Parachute Center skydiving flight crash, Mokuleia, Hawaii, June 21, 2019, 11 fatalities
- The Jumping Place Skydiving Center skydiving flight crash, Swainsboro, Georgia, August 25, 2018, four fatalities
- FlyNYON sightseeing flight crash, New York City, New York, March 11, 2018, five fatalities, one injury

Safety Recommendations to the Federal Aviation Administration on the Most Wanted List – Improve Safety of Part 135 Flight Operations (as of July 8, 2019)

Number	Date Issued	Status	Safety Recommendation
A-07-018	2/27/07	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: In cooperation with Hawaii commercial air tour operators, aviation psychologists, and meteorologists, among others, develop a cue-based training program for commercial air tour pilots in Hawaii that specifically addresses hazardous aspects of local weather phenomena and in-flight decision-making.
A-07-019	2/27/07	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Once a cue-based training program that specifically addresses hazardous aspects of local weather phenomena and weather-related, decision-making issues is developed (as requested in Safety Recommendation A-07-18), require all commercial air tour operators in Hawaii to provide this training to newly hired pilots.

A-07-112	12/21/07	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Ensure that the minimum equipment lists for helicopters used in helicopter emergency medical services operations require that radar altimeters be operable during flights conducted at night.
A-09-092	9/24/09	Closed - Acceptable Action	TO THE FEDERAL AVIATION ADMINISTRATION: Permit the helicopter emergency medical services (HEMS) Aviation Digital Data Service Weather Tool to be used by HEMS operators as an official weather product.
A-10-029	2/23/10	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Require 14 Code of Federal Regulations Part 121, 135, and 91K operators to (1) routinely download and analyze all available sources of safety information, as part of their flight operational quality assurance program, to identify deviations from established norms and procedures; (2) provide appropriate protections to ensure the confidentiality of the deidentified aggregate data; and (3) ensure that this information is used for safety-related and not punitive purposes.
A-13-012	5/6/13	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Require the installation of a crash-resistant flight recorder system on all newly manufactured turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a flight data recorder and a cockpit voice recorder and are operating under 14 Code of Federal Regulations Parts 91, 121, or 135. The crash-resistant flight recorder system should record cockpit audio and images with a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all as specified in Technical Standard Order C197, "Information Collection and Monitoring Systems."
A-13-013	5/6/13	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a flight data recorder or cockpit voice recorder and are operating under 14 Code of Federal Regulations Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio and images with a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all as specified in Technical Standard Order C197, "Information Collection and Monitoring Systems."
A-15-007	1/22/15	Open - Unacceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Require that all existing aircraft operated under Title 14 Code of Federal Regulations (CFR) Part 121 or 135 and currently required to have a cockpit voice recorder and a flight data recorder be retrofitted with a crash-protected cockpit image

			recording system compliant with Technical Standard Order TSO-C176a, “Cockpit Image Recorder Equipment,” TSO-C176a or equivalent. The cockpit image recorder should be equipped with an independent power source consistent with that required for cockpit voice recorders in 14 CFR 25.1457. (Supersedes Safety Recommendation A-00-30)
A-15-008	1/22/15	Open - Unacceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Require that all newly manufactured aircraft operated under Title 14 Code of Federal Regulations (CFR) Part 121 or 135 and required to have a cockpit voice recorder and a flight data recorder also be equipped with a crash-protected cockpit image recording system compliant with Technical Standard Order TSO-C176a, “Cockpit Image Recorder Equipment,” or equivalent. The cockpit image recorder should be equipped with an independent power source consistent with that required for cockpit voice recorders in 14 CFR 25.1457. (Supersedes Safety Recommendation A-00-31)
A-16-034	11/7/16	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Require all 14 Code of Federal Regulations Part 135 operators to install flight data recording devices capable of supporting a flight data monitoring program.
A-16-035	11/7/16	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: After the action in Safety Recommendation A-16-34 is completed, require all 14 Code of Federal Regulations Part 135 operators to establish a structured flight data monitoring program that reviews all available data sources to identify deviations from established norms and procedures and other potential safety issues.
A-16-036	11/7/16	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Require all 14 Code of Federal Regulations Part 135 operators to establish safety management system programs.
A-17-035	5/9/17	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Implement ways to provide effective terrain awareness and warning system (TAWS) protections while mitigating nuisance alerts for single-engine airplanes operated under 14 Code of Federal Regulations Part 135 that frequently operate at altitudes below their respective TAWS class design alerting threshold.
A-17-037	5/9/17	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Work with members of the Ketchikan air tour industry to improve existing training programs aimed at reducing the risk of weather-related accidents involving continuation of flight under visual flight rules into instrument meteorological conditions, with special attention paid to the human factors issues identified in this investigation, including (1) the need to help pilots better calibrate what constitutes safe weather conditions to conduct flights based on objective standards and requirements, such as

			set criteria for what landmarks must be clearly visible from which locations in order to proceed on a particular route; (2) the need to help pilots who are new to the area recognize dynamic local weather patterns that can place them in a dangerous situation; and (3) operational influences on pilot decision-making.
A-17-038	5/9/17	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Expand the application of Federal Aviation Administration Order 8900.1, volume 3, chapter 19, section 6, "Safety Assurance System: Flight Training Curriculum Segments," paragraphs 3-1251(B) and 3-1252, which address controlled flight into terrain-avoidance training programs for 14 Code of Federal Regulations (CFR) Part 135 helicopter operations, to all 14 CFR Part 135 operations.
A-17-042	5/9/17	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Analyze automatic dependent surveillance-broadcast data from Ketchikan air tour operations on an ongoing basis and meet annually with Ketchikan air tour operators to engage in a nonpunitive discussion of any operational hazards reflected in the data and collaborate on mitigation strategies for any hazards identified.
A-17-043	5/9/17	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Develop and implement special operating rules for the Ketchikan air tour industry that include en route visual flight rules weather minimums that are tailored to the industry's unique requirements and are more conservative than those specified in 14 Code of Federal Regulations Part 135.
A-18-013	4/26/18	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Although controlled flight into terrain (CFIT)-avoidance training programs are not required by federal regulation for Title 14 Code of Federal Regulations Part 135 fixed-wing operations, work with Part 135 operators in Alaska to improve any voluntarily implemented training programs aimed at reducing the risk of CFIT accidents involving continuation of flight under visual flight rules (VFR) into instrument meteorological conditions, with special attention paid to the human factors issues identified in recent Alaska accident investigations, including, but not limited to, (1) the challenges of flying in mountainous terrain in Alaska and low-altitude VFR flight in an area subject to rapid changes in weather; and (2) limitations of the Alaska infrastructure, particularly weather observations, communications, and navigation aids.
A-18-014	4/26/18	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Work with Title 14 Code of Federal Regulations Part 135 certificate holders that operate under visual flight rules in the aircraft's required terrain awareness and warning system (TAWS) class to

			(1) ensure that management and pilots are aware of the risks associated with distraction (from continuous nuisance alerts) and complacency (brought about by routine use of the terrain inhibit feature); (2) develop plans for mitigating those risks and minimizing nuisance alerts; and (3) develop procedures that specifically address when pilots should test, inhibit, and uninhibit the TAWS alerts, considering the operator's typical operations and the TAWS manufacturer's guidance.
A-18-016	4/26/18	Open - Await Response	TO THE FEDERAL AVIATION ADMINISTRATION: Install communications equipment throughout Alaska, after determining what would be most effective, to allow increased access to the instrument flight rules system, giving priority to those areas used by Title 14 Code of Federal Regulations Part 135 operators.
A-18-017	4/26/18	Open - Await Response	TO THE FEDERAL AVIATION ADMINISTRATION: Ensure that Alaska airports that are served by Title 14 Code of Federal Regulations (CFR) Part 135 operators and have instrument approaches are equipped with weather-reporting capabilities to enable instrument flight rules operations in accordance with 14 CFR 135.225(a).

Safety Recommendations to the Federal Aviation Administration on the Most Wanted List – Reduce Fatigue Related Accidents (as of July 8, 2019)

Number	Date Issued	Status	Safety Recommendation
A-13-003	3/1/13	Open - Acceptable Alternate Response	TO THE FEDERAL AVIATION ADMINISTRATION: Require that personnel performing maintenance or inspections under 14 Code of Federal Regulations Parts 121, 135, 145, and 91 Subpart K receive initial and recurrent training on human factors affecting maintenance that includes a review of the causes of human error, including fatigue, its effects on performance, and actions individuals can take to prevent the development of fatigue.
A-14-072	9/25/14	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Require principal operations inspectors to ensure that operators with flight crews performing 14 Code of Federal Regulations Part 121, 135, and 91 subpart K overnight operations brief the threat of fatigue before each departure, particularly those occurring during the window of circadian low.
A-94-194	11/30/94	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Revise the Federal Aviation Regulations contained in 14 CFR Part 135 to require that pilot flight time accumulated in all company flying conducted after revenue operations-such as training and check flights, ferry flights and repositioning flights-be included in the

			crewmember's total flight time accrued during revenue operations.
A-95-113	11/14/95	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Finalize the review of current flight and duty time regulations and revise the regulations, as necessary, within 1 year to ensure that flight and duty time limitations take into consideration research findings in fatigue and sleep issues. The new regulations should prohibit air carriers from assigning flight crews to flights conducted under 14 Code of Federal Regulations (CFR) Part 91 unless the flight crews meet the flight and duty time limitations of 14 CFR Part 121 or other appropriate regulations.

Safety Recommendations to the Federal Aviation Administration on the Most Wanted List – Increase Occupant Protection (as of July 8, 2019)

Number	Date Issued	Overall Status	Safety Recommendation
A-15-012	7/23/15	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Require, for all newly manufactured rotorcraft regardless of the design's original certification date, that the fuel systems meet the crashworthiness requirements of 14 Code of Federal Regulations 27.952 or 29.952, "Fuel System Crash Resistance."
A-16-025	10/6/16	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Require 14 Code of Federal Regulations Part 121 operators to provide (1) guidance that instructs flight attendants to remain at their assigned exits and actively monitor exit availability in all non-normal situations in case an evacuation is necessary and (2) flight attendant training programs that include scenarios requiring crew coordination regarding active monitoring of exit availability and evacuating after a significant event that involves a loss of communications.
A-16-026	10/6/16	Open - Unacceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Develop best practices related to evacuation communication, coordination, and decision-making during emergencies through the establishment of an industry working group and then issue guidance for 14 Code of Federal Regulations Part 121 air carriers to use to improve flight and cabin crew performance during evacuations.
A-18-009	2/6/18	Open - Acceptable Response	TO THE FEDERAL AVIATION ADMINISTRATION: Conduct research to (1) measure and evaluate the effects of carry-on baggage on passenger deplaning times and safety during an emergency evacuation and (2) identify effective countermeasures to reduce any determined risks, and implement the countermeasures.