FORUM

ISASI

Air Safety Through Investigation

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Corporate ISASI member JetBlue's first A321neo LR leaves Airbus at Hamburg Finkenwerder Airport in late April 2021 bound for John F. Kennedy International Airport (JFK). The aircraft will be put into operation for the airline's new extended-range twin-engine operational performance standards (ETOPS) service between JFK in New York and Heathrow Airport in England. Photo courtesy of JetBlue.

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AIR SAFETY INVESTIGATORS
INCORPORATED AUGUST 31, 1964

PRESIDENT'S VIEW

> "I am confident that ISASI will survive this difficult period and remain an effective defender of flight safety throughout the world—and, maybe, even beyond our world as commercial and perhaps general aviation flight reach from Earth into space."

During the beginning of August, I sent all ISASI members an e-mail newsletter with reports of the recent activities of ISASI and our national and regional councils and chapters. If you did not receive it, then ISASI does not have your correct e-mail address. The newsletter is also posted to the ISASI website. By the time you read this "President's View" we will have had our virtual annual conference, which I will discuss in more detail in the next *Forum*. The ISASI International Council meeting was held virtually before ISASI 2021 to conduct the Society's business, including reviewing and finalizing ISASI's budget for 2022 and discussing possible sites for the 2023 seminar. The International Council reviewed activity reports from national and regional societies, chapters, committees, and working groups. Resolutions brought before the International Council were considered and acted upon. A recent bylaw change, approved by ISASI members, establishes that the International Council meeting minutes will be posted to the ISASI website within 60 days of their approval.

I hope, as I am preparing this column, that you were able to attend ISASI 2021 and that you found participation worthwhile. Even if you were not able to "attend" the conference, the sessions were taped and will be available to registered participants for 60 days following ISASI 2021. I also hope that ISASI 2022 in Brisbane, Australia, will be in person. Although the ISASI 2021 host committee prepared an interesting program with a lively format and thoroughly tested the virtual technology that many national and regional ISASI societies have used successfully, I personally miss the camaraderie and face-to-face contact that we cannot completely duplicate sitting in front of a computer screen. Keeping all of us as safe as possible while continuing our professional advancement through presentations and networking is essential to our careers and to all who rely on us to promote global flight safety. Nothing less is acceptable.

Even though aircraft of all sizes and purposes are returning to flight, the world is still reeling from COVID-19 and now variants that are more virulent, contagious, and adapting to our efforts to fight back. Many people in too many parts of the world are still unable to obtain vaccines, and we are not able to inoculate enough people to slow the virus and its evolving forms from spreading.

International travel is still restricted with no end in sight. And speaking of staying safe—ISASI members who must travel by air to investigation sites should take every possible precaution to be safe aboard an aircraft. There have been far too many recent incidents of unruly passengers disrupting cabin procedures, assaulting airline personnel, and endangering everyone around them. I am confident that ISASI will survive this difficult period and remain an effective defender of flight safety throughout the world—and, maybe, even beyond our world as commercial and perhaps general aviation flight reach from Earth into space. New individual members are joining the Society to mitigate some of the membership losses due to the COVID-induced global economic downturn, and recently the Far East University, Department of Aviation Safety Management (Korea) signed up as a corporate member.

After serving on the National Transportation Safety Board for 15 years with the last four years as chairman, ISASI member Robert Sumwalt recently retired. Robert participated in the Air Line Pilots Association's safety structure for many years and was a captain with US Airways. He was a well-received keynote speaker during several ISASI seminars and Mid-Atlantic Regional Chapter meetings. President Joe Biden nominated and the Senate has confirmed former Capitol Hill staffer and board member Jennifer Homendy as the next NTSB chair. There is also a new International Civil Aviation Organization (ICAO) secretary general. Juan Carlos Salazar, previously director general of civil aviation in Colombia, was recently appointed to the ICAO position for a three-year term. And regarding the David King appointment announcement in my last "President's View," David is a member of the ISASI Awards Committee, not the Kapustin Scholarship Committee.

Stay safe. ◆

Frank Del Gandio
ISASI President

The Head Injury Criteria And Future Accident Investigations

By Jan M. Davies, Professor of Anesthesiology, Perioperative, and Pain Medicine, Cumming School of Medicine and Adjunct Professor of Psychology, Faculty of Arts, University of Calgary, IBRACE (International Board for Research into Aircraft Crash Events) Chair, and ISASI Associate Member; W.A. Wallace, Professor Emeritus, University of Nottingham, UK; C.L. Colton, Professor Emeritus, University of Nottingham, UK; O. Tomlin, Engineering Director, GRM Consulting Ltd, UK; and A.R. Payne, Crashworthiness Engineer, Ret., UK

(Adapted with permission from the authors' technical paper The Head Injury Criteria and Future Accident Investigations *presented during ISASI 2019, Sept. 3-5, 2019, in The Hague, the Netherlands. The theme for ISASI 2019 was "Future Safety: Has the Past Become Irrelevant?" The full presentation can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)*

As we look back at ISASI's first 50 years, we remember the numerous investigations carried out during that period by its members and others, as well as more distant investigations. The first ISASI seminar was held in 1969, a busy year for accident investigators, with at least 50 accidents involving commercial passenger aircraft.

Previous Investigations

Some 61 years before that, Orville Wright undertook a demonstration flight at Fort Myer, Virginia, with Lieutenant Thomas E. Selfridge as a passenger. Selfridge was also a pilot and aircraft designer, as well as a passenger on the "first recorded passenger flight of any heavier-than-air craft in Canada" and the "first U.S. military officer to pilot a modern aircraft."

At a quarter past five in the afternoon of Sept. 17, 1908, Wright and Selfridge were on their fifth circuit of the Fort Myer base and at an altitude of about 150 feet when they heard two loud thumps: the righthand propellor broke off. The plane lost thrust and Wright shut off the engine, gliding down to about 75 feet. A vibration was felt. Part of the propeller hit a guy-wire that braced the rear vertical rudder, which then swiveled to horizontal. Wright lost control of the plane, which nose-dived into the ground. Both pilot and passenger were entangled "in a twisted mess of wood, wire, and cloth."

Wright was rescued first and was carried by stretcher to the base's hospital, while efforts continued to extricate Selfridge from the wreckage. Sadly, Selfridge died some hours later. Following Selfridge's extrication from the wreckage, what remained of the aircraft was moved to a large balloon hangar. During his seven-week hospitalization, Wright investigated the crash, having his two assistants bring pieces of the wreckage to him. He was able to find the cause of the accident and to explain his conclusions to the Army. (His was, in a way, also the first investigation of a passenger fatality.) The investigation led to safety recommendations and changes to the next Wright aircraft, using the 35-horsepower engine salvaged from the wreckage and shortening the wings by two feet.

Since that accident in 1908, investigations themselves have changed. No longer is the pilot who flew the craft the principal investigator, and formal additions have been made to investigation guidelines and protocols, one of the latest being cabin safety investigations.

Survivability

Many investigations have resulted in aircraft design improvements, some of which have contributed to increased crashworthiness, or how well an aircraft protects its cabin occupants in the event of an accident. This requires that crash forces remain below human tolerance limits and that the onboard environment provides a livable volume.

A "survivable" accident is defined as one "where there were one or more survivors or there was potential for survival." However, a survivable crash does not mean that all passengers and crew will actually survive the accident. Factors that determine passengers' and crews' survival include the container, the restraint system, the environment, energy absorption and postcrash conditions (CREEP). Of these five factors, the second, third, and fourth can be affected by the design and subsequent testing of new aircraft cabin interiors. The latter are bound by regulations developed by the European Union Aviation Safety Agency (EASA) and the Federal Aviation Administration (FAA), among others.

One of the earliest accident investigations for survivability factors was that of National Airlines Flight 101 on Feb. 11, 1952. In that accident, a DC-6 crashed shortly after takeoff from Newark Airport in New Jersey. The pilots were unable to return to the airport, and the plane, while in a partially controlled descent, hit the roof of a low-rise apartment, skidded, and landed on the ground at about 140 miles per hour at an angle of 10–15 degrees nose down. The airplane bounced, cartwheeled, and broke into three main parts. The front section of the plane disintegrated while the back section was torn loose from the wing section and crashed against and into a large tree trunk at a distance of 280 feet from the initial ground impact point.

In the introduction to his 1952 report, Hugh de Haven, one of the two men credited with coining the term "crashworthiness," suggested that there could be a class of accidents that "could be termed survivable or at least partly survivable." He went on to say, "such accidents usually involve impact speeds, deceleration distances, structural damage, and impact forces which can be tolerated by human beings without fatal or dangerous injury. A 1953 report's author, Howard Hasbrook, stated that the severity of an accident should not be based solely on the "overall destruction" of the aircraft, using a short description of Flight 101's crash: "Complete disintegration of major portions of the passenger cabin—followed by fire, a 600-foot wreckage pattern, and a 140-mile-per-hour impact speed." Rather, Hasbrook reasoned that should "some portion of the cabin" remain "reasonably intact" then "information of value for the use of design engineers" could be obtained from accidents such as these. He gave the relevant survivability-related factors, but first on his list was the "known 'crashworthiness' of human structure."

Of the 27 passengers who suffered fatal injuries, approximately 50 percent had both skull and rib fractures, approximately 33 percent had skull fractures only, and approximately 10 percent had either rib fractures or internal injuries. Eight survivors had "dangerous injuries" (defined as "life-threatening" even with "prompt medical care"). These included skull and rib fractures, internal injuries, and long bone fractures. Nearly 90 percent of these eight suffered concussions. Nine of the passengers and the sole female cabin crewmember had minor or no injuries. Minor injuries included "bruises, contusions, and/or lacerations," with four having no injuries whatsoever. Two of those without any injuries apparently then "took a taxi to the airport immediately after the accident and boarded another airplane to their intended destination." This report demonstrates the variability of human crashworthiness as well as the potential psychological resilience.

The injuries suffered by the survivors were classified according to a scale that was "based on observations during the first 48 hours after injury and previously normal life expectancy" (see Table 1, page 7). This scoring system was developed by de Haven for review of survivors of light plane accidents and then applied to traffic accidents by the Cornell Injuries Research Group. Both scales were considered forerunners of the Abbreviated Injury Scale (AIS), developed by the American Medical Association Committee on Medical Aspects of Automotive Injury in 1971.

The AIS is an "anatomically based, consensus-derived global severity scoring system that classifies each injury in every body region according to its relative severity on a six-point ordinal scale" from minor, moderate, and serious to severe, critical, and maximal, with the latter being considered "currently untreatable." The body is divided into nine regions from the top downward: head, face, neck, thorax, abdomen, spine, upper extremity, lower extremity, external, and other. The Injury Severity Score (ISS) is a mathematical derivation from the AIS, and these scores are used in the measurement and study of injuries, for example, over time.

Injury Criteria

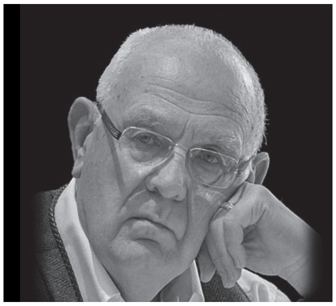
Development of the AIS was an important advancement in aviation crash survivability. One of the parameters used in the testing process is that of "injury criteria." This was originally derived for the automobile industry from multiple experiments, including both cadaveric and animal studies (and their autopsy results). Some studies of human tolerance employed human volunteers, all of whom were likely to be male military personnel, who, though tested at sub-injury thresholds, would have also demonstrated involuntary muscle tension and reflexes. (These studies generated measurements of "voluntary human tolerance" rather than injury criteria.)

The introduction of anthropomorphic test devices, as human surrogates, allowed the use of invasive, rather than superficial, test monitors, the results from which could then be correlated with computer simulations carried out in parallel. Engineering parameters and injury forces became measurable, and statistical calculations could be used to determine "human injury tolerance levels." Injury test results were then classified according to the degree of severity of the injury in the 1990 AIS manual, with "no injury" representing the "absence of injuries or minor injuries of AIS<3" and "injury" representing "serious injuries of AIS>3."

Injury criteria were first applied to aviation in the early 1980s, after a working group of the General Aviation Safety Panel (GASP) recommended crashworthiness improvements for general aviation aircraft. At the top of the list was dynamic testing of seats and restraint system performance, and results from aviation accidents proved helpful. Injuries seen in cars, such as those from the steering wheel, would not be seen in aviation, as the aircraft control column is not fixed, otherwise it would not function. Studies from aviation, such as Coltart's review of 25,000 fractures and dislocations in patients treated by surgeons working in


Jan M. Davies


W.A. Wallace


C.L. Colton


O. Tomlin


A.R. Payne

Royal Air Force orthopedic units between 1940 and 1945, focused on injuries to the talus bone in the ankle. The specific mechanism in many of these injuries was from the force of the plane's impact with the ground, with the pilot's "sole of the foot resting on the rudder bar." The impact pressed the rudder bar "into the instep just in front of the heel," with the talus then fracturing as it took the brunt of the force. Other military experience also contributed: reducing deaths from one source, for example, by providing effective upper body restraint, meant that nonfatal injuries, such as those to the spinal column, would become more frequently observed. All of these factors contributed to the development and inclusion of injury criteria for the GASP recommendations.

To return to the crash of 1908, Wright suffered a fractured left thigh, a damaged hip, and several fractured ribs. His seven-week hospitalization was standard at that time for the treatment of femoral fractures, which would have been immobilized in a resting splint with the leg in traction for six weeks, during which time he was confined to bed. After that, Wright would have gradually been allowed to bear weight on that leg, possibly wearing a weight-relieving caliper, or a hip spica. Despite standard treatment, Wright's back and "damaged" hip affected him for the rest of his life. In those days, X-ray techniques were relatively unsophisticated. Although his femoral fracture would have been clearly visible on an X-ray of the femoral shaft, it would have been easy to miss a fracture through the acetabulum of the hip, which later could develop arthritis. He might also have suffered one or more compression fractures of his spine at the time of impact with the ground.

Wright's AIS score for those injuries would have likely been 3 for the long-bone fracture of the femur (extremities). (In actuality, his AIS could have been either 3 if the fracture was "closed" or 4 if the fracture was "open" because in 1908 an open [or compound] fractured femur was a life-threatening injury.) Similarly, his AIS for any bruises or abrasions, for example, over his lower back would have been 1.

Head Injury Criterion

The head injury criterion (HIC) is an excellent example of another useful injury criterion. Basically, the HIC expresses the likelihood of someone developing a head injury from an impact. Although HIC is now derived from measurement of acceleration over time by an accelerometer placed at the center of gravity of a test dummy's head, HIC was initially derived from studies in 1960 of short-duration impacts on human cadaveric heads to produce linear skull fractures. These studies were followed by those using human volunteers and animals. In 1965, data analysis produced a plot of acceleration versus pulse duration, known as the Wayne State Tolerance Curve and from which the HIC was derived.

Further calculations were performed and cumulative distribution curves were constructed to give the probabilities of skull fracture and brain damage. These showed that an HIC of 1,500 was considered "too high an apparent risk of brain damage/skull fracture" (at 56 percent), with seven of 10 tests showing HIC scores of 1,000–1,500 and "brain damage." At an HIC of 1,000, the probability of a life-threatening head injury (AIS 4) has been quoted as being either 16 percent or 18 percent. This can be interpreted to mean "for a group comprised of 50th percentile U.S. males subjected to the collision," some 16–18 percent "would not be expected to survive" with the remaining 82–84 percent suffering nonlife-threatening injuries.

FAA Advisory Circular AC No: 25.562-1B from 2015 stipulates an HIC of 1,000 when testing new equipment, e.g., seat-back entertainment systems. A score above 1,000 fails, whereas a score of 999 passes (and with only one test run). What does this mean for passengers? At an HIC of 900–1,254, the Prasad-Mertz curves show that the average adult passenger has a 90 percent probability of suffering an AIS 2 or "moderate" head injury, which means that the passenger could be unconscious for up to one hour and have a linear skull fracture. The probability that the same passenger could have a serious head injury (AIS 3) is 55 percent, which would render the passenger unconscious for one to six hours and with a depressed skull fracture.

Thus, these current aviation regulations may not truly reflect passengers' or crews' injuries and survivability in a crash. Airlines and aircraft and aircraft seat manufacturers spend millions of euros, pounds, and dollars to show compliance with the regulations. Yet, an HIC score of 1,000 and its associated clinical states suggest that the next part of the regulatory requirement—FAA-mandated passenger evacuation in 90 seconds—could not possibly be met. Thus, by not ensuring passengers' consciousness, the current regulations could feasibly result in unconscious passengers being unable to exit the aircraft to a place of safety and thus succumbing to their injuries.

More than 50 years ago, the need for that part of the regulation was clearly described by John Swearingen from the FAA's Office of Aviation Medicine: "In airline crashes, it is important for the passengers to remain conscious so that they can escape rather than be asphyxiated or burned to death even though otherwise uninjured." He followed this with recommendations to mold seat backs and serving trays of "light aluminum sheet or other material that will deform at loads less than 30g's and contour itself to the head and face," as well as padding "all exposed areas with sufficient slow-return foam to aid distribution of the impact force over the contour of the face."

The principle behind Swearingen's statement has been known since at least the time of Hippocrates. In about 400 BCE, he wrote: "Of those who are wounded in the parts about the bone, or in the bone itself, by a fall, he who falls from a very high place upon a very hard and blunt object is in most danger of sustaining a fracture and contusion of the bone, and of having it depressed from its natural position; whereas he who falls upon more level ground, and upon a softer object, is likely to suffer less injury in the bone, or it may not be injured at all."

The HIC in aviation contrasts markedly with that in the UK railway industry, where the HIC is set at 500. Above this level, at an HIC of 520–899, passengers might be unconscious for less than one hour. The railway injury experts further recommended that the HIC be lowered to 150 in order to reduce the risk of temporary confusion that might prevent movement to a place of safety. At an HIC of 135–519, passengers could have no more than a headache or dizziness while still being able to move away from smoke, fire, or water (see Table 2, page 8).

Again, returning to the crash of 1908, Selfridge was not as fortunate as Wright.

Table 1. Classification of Injuries

Type	Degrees of Injury	Description	Examples
A. Minor or none	1	None	No injury.
	2	Minor	Contusions, lacerations, abrasions.
B. Nondangerous	3	Moderate	Dazed or slightly stunned. Mild concussion (no loss of consciousness).
	4	Severe, but not dangerous (survival normally ensured)	
C. Dangerous to life	5	Serious, dangerous (but survival probable)	
	6	Critical, dangerous (survival uncertain or doubtful)	
D. Fatal	7	Fatal within 24 hours of accident	More severe contusions, lacerations, abrasions in any area(s) of the body. Simple factures of long bones, jaw, or cheeks. Concussion less than five minutes and no other brain injury.
	8	Fatal within 24 hours of accident	Fatal lesions in single region of the body, with other injuries to 5th or 6th degree.
	9	Fatal	Two fatal lesions in two regions of the body, with or without other injuries elsewhere.
	10	Fatal	Three or more fatal injuries up to demolition of body.

Selfridge was finally extricated from the wreckage, unconscious and bleeding, and was taken to Building 59, which functioned as the hospital on the Fort Myers base. X-rays in those days would not have helped diagnose the cause of Selfridge's state of unconsciousness. But in various articles, he is described as having a basal skull fracture, most likely a vertical deceleration injury, with midbrain damage.

Application to Future Investigations

How do the HIC and other injury criteria apply to the future of crash investigations? To connect the injury criteria from the crash impact laboratory with human passengers' and crews' injuries or deaths, clinically qualified individuals must be able "to compare the kinematics of real people in real collisions with that of dummies in comparable collisions." These experts therefore need access to complete accident reports. For example, lowering the HIC to 500 for the UK railways and making further recommendations for an HIC of 150 came from accident investigation reports reviewed by a team that included clinically qualified individuals. Similarly, development of the "Kegworth" variant of the emergency brace position came from clinical and laboratory studies of the Kegworth accident.

Table 2. Head Injury Criteria (HIC), Comparable Injuries, and AIS Score

Head Injury Criterion	Comparable Injuries	AIS Code
>1,860	Nonsurvivable	6
1,859	Unconscious > 24 hours; large hematoma	5
1,575		
1,574	Unconscious 6–24 hours; open skull fracture	4
1,255		
1,254	Unconscious for 1–6 hours; depressed skull fracture	3
1,000	*Current aviation limit for acceptable HIC test results*	
900	Unconscious for 1-6 hours; depressed skull fracture	
899	Unconscious for < 1 hour; linear skull fracture	2
520		
519	Headache or dizziness	1
500	*Current UK railways limit for acceptable HIC test results*	
150	*Recommended UK railways limit for acceptable HIC test results*	
135	Headache or dizziness	
<135	No head injury	0

Thus, these clinical investigators need access to complete investigation reports that include information such as seating charts and individual-specific descriptions of injuries and fatalities, as well as any brace positions adopted to enable them to add their clinically and forensically evidenced reviews. These reviews could then be either included in the official accident report or in a separate publication, as with the report by Hasbrook in 1953.

The crash of an aircraft with its potential loss of life, or severe injuries, is a horrible and traumatic event for all concerned. It is therefore imperative that every possible piece of information be gleaned, not only the technical and procedural factors to minimize recurrence, but also the clinical and forensic data, wherever possible from fatalities and survivors. Nor should psychological data be excluded. Questionnaires and interviews after an accident can help provide information about why passengers do not pay attention to safety briefings, passengers' choice of exit, and attitudes focused on surviving. All these factors will contribute to a better understanding of cabin safety and passenger and crew survivability. This is not a new concept and has contributed greatly to the advances made in automobile safety-related designs.

We owe our best efforts to help those who are healing and grieving to see that there may be some good from the bad and the possibility of minimizing future events. We must continue to remember all those who were lost. In doing so, the past will not become irrelevant but an ongoing reminder of what we need to accomplish to ensure that the future of accident investigations includes clinically applicable and systematic cabin safety studies that continue to improve passenger and crew survivability. ◆

Jon Lee

Working with Flight Deck Image Data

By Jon Lee, Western Regional Manager, Transportation Safety Board of Canada

(Adapted with permission from the author's technical paper Working with Flight Deck Image Data *accepted for ISASI 2020 in Montréal, Qué., Canada. ISASI 2020 was postponed until 2021 due to COVID-19 restrictions. The full technical paper can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)*

On Aug. 1, 2018, after completing two hours of survey work near Penticton, B.C., Canada, an Aries Aviation International Piper PA-31 aircraft (Registration C-FNCI, Serial Number 31-8112007) proceeded on an instrument flight rules flight plan from Penticton Airport to Calgary/Springbank Airport (CYBW) in Alberta, Canada, at 15,000 feet above sea level. The pilot and a survey technician were on board.

When the aircraft was approximately 40 nautical miles southwest of Calgary/Springbank Airport, air traffic control began sequencing the aircraft for arrival into the Calgary airspace and requested that the pilot slow the aircraft to 150 knots indicated airspeed and descend to 13,000 feet above sea level. At this time, the right engine began operating at a lower power setting than the left engine. About 90 seconds later, at approximately 13,500 feet above sea level, the aircraft departed controlled flight. It collided with terrain near the summit of Mount Rae at 1:36 mountain daylight time.

A brief impact explosion and fire occurred during the collision with terrain. The pilot and survey technician both received fatal injuries. The Canadian Mission Control Centre received a 406 MHz emergency locator transmitter signal from the occurrence aircraft and notified the Trenton Joint Rescue Coordination Centre. Search and rescue arrived on site approximately one hour after the accident. The final Transportation Safety Board (TSB) of Canada Aviation Investigation Report A18W0116 was released to the public on Aug. 1, 2019.

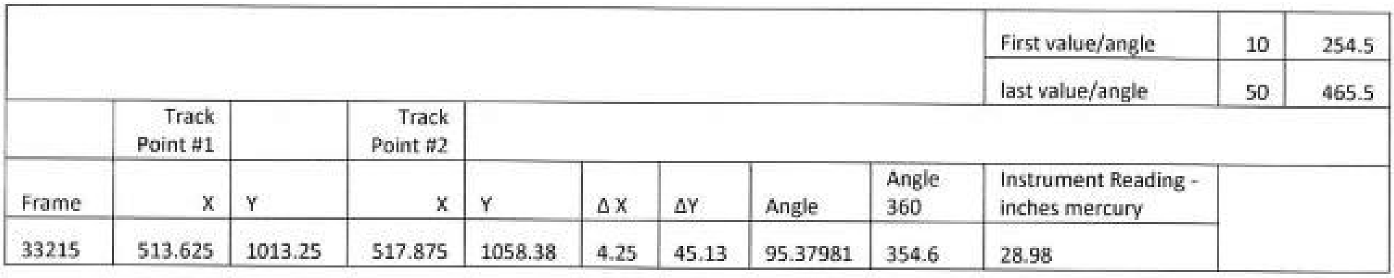
The accident aircraft was equipped with an Appareo Vision 1000 (Appareo) flight data monitoring system that included flight deck imaging. This paper discusses the challenges that were experienced during the investigation when working with these types of data recorders, including

- the amount of data,
- the amount of time to process that data,
- what data you can get,
- the information that you do not get,
- different resolutions that the imagery can be portrayed in and how that can affect the accuracy of the information being collected,
- techniques that can be used on the imagery data to acquire more information,
- installation and ongoing maintenance requirements,
- the requirements for operators and pilot associations to understand the sensitivity of the data and how to manage the data in a just culture, and
- the privilege afforded to images captured on a flight deck.

Although this paper is specific to the experience with the Appareo, other similar units in use in aviation will present similar challenges. It is hoped that the reader will come away with a set of guidelines with which to work when a flight data recorder with imaging is available for the investigation.

Privilege

It is important that an investigator is familiar with the provisions in International Civil Aviation Organization (ICAO) Annex 13 and the state legislation under which investigative work is accomplished with respect to the protection of images recorded on an aircraft flight deck. ICAO Annex 13 describes that a state conducting an investigation in which there are airborne image recordings recovered shall not make



									First value/angle	10	254.5
									last value/angle	50	465.5
	Track Point #1		Track Point #2								
Frame	X	Y	X	Y	Δ X	ΔY	Angle	Angle 360	Instrument Reading - inches mercury		
33215	513.625	1013.25	517.875	1058.38	4.25	45.13	95.37981	354.6	28.98		

Figure 1. Example of the manifold pressure gauge value determined from pixel tracking of the manifold pressure gauge needle.

those records available for purposes other than accident or incident investigation. The exception is when a state determines "that their disclosure or use outweighs the likely adverse domestic and international impact such action may have on that or any future investigation."

The Canadian Transportation Accident Investigation and Safety Board Act aligns with ICAO Annex 13 in that it assigns privilege to onboard recordings that also include video recordings of the activities of the operating personnel of an aircraft. The act further defines an onboard recording as equipment that is intended to not be controlled by the flight crew on the flight deck of an aircraft. It also states that transcriptions made from the recordings are also privileged.

If privilege is going to be afforded to the images captured from the flight deck, it is important to establish various workflows and information technologies to ensure confidentiality of those images.

As image-capturing technology becomes more prevalent on the flight deck, it is important that accident investigation agencies, where feasible, educate operators of the privilege afforded to that data and ensure that it is used for flight safety purposes only, such as the case with cockpit voice recorders.

Appareo Vision 1000

The Appareo Vision 1000 is a self-contained flight data recording system that only requires a power and ground lead from the aircraft's electrical system to operate. The information captured includes the following:

- attitude data (pitch, roll, yaw, etc.),
- WAAS (wide area augmentation system) GPS (latitude, longitude, ground speed, vertical speed, GPS altitude, etc.),
- flight deck imaging,
- ambient audio, and
- intercom system audio for crew and ATC communications (optional).

In total, the unit can record up to eight gigabytes of data, which include approximately 2.6 hours of still images at four frames per second (about 37,500 jpeg images), 2.6 hours of two channels of audio, and 200 hours of flight parameter data. Please refer to ISASI *Forum*, July–September 2016, page 18, which provides more details about what the Appareo can do and how it can benefit accident investigation.

The unit is not crashworthy or fireproof; however, in this occurrence, despite significant impact forces and exposure to a brief fire, the unit had minimal damage. There was an issue in recovering images from the last few minutes of the flight. Appareo suggested using its internal engineering software to recover the missing files. This software was shared with the TSB, and the remaining images were recovered.

Visualizing the Flight Deck Images

Since the Appareo records still images, there are a few ways to view the data. Individual images can be viewed one at a time, but this is not practical for 37,000 plus images. Appareo provides software that can play back the still images like a video. The TSB laboratory provided the investigator-in-charge videos of this playback to use at the investigator's workstation. The playback screen also contained flight path data.

The images can also be used along with the flight path data to produce a combined view of all the data. CAE Flightscape Insight software was used for this particular option of viewing multiple data sets.

The process of creating a video from the source data/still images compresses the images and some data is lost. During the investigation, it was found that data that was pixelated could be recovered or "seen" when the original JPEG images were viewed. The filenames for the Appareo images were related to time, so a spreadsheet formula was created from which the time in the video could be converted to the file name to find the appropriate still image.

Workflow for Analyzing Images

If a multimedia investigation specialist is available, it would be advantageous to enlist their expertise. If a specialist is not available, the following are some suggestions on how to go about reviewing the data in sufficient detail so information is not missed. Keep in mind that human beings tend to see what they are looking for and, as a result, may miss other valuable data. A methodical process is required to prevent missing important information. To assist the review, detailed photos of the actual flight deck should be available or if there is too much destruction, a "before" photo of the flight deck or even representative images from a similar aircraft are useful.

Step 1: Watch the entirety of the images/video to know what you are dealing with. Pay attention to where in time the video starts and where it stops and note areas of missing data. Does the video even capture the accident? If not, the video still may hold important clues.

Step 2: Watch the images again and create a sequence of events of where major events occur (takeoff, climb, level off, descent, etc.) and note the time at which they occurred. This will help get to specific areas of the data quickly.

Step 3: For those areas of interest or where safety-significant events occur, select the relative area and commence a methodical review of the images. This may take several viewing sessions to focus on certain items in the image area. For example, you might concentrate only on the engine gauges and note their readouts or the autopilot mode annunciator panel. Other areas of interest are those portions of the panel that reflect light and what can you see in the reflections of instrument faces, windscreens, and other reflective surfaces. This level of review can take many hours. Save a copy of the important JPEG images and paste them into image-viewing software, such as PowerPoint, for easy labeling and basic image manipulation such as zooming, cropping, brightness, and contrast.

Obtaining Additional Data from the Images

For this particular investigation, several analogue instrument readings were required to support the aircraft performance analysis. Unlike a flight data recorder, visual images representing numerical values of gauge readings are not user friendly for performance analysis, and manually recording the values for each image was not practical. A method was developed to convert the image of the position of the needle to an angular numerical value and then convert that to the numerical value on the actual instrument face.

The multimedia investigation specialist from the TSB engineering laboratory analyzed the last six minutes of the flight (1,440 images) to provide digital values for the following analogue instruments:

- altimeter,
- manifold pressure for left and right engines,
- propeller revolutions per minute for left and right engines,
- exhaust gas temperature for left and right engines,
- fuel flow for left and right engines,
- fuel level for left and right fuel tanks (every two minutes per a two-hour span), and
- tight side airspeed indicator.

Adobe After Effects was used to do the analysis as it has the capability to track pixel position. For each needle on the instrument, a separate tracker was used that featured two points representing each end of the needle. The pixel position information was then exported to a spreadsheet on which the data was converted to an angular position (0 to 360 degrees). This position was then translated to a numerical instrument value based on the measurements taken from the actual instrument faces recovered from the aircraft (see Figure 1).

Missing Information

Although there was considerable information available to the investigation provided by the flight deck image recorder, there were still limitations and omissions of data.

Lighting—There were lighting situations in which the data was not conclusive, particularly when there was bright sunlight in the image and the area desired was in the shadows. Some success was realized when the images were imported to a photo-editing program and were manipulated to enhance the information.

Camera resolution—Although good, some details on the instrument faces were pixelated due to their relative small size compared to the area of the flight deck covered by the camera's sensor. Newer generations of these cameras with higher pixel density will eventually overcome this limitation.

Camera vibration—Since the camera was mounted to the airframe, vibrations from the airframe also affected the quality of the still images captured, especially those readings from instrument faces. Attention to vibration dampening on installation would have a great effect on improving clarity of the images.

Coverage of area—The camera is limited to what it can see, and the position of the camera is important. In this occurrence, the camera had been moved/bumped from its original position and, as a result, several key areas of the flight deck were not in view. The new position of the camera also introduced errors into the flight data. The investigation pointed out that there were no established continuing airworthiness maintenance requirements to recalibrate the camera to ensure that it was pointed at relevant areas of the flight.

Summary

Investigators are driven by the quest for information, which is motivated by the desire to understand the events and reasons behind aircraft occurrences to prevent reoccurrence. The more information that is available, the better the investigation report—and hence requests over the years from many investigation agencies to regulatory authorities to make image-capture technology on flight decks mandatory and complimentary to the cockpit voice recorder/flight deck recorder.

In this investigation, investigators were given an abundance of information and with it a fairly intense workload due to the amount of data that was actually available. Initially, it was thought that answers would come easily, and some did. But it also brought many more avenues for investigation due to the sheer volume of information collected.

When working with flight deck images, be patient, be thorough, and be systematic. Although many answers can be found, many may be missed due to the temptation to only look for the obvious. ◆

As image-capturing technology becomes more prevalent on the flight deck, it is important that accident investigation agencies, where feasible, educate operators of the privilege afforded to that data and ensure that it is used for flight safety purposes only, such as the case with cockpit voice recorders.

THE IMPORTANCE OF HIGH LOAD EVENT REPORTING

By Arben Dika, Member of AAIIC/Investigator, Republic of Kosovo

(Adapted with permission from the author's technical paper The Importance of High Load Event Reporting presented during ISASI 2019, Sept. 3–5, 2019, in The Hague, the Netherlands. The theme for ISASI 2019 was "Future Safety: Has the Past Become Irrelevant?" The full presentation can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)

History of the Flight

On Dec. 1, 2017, at 20:55, an Airbus A320-232 took off from EuroAirport Basel Mulhouse Freiburg (LFBS) and landed at Pristina International Airport "Adem Jashari" (BKPR) at 23:49 local time. The flight was a night charter flight, and there were six crewmembers and 178 passengers aboard. The pilot-in-command (PIC), the pilot flying (PF), was seated on the left side while the copilot, the pilot monitoring (PM), was in the right seat. The approach was conducted on Runway 35 via VOR/DME P (a nonprecision approach).

The weather on the day of the incident at BKPR at 22:30 UTC according to METAR information was light snow, wind direction 320 degree, and wind speed 7 knots.

Operators had internal procedures in which all landings at BKPR would be made by the captain seated on the left side of the cockpit (the more experienced one of the flight crew).

During the flight, the PF had an issue with the left sliding window. The heat in this window was not working, and the captain had a foggy window and almost no peripheral view. This issue was a minimum equipment list (MEL) item, and the flight crew was informed about the data through the aircraft technical logbook. According to the Airbus report and the data downloaded from the flight data recorder (FDR), the flight toward BKPR progressed normally and the PF prepared the aircraft for a flap full landing on Runway 35, adjusting the approach speed in the flight management system (FMGS) to ensure a 5-knot margin above VLS.

The flight crew disengaged the autopilot at 609 meters radio altitude (RA), and the aircraft was manually handled by the PF with the autothrust engaged and active. The speed was managed by the crew, and the calibrated airspeed (CAS) was following the speed target.

```
BKPR, Pristina (Kosovo).
WMO index: 13481. Latitude 42-39N. Longitude 021-09E. Altitude 545 m.

METAR/SPECI from BKPR, Pristina (Kosovo).
SA 01/12/2017 23:30-> METAR BKPR 012330Z 34006KT 4000 -SHSN BR SCT010 OVC025 01/M01
                      Q1011 NOSIG RMK 17290095=
SA 01/12/2017 23:00-> METAR BKPR 012300Z 32006KT 5000 -SN BR SCT010 OVC025 01/M01
                      Q1011 NOSIG RMK 17290095=
SA 01/12/2017 22:30-> METAR BKPR 012230Z 33007KT 8000 -RASN SCT014 BKN040 02/M00
                      Q1011 NOSIG RMK 17290095=
SA 01/12/2017 22:00-> METAR BKPR 012200Z 32006KT 8000 -RASN SCT012 OVC030 02/M00
                      Q1011 NOSIG RMK 17290095=
```

Figure 1. METAR information 18 minutes before the event. Source: BKPR

At 3 nautical miles, the flight crew had visual contact with the runway. At 304 meters RA, the PM called out the stable approach parameters in accordance with the operator's standard operating procedures and the final approach of the aircraft was consider stabilized.

The pilot and copilot conducted a briefing during the landing approach and agreed to have a positive landing because of the weather conditions (snow).

The crewmembers reported they did not feel any abnormality during the landing, and everything seemed normal. The flight crew also did a postlanding briefing and discussed the landing, and both agreed that the landing was not an "unusual landing" because of the positive landing. There were no fault messages from the electronic centralized aircraft monitor and the FMGS, as per system intent. The automatic print out of the LOAD <15> report, which would indicate a hard landing, did not occur due to missing paper in the data management unit (DMU), and the flight crew knew about this (MEL items 31-30-07 A).

There were no actions taken by the PF regarding the landing. There was a postlanding discussion between the flight crew and the cabin crew about the landing, and the PF stated that the landing was a little bit hard but within the limits. No recordings were entered into the aircraft technical logbook by the PF.

The aircraft continued to fly eight more sectors to LFBS and back to BKPR. Two days after the hard landing, the copilot had a private talk with the training manager of the operator regarding the night of the incident because he was doubtful about that landing. After the conversation, immediate actions were taken to load paper into the DMU. On May 12, 2017, the DMU was filled with paper and generated a LOAD <15> report. The parameters showed that that vertical acceleration (VRTA) was 3.04 g's. The data had exceeded the limit given by the Airbus aircraft maintenance manual (AMM), and the aircraft was declared "aircraft on ground" and grounded for further checks on December 6. On December 15, Airbus provided special permission to fly maintenance, repair, and overhaul to Craiova, Romania, following detailed inspections. All inspections were completed before permanent release, and all four main landing gear wheels and the right-hand shock absorber assembly were replaced

The aircraft was released into service on December 28.

Meteorological Information

BKPR weather observation at 22:30

Arben Dika

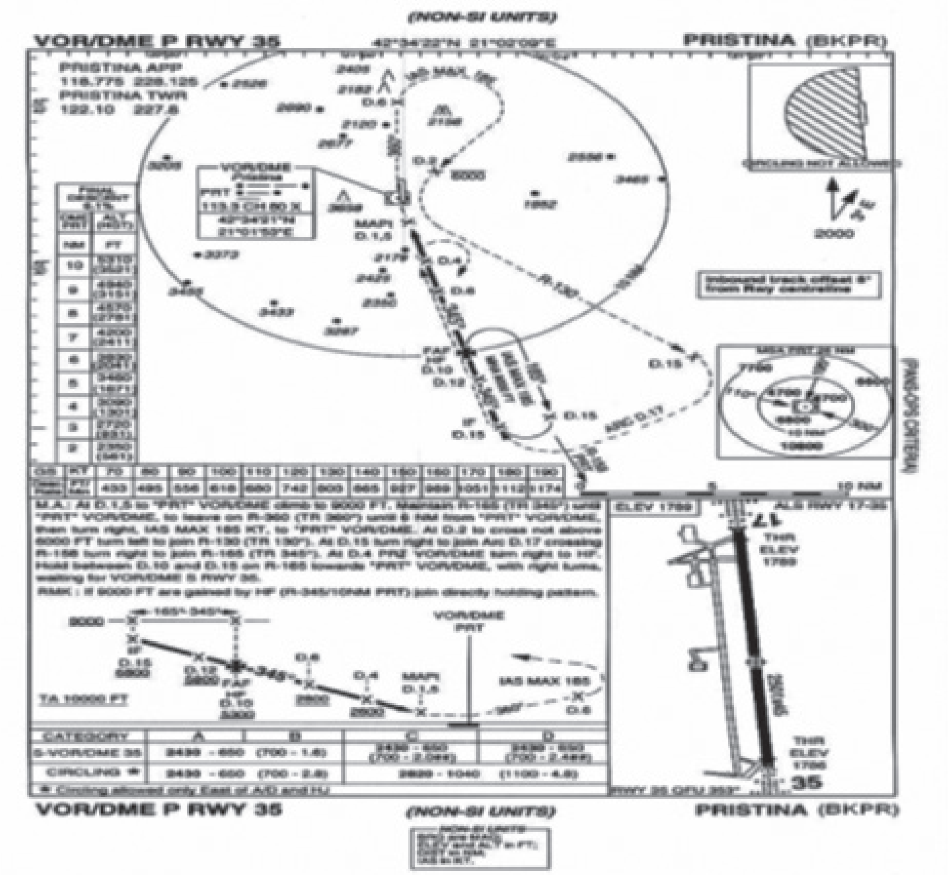


Figure 2. Runway 35 VOR/DME P approach chart. Source: AIP Kosovo

UTC: visibility 8,000 meters, light snow, scattered clouds at 426 meters, broken clouds at 1,219 meters, wind direction 330 degrees, wind speed 7 knots, air pressure 1011 hPa, temperature +2 degrees Celsius, dew point 0 degrees Celsius.

The next METAR information was published 12 minutes after the event with no significant change.

Aids to Navigation

The night of the event, Runway 35 was used for landing at BKPR. Runway 35 is a nonprecision approach VOR/DME P, and some of the runway characteristics are as follows:

- Magnetic orientation of runway (QFU): 353 degrees
- Length: 2,501 meters
- Width: 45 meters
- Elevation: 544 meters

During the final approach to Runway 35 VOR/DME P, the pilot needs to turn right. This right turn happens at approximately 152 meters RA.

Data from FDR

The FDR used on the aircraft was a digital FDR, and it was provided by the operator. Prior to the four consecutive flights after the incident, the CVR was overwritten. Flight data was recovered and extracted from the FDR.

- At 609 meters RA, the autopilot (AP1) was disengaged by the flight crew. The PF was manually flying the aircraft, and the aircraft configuration was CONF FULL (slats/flaps 27 degrees/40 degrees). The landing gear was selected down, the autobrake was armed in MED mode, and the ground spoilers were not armed. The flight directors (FDs) were engaged in DES (vertical) and NAV (lateral) modes. The autothrust was engaged and active in "THRUST" mode, the lowest selectable airspeed VLS was 13 knots, and the speed target was managed at 138 knots (VAPP=VLS +5 knots) so the CAS was 138 knots. The rate of descent was approximately 426 meters per minute with pitch angle 0 degrees and the heading 2 degrees higher than the final approach heading (final course approach 345 degrees).
- During the final approach and with the alignment of the aircraft to the runway at approximately 91 meters, the ground spoilers were armed and both FDs were disengaged.
- On the longitudinal axis, the PF's sidestick inputs varied between approximately 3/5 of full nose up and 3/4 of full nose down deflection. Pitch angle varied between -2.5 degrees (nose down) and +4.5 degrees (nose up).
- The speed target varied between 138 knots and 141 knots. CAS varied between 133 knots (=VAPP -5 knots) and 142 knots (=VAPP +2 knots). The rate of descent varied between approximately 731 meters per minute (around 579 meters RA) and approximately 182 meters per minute. Vertical load factor varied between +0.9 g's and +1.1 g's.
- On the lateral axis, the PF's sidestick inputs varied between approximately 1/2 of full right and approximately 3/5 of full left deflection. Roll angle varied between -3 degrees (left wing down) and +10 degrees (right wing down). Heading increased from 341 degrees (final approach course) to 353 degrees (QFU 353 degrees). Drift angle varied between -3 degrees (aircraft nose toward to the left of the track) and +2 degrees (aircraft nose toward the right of the track).
- No significant lateral load factor was recorded.
- Between 91 meters RA to flare 6 meters RA on the longitudinal axis, the PF's sidestick inputs varied between approximately 1/2 of full nose up and approximately 3/4 of full nose down deflection. Pitch angle varied between +2 degrees (nose down) to +6 degrees (nose up). The rate of descent varied between 243 meters per minute and 60 meters per minute. Vertical load factor varied between +0.8 g's and +1.1 g's. The speed target

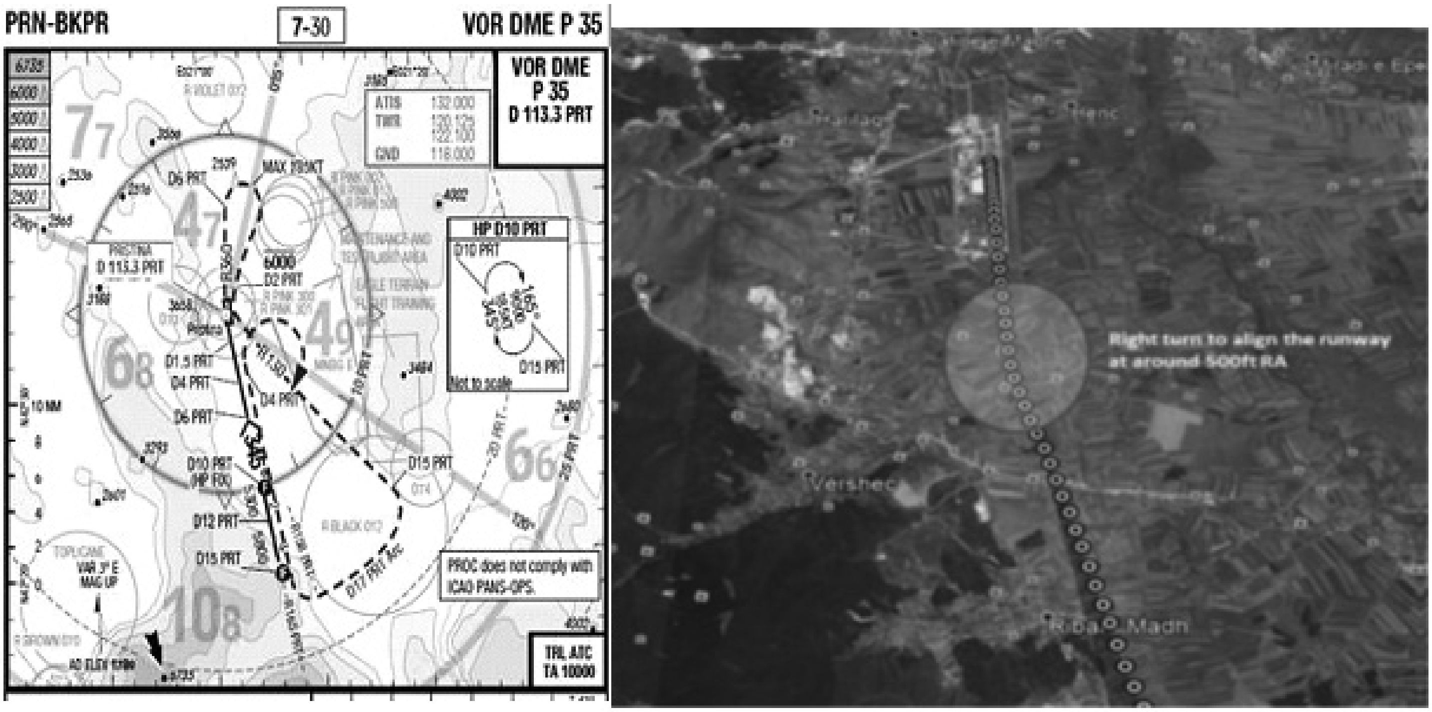


Figure 3. BKPR approach Runway 35.
Source: Airbus

decreased from 141 knots to 138 knots. CAS varied between 134 knots (=VAPP -6 knots) to 139 knots (=VAPP -2 knots).

- On the lateral axis, the PF's side stick varied between approximately 3/4 of full right and left deflection. Roll angle varied between +4 degrees (right wing down) to -3 degrees (left wing down). Rudder pedal input was applied up to approximately 1/4 of full left deflection. No significant lateral load factor was recorded.
- The drift angle increased from 0 degrees to +3 degrees (aircraft nose toward the left of the track).
- The heading decreased from 353 degrees to 350 degrees (QFU 353 degrees).
- From flare at 6 meters RA to touchdown on the longitudinal axis, a full back stick was applied by the PF, and pitch angle gradually increased from +2 degrees to +3.5 degrees. The vertical load factor varied between +0.96 g's and +1.05 g's. The rate of descent decreased from approximately 268 meters per minute to approximately 128 meters per minute. CAS decreased from 138 knots (VAPP) to 135 knots (=VAPP -3 knots). Autothrust was still engaged. On the lateral axis, the PF's sidestick input varied between approximately 1/2 of full right and approximately 1/4 of full left. The roll angle increased from +0 degrees to +2.5 degrees (right wing down). The rudder pedal input was maintained to approximately 1/4 of full left deflection. The heading remained around 350 degrees (QFU 353 degrees). The drift angle reached +3 degrees (aircraft nose toward the left of the track).

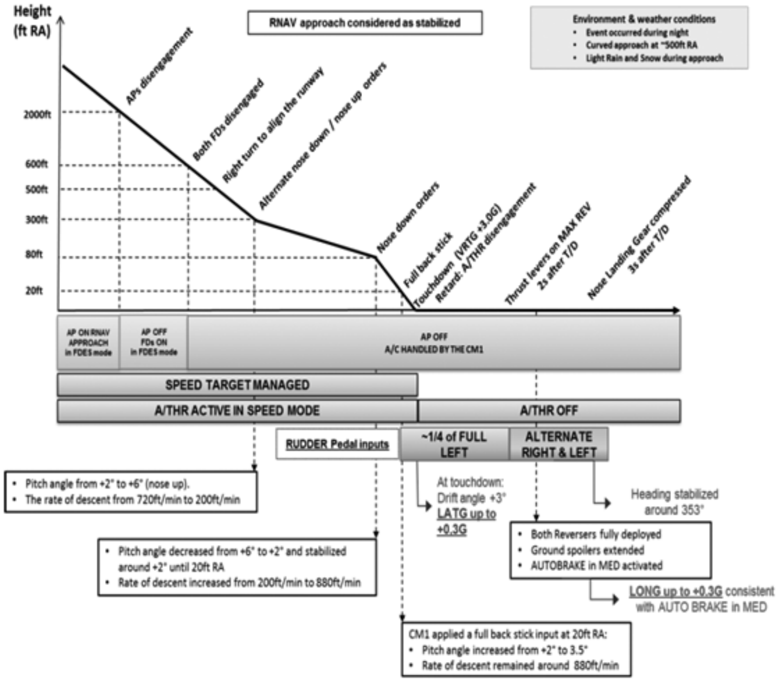


Figure 4. The approach sequence and touchdown.
Source: Airbus

The aircraft touched down with the following data on the longitudinal axis:

- +3.5 degrees of pitch angle.
- -5 meters per second (±.60 meters per second) of recalculated aircraft vertical speed.
- +3.0 g's of vertical load factor.
- +2.5 degrees of roll angle (right wing

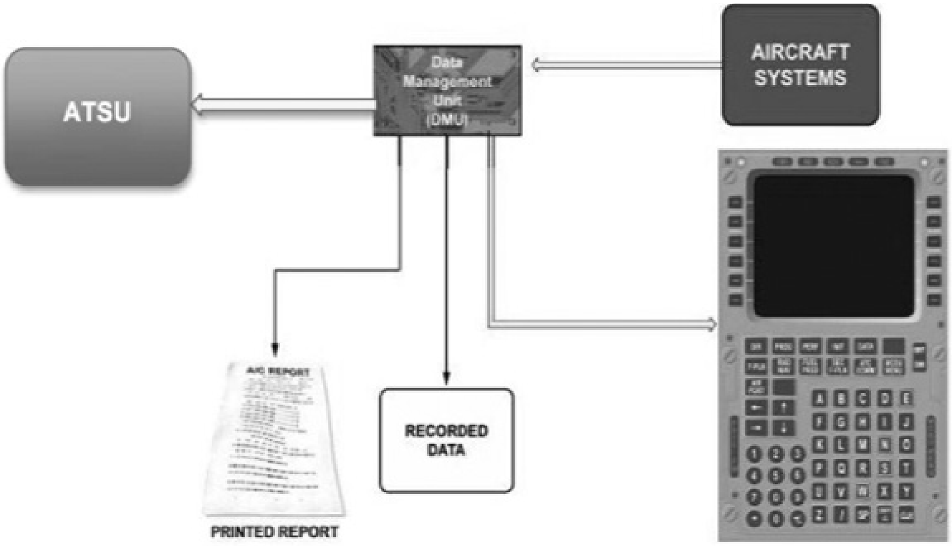


Figure 5. Function of the DMU. Source: BEA

down).

- +3 degrees of drift angle (aircraft nose to the left of the track)
- Thrust levers were retarded to "IDLE" and autothrust was disengaged.
- Ground spoilers started to extend.
- CAS was 135 knots (=VLS +2 knots).
- Ground speed was 138 knots.

And on the lateral axis:

- 350 degrees of heading (QFU 353 degrees).
- +3 degrees of drift angle (aircraft nose toward the left of the track).
- Lateral load factor was at +0.3 g's (consistent with drift angle).

General Information on Hard Landings

The definition of hard landing is when the aircraft touches the ground with a greater vertical speed than a normal landing.

The first information regarding a hard landing comes from the report of the flight crew.

In addition, today's aircraft are equipped with an integrated data system that shows and reports the landing parameters. The system is called AIDS, and it automatically collects and processes aircraft information. The software generates reports from AIDS-monitored aircraft systems. These reports can be requested manually or started automatically.

Collected monitored aircraft data is automatically supplied for related systems during unusual aircraft operations. The automatic modes for printing and ACARS are fully customizable by each operator for both triggering thresholds and logic. These may be changed at the operator's discretion.

The monitoring functions have fixed trigger mechanisms, fixed data collection, and output formatting. The output of data is done by the DMU.

Load Report <15>

- A320 aircraft are equipped with AIDS, which receives information from many other systems through its DMU. The DMU then processes this data and produces reports based on various parameters. The report generated that identifies hard landings is the Load <15> report. This report will be produced automatically if any of the following conditions are met:
- The VRTA is higher than 2.6 g's (at +/-5 seconds) during the landing and after.
- The RA descent rate is greater than 2.7 meters per second during the landing (at +/-5 seconds).
- When the aircraft's gross weight (GW) is higher than the maximum landing gross weight (GWL) and the radio altimeter descent rate is less than 1.8 meters per second.
- When the aircraft's GW is higher than the maximum GWL and VRTA is higher than 1.7 g's.
- For a bounced landing, VRTA is higher than 2.6 g's (at +/- 5 seconds) during the landing.
- The Load <15> report is a structural exceedance report that identifies if a hard landing has occurred so that appropriate checks and inspections are followed by AMM reference.

MEL

For the operation of the aircraft, specific conditions of the flight, or with particular equipment inoperative, the operator has to have an MEL. The MEL has to be in conformity or more restrictive than the master minimum equipment list (MMEL) established for the aircraft type (ICAO Annex 6: Operation of Aircraft).

The MMEL is a list established for a particular aircraft type by the organization responsible for the type design with the approval of the state of design that identifies items that individually may be unserviceable at the start of a flight.

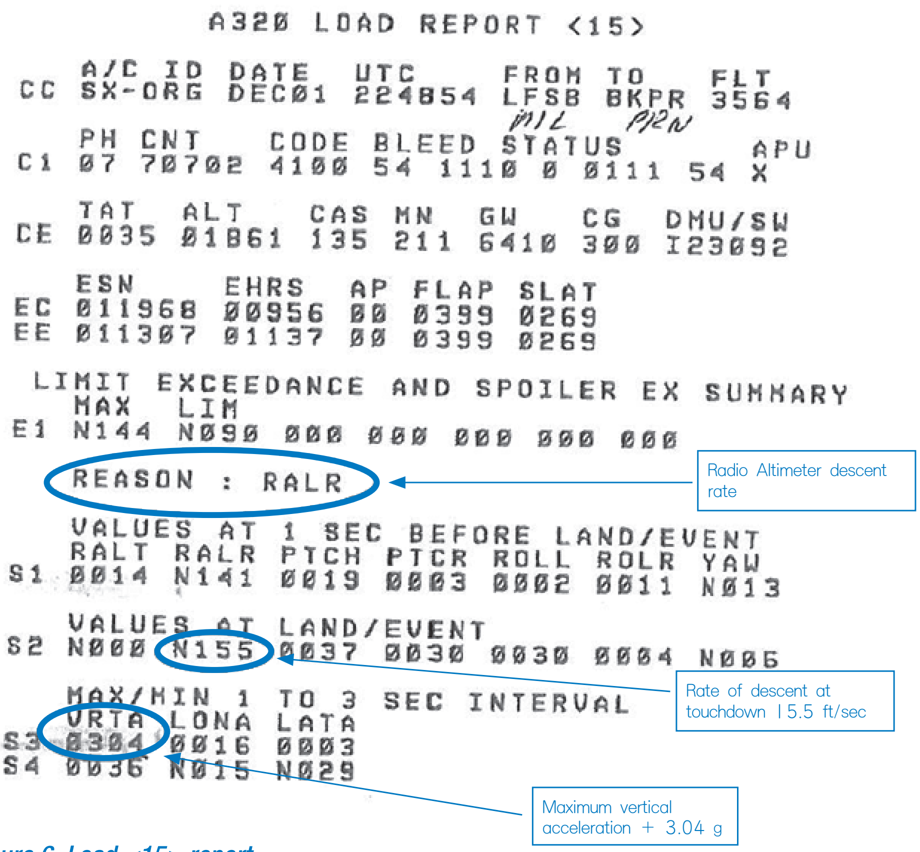
The operator will include in the operations manual an MEL approved by the state of the operator that enables the pilot-in-command to determine whether a flight may be commenced or continued from any intermediate stop should any instrument, equipment, or system become inoperative.

According to the operator's MEL, the missing paper in the DMU was categorized as MEL item Category D, which indicates that the item is required to be repaired within 120 consecutive calendar days, excluding the day of discovery.

Aircraft Examination

After the event, the aircraft was grounded at BKPR for further inspections. The maintenance engineers could not perform a complete AMM 05-51-11 inspection due to the lack of aircraft jacking facilities on site. The items that need to be inspected while the aircraft is on jacks are the nose landing gear and the main landing gear.

The operator requested a ferry flight to a suitable maintenance facility to carry out further maintenance related to the event.



```
        A320 LOAD REPORT <15>
   A/C ID  DATE   UTC     FROM TO    FLT
CC SX-ORG  DEC01  224854  LFSB BKPR  3564
                          MIL  PRN
   PH CNT     CODE BLEED STATUS          APU
C1 07 70702  4100  54  1110 0 0111  54   X
   TAT   ALT    CAS  MN   GW    CG   DMU/SW
CE 0035  01861  135  211  6410  300  I23092
   ESN     EHRS   AP  FLAP  SLAT
EC 011968  00956  00  0399  0269
EE 011307  01137  00  0399  0269
  LIMIT EXCEEDANCE AND SPOILER EX SUMMARY
   MAX  LIM
E1 N144 N090 000 000 000 000 000
    REASON : RALR
    VALUES AT 1 SEC BEFORE LAND/EVENT
    RALT RALR PTCH PTCR ROLL ROLR YAW
S1  0014 N141 0019 0003 0002 0011 N013
    VALUES AT LAND/EVENT
S2  N000 N155 0037 0030 0030 0004 N006
    MAX/MIN 1 TO 3 SEC INTERVAL
    VRTA LONA LATA
S3  0304 0016 0003
S4  0036 N015 N029
```

Radio Altimeter descent rate

Rate of descent at touchdown 15.5 ft/sec

Maximum vertical acceleration + 3.04 g

Figure 6. Load <15> report.
Source: Operator

Before receiving approval from the manufacturer for the ferry flight, certain aircraft structure inspections need to take in place. Inspections were performed on the aircraft with zero findings. The ferry flight was conducted with the following conditions/restrictions according to Airbus–Flight Conditions
for a Permit to Fly with the approval number 80392630/089/2017-1:

- The aircraft should be operated at the lowest possible weight.
- Fuel load should be limited to the quantity necessary to perform the intended leg.
- Only the crewmembers in charge of the flight should be on board.
- Zero payload as per weight and balance manual.
- The aircraft is permitted to perform two "zero payload" flight cycles with the landing gears down and locked.

At the maintenance facility, the AMM 05-51-11 jacked inspections of the nose landing gear and main landing gear were completed with zero findings. Detailed Structure Inspections Program Issue 3 were also completed with zero findings.

Following the inspections, the operator initially requested that Airbus replace the right-hand shock absorber and all four wheels on the main landing gear. Airbus Ref: 80392630 133 indicated that there was no need to remove the wheels, but the operator replaced all main wheels and the right-hand shock absorber.

The maintenance company made the requested changes and on Dec. 28, 2017, released the aircraft back to service with an aircraft certificate of release to service.

Contributing Factors

There were several contributing factors to the hard landing.

The PF made several nose up and nose down stick inputs at very low height seconds before touchdown.

The PF applied a late full back stick at 6 meters RA. This action was too late to change the vertical descent rate, so the hard landing was unavoidable at this point.

It was snowing and the runway was wet.

The flight crew's decision to have a positive landing resulted in an increased rate of descent.

Touchdown occurred with a high rate of descent (268 meters per minute). As a result, a severe hard landing occurred.

The PF's left side window was foggy and was out of order because the heating mechanism was not working so the captain had a reduced peripheral view. This malfunction was an MEL item, was inoperative, was out of order, and the flight crew was aware of it.

Risk Findings

There were several risk findings regarding the landing.

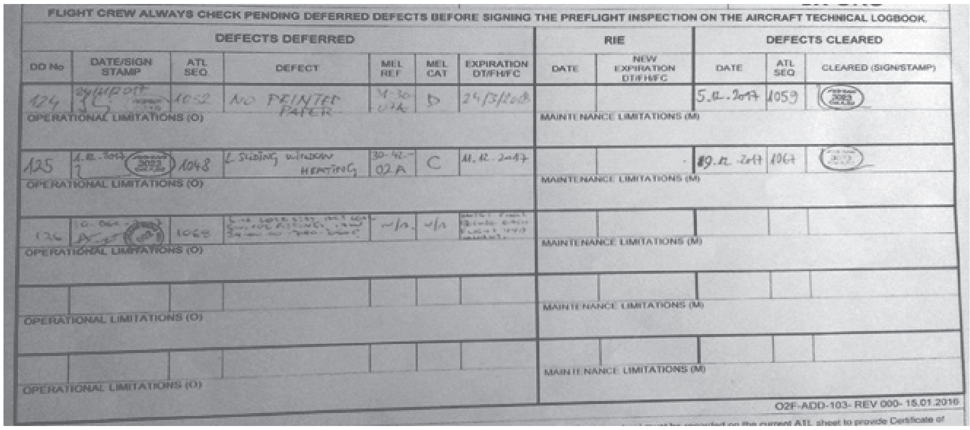
The flight crew failed to report the hard/overweight landing.

Missing printer paper in the DMU was an MEL item, but it also crucial for printing the Load <15> report and confirming the landing parameters.

The aircraft continued to fly eight more sectors without any inspection, which might have compromised the safety of flight operations.

Safety Recommendation

Safety Recommendation AAIIC 2018-02



FLIGHT CREW ALWAYS CHECK PENDING DEFERRED DEFECTS BEFORE SIGNING THE PREFLIGHT INSPECTION ON THE AIRCRAFT TECHNICAL LOGBOOK.

DEFECTS DEFERRED							RIE		DEFECTS CLEARED		
DD No	DATE/SIGN STAMP	ATL SEQ	DEFECT	MEL REF	MEL CAT	EXPIRATION DT/FH/FC	DATE	NEW EXPIRATION DT/FH/FC	DATE	ATL SEQ	CLEARED (SIGN/STAMP)
124	24/11/2017	1052	NO PRINTER PAPER	[illegible]	D	24/3/2018			5.12.2017	1059	
OPERATIONAL LIMITATIONS (O)							MAINTENANCE LIMITATIONS (M)				
125	4.12.2017	1048	L SLIDING WINDOW HEATING	30-42-02A	C	14.12.2017			19.12.2017	1064	
OPERATIONAL LIMITATIONS (O)							MAINTENANCE LIMITATIONS (M)				
126	[illegible]	1068	[illegible]	N/A	N/A	[illegible]					
OPERATIONAL LIMITATIONS (O)							MAINTENANCE LIMITATIONS (M)				
OPERATIONAL LIMITATIONS (O)							MAINTENANCE LIMITATIONS (M)				
OPERATIONAL LIMITATIONS (O)							MAINTENANCE LIMITATIONS (M)				

O2F-ADD-103- REV 000- 15.01.2016

Figure 7. The aircraft's maintenance logbook.
Source: Operator

METHODS, TECHNIQUES, AND PRACTICES: THE LOST REQUIREMENT FOR CRITERIA

Pete Kelly

By Pete Kelly, Aviation Safety Inspector for Airworthiness,
Federal Aviation Administration

(This article is adapted with permission from the author's technical paper Methods, Techniques, and Practices and the Lost Requirement for Criteria accepted *for ISASI 2020 in Montréal, Qué., Canada. ISASI 2020 was postponed until 2021 due to COVID-19 restrictions. The views expressed in this paper do not necessarily represent the views of the United States, the U.S. Department of Transportation, the Federal Aviation Administration, or any other federal agency. The full technical paper can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)*

The privileges of a mechanic certificate to perform maintenance was always limited to applying objective criteria in determining airworthiness, as opposed to using subjective judgements. A given condition was, by definition, either airworthy or not airworthy and that determination should not have varied depending upon who was making the determination. In the United States, the requirement for an objective basis for airworthiness determinations is methods, techniques, and practices.

This paper will show the regulatory basis for, and definition of, methods, techniques, and practices and from a recent accident show that no criteria were used in previous inspections of the aircraft. It will show the normalized deviation of the lack of criteria for maintenance institutionalized in the airworthiness directive resulting from the accident. The paper ends with an appeal to extend future accident investigations to include identifying the failure of the application of criteria in airworthiness determinations, especially during inspections.

There are things I was taught in aircraft maintenance technician (AMT) school in 1971 that no longer seem to be true. One was that there is no such thing as an old aircraft; only airworthy aircraft and unairworthy aircraft. This meant that the airworthiness standards did not lower because they were more difficult to meet as the aircraft aged. Another was that AMTs did not make subjective determinations of airworthiness; they could only apply objective criteria when making airworthiness determinations.

The Regulations:

Title 49 of the United States Code (49 U.S.C.) § 44701, General Requirements

(a) Promoting safety—The administrator of the Federal Aviation Administration (FAA) shall promote safe flight of civil aircraft in air commerce by prescribing—

(1) minimum standards required in the interest of safety for appliances and for the design, material, construction, quality of work, and performance of aircraft, aircraft engines, and propellers;

(2) regulations and minimum standards in the interest of safety for—

(A) inspecting, servicing, and overhauling aircraft, aircraft engines, propellers, and appliances;

(B) equipment and facilities for, and the timing and manner of, the inspecting, servicing, and overhauling; and

(C) a qualified private person, instead of an officer or employee of the administration, to examine and report on the inspecting, servicing, and overhauling;

14 CFR 43 Maintenance Performance Rule, § 43.13

(a) Each person performing maintenance…(14 CFR 1: Maintenance means inspection, overhaul, repair, and the replacement of parts)…shall use

- the methods, techniques, and practices prescribed in the current manufacturer's maintenance manual.
- or instructions for continued airworthiness (ICAs) prepared by its manufacturer (which are methods, techniques, and practices),
- or other methods, techniques, and practices acceptable to the administrator.

This should require actual existing methods, techniques, and practices be followed when performing maintenance, which includes performing inspections.

§ 43.13(b) Each person maintaining or altering, or performing preventive maintenance, shall do that work in such a manner and use materials of such a quality

- that the condition of the aircraft, airframe, aircraft engine, propeller, or appliance worked on will be at least equal to its original or properly altered condition.
- (with regard to aerodynamic function, structural strength, resistance to vibration and deterioration, and other qualities affecting airworthiness).

This includes condition inspections. The condition found during inspection should be that which has the same resistance to vibration and deterioration as its original design and condition. This requires criteria as a way of knowing that the condition actually provides this.

FAA Advisory Circular (AC) 120-77, Maintenance and Alternation Data, states concerning § 43.13(b) that its requirements are usually met by following the maintenance manuals. In Section 10. Methods, Techniques, and Practices Versus Technical Data, AC 120-77 states:

> *"The terms 'methods, techniques, and practices' (AKA 'acceptable data') and 'technical data' have often been confused. While the concepts are related, each has a distinct meaning. The methods, techniques, and practices referenced in Section 14 CFR 43.13(a) are the step-by-step instructions for performing maintenance (including inspections). These 'how to' instructions are normally contained in manufacturers' maintenance manuals and other service documents."*

This advisory circular clarifies that the methods, techniques, and practices required by § 43.13(a), are step-by-step, how-to-work instructions. This would include when performing a condition inspection how the mechanic would know that a condition is airworthy. That is whether its original resistance to vibration and deterioration, or a level of resistance, which is known to be airworthy, exists by substantiation back to its approved design.

The regulations further require in 14 CFR 65 Subpart D–Mechanics, § 65.81 General Privileges and Limitations, (b) that a certificated mechanic may not exercise the privileges of the certificate and rating unless the AMT understands the current instructions of the manufacturer, and the maintenance manuals, for the specific operation concerned. The AMT cannot blindly follow work instructions. This also implies that the privileges of the mechanic certificate does not extend beyond following work instructions, which are ultimately substantiated and known to ensure the aircraft is airworthy.

So when performing maintenance, which includes inspections, the AMT must be following "step-by-step, how-to" work instructions, called in the rule "methods, techniques, and practices," that they understand. There is no regulatory authorization to make airworthiness determinations without such instructions or criteria. There is no regulatory authorization to use subject judgement in making airworthiness determinations!

The Problem

Title 49 of the United States Code (49 U.S.C.) § 44701 intends that the regulation, 14 CFR 43 Maintenance Performance Rule, provide the minimum standard for the performance of maintenance. § 43.13(a) requires the use of methods, techniques, and practices known to ensure meeting the requirement of § 43.13(b) so that its condition will be at least equal to its original or properly altered condition. These two requirements constitute the definition of airworthy. One source of this definition is FAA (AC) 120-77, in which airworthy is defined as

(1) The aircraft must conform to its type certificate (TC). Conformity to type design is considered attained when the aircraft configuration and the components installed are consistent with the drawings, specifications, and other data that are part of the TC and would include any supplemental type certificate (STC) and field-approved alterations incorporated into the aircraft.
(Which § 43.13(a) requires)

(2)The aircraft must be in a condition for safe operation. The condition of the aircraft relative to wear and deterioration (e.g., skin corrosion, window delamination/crazing, fluid leaks, tire wear, etc.) must be acceptable.
(Which § 43.13(b) requires)

For all this to work, there must actually be methods, techniques, and practices that exist and that are being used! The problem today is that this minimum standard of safety needed to ensure airworthiness is no longer enforceable. The existence of methods, techniques, and practices is no longer required. Hence, the objective basis for airworthiness determinations originally intended by the regulations to ensure a minimum level of safety, required by 49 U.S.C. § 44701, is no longer required.

FAA legal interpretations say that the administrator must show that what was done was "unacceptable" by proving the adverse impact on the level of safety that the aircraft's conformity to its type design is intended to ensure. This is different from being required to actually use methods, techniques, and practices known to return the aircraft to its original or properly altered condition. The basis for this is a court case in 1986, *Administrator v. Calavaero, Inc.*, National Transportation Safety Board (NTSB) Order No. EA-2321. That case held that not "every scratch, dent, pinhole of corrosion, missing screw, or other defect, no matter how minor or where located on the aircraft, dictates the conclusion that the aircraft's design, construction, or performance has been impaired by the defect to a degree that the aircraft no longer conforms to its type certificate."

The effect of this interpretation on condition inspections can become very much like the drift into normalized deviation at NASA associated with the Challenger accident. That is changing the basic philosophy from proving that it is safe to fly (airworthy) to proving that it is not safe (unairworthy). Without the actual requirement for methods, techniques, and practices, AMTs performing condition inspections are put into the situation of having to use subjective judgements when making airworthiness determinations. The effect of this interpretation on the performance of noninspection maintenance can grant license to deviate from the procedures (step-by-step, how-to-work instructions) in the maintenance manuals. This volitional "failure to follow procedures" is found in most accidents in which maintenance was the cause.

The Normalized Deviation

Historically, manufacturers of general aviation aircraft did not prescribe methods, techniques, and practices for standard technologies like structures, cables, hydraulics, wiring, etc., because the FAA provided methods, techniques, and practices for them in Advisory Circular 43.13-1. The knowledge of these standard practices and of the requirement for their use in the absence of manufacturer-provided methods, techniques, and practices is no longer the norm today. The norm today is the belief that subjective judgment can be used, instead of such objective criteria. The legal interpretation makes the enforceable regulatory standard, knowing that it is unsafe. The regulations have never intended this responsibility for the AMT. The result can be catastrophic.

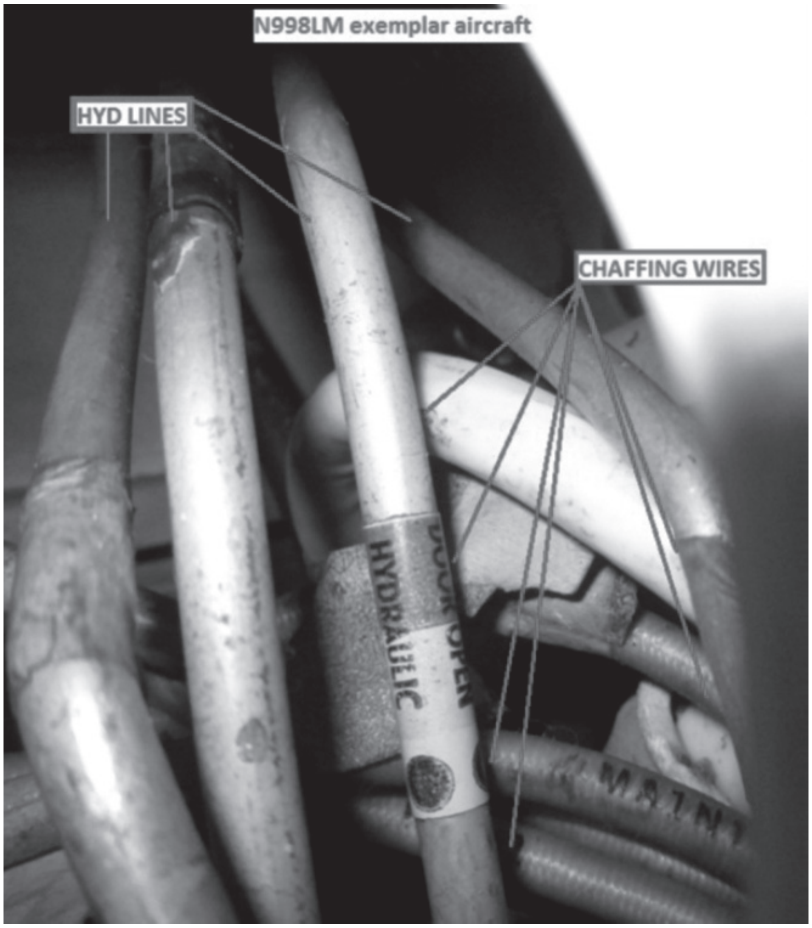


Figure 1. Chaffing contact found on all exemplar aircraft.

Aircraft accident NTSB # WPR16FA153 illustrates this problem, evidences its systemic nature, and demonstrates the lack of criteria norm normalized in an airworthiness directive. It involved a Piper PA-31T aircraft in a Part 135 aeromedical flight, which broke up in flight shortly after the pilot reported smoke in the cockpit, resulting in four fatalities. There had been previous PA-31T in-flight fires, the cause of which could not be determined because the aircraft completely burned up at the accident site. The aircraft in WPR16FA153 broke up in flight, extinguishing the fire and allowing the source of the fire to be determined. The fire was found to have been caused by chafing between hydraulic lines and the electrical wires in an unpressurized section of the aircraft below the floor between the pilots' seats. This area had been inspected 22.4 flight hours prior to the accident. The wires were main power feed wires going to the bus tie circuit breakers.

Six exemplar Piper PA-31T maintained by various individuals/operators all had electrical lines and hydraulic lines found in direct contact with electric wires. This shows a systemic failure of the aircraft inspection program to ensure airworthiness (see Figure 1).

§ 91.409 Inspections, Sections (e) and (f) (3) requires…"turbopropeller-powered multiengine airplanes" use a current inspection program recommended by the manufacturer. The PA-31T, a turbopropeller-powered multiengine aircraft, inspection program defined "inspections" as "examinations performed only by certified mechanics, using acceptable methods, techniques, and practices to determine physical condition and detect defects." It is dependent upon the detail in AC 43.13-1B to be used during inspection. Historically, this was the regulatory norm.

The methods, techniques, and practices for inspection of the wiring in AC 43-13-1B, section 11-96 are

(a) Wiring must be visually inspected for the following requirements: sup-

> *ported by suitable clamps, grommets, etc., and be securely held in place without damage to the insulation, with no interference with other wires, etc. Ensuring that chafing will not occur against the airframe or other components.*

Special Airworthiness Information Bulletin (SAIB) CE-17-05 issued in response to WPR16FA153 recommended best practices for securing high electrical current wires in the aircraft to ensure that proper hydraulic line and wire clearance is maintained. It said to use AC 43.13-1B as guidance. The SAIB is not mandatory, and the AC 43.13-1B is not mandatory in and of itself, but some acceptable methods, techniques, and practices are required to meet the intent of § 43.13(a). Since "nothing" cannot be a method, technique, or practice, something applicable must be! AC 43.13-1B, historically, and by its own purpose statement, is meant to be that acceptable source of methods, techniques, and practices in this case. It states:

> *"1. Purpose. This advisory circular (AC) contains methods, techniques, and practices acceptable to the administrator for the inspection and repair of nonpressurized areas of civil aircraft, only when there are no manufacturer repair or maintenance instructions.*

> The following is an SAIB-provided excerpt from AC 43.13-1B"11-126. Flammable Fluids and Gasses:

> *"An arcing fault between an electrical wire and a metallic flammable fluid line may puncture the line and result in a fire. Every effort must be made to avoid this hazard by physical separation of the wire from lines and equipment containing oxygen, oil, fuel, hydraulic fluid, or alcohol.... Wiring must be routed so that it does not run parallel to the fluid lines. A minimum of 2 inches must be maintained between wiring and such lines and equipment, except when the wiring is positively clamped to maintain at least 1/2-inch separation, or when it must be connected directly to the fluid-carrying equipment."*

Service Bulletin 1301 and Emergency Airworthiness Directive (AD) 2017-02-06 issued in response to the accident demonstrates the loss of the requirement for AMTs to use criteria when making airworthiness determinations. The AD requires repetitive inspection of the area shown in Figure 1 to be conducted as per Service Bulletin 1301, which had only the subjective requirement of

> *"Inspect the routing of all wiring. Reroute or rework as necessary to minimize the likelihood of chafing contact between adjacent components such as fluid-carrying lines, airframe structure, and other wiring."*

"Minimize the likelihood of chafing" is not criteria! It does not provide an objective standard for the aircraft mechanic to apply. It is not a method, technique, or practice as intended by § 43.13(a) to enable the AMT to work within the privileges provided by the mechanic certificate. It puts the AMTs in the position of using their subjective judgement in making the airworthiness determination.

Of equal concern is that the accident report for WPR16FA153 did not mention the failure of the inspection program to ensure airworthiness of the aircraft. Failure of the inspection program to ensure airworthiness was evident on multiple aircraft with different maintainers. The failure of the inspection program was systemic and normative. This universal underlying cause of the accident remains unaddressed. All general aviation aircraft inspection programs are subject to the erroneous belief that unless the manufacturer provided specific condition criteria, the aircraft mechanics are allowed to and expected to use their individual subjective judgement in determining airworthiness.

AD 2017-02-06 addressed a critical safety problem by requiring what an inspection program should already be ensuring. If the failure of inspection programs is a consequence of believing that no criteria are applicable unless explicitly prescribed by the manufacturer, the AD normalized and institutionalized the problem when it did not provide some specific criteria. If the standard separations are not attainable, the instructions could have been to maximize the separation and ensure some minimal separation, such as 1/8 of an inch. Instead, it allowed subjective judgements by the aircraft mechanics to be used in determining what would "minimize the likelihood of chafing," rather than requiring that objective criteria be used. This shifts a responsibility from the regulator and the holder of the type design to the AMT.

The Challenge

If AC 43.13-1B had been applied to the six exemplar aircraft, they would not have been found with electrical wires in contact with hydraulic lines. If the intended standards are systemically not being applied in this general aviation aircraft inspection, there is no reason to expect that the correct and intended inspection standards are being applied in other areas of general aviation.

The only way to correct this problem is for the accident database to identify it. To find all the contributing causes, the investigation needs to go several "why" questions deep. The accident report for WPR16FA153 stopped at the first why, the chaffing of the electrical wire on the hydraulic lines. It did not ask or answer the further why questions concerning why all six exemplar aircraft, maintained by different maintainers, all had the same condition. Some of the difficulties in preventing the chaffing could be from design or alteration, but the fault of the actual chaffing condition existing is the failure of the inspection program.

Therefore. aircraft accident investigations should go further into why the unairworthy condition existed and when "failure of inspection program to ensure airworthiness" was a factor, they should be identified as such. A taxonomy category to code such accidents should be used, like CFIT. Maybe FIP (failure of inspection program). ◆

IF THE INTENDED STANDARDS ARE SYSTEMICALLY NOT BEING APPLIED IN THIS GENERAL AVIATION AIRCRAFT INSPECTION, THERE IS NO REASON TO EXPECT THAT THE CORRECT AND INTENDED INSPECTION STANDARDS ARE BEING APPLIED IN OTHER AREAS OF GENERAL AVIATION.

Sometimes Faster Is Safer

By Tjimon Louisy, Recent Florida Tech Graduate with a Strong Background in Aerospace Engineering and Flight Safety Management

Tjimon Louisy

(Adapted with permission from the author's technical paper Sometimes Faster Is Safer *accepted for ISASI 2021, a virtual meeting hosted from Vancouver, B.C., Canada, due to COVID-19 restrictions. The full technical paper is posted on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)*

Technology innovations in regard to data capture, storage, and retrieval have over the last decade advanced at a rapid pace. However, despite such tremendous advancements in technology, the aviation industry, and in particular the accident investigation segment, still lags behind with technology integration. In the norm of "slow and late," the industry is yet to maximize the application of these available technological tools to advance the accident investigation process.

The most common complaint from the aviation public, particularly the personnel who operate in the Part 91 regime (general aviation), is related to the length of time it takes for accidents to be investigated and the subsequent implementation of safety recommendations. The consensus is that such critical safety-related information needs to be disseminated in a timelier manner so that operators and other stakeholders within Part 91 operations can heed the lessons learned and begin the process of implementing the necessary mitigating measures at the earliest. Some operators and stakeholders claim the National Transportation Safety Board (NTSB) is "slow" based on the long time lags between the occurrence of an accident and the eventual furnishing of a final report that outlines root cause and proposes safety recommendations. On average, the final report for an accident is released two years after the occurrence.

People in general aviation have suggested that many similar-type accidents that have occurred within this two-year time frame, that is between initial accident and final report, could have been avoided if the critical safety information generated from the initial accident investigation was made available earlier. While a two-year lag does seem like too long a time to wait for such vital information, aviation industry personnel understand this long time lag is not due to incompetence of any sort on the part of the NTSB, but rather, largely due to the NTSB's limited access to accident-related data.

A fundamental reason for this data issue is that general aviation aircraft operated under Part 91 have no requirements for cockpit voice recorders (CVRs) or flight data recorders (FDRs). Thus, information gathering by investigators is limited primarily to eyewitness accounts and the contents of wreckage. While this is the best-case scenario for investigators, in many airline crashes, either one or both primary data sets are not available. Firstly, it is not possible to guarantee that an eyewitnesses will be present at an accident, and, furthermore, eyewitness statements are not necessarily accurate and need to be properly vetted to ensure that the investigation proceeds in the right direction. Secondly, the wreckage may be inaccessible, especially in situations in which the terrain is very rugged, or the aircraft has sunk below the ocean and cannot be retrieved due to financial constraints.

While the traditional method of boots on the ground to interview eyewitnesses and inspect the wreckage will likely still be required to accurately determine the most probable cause, technological advancements, particularly as they pertain to data capture and retrieval, have now made it possible to generate an additional data set, which could increase the probability of determining the cause within a much shorter time.

One case in point is the advent of automatic dependent surveillance-broadcast (ADS-B) technology in Part 91 operations. ADS-B is a surveillance technology by which an aircraft determines its position via a wide area augmentation system (WAAS)-capable GPS on board and periodically broadcasts this position information to satellites, which then relay this information to receivers allowing the aircraft to be tracked. An in-depth discussion of ADS-B technology is outside the scope of this paper. However, in simple terms, ADS-B provides three-dimensional data (latitude, longitude, and altitude) of an aircraft allowing air traffic controllers and pilots to maintain separation between aircraft. An additional benefit derived from ADS-B is the capability to reconstruct aircraft flight paths based on the continuously broadcasted positions. ADS-B–equipped aircraft can be tracked live on free websites such as FlightAware or Flightradar24. In addition, historical flight information from previous flights is also stored for a period of time on these websites. This historical data provides investigators with another data set, as the flight can be reconstructed and secondary information such as ground speed and vertical speed can be derived from the ADS-B data, giving further insight as to what the aircraft was doing leading up to the accident.

Rule 14 CFR 91.225 established ADS-B Out, mandatory to operate within specific airspace, and ADS-B has fast become the preferred method of surveillance for air traffic control in the national airspace system (NAS). The live information can be received by air traffic control and other aircraft that have ADS-B In capabilities and then broadcasted automatically with no pilot input required.

While beneficial in helping investigators develop a better understanding of the accident, ADS-B data is still limited in nature and often not sufficient to make concrete conclusions. However, ADS-B outlines the template for critical data being streamed and stored in an area outside of the aircraft, thereby allowing for ease of recovery without having to access the aircraft. The technology is such that the data can be integrated into a larger data set (as opposed to using only the data sets required to determine aircraft position).

Noteworthy in this context is 14 CFR 135.152, which outlines the requirements for FDRs for applicable multiturbine-engine powered aircraft. Also, though not applicable to Part 91, recent advancements in glass-panel technology are now being utilized by Part 91 operators to record numerous—if not all (depending on the specific technology utilized)—of the parameters outlined in CFR 135.152. These parameters are stored within the avionics systems and can be retroactively downloaded to a data card and then exported for pilots to review. Given that some technologies only facilitate live recording to a data card, the installation of a data card would, therefore, be required for data gathering during the subject flight. With the parameters already being recorded, the next limiting factor to overcome is the actual streaming of data, as a retroactive download of in-flight data might not be possible in the case of an accident if the aircraft is inaccessible or damaged.

As previously mentioned, Part 135 operators and commercial operators (Part 121) require FDRs as well as CVRs, commonly referred to as black boxes. These recording devices are certified to stringent requirements so that they withstand crashes and are generally installed in the most "crash survivable" part of the aircraft to mitigate the risk of damage and ensure that the data contained on these devices is retrievable. FDRs provide investigators with numerous parameters pertaining to aircraft flight path, attitude, airspeed, and engine power, along with configurations of high-lift devices, all of which are necessary for diagnosing the root cause of accidents involving these highly complex machines (aircraft operated under Part 121 and Part 135, particularly 121, are significantly larger and contain complex automated systems when compared to aircraft operated under Part 91). CVRs are just as important as FDRs, as they function as the "context provider." CVRs record all sounds within the cockpit, providing investigators with insight into the thought process of the pilots and what was being experienced around the time of the incident. When synced with the FDR, investigators can begin to delineate changes in flight parameters that were a result of intentional pilot action as well as changes that were a result of factors outside the control of the pilot.

Despite being "virtually indestructible," CVRs and FDRs occasionally become damaged to the extent that the stored data is affected. However, the likelihood of this occurring is low. The major limitation of black boxes is that they need to be physically recovered to access the stored data. Generally, black boxes tend to survive an accident but in a few instances have been unrecoverable, as was the case in Malaysia Airlines Flight MH370 accident. Furthermore, the recovery of black boxes is a time-consuming and costly exercise. This can significantly reduce the capabilities of the investigators, resulting in prolonged investigations and major delays in the dissemination of important safety findings and recommendations deduced from an accident. It is probable that this limitation can reasonably be overcome through the development of systems for live upload of the data and storage on the recorded data to a cloud. The data could then be easily retrieved retroactively, in the unfortunate event of an accident.

Given that Part 121 aircraft (commercial aircraft) generally have significant download capabilities (used for weather reports, clearances, etc.) combined with some limited upload capabilities, the implementation of live-streamed flight data need not require the creation of brand-new technology for this live upload. Rather, the challenge would adapting existing technology to achieve the desired solution. Furthermore, large data sets of flight data are already being downloaded from aircraft operated under Part 121 to fulfill requirements for flight operations quality assurance (FOQA). Airlines download data from flights to ensure that standard operating procedures were followed and that standard requirements are not being deviated from, as well as for monitoring overall pilot performance. While data is often retrieved post flight via a secure digital (SD) card or other means, there are plenty of commercially available systems that stream data using cellular or radio waves.

The introduction of ADS-B for Part 91 operations has provided investigators with another data set allowing for more efficient investigations. Hence the recent rise in availability of cost-effective glass panels now provides that further step in how general aviation accidents are investigated. Glass panels generally record pertinent flight parameters as opposed to their analog predecessors, which only display to the pilot what is happening at a given instance that can be retrieved retroactively through data download. The main challenge, therefore, with regard to integrating the use of glass-panel technology is that these avionics have the potential to be damaged during an accident, which may make retrieval difficult, if not nearly impossible.

Furthermore, the general aviation fleet is aging, and retrofitting these aircraft with glass-panel technology is not likely to be cost effective. This paper therefore recognizes that the short-term objective should first be to make glass-panel technology more affordable so that more general aviation aircraft could be equipped with such technology.

While the main focus of this paper is aircraft data capture and retrieval systems in the protection of safety information, the additional benefit of electronic flight displays (EFDs) remains a useful consideration. Manufacturers of EFDs can be encouraged and incentivized to focus on increasing the crashworthiness of this type of storage device for flight data, which would help to maximize the probability of recovery. In this regard, the actual displays need not survive the crash if all the data is stored on a SD card that could be protected from the elements.

The recommendation in terms of the longer-term goal will be to fully establish and implement the means of streaming such flight data, thereby eliminating the need to physically recover an SD card or an alternate storage component. While this will likely come at a huge cost and is not necessarily feasible at this current time, it would warrant early attention and exploration in the short to medium term. The most practical solution would be for such technology to be implemented in commercial aviation first, with general aviation then piggybacking onto the infrastructure and processes established by commercial operators. This would significantly reduce the cost to general aviation operators of implementing such technology.

The infrastructure required for implementing such technology is already available for commercial aircraft operated under Part 121. Commercial aircraft currently have air upload and download capabilities (upload capabilities are more limited) along with streaming capabilities over mediums such as WiFi. Furthermore, flight data is regularly downloaded from these aircraft in support of FOQA. Airlines already have the capability to retrieve (albeit retroactively), store, and analyze these large volumes of data across their fleet. The next steps would be to combine and improve the upload capabilities to allow flight data that is currently being retroactively downloaded to be live streamed and uploaded to the already existing storage media. In the event of an accident, NTSB investigators would easily be able to retrieve flight-critical data with assistance from the involved parties, without necessarily having to physically access the aircraft.

It is important to highlight though that live streaming of such flight data is by no means a small task. Issues such as connectivity, storage, and bandwidth are some of the likely technological challenges that would have to be overcome to effectively implement such technology. However, if the burden associated with constructing/developing the streaming technology is spread across the industry, it would make this opportunity more viable. Additional benefits could also be derived from such technology, such as live diagnostics, as subject-matter experts would now have access to live data, allowing them to help flight crews diagnose issues in flight and make more informed decisions. Careful considerations, however, must be made for security and privacy of data, and strict policies would need to be established in regard to the uses of such data. For example, pilots must be protected from the data being potentially used for other purposes.

The aviation industry continues to spearhead safety through its extensive and thorough nature of evaluating new technologies prior to implementation. However, this rigor could sometimes be limiting to the industry's advancement in this sphere if this significantly delays the timeline for the introduction of critical safety technologies.

The industry's current handling of critical safety information has tremendous possibility for significant advancement, and these times present us with a tremendous opportunity to do so. Existing technologies such as FDRs and CVRs, commonly referred to as black boxes, can be utilized on the commercial side of the industry in conjunction with emerging technologies for live streaming data to improve data storage and retrieval. Live uploading of data stored on these existing recording devices to a cloud could then be retroactively retrieved and utilized for timely investigations and implementation of safety recommendations.

The implementation of technologies for live data uploading, in parallel with existing methods (black boxes), is not likely to result in any reduction in the functional capabilities or safety margins of aircraft operations. And the safety benefits associated with such improvements are significant.

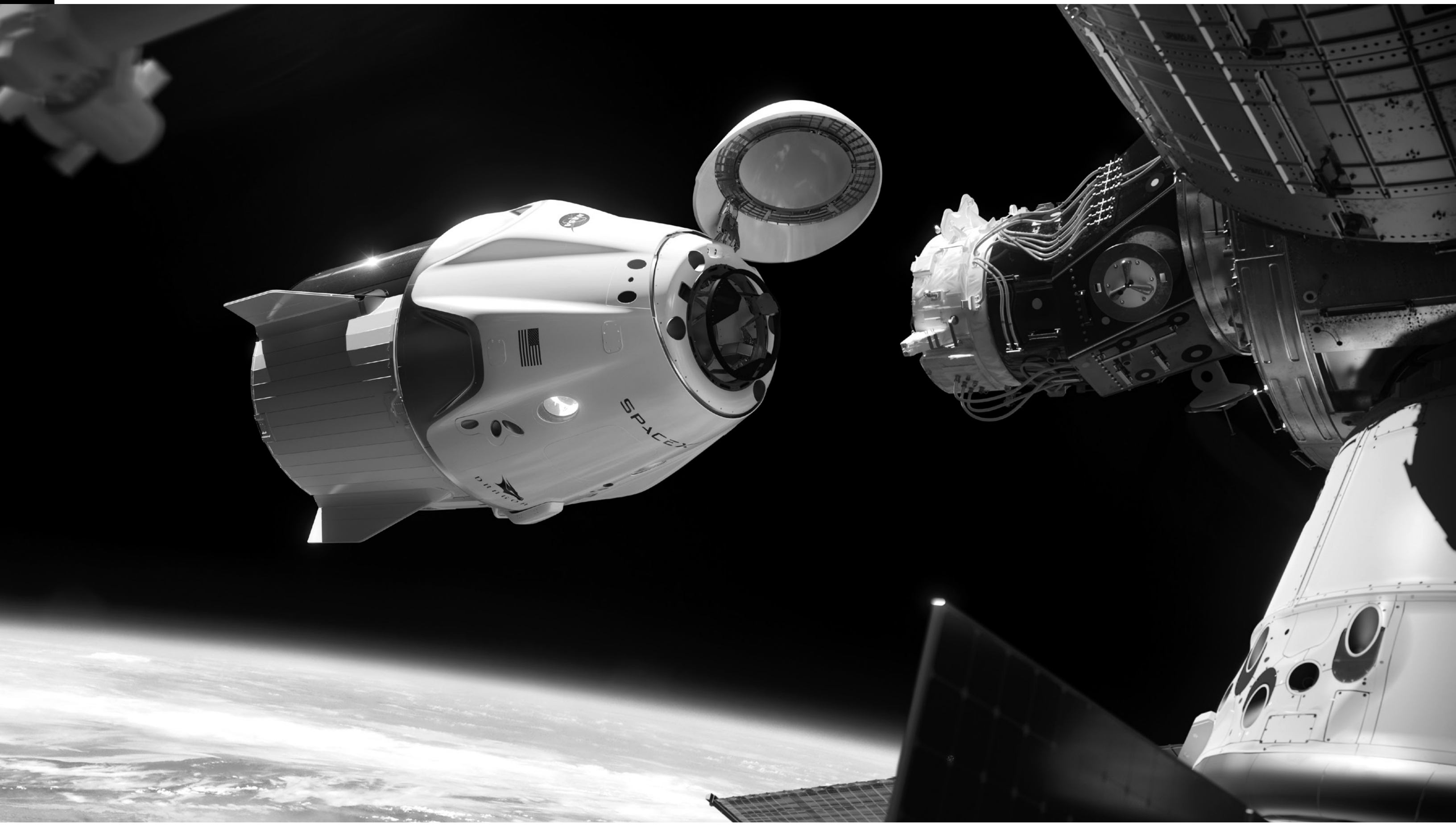
Undoubtedly, very close collaboration would be required among commercial operators, avionics systems suppliers, and regulators to overcome the range of challenges posed in seeking to integrate these technologies.

Technologies such as datalink and WiFi are already being upgraded to improve performance, and the developments in such technologies (and similar technologies) should begin to take into account the potential functionality to live stream flight data. Such technology may not be practical for implementation at the general aviation level as yet due to the high cost associated with potential hardware requirements and difficulty retrofitting an already aging fleet, yet if considered as a long-term goal, this would result in laying the groundwork for future implementation. If live stream of flight-critical data is considered a long-term industry goal for general aviation, then the consequent short-term target should be to make EFDs more accessible and affordable, given that these systems already have built-in recording and storage capabilities. General aviation crashes tend to be lower energy and less destructive than accidents involving their commercial counterparts, and the probability of the flight data surviving the crash is increased. A medium-term goal then, following the large-scale implementation of EFDs, would be to find a cost-effective means of increasing the survivability of the recording/storage devices (perhaps a small-scale FDR) to further increase the probabilities of the data being retrieved.

The aviation industry can certainly boast of having as its key strength the art of being meticulous. However, this very strength can sometimes prove to be a hindrance to dynamic advancements, particularly as it pertains to the adoption of new technologies. This paper by no means suggests that the aviation industry should forego its thorough and methodical approach to the adoption of new technologies. But it does suggest the means to explore the potential opportunities such technologies will afford the industry, specifically pertaining to the application of critical safety technologies to reduce accident investigation report delays and the consequent earlier implementation of safety recommendations. ◆

COMMERCIAL SPACE OPERATIONS:
A GROWING CONCERN TO THE AIRINE INDUSTRY

By Christopher Freeze, Senior Aviation Technical Writer, Air Line Pilots Association



In recent months, rocket launch debris that's reentered Earth's atmosphere has made riveting news media headlines.

On March 25, a SpaceX Falcon 9 second stage reentered over the northwest United States and southwest Canada with debris as heavy as 300 pounds surviving the fall on Washington state and likely parts of Canada. And on May 9, the uncontrolled reentry of a Long March 5B first stage had a four-hour window of uncertainty. Arriving 50 minutes early, it rained debris over Africa before landing in the Indian Ocean. Had it been 15 minutes late, it would have reentered over central Florida. A late reentry of 105 minutes would have placed any debris in the airspace above Washington, D.C., along a line from Texas to New Jersey. Rocket debris can easily penetrate an aircraft and cause serious damage.

These events triggered a solution-based response from ALPA to the International Civil Aviation Organization (ICAO), underscoring the Association's decades-long commitment to the safe integration of commercial spaceflight into the airspace system. On May 14, Capt. Joe DePete, ALPA's president, sent a letter to ICAO Secretary General Dr. Fang Liu highlighting the threat posed by the reentry of debris from orbit as commercial space operations continue to grow in frequency.

ALPA is calling on ICAO to work with the United Nations to create global standards for launch planning and recovery, to promote guidelines for vehicles that are designed to burn up completely upon reentry, to engage with national regulators and air navigation service providers to provide timely warning of any reentry, and to develop procedures to divert aircraft away from potential reentry hazards. In the letter, DePete reaffirms ALPA's offer to assist ICAO in addressing this reentry safety hazard "in the belief that through collaboration and a common goal to achieve the highest possible safety levels, that

In low Earth orbit, SpaceX's Crew Dragon prepares to dock with the International Space Station.

Photo: NASA

the global aviation community can rise above the challenges we're currently facing to the benefit of all humanity."

"The airline industry long ago realized that the 'big sky theory' wasn't an acceptable collision risk-mitigation strategy, and yet there seems to be an ongoing view that the big sky theory is an acceptable level of risk for space debris reentry," the letter states. "The problem becomes even more apparent when looking at the forecast for future launches."

PROACTIVE SAFETY CULTURE

Although ALPA's advocacy on the safe integration of commercial spaceflight and education regarding the impact of commercial space operations has been ongoing for years, much work remains to accomplish this critical goal given the uptick in frequency of rocket launches and the potential growth of "space tourism."

Worldwide, the number of space launches has increased by 54 percent, from 74 launches in 2010 to 114 launches in 2020. This trend is expected to continue, with the Federal Aviation Administration's (FAA) Office of Commercial Space forecasting a further increase between 36 to 100 percent just in the U.S. by fiscal year 2025. Industry estimates are even higher, with fiscal year 2025 growth of 177 percent over 2020 figures.

ALPA has promoted collaboration among those impacted by commercial space operations in highly visible forums, most recently in October 2019 when the Association jointly held a conference with the Commercial Spaceflight Federation (CSF).

During the conference, keynote speaker Sen. Ted Cruz (R-TX), then chair of the U.S. Senate Subcommittee on Aviation and Space, observed, "I believe we can have a safe and efficient commercial spaceflight industry and also a safe and efficient civil aviation industry. I believe the two industries can and should work together in tandem."

At the conclusion of the conference, DePete and Eric Stallmer, then CSF president, issued a joint statement, saying, "ALPA and CSF vow to continue to work together to improve the commercial aviation and space community's understanding of each other's technologies, operations, and constraints; to explore potential solutions to conflicting demands for airspace; and to advocate for optimized use of airspace around launch and reentry activities. We agree that the status quo can't continue and that the private sector must help the FAA innovate to minimize any negative impacts of the growing commercial aviation and space industries. As leaders of our respective industries, ALPA and CSF have taken cooperative action to solve these problems. We're working with colleagues and other key stakeholders to improve how we operate today, as well as advocating for investments in new air traffic control tools that will better optimize airspace while preserving safety as we enjoy future growth in both air and space transportation."

FOR THE COMMON GOOD

In conjunction with the 2019 conference, ALPA published an updated white paper, "Safe Integration of Commercial Space Operations into the U.S. National Airspace System and Beyond," that takes a deeper look into the integration of commercial space operations into the national airspace system (NAS) and beyond, particularly in the area of oceanic air traffic management.

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Christoper Freeze

In ALPA's original white paper on space operations, released in 2018 and titled "Addressing the Challenges to Aviation from Evolving Space Transportation," numerous considerations were highlighted that the tremendous growth in commercial space operations will present to the nation, including space operator approval, spaceport licensing, regulations for spacecraft crew and participants, spacecraft design standards, and other critical issues.

ALPA projects that the number of commercial space launches and recoveries will rapidly escalate in the next 10 years and that the U.S. will lead by example in successful commercial space operations that are safely integrated with the mature commercial aviation industry.

However, this growth is taking place much faster than anticipated and as a result of launches and recovery operations, the Association points out that an undue burden has been placed on critical and limited public resources—namely, the NAS, air traffic management, ground infrastructure, and airport services. For example, current space launches require closing large volumes of airspace, which not only places large administrative burdens on commercial space operators, but also causes significant disruption to aviation.

ALPA's updated white paper highlights the opportunity that exists today for the aviation and commercial space industries to collaborate on and benefit from a joint vision for the future, and addresses the evolution from today's manual, segregated operations to a future that's highly integrated—not just with airspace sharing, but also in information sharing, situational awareness, collaborative decision-making, and operational procedures. Integrating commercial space operations and commercial aviation operations into the NAS is an urgent need that requires careful planning and commitment from many different sectors of the industry.

By working together, both the aviation and space communities have the opportunity to benefit from investments in national airspace infrastructure, as ALPA identifies numerous opportunities in the paper that are a win-win for stakeholders in both the aviation and space industries. These include investments in communications, navigation, and surveillance of oceanic airspace; improvements to air traffic control automation; and the development of new procedures and separation standards.

Along with the creation of spacecraft design-assurance standards and operator and crew certification, ALPA foresees that in the near future space operators can "file and fly" like any other operator in the NAS, with separation standards and a harmonized safety approach.

For both commercial aviation and space operations, future growth and success are dependent upon safe and efficient access to the same shared public resource—the NAS. Since airline pilots have the unique advantage of being daily users of the NAS, ALPA has been a leading voice for the safe integration of space transportation operations into commercial aviation infrastructure and operations.

The Association and the aviation industry recognize the responsibility to share the safety lessons learned so that others don't repeat them, and ALPA is dedicated to facilitating the safe integration of new and expanding users of the NAS. This commitment applies to all users, including unmanned aircraft systems, hypersonic and supersonic flight, and commercial space. By working together, the aviation and commercial space industries have an opportunity to use a data-driven, risk-predictive approach to safely integrate commercial spaceflight into the airspace.

ADDRESSING CONCERNS

However, the safe integration of commercial space operations comes with challenges. In 2018, officials in Colorado received a commercial spaceport license from the FAA for the Front Range Airspace (now known as the Colorado Air and Space Port) despite concerns about conflicts with aviation. The spaceport—one of 18 in the U.S.—is located just six miles southeast of Denver International Airport, one of the busiest airports in the U.S.

At a June 2018 House Aviation Subcommittee hearing on commercial space transportation regulatory reform, Rep. Peter DeFazio (D-OR) said, "I recently met…people raising concerns about the proximity of a proposed spaceport…proximate to Denver International Airport and the potential for interference with operations there."

Also speaking at the hearing, Capt. Tim Canoll, then ALPA's president, expressed concern that it would be difficult for ALPA to assess specific impacts of launches from the spaceport on operations at Denver International Airport because any vehicle that planned to use the spaceport would require a launch license from the FAA, a process that would include separate reviews of how it would affect airport operations.

In December 2020, Japanese space tourism company PD Aerospace signed a partnership agreement with the spaceport to test craft there. And while no launches have yet to occur from the Colorado facility, ALPA continues to actively monitor any developments and associated risks.

In mid-May, a private company in Canada secured $10.5 million in financing for a launch vehicle and site preparation at Canada's first commercial spaceport to be built in Nova Scotia. The planners intend to conduct up to eight launches annually at the location, starting in 2023.

While the facility may be an economic boon for Canada, rocket launches from the site are on the Atlantic Ocean and have the potential to affect many transoceanic airline routes.

SUCCESSFUL INTEGRATION

Wayne Monteith, FAA associate administrator of commercial space transportation, has observed, "Both of these industries, commercial aviation and space, must be successful—not just from a national economic standpoint but from a national security standpoint. So we have to figure our way through this dilemma of shared airspace—a finite national airspace system—as today we primarily segregate commercial space traffic from other operations. We need to move to the point where we can integrate."

The impact of airplanes and space operations sharing airspace was evident during the first launch of SpaceX's Falcon Heavy rocket in 2018. During the launch, a large swath of airspace over the Atlantic Ocean was closed to airplanes for more than three hours. To avoid the restricted area, a Delta Air Lines flight from New York to San Juan, Puerto Rico, was required to fly along the shore with many other flights, increasing the fuel burned and distance flown and delaying its arrival.

According to the FAA, in 2018, 1,400

A SpaceX Falcon 9 rocket soars upward from Launch Complex 39A at NASA's Kennedy Space Center in Florida on April 23, 2021.

Photo: NASA

flights were affected by spacecraft launches, which caused airlines to fly an additional 70,000 miles.

"When the SpaceX Falcon Heavy first launched, I was running the Eastern Range [the missile and rocket launch range, covering more than 10,000 miles from the Florida mainland through the south Atlantic and into the Indian Ocean]," said Monteith. "The risk and danger from that mission was over in about eight and a half minutes, yet it was at least three times that long before the airspace was reopened."

SHARING EXPERIENCE AND LEADERSHIP

Ultimately, multiple conversations with a diverse array of industry and businesses need to take place, and ALPA continues to work to facilitate such discussions.

"For nearly 90 years, ALPA has been at the forefront of creating the safest form of long-distance transportation in human history," DePete stated in the Association's 2019 white paper. "Some of these safety gains carried a high human cost that should not be borne again. The pilots of ALPA, and the aviation industry at large, stand willing and ready to share our experience and expertise with the commercial space industry in the hope of avoiding past mistakes, capitalizing on hard-earned lessons, and building a future we can all be proud of." ◆

NEWS ROUNDUP

ISASI Conducts Bloodborne Pathogen Protection Training

With preplanning and lots of preparation by onsite hosts Catherine Chan and Cassandra Yeo, ISASI was able to conduct Bloodborne Pathogen Protection Training for Accident Investigators "live online" using the WebEx platform.

The training was highly successful with the onsite hosts prestudying all of the information and preparing full protection kits for each participant. Elaine Parker was able to conduct the training session remotely with PowerPoint in an interactive presentation, answering questions as they arose.

The "hands-on" portion included do's and don'ts demonstrated by the onsite hosts. Parker was able to confirm their competence to review all other participants. The entire group dressed (and sweated we're sure) and obtained their certification.

A $500 support fee was donated to the ISASI head office from the participating organizations—a win-win for everyone.

The Bloodborne Pathogen Training package, developed and updated over the years by Barbara Dunn and Parker with the Canadian Society of Air Safety Investigators, is available as a video with contact information for the supporting materials at https://www.youtube.com/watch?v=IuoeqIHTZu8&t=102s. ◆

ISASI conducts the Bloodborne Pathogen Protection Training for Accident Investigators course.

Fifth International Accident Investigation Forum Scheduled for May 2022

Singapore's Transport Safety Investigation Bureau (TSIB) will be hosting its Fifth International Accident Investigation Forum (IAI Forum/5), tentatively scheduled for May 9–13, 2022. The triennial three-day IAI Forum aims to bring together the world's top government investigation officials and experts to discuss issues relating to the organization, infrastructure, and management of accident investigation.

The forum is open to investigation officials responsible for discharging their state's obligation under Annex 13 to the Convention on International Civil Aviation, regulatory officials, and aviation safety professionals from the aviation industry. The tentative program for the three-day forum includes

- International Civil Aviation Organization-related matters,
- Challenges during the COVID-19 pandemic,
- The automation paradox,
- Investigation of issues relating to safety management,
- Accident Investigation Panel experience in the state safety program implementation assessment, and
- New challenges in investigation.

FIFTH
INTERNATIONAL
ACCIDENT
INVESTIGATION FORUM

Week of 9-13 May 2022 (tentative)
Singapore

Hosted By:
TSIB
SINGAPORE

The TSIB looks forward to welcoming you and your colleagues to the IAI Forum. If you wish to present a paper at the forum or require more information, please contact Pang Min Li (e-mail: pang_min_li@mot.gov.sg) and Jen Tan (e-mail: jen_tan@mot.gov.sg). ◆

ICAO/ISASI Working Group Participates in AIGP6

The International Civil Aviation Organization (ICAO)/ISASI Working Group participated in the 6th Accident Investigation Panel meeting (AIGP6) in May 2021. Ron Schleede, Bob Macintosh, and Mark Clitsome represented ISASI. The meeting was conducted virtually via Zoom from May 10–21. ISASI representatives contributed to the discussions on various topics.

Topics discussed included amendments to ICAO Annex 13, Annex 6, and guidance materials. Several tasks were completed, and a few new tasks were generated during the meeting. The work of the AIGP will continue via conference calls and e-mail. It's anticipated that AIGP7 will be convened in Montréal, Qué., Canada, in person in May 2022, and ISASI will participate.

A full report of the AIGP6 meeting is being prepared and will be available to authorized personnel via their respective states' ICAO representatives. ◆

We Met by Accident

ISASI President Frank Del Gandio reviewed the Canadian Society of Air Safety Investigators' (CSASI) recent change in officers and acknowledged that longtime CSASI President Barbara Dunn decided not to run for another term. He recalled that Air Canada Flight 797, a DC-9, had an in-flight fire and made an emergency landing at Cincinnati/Northern Kentucky International Airport on June 2, 1983. The aircraft had departed Dallas, Texas, on a scheduled flight to Montréal, Qué., Canada. The accident was fatal to 23, and there were 23 survivors. "I was representing the

Federal Aviation Administration," he said, "and Barbara Dunn was representing the Canadian Flight Attendants Association. We had briefly interacted during the investigation and later at the National Transportation Safety Board's public hearing. At the time, I did not realize the future relationship that would unfold.

"Barbara subsequently joined ISASI in 1990 and started to attend our national seminars. In 1994, she became the president of CSASI. We quickly established a working relationship, and, in 2003, I appointed her to the position of International Seminar chair. In this position, Barbara was responsible for the coordination and execution of all annual seminars—a position she still holds today. Our seminars have been a technical and financial success due to the skilled expertise of Barbara. She rewrote the ISASI seminar manual and updated it after most seminars due to 'a better way to do it.'

"Barbara is recognized around the world as a cabin safety specialist and is frequently sought out to assist, review, and conduct cabin safety training programs. She currently consults in aviation safety and is a member of the International Civil Aviation Organization [ICAO] Cabin Safety Working Group and ICAO Human Factors Working Group. Barbara has participative authorship in several published studies regarding cabin safety issues, flight attendant training, emergency evacuation, and accident investigation. She is the recipient of numerous accolades and awards including the Transport Canada Aviation Safety Award in 1995.

"Recently Barbara stepped down as president of CSASI. The baton was passed to Barry Wiszniowski.

"Barbara's role in ISASI is nothing short of phenomenal. Her membership was updated to Fellow in 2005. She will continue in her role as seminar chair. ISASI is deeply indebted to Barbara for her many contributions and untiring role in the organization."

The new Canadian ISASI officers are President Barry Wiszniowski, Vice President Bryon Mask, and Secretary-Treasurer Steve Roberts. ◆

ESASI Holds Virtual 2021 Seminar

Rob Carter, European Society of Air Safety Investigators (ESASI), reported that the European Society held its 2021 seminar in a virtual format on July 1–2. He noted there was good attendance, both for numbers—of the 227 registered participants, more than 181 were online at one time—and geography as there were participants from Argentina; Seattle, Wash.; Singapore; and Australia.

Peter Swaffer, Swedish Accident Investigation Authority (SHK), reviewed a fatal accident in Sweden involving a parachuting Airvan with eight jumpers that experienced a rapid descent and in-flight breakup after entering clouds. He showed part of an SHK-generated video describing the investigation and the safety recommendations. Swaffer also described the advantages of discussing the recommendations with the regulator, the European Union Aviation Safety Agency (EASA), following their publication and before, which was a good way to have his investigators meet the EASA staff assessing the report.

Mark Jarvis, UK Air Accidents Investigation Branch (AAIB), discussed the AAIB's first deployment to a UAS accident, an Australian-built racing prototype weighing about 90 kilograms being demonstrated at a public event. After loss of ground control, the UAS climbed, out of control, to an apogee of about 8,000 feet into controlled airspace before crashing near housing when its batteries ran out. The AAIB investigation generated 15 safety recommendations, particularly on design standards and the regulator's role in the approvals process.

Toni Flint and Mark Ellis, UK AAIB, gave an account of a serious incident in which an Airbus A321 (G-POWN) suffered engine issues on takeoff due to the overdosing of fuel with biocide. The incident was rich in human factors aspects, including the dose miscalculation and the error not being caught before flight. Several safety recommendations were made to worldwide regulators to make biocide treatment a critical maintenance task.

In Memoriam

Greg Maddon: Australian Society of Air Safety Investigators President John Guselli reports with a deep sadness that Greg Madden passed away at his home on July 10, 2021, as the result of a heart attack. Guselli noted that Madden played a prominent role within the industry over many years and will be fondly remembered for his professional abilities. Of even greater significance to his memory was his genuinely friendly personality and easy-going nature. He will be sorely missed by all who knew him.

Nick Stoss: Ron Schleede reported that Niclas G. "Nick" Stoss died on July 23, 2021. Schleede said he met Stoss in the late 1980s when he worked at the Canadian Aviation Safety Board. "When that agency became the Transportation Safety Board [TSB] in 1990," Schleede added, "Nick spent a month in my office at the National Transportation Safety Board gaining information to compile the Canadian accident investigation manual.

"Nick became the director of Air Investigations for the TSB in 2002. Before retiring, he was the chair of the International Civil Aviation Organization [ICAO] Accident Investigation Divisional meeting in Montréal, Qué., Canada, during 2008 (AIG/08), which over 300 aviation specialists from more than 100 countries attended. In 2015, Nick joined the ISASI/ICAO Working Group and participated in meetings in Montréal and in other work on behalf of ISASI. About three years ago, he asked to give up the work for ISASI because of memory/concentration issues. "Nick was a very good friend," Schleede said, "and visited my cottage in Canada several times for fishing."

"On behalf of the Canadian Society of Air Safety Investigators, we would like to express our sincere condolences to the family and friends of Nick Stoss," said Barry Wiszniowski, Bryon Mask, and Steve Roberts. "Nick was a friend and mentor to many. He held a Lifetime ISASI membership and made a significant contribution to both the Canadian Society and the International Society of Air Safety Investigators. Nick will be missed for his proven leadership and outstanding commitment to aviation safety." ◆

The Airspeeder UAS in flight at its apogee over the south coast of England.

Tim Rolfe and Duncan Trapp, representing the wider operator membership of HeliOffshore, shared their experiences with accident investigations from operators' viewpoints. They support professional safety investigation authorities' investigation, the appropriate use of cockpit cameras, the consistent involvement of the operator as a key stakeholder, and encouraging better implementation of safety recommendations.

Ragnar Gudmundsson, Icelandic Transportation Safety Board, described a published B757-200 (TF-ISR) enhanced ground proximity warning system go-around event, which occurred on approach to Keflavík in very poor weather and included a sink rate of 1,700 feet per minute and a minimum height of 221 feet above ground level. The report included eight safety recommendations.

Philip Plantholt, Flightradar24, discussed the use of Flightradar24 in safety investigations. The ADS-B receiver volunteer network keeps expanding rapidly, giving good coverage in most parts of the world, The system also integrates third-party data such as flight plans and flight status. He stressed that Flightradar24 can provide this service for commercial aviation safety cases only, that requests must be timely, and that the data provided within this free service can only be offered "as available."

David Ferrullo, Airbus Helicopters, discussed "the myth of losing tail rotor effectiveness." He provided a description of the apparent phenomenon of tail rotor stall, more accurately described as unanticipated yaw. Accidents with unanticipated yaw are still common. Tests demonstrated how a pilot may feel that the tail rotor is ineffective and showed the need for early and full pilot opposing pedal reaction to unanticipated yaw. This builds a clear and consistent message, appropriate to the low height conditions during which the problem occurs, to be propagated by authorities, industry, and flight schools.

Dr. Marcus Bauer, iwiation GmbH, described novel techniques for flight data reconstruction based on video evidence, mostly from witnesses and security cameras. He showed a number of instances of video evidence assisting investigations, giving useful flight parameters not available otherwise. Looking forward, he reviewed a visual object identification using artificial intelligence, including algorithms for automatic detection of aircraft attitude that will support further accurate data reconstruction based on video evidence.

ESASI also held its annual meeting with the committee reporting on the year and presenting its new constitution for adoption by the membership. ESASI President Olivier Ferrante, chair of the International Civil Aviation Organization Accident Investigation Group Panel (AIGP), also gave an update on the recent AIGP6 virtual meetings.

"ESASI is looking forward," Carter noted, "to getting together for the 2022 seminar in Budapest, Hungary. Before that is our next ESASI event in November, 'Focus On… Protected Information.' ESASI hopes to see you there. Details are on the ESASI website." ◆

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Adnan Zuhairy Engineering Consultancy
Aegean Airlines
Aer Lingus
Aero Republica
Aerovias De Mexico, S.A. De C.V.
Agenzia Nazionale Per La Sicurezza Del Volo
AHK Air Hong Kong Ltd
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Air Accident Investigation Bureau of Mongolia
Air Accident Investigation Bureau of Singapore
Accident Investigation Committee of Thailand
Air Accident Investigation Unit-Ireland
Air Accident Investigation Sector, GCAA, UAE
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Air Asia Group
Air Astana JSC
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Air Canada Pilots Association
Air Line Pilots Association
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Airclaims Limited
Air New Zealand
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All Nippon Airways Co., Ltd. (ANA)
Allianz
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ASPA de Mexico
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Association of Professional Flight Attendants
Australian and International Pilots' Association (AIPA)
Australian Transport Safety Bureau
Aviation Accident and Incident Investigation Division/Ministry of Infrastructure, Rwanda
Aviation Investigation Bureau, Jeddah, Kingdom of Saudi Arabia
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Civil Aviation Safety Investigation and Analysis Center
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Military Air Accident Investigation Branch
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Ministry of Transport, Transport Safety Investigation Bureau, Singapore
National Aerospace Laboratory, NLR
National Department of Investigation (Argentina)
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Pakistan Air Force-Institute of Air Safety
Pakistan Airline Pilots' Association (PALPA)
Pakistan International Airlines Corporation (PIA)
Papua New Guinea Accident Investigation Commission (PNG AIC)
Parker Aerospace
Petroleum Air Services
Phoenix International Inc.
Plane Sciences, Inc., Ottawa, Canada
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Southwest Airlines Company
Southwest Airlines Pilots' Association
Spanish Airline Pilots' Association (SEPLA)
State of Israel
Statens haverikommission
Swiss Accident Investigation Board (SAIB)
Taiwan Transportation Safety Board (TTSB)
The Air Group
The Boeing Company
The Japanese Aviation Insurance Pool (JAIP)
Transportation Safety Board of Canada
Turbomeca
Ukrainian National Bureau of Air Accidents and Incidents of Civil Aircraft
UND Aerospace
United Airlines
United States Aircraft Insurance Group
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University of Southern California
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WHO'S WHO: JETBLUE

(Who's Who is a brief profile prepared by the represented ISASI corporate member organization to provide a more thorough understanding of the organization's role and function.—Editor)

JetBlue is the sixth largest airline in the United States, serving more than 100 destinations throughout the Americas. The airline took to the skies in 2000 and currently employs more than 20,000 crewmembers, flies more than 270 aircraft, and operates six focus cities in New York, N.Y.; Boston, Mass.; Fort Lauderdale and Orlando, Fla.; Los Angeles, Calif., and San Juan, P.R. In 2021, JetBlue is launching service to London, England, from New York and from Boston in 2022 aboard its new Airbus A321LRs, marking the airline's first-ever transatlantic service and entry into extended-range twin-engine operational performance standards (ETOPS) operations. JetBlue's entrance into the transatlantic market introduces a new era of customer-focused, low-fare travel for leisure and business travelers.

The JetBlue fleet consists of Airbus A220-300s; Airbus A320ceos; Airbus A321ceo, neo, and LR variants; and Embraer E190s. Additionally, the airline has more than a dozen A321XLRs on order, which it intends to operate between the U.S. and additional European destinations in the coming years.

Both safety and sustainability are cornerstones of JetBlue operations, and optimizing how we fly can realize significant safety and efficiency improvements. JetBlue was the first airline in the congested New York airspace to utilize next generation air transportation system (NextGen) navigation equipment. Equipping our aircraft with NextGen systems and utilizing new satellite-based approaches results in shorter flying times, less congestion, fewer delays, decreased fuel burn, and safer operations.

Advanced safety systems such as traffic alert and collision avoidance and ground proximity warning are installed across the fleet, while new deliveries incorporate the latest technology such as the runway overrun protection system. The A321LR fleet also has dual combined voice and data recorders to increase aircraft data availability for safety investigations, proactive flight monitoring programs like flight operations quality assurance, and technical aircraft dispatch reliability monitoring. JetBlue Safety Investigations manages the Accident Investigation Team (AIT). Comprised of crewmembers from a cross section of the company, the AIT can be activated to support accident or serious incident investigations involving our fleet.

Our Technical Operations Team, composed of more than 1,200 crewmembers with a footprint that spans 12 cities and support centers across the U.S. and Puerto Rico, maintains a highly reliable and safe fleet. Aircraft maintenance hangars are located at John F. Kennedy International, Boston Logan International, and Orlando International Airports. During the recent pandemic, Tech Ops developed and implemented aircraft parking, storage, and return-to-service programs, as well as new aircraft cleaning and disinfection protocols to ensure the safety of our customers and crew. More recently, the Tech Ops Team has been hard at work on ETOPS certification while continuing to receive new aircraft as the fleet continues to grow and evolve.

JetBlue is an industry leader in mitigating climate risk. In 2020, we became the first major U.S. airline to achieve carbon neutrality for all domestic flights, later announcing a commitment to net-zero carbon emissions by 2040. The introduction of the newest aircraft to the fleet, the A321neo and A220, significantly reduces emissions and brings fuel economy improvements of 20–40 percent per seat, supporting our commitment to sustainability.

JetBlue was also the first airline in the world to make the decision to retrofit its in-service fleet with sharklets—wingtip devices that improve aerodynamics, save fuel, and reduce emissions by up to 4 percent. We began regularly flying on sustainable aviation fuels in 2020 out of San Francisco International Airport. With safety as our Number 1 value, we ensure that sustainable aviation fuel is fully compatible with existing jet engine technology and the fuel distribution infrastructure.

The airline's Mint® premium experience promises to offer customers a fresh choice when flying between the U.S. and the UK. JetBlue's industry-leading core experience has also been reinvented for crossing the Pond and will offer a new level of service to customers who want a great experience at a low fare. ◆

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