FEATURES

4 Extending the Network and Using Available Resources
By Michael Guan, Ph.D.; Brian C. Kuo, Ph.D.; and Yann Torres—The authors, using two aircraft accidents as examples, examine how a small investigative agency can successfully determine causal factors and recommend air safety improvements.

10 Collaborative Component Examinations
By Eric J. East, Air Safety Investigator, Boeing Commercial Airplanes—The author observes that one of the key links in the process for determining probable cause of an aircraft incident is the physical examination, interpretation, and relevance of hardware and data that are recovered from an incident or accident site.

15 What Makes a Good Air Safety Recommendation?
By Maria Gregson, Faculty of Engineering, University of Nottingham, UK—The author is one of ISASI’s four Kapustin scholarship winners for 2017. She presented her winning essay during ISASI’s 2017 seminar.

18 Linkages Between Occurrences and Safety System Performance
By Heather Fitzpatrick, Senior Transport Safety Investigator, Australian Transport Safety Bureau—The author details the utility of the Australian Transport Safety Bureau’s fatigue and fatigue risk management system in establishing a tangible link between the performance of an organization’s systems and an occurrence event.

24 Safety Recommendations: Strengthening EASA’s SRM Process
By Mario Colavita, Safety Investigation Officer, European Aviation Safety Agency—The author describes the existing link between the European Aviation Safety Agency’s safety risk management process and the use of safety recommendations as a key element for the identification of the systemic safety issues and their prioritization.

DEPARTMENTS

2 Contents
3 President’s View—Air Safety Investigators Make a Positive Difference
28 News Roundup
30 ISASI Information
32 International Council Meets in San Diego

ABOUT THE COVER

A TransAsia Airways ATR 72 experienced a loss of control during initial climb from Taipei’s Songshan Airport on February 4, 2015 and crashed into the Keelung River resulting in 43 fatalities and injuries to surviving passengers, a flight crew member, a taxi driver and his passenger. (See ”Extending the Network and Using Available Resources”, page 4.)
AIR SAFETY INVESTIGATORS MAKE A POSITIVE DIFFERENCE

We recently completed a very successful ISASI seminar in San Diego, California, during which more than 360 delegates and companions participated in three days of technical presentations and heard pertinent keynote addresses from U.S. National Transportation Safety Board Chairman Robert Sumwalt (a longtime ISASI member) and James Viola (also an ISASI member), head of the U.S. Federal Aviation Administration’s Office of General Aviation Safety Assurance. Participants had an opportunity to meet and share experiences with colleagues from 35 countries and visit local sites of interest.

Two tutorials preceded the seminar.

AN AIR SAFETY INVESTIGATOR’S JOB IS COMPLICATED AND DIFFICULT. WE ALL KNOW THIS TOO, BUT HOW WE RESPOND TO THIS DIFFICULTY CAN MAKE THE DIFFERENCE BETWEEN HAVING A SUSTAINABLE, LONG-TERM CAREER OR AN EARLY BURNOUT.

Nearly 50 military participants attended an all-day session that took a look at how military air accident investigators from many different countries do their job. Some 74 civilian air accident investigators attended two half-day presentations: flight recorders beyond International Civil Aviation Organization Annex 13 and how air accident survival factors help to lower fatal accident rates and reduce injuries.

Four Kapustin scholars presented essays—one of which appears in this issue. The number of annual scholarships that ISASI provides depends entirely on the amount of donations from ISASI members. More information about the scholarships—how to donate and how to apply—can be found on our website under the Awards tag. I hope you’ll continue to provide an opportunity for these exceptional students to attend our seminar and to find career opportunities in their respective aviation fields.

The gathering culminated with the annual awards dinner during which Chan, Wing Keong was recognized with the Jerome Lederer Award for his leadership and extraordinary efforts to enhance air safety investigation in Singapore and to encourage international air safety cooperation well beyond the Asian region. An article on the seminar will appear in the next issue of ISASI Forum.

The theme of this year’s gathering asked the question does air safety investigation make a difference? As I have said many times, ISASI members all know the correct answer to this question. However, what we actually accomplish can get lost in the fog of day-to-day responsibilities, regulations, paperwork, and when that inevitable phone call arrives demanding our immediate presence at yet another air accident investigation.

There are a number of ways to help clear the fog.

• Focus on how we do make a positive difference in air safety.
• Realize our part in developing and promoting the technical and procedural changes brought about from safety recommendations that have saved peoples’ lives.
• Remember that we’re not alone. The men and women who are ISASI members, the agencies that employ ISASI members, the states that establish and fund these agencies, and the international organizations that establish safety guidelines for member states all have the same ultimate goal—making air travel safer and developing best practices for those of us who must investigate accidents and incidences.
• Develop positive working relationships among the various aviation agencies, corporations, and organizations that affect air safety—the interested parties that converge on an accident investigation—prior to getting the phone call to go to the site.
• Talk to family and community members about the positive aspects of our work.
• Share our experiences and expertise with young people who’ve recently begun their air safety careers or who are studying to do so in the future. They want and need to hear from those of us who’ve been longtime investigators and safety advocates. Becoming an ISASI student mentor often has as many benefits for us as it does for the students with whom we interact.
• Identify our personal support systems—people who can help us stay on track when we start to lose sight of our priorities or our best path to stable physical or mental health.
• Attend ISASI meetings and seminars at the regional, state, or international levels with colleagues from different agencies, countries, and cultures to develop working relationships in a friendly, supportive environment to enhance teamwork that will carry over to cooperation on some future investigation.

There are many reasons why air accidents have reduced in numbers and fatalities in recent years—the professionalism, expertise, and commitment of ISASI members to enhance all aspects of air safety, our efforts—are among the most effective of those reasons.

Frank Del Gandio
ISASI President
EXTENDING THE NETWORK AND USING AVAILABLE RESOURCES

By Michael Guan, Ph.D.; Brian C. Kuo, Ph.D.; and Yann Torres

(Adapted with permission from the authors’ technical paper entitled Extend the Network and Exploit Available Resources—Lessons Learned from Two Major Investigations presented during ISASI 2016 in Reykjavik, Iceland. The full presentation can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)

Compared to Australia, Europe, and North America, aviation safety investigations and safety studies in Taiwan began relatively recently—about 20 years ago. The Aviation Safety Council (ASC) was established in May 1998 as an independent government agency in Taiwan, the Republic of China, responsible for the investigation of civil, public, and ultra-light aircraft accidents and serious incidents (Aviation Occurrence Investigation Act 1, 2), as well as safety recommendations issuance directly to the premier and follow-up. Since its establishment, the ASC has investigated 118 occurrences and issued 937 safety recommendations.

The ASC investigation lab, with a staff of five, is in charge of providing technical support to aviation occurrence investigation. This includes, but is not limited to, site survey, flight recorder readout, flight path reconstruction, radar data and GPS data processing, performance analysis, and visualization. The lab also undertakes several safety studies and research programs, e.g., wet runway performance, locating black boxes under water, structural examination, and failure analysis.

The ASC investigation lab has also been involved in several foreign investigations, for which the ASC has appointed accredited representatives. In order to build experience in flight recorder readout and analysis, the ASC also provides technical assistance to other agencies. In 2014, the lab completed seven CVR and 76 FDR/QAR readouts, seven animation sets, and 13 sets of GPS/radar data and satellite map superposition (see Table 1).

**Domestic and international collaboration**

To continue fostering working partnerships developed over the years with domestic and international agencies and sharing a common vision of improving air safety by exchanging and analyzing safety data, the ASC believes that technical cooperation is a key to link each agency to work together. Depending on available resources, there are four kinds of international technical collaboration, including workshop/seminar, joint training/exercise, technical assistance, and occurrence investigation.

For instance, pursuing knowledge on flight recorder readout is a top priority for the ASC; therefore, investigators were sent to flight recorder manufacturers for flight recorder training courses. The ASC is also interested in on-job training (OJT) at accident investigation authorities (AIAs).

Nowadays, in order to manage a shortage in the budget and extend the technical capabilities for future investigations, the ASC lab continues to seek different forms of technical collaborations with domestic agencies and foreign AIAs.

**Domestic collaboration**

The ASC signed memorandums of understanding (MOUs) with seven domestic (government) agencies, including the Civil Aeronautics Administration (CAA), the Chinese Ocean and Underwater Technology Association (COUTA), the Ministry of National Defense (MND), the Ministry of Justice (MOJ), the National Airborne Service Corps (NASC), the National Fire Agency of the Ministry of the Interior (NFa/ MOI), and the Taoyuan International Airport Company (TIAC).

Based on those MOUs, the ASC maintains excellent collaboration with national judicial agencies and criminal investigation units to perform necessary examinations (e.g., autopsy, DNA, and medical). After training by ASC investigators, CAA inspectors and TIAC technical staff are capable of following ASC’s SOP to assist in securing perishable evidence during occurrences before the ASC goes to the occurrence site.

The benefits of domestic bilateral agreements include sharing training resources, transportation, wreckage handling capabilities, and providing technical support on sea crash accident investigation.

**International collaboration**

In addition, the ASC has reached technical collaboration with 15 worldwide AIAs and has signed seven MOUs with the UK Air Accidents Investigation Branch (UK AaIB), the Australian Transport Safety Bureau (ATSB), the Bureau d’Enquêtes et d’Analyses pour la sécurité de l’aviation civile (BEA), the Japan Transport Safety Board (JTSB), the Korean Aviation and Railway Accident Investigation Board (KARAIB), the U.S. National Transportation Safety Board (NTSB), and the Transportation Safety Board of Canada (TSB).

In the last decade, ASC investigators have learned techniques to process damaged flight recorders and investigation methodology from the ATSB, the BEA, the NTSB, and the TSB. Based on OJT and accident investigations in practice, ASC investigators have adhered to Attachment

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**Table 1. Summary of Flight Data Readouts**

<table>
<thead>
<tr>
<th>Year</th>
<th>CVR</th>
<th>FDR/QAR</th>
<th>ANI</th>
<th>GPS/Radar</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>4</td>
<td>21</td>
<td>4</td>
<td>(15)</td>
<td>35</td>
</tr>
<tr>
<td>2012</td>
<td>9</td>
<td>16</td>
<td>9</td>
<td>(0.5)</td>
<td>39</td>
</tr>
<tr>
<td>2013</td>
<td>8</td>
<td>9</td>
<td>0</td>
<td>(0.2)</td>
<td>10</td>
</tr>
<tr>
<td>2014</td>
<td>7</td>
<td>76</td>
<td>7</td>
<td>(6.7)</td>
<td>105</td>
</tr>
<tr>
<td>2015</td>
<td>5</td>
<td>17</td>
<td>4</td>
<td>(14)</td>
<td>31</td>
</tr>
</tbody>
</table>
D “guidelines for flight recorder readout and analysis” of the International Civil Aviation Organization’s (ICAO) Annex 13, have maintained proper technical capabilities to support ASC occurrence investigation, and have assisted nearby AIAs in setting up their readout capabilities.

The benefits of international bilateral agreements include sharing training resources, developing and testing new tools, exchanging safety databases, and providing technical supports to ICAO Annex 13 investigations.

Technical cooperation between the ASC and the BEA
In May 2002, the ASC signed a MOU with the MOJ Taiwan regarding aviation occurrence investigation and criminal investigation to establish a coordination mechanism and share technical resources. For criminal investigation in Taiwan, the MOJ relies on the Criminal Investigation Bureau (CIB) and the MOJ to examine evidence and provide technical findings to assist MOJ prosecutors. Major technical capabilities of the CIB include DNA testing, examining dangerous goods and weapons, victim identification, and ground survey tools.

In any fatal aviation accident that occurs in Taiwan, the CIB plays a key role coordinating with the ASC and the MOJ. The three agencies have shared training resources and performed joint exercises to improve on-scene survey knowledge and analysis skills for multidata sets. For example, the ASC assisted the CIB and the MOJ with a marine criminal investigation in 2009 and 2013.

Technical research projects and exercises
There are two kinds of technical research projects at the ASC—self-study safety projects and joint research projects. Typically, self-study safety projects are executed by ASC investigators and include audio spectrum analysis, a annual survey of flight recorder installation on national registered aircraft, investigating wet runway occurrences related to suspected hydroplaning, ECCAIRS, and HFACS coding application.

The Execute Yuan or the Ministry of Science and Technology (MOST) fund these joint research projects. ASC board members review safety statistical data, prioritize relevant safety study topics, and encourage ASC investigators to invite academic researchers to join these specific topics. Two big projects were finished in 2009 and 2010. There are another two projects in the works. The major objectives of joint research projects, based on the lessons learned from ECCAIRS and HFACS coding, adopt ATSB safety analysis methodology into ASC investigation procedures, which aim to improve general aviation safety in Taiwan and evaluate lightweight

Technical cooperation between the ASC and the CIB

Technical research projects and exercises
Statistics of civil fixed-wing and rotary-wing aircraft

Figure 1. Statistics of civil fixed-wing and rotary-wing aircraft.

The theme of ISASI 2016 was “Every Link Is Important.” This paper highlights the bilateral benefits in four areas: the annual survey of flight recorder installation, the joint exercise for the sea search and recovery of black boxes, the development of UAV-based aerial mapping systems for aviation occurrence investigation, and industrial cooperation on flight recorder readout and analysis. Regarding these efforts, the authors will present factors for cooperation from two major investigations to demonstrate how the ASC adheres to ICAO Annex 13 protocol and collaborates with AIAs, aircraft manufacturers, judicial agencies, and airline operators.

Annual survey of flight recorder installation on national registered aircraft

The ASC carries out a routine survey of flight recorder installation for national registered aircraft. The goal of this survey is to review the installation of CVRs, FDRs, FDAUs, and QARs at various national operators. The findings are the basis for enhancing the readout capability of the investigation laboratory and flight recorder readout in relation to occurrence investigations.

The ASC conducted its annual survey in August 2015. This survey included 20 operators and three government agencies. According to the responses from all the agencies, there are 280 aircraft, including 243 fixed-wing and 37 helicopters. Out of these, 247 are civil aircraft, and 33 are public aircraft.

The statistics for civil fixed-wing and rotary-wing aircraft are shown in Figure 1. The number of civil aircraft with CVRs and FDRs are 94.3% and 92.3%, respectively. The number of civil aircraft with tape-based CVRs and FDRs are 0% and 0.4%, respectively. The number of the civil aircraft with 30-minute CVRs and 120-minute CVRs are 8.5% and 85.8%, respectively.

- The number of civil aircraft with an FDR readout database in paper and an electronic file is 52.5% and 72.5%, respectively.
- The number of FDR readout databases with verification is 93.3%.
- The number of the civil aircraft with QARs is 85.4%.

After checking, accepting, and reviewing the training progress, by the end of 2015 the ASC readout capability for the surveyed CVRs and FDRs was 99.6% and 99.6%, respectively. The ASC determined that only one recorder from a new Gulfstream G280 did not have its own download equipment.

Joint exercise for sea search and black box recovery

In recent years, the ASC has held seven trainings sessions on sea search and recovery of black boxes. The ASC invited the Asia-Pacific AIAs to join those activities. The ASC shared lessons learned from the sea crash accident investigations and provided site operational databases and in-house programs for its partners to strengthen coordination among the relevant domestic agencies and organizations and enhance cooperation on the use of resources and technical personnel when necessary.

The ASC held an exercise on underwater recovery of flight recorders in May 2010. The ASC invited the Coast Guard, the Hong Kong Civil Aviation Department, the KARAIB, and the Singapore AAIB to join this activity. Some of the attendees took the lessons learned from this sea search exercise and helped the KARAIB perform the sea search mission of Asiana Airlines Flight 991, which crashed into the East Sea on July 28, 2011.

Based on MOUs, the ASC can use relevant resources from the Coast Guard, the COUTA, and the MND to execute a sea search and locate the black box.

Development of UAV-based aerial mapping system

In 2004, the ASC began evaluating the use of light RPV or UAV in investigations. The ASC determined that RPVs and UAVs would not be used for long endurance search and rescue but for wreckage distributed over a wide area or in rugged terrain to gather aerial images of the wreckage and generate high-resolution photos.

In 2005, the ASC purchased a first-generation RPV. Due to several operational experiences and lessons learned from the ASC/CIB joint exercise on ground vehicle explosions, the ASC decided in 2010 to acquire a second-generation UAV.

Between 2011 and 2014, the ASC conducted more than 10 exercises to improve its own UAV operational skills, develop SOPs, review the evaluation guide to site hazards, standardize mission plans and flight routes, develop an in-house program to improve the quality of aerial mapping, generate precise terrain information, and integrate the information into a flight animation system.

The ASC presented its technical paper “UAV Aerial Photography on Debris Mapping” in the second AsiaSASI meeting in Taipei in 2013 to pursue better solutions for UAV mapping and deepen the technical cooperation with AIAs of the Asia-Pacific region. The ASC also provided a UAV demonstration flight to simulate application tips for occurrence investigation.

The ASC invited the Singapore AAIB to join this activity. Some of the attendees took the lessons learned from the joint exercise and helped the KARAIB perform the sea search exercise and helped the KARAIB perform the sea search mission of Asiana Airlines Flight 991, which crashed into the East Sea on July 28, 2011.

Based on MOUs, the ASC can use relevant resources from the Coast Guard, the COUTA, and the MND to execute a sea search and locate the black box.

Industrial cooperation program

Since 2010, the ASC has pursued industrial cooperation on flight recorder readout and analysis. In October 2015, the ASC signed an international cooperation agreement with U.S. defense contractor
Raytheon regarding the latest technology on flight data management and analyses to enhance the nation’s capabilities in investigating aviation accidents.

Raytheon and the ASC selected Plane Sciences Inc. of Canada to be the technology partner based on the company’s unique capability and its position as a leader in flight data recorder-related technologies. The agreement established a cooperative framework between participants to execute collaborative projects in areas that meet the mutual interest of the parties. There were 40 participants, including the ASC, the CAA, airline operators, and the Taiwan Army, Navy and Air Force (see Figure 2).

The objectives of the 10-day training program and three-day technology sharing with Plane Sciences Inc. and the ASC were to

- improve aviation safety capability and expertise in Taiwan through collaboration and technology sharing with North America and other international locations.
- establish readout capability of next-generation flight recorders at the ASC and receive international certification.
- mitigate flight occurrence rate/risks on runway safety and hazardous weather incidents through technology sharing, international certification, and training in order to achieve international standards.
- increase trainees’ abilities in flight data analysis and safety risk identification and management and conduct occurrence investigation in accordance with ICAO Annex 13.

**Lessons learned from two major investigations**

The ASC recently completed two major investigations that had common challenges, including an insufficient budget, limited knowledge about SMS, and engine flameouts. Based on international technical collaboration, best practices and procedures have been established from the relevant safety studies, joint exercises, and excellent teamwork between the ASC and the accredited representatives.

An insufficient budget and shortage of investigative human resources are typical problems for a small safety investigation agency. The ASC has applied an emergency reserve budget to support on-scene wreckage handling and overseas investigation activities.

In addition, strong intergovernmental cooperation was a key to success in two major investigations. The following sections describe the technical aspects and lessons learned from two ATR 72 accident investigations. According to the final reports of both ATR 72 accident investigations, the majority of the causal analysis issues emphasize organizational deficiencies and CAA audits. This paper interprets the links between the sequence of events from flight recorders and highlights the teamwork among the flight recorder group, other groups (e.g., flight operation, airworthiness), accredited representatives, and technical advisors.

**TransAsia Airway Flight GE222**

On July 23, 2014, an ATR-GIE Avions de Transport Régional ATR 72-212A (ATR 72), registered B-22810, TransAsia Airways (TNA) Flight GE222, with two pilots, two cabin crew, and 54 passengers, was operating on instrument flight rules (IFR) regular public transport service from Kaohsiung to Magong in the Penghu archipelago. At 1906 Taipei local time, the aircraft impacted with terrain approximately 850 meters northeast of the threshold of Runway 20 at Magong Airport and then collided with a residential area on the outskirts of Xixi Village approximately 200 meters to the southeast of the initial impact zone. At the time of the occurrence, the crew was conducting a very high frequency omnidirectional radio range (VOR) nonprecision approach to Runway 20.

The aircraft was destroyed by impact forces and a postimpact fire. Ten passengers survived the occurrence, and five residents on the ground sustained minor injuries. The occurrence was the result of controlled flight into terrain. The crew members continued the approach below the minimum descent altitude when they were not visual with the runway environment, contrary to SOPs.

The investigation report identified a range of contributing and other safety factors relating to the flight crew of the aircraft—TNA’s flight operations and safety management processes, the communication of weather information to the flight crew, coordination issues at the civil/military joint-use airport, and the regulatory oversight of TNA by the CAA. This investigation identified important learning opportunities for pilots, operators, and regulatory agencies to improve future aviation safety to ensure such an accident would never happen again.

There were a total of 46 findings from the final report and 29 safety recommendations issued to the related organizations, including TNA, the CAA, and the MND. This paper highlights four technical issues found during the on-scene investigations.

**FDR readout document contained unclear information**

Based on the ATR’s FDR readout document, three types of issues were identified with the nonmandatory FDR parameters:

1. Erroneous definition for sign convention;
2. Mixture of two parameters into one;
3. Unclear descriptions on several parameters.

In summary, certain parameters listed in ATR’s FDR readout document contained unclear or erroneous information in their sign convention and triggering conditions. The parameter “selected vertical speed” was confusing, and it had an adverse effect on the efficiency of the occurrence investigation. A reduction in the complexity of ATR’s FDR readout document, by applying the principles of ED-112A137, would assist future occurrence investigations.

**Finding:** ATR’s FDR document contained unclear information that affected the efficiency of the occurrence investigation.

Safety recommendation to ATR: Review the FDR readout document for any...
time flew over trees.

Figure 3. The relationship of terrain height and corrected altitude of GE222 during the time flew over trees.

erroneous information and provide timely revisions to the manual to assist airline operators and aviation occurrence investigation agencies.

Flight data correction and performance analysis

Wreckage distribution illustrated that the aircraft collided with trees, and several items were separated from the aircraft. No evidence showed that the vertical tail and elevators had collided with trees.

Based on the CVR and FDR data, at 1906:11, the flight crew called a "go around." The power levers of both engines were increased to 78 degrees then dropped to 35 degrees. About three seconds later, the NP speed of the number 1 engine and indicated airspeed decayed rapidly. The NP speed of the number 2 engine was maintained at 100%. The pressure altitude contained some spike points, and its trend approximated 60 feet. Radio height indicated that the aircraft approached the ground, and the main landing gear was changed from "air mode" into "ground mode."

During the on-scene investigation period, the flight recorder group focused on specific questions when the aircraft passed through trees near Xixi Village:

- How to calibrate the FDR recording parameters (e.g., pressure altitude or radio height)?
- How to derive the vertical speed from FDR parameters?
- How to evaluate the strength of turbulence?

In summary, during GE222's collision with the trees, ground effect caused the pressure altitude to be unreliable. The accuracy of radio height may also have been affected by the dense trees. Based on terrain data and the height of truncated bush trees, the aircraft’s corrected altitude was derived—denoted as Corr. Alt. (see Figure 3). Most likely, its pitot tube was damaged and caused the indicated airspeed record to drop to zero at 1906:16. The drop in each engine’s rotor speed was caused by the collision with the trees. The aircraft ground speed and its attitude data should be reliable and could be used in further impact analysis with the first impacted building.

As stated in ICAO Annex 3, the EDR is an aircraft-independent measure of turbulence. The relationship between the EDR value and the perception of turbulence is a function of aircraft type and the mass, altitude, configuration, and airspeed of the aircraft. The EDR values of the occurrence flight were calculated. Similar to the vertical acceleration, the EDR values were less than 0.2 most of the time during the last two minutes of the flight. At about 1906:00, the EDR value started to increase and reached the maximum of 0.65 just before the aircraft contacted with the trees.

Examining the FDR data between 1906:00 and the end of the flight, the occurrence aircraft had numerous pitch and roll angle changes. The increased vertical acceleration and EDR values probably were caused by the combination of turbulence and the aircraft maneuver.

Finding: The occurrence flight had increased its rate of descent from 150 feet per minute to 1,600 feet per minute between 1906:05 and 1906:10, which was the result of an elevator control input by the captain. Based on the values, the turbulence strength of the occurrence flight during the last two minutes could be classified as "light to moderate."

FOQA is a key tool for SMS investigation

Based on the CVR and FDR data, ASC and BEA investigators worked together to determine the sequence of events then planed further investigation efforts, including 20 ATR 72 line observation flights, five days of flight simulator use, 75 interviews, and 104 records of FOQA events. A review of the TNA FOQA monthly data analysis reports (for one and a half years) identified recurring flight data events such as long flare, GPWS warning between 500 and 1,000 feet, and heading deviation during landing roll. There was no evidence to indicate that those events or the FOQA trend analysis results were discussed during safety meetings. The TNA FOQA program was not used as an effective tool to identify SOP noncompliance events and provide the relevant information to flight operations for training intervention. In addition, the program did not function as required to provide a systematic tool to proactively identify hazards and assess and mitigate the associated risks.

The parameters and threshold values of the TNA FOQA program were in accordance with the manufacturer's suggestions. Based on the airline's FOQA program, on the day of occurrence Flight GE220 triggered three red events: altitude below 500 feet—heading deviation greater than 20 degrees, GPWS warning triggered 24 seconds, and level off below 1,400 feet above field elevation (AFE) exceeded 10 seconds. The occurrence Flight GE222 triggered two red events: excessive bank angle on final approach below 100 feet AFE and high rate of descent on approach between 500 and 50 feet.

However, the traditional FOQA program was not configured to be able to readily identify, without further analysis, those events that were indicative of noncompliance with SOPs, including violations of approach procedures such as descent below minimum safe altitudes. No current FOQA program can readily integrate all the required data sources needed to identify some violations of SOPs.

Finding: The TNA FOQA settings and analysis capabilities were unable to readily identify those events involving SOPs noncompliance during approach and likely other stages of flight. The FOQA events were not analyzed sufficiently or effectively, leaving some safety issues in flight operations unidentified and uncorrected. Some problems with crew performance and reductions in safety indicated in the FOQA trend analyses were not investigated further. Clearly, the
airline’s FOQA program was not capable of facilitating proactive operational safety risk assessments.

Safety recommendation to TNA: Implement a more advanced FOQA program with adequate training and technical support for the FOQA staff members to ensure that they can exploit the analytical capabilities of the program. As such, the FOQA staff can more effectively identify and manage the operational safety risks confronting flight operations.

Emerging technologies—UAV and flight animation

After receiving GE222 occurrence notification from the CAA, the ASC launched a UAV site survey team. During the second day of investigations, the ASC site survey team arrived at the crash site to evaluate operation zones and then prepared a UAV operation form for the CAA.

Based on the UAV aerial survey and ground survey data, and ASC investigator acquired aerial survey video clips from three mass media. Those data indicated the aircraft drifted to the left during the final approach, and both landing gears created two parallel grooves through the brushwood on a heading of 170 degrees with a width between five and seven meters.

On the seventh day of the investigation, the ASC arranged a second UAV aerial survey mission of about three hours and spent another four hours finishing geo-image mapping. The ground resolution of the aerial images is about eight centimeters. The ASC spent another day generating high-resolution terrain data with accuracy of about 10 centimeters. All of the geo-images and terrain data have been integrated for further applications—flight path reconstruction, flight animation, etc.

TNA GE235 Flight

On Feb. 4, 2015, about 1054 Taipei local time, TNA Flight GE235, an ATR 72-212A (ATR 72-600), registered B-22816, experienced a loss of control during initial climb and impacted Keelung River, three nautical miles east from its departing Runway 10 at Taipei’s Songshan Airport (see Figure 4). Forty-three occupants were fatally injured, including three flight crew, one cabin crew, and 39 passengers. The remaining 13 passengers and one cabin crew sustained serious injuries. One passenger received minor injuries. The aircraft was destroyed by impact forces. The aircraft’s left wingtip collided with a taxi on an overpass before the aircraft entered the river. The taxi driver sustained serious injuries, and the only taxi passenger sustained minor injuries. Flight 235 was on IFR during regular public transport service from Songshan to Kinmen.

The accident was the result of many contributing factors that culminated in a stall-induced loss of control. During the initial climb after takeoff, an intermittent discontinuity in engine number 2’s auto-feather unit (AFU) may have caused the automatic takeoff power control system (ATPCS) sequence to activate, which resulted in the uncommanded auto-feather of engine number 2’s propellers.

Following this uncommanded auto-feather, the flight crew did not perform the documented abnormal and emergency procedures to identify the failure and implement the required corrective actions. This led the pilot flying (PF) to retard power to operative engine number 1 and ultimately shut it down. The loss of thrust during the initial climb and inappropriate flight control inputs by the PF generated a series of stall warnings, including activation of the stick shaker and pusher.

After engine number 1 was shut down, the loss of power from both engines was not detected and corrected by the crew in time to restart engine number 1. The crew did not respond to the stall warnings in a timely and effective manner. The aircraft stalled and continued descent during the attempted engine restart. The remaining altitude and time to impact were not enough to successfully restart the engine and recover the aircraft.

Had the crewmembers prioritized their actions to stabilize the aircraft flight path, correctly identify the propulsion system malfunction that caused the engine number 2 loss of thrust, and then take actions in accordance with procedures for engine number 2 flameout at takeoff, the occurrence could have been prevented. The investigation report identified a range of contributing and other safety factors relating to the engine’s AFU, crew of the aircraft, TNA’s flight operations and management processes, and the regulatory oversight of TNA by the CAA.

This investigation identified important learning opportunities for pilots, operators, regulatory agencies, and the aircraft manufacturer to improve future aviation safety to ensure such an accident would never happen again. The ASC issued a series of safety recommendations to TNA, the CAA, and aircraft, engine, and component manufacturers to correct the serious safety deficiencies identified during the investigation. The manufacturers of aircraft, engines, and AFUs have also implemented various safety actions in response to the occurrence.

Finding: An intermittent signal discontinuity between the AFU number 2 and the torque sensor may have caused the ATPCS not to arm steadily during the takeoff roll. However, it was activated during initial climb, which resulted in a complete ATPCS sequence including auto-feathering of engine number 2.

Teamwork on the AFU and torque sensors examination

The recovered wreckage represented approximately 85% of the whole aircraft. The remaining unrecovered 15% of the aircraft was primarily in the area aft of the cargo area and forward of the ice shield area. ASC investigators worked together with three accredited representatives, the BEA, the NTSB, and the TSB) and technical

Continued on page 30
ne of the key links in the process of determining probable cause is the physical examination, interpretation, and relevance of hardware and data that are recovered from an incident or accident site. Technique, equipment, skill, and facilities have evolved considerably over time. Examination of components has not only reinforced investigation postulations, but has also on occasion provided evidence of the unexpected. The links that tie all the equipment, plans, and interpretation of evidence together are the participants. When examining and analyzing parts, each individual participant is guided by his or her training, experience, abilities, as well as personal influences and motivations. Invaluable expertise lies with many participants regardless of whether they are at the core of or in a support role to the investigation.

Participation in component examinations by the states’ accredited representatives and their advisers is encouraged in an Annex 13 investigation. Participation in these activities is implemented in practice by the accident investigation authority of the state conducting the investigation. One such approach is the National Transportation Safety Board (NTSB) party system in the United States. In the party system, organizations whose employees, functions, activities, or products involved in the accident or incident may be invited to participate by providing suitable qualified technical personnel to assist in the investigation as defined in Title 49 US C.F.R. § 831.11. Party members can include regulatory agencies, the airline, pilots’ and flight attendants’ unions, airframe and engine manufacturers, as well as other parties that can contribute knowledge and expertise. This approach encourages open collaboration between the party members for both on-scene and off-scene activities, such as component examination, to develop a complete and accurate factual record. The effectiveness of the collaboration among examination participants—even in a very open environment such as the party system—can be enhanced by considering the unspoken influences affecting each participant.

There are many variables that affect participants’ interpretation of what is being witnessed, their ability to be an impartial participant, and the recommendations they will make on how to proceed. Participants come from different fields of expertise, experience levels, and cultures. We must work together to collect factual evidence during a thorough examination of a component that may have been involved in an accident—an accident that may have resulted in serious or fatal injuries. The results of the examination may show that a component contributed to this accident. The component in question may have been manufactured by the company you work for, installed on the airplane that you maintain, or operated by the airline that you represent. How do you maintain impartiality? Are there personal, professional, or political pressures from back home? Do you feel overwhelmed by all the experts in the room? Are you the expert who already knows the “ah ha” discovery? We have to be aware of all of these unspoken influences and how they can contribute to the environment of the examination.

The information that follows will provide a brief overview of component examination at Boeing, current methods of examination, and case studies of component examinations. It details the process and the “rules of etiquette” that have been found to contribute to a collaborative atmosphere and successful outcomes.

Boeing equipment quality analysis
Equipment quality analysis (EQA) at Boeing Commercial Airplanes has been in existence since 1956, encompassing all airplane programs at the Seattle, Renton, and Everett sites in Washington state. Our experienced EQA personnel participate in an average of approximately 300 examinations per year. The EQA process is based upon collaborative investigations in which the expertise of others is highly valued. Through systematic examination, the experience of various approaches, techniques, and discoveries throughout the history of the EQA has resulted in recognition throughout the industry as a model of component analyses.

The EQA facilities in Washington state have a unique variety of collocated equipment found in many test and examination laboratories. Real-time X-ray/digital radiography (DB) and computed tomography (CT) are typically utilized for initial noninvasive evaluations. If any special tooling or alteration is required, dedicated machining equipment is available. Highly accurate dimensional evaluations are conducted using techniques such as laser surface and optical measurement equipment. Hydraulic test benches, environmental chambers, form scan, mass spectroscopy, and digital microscopy are just some of the other capabilities readily available at our EQA labs. If follow-on evaluation is needed, access to collocated specialized research and materials laboratories is also available, including EMI (electromagnetic interference), EME (electromagnetic effects) lightning, chemical, and metallurgical facilities.

In order to maintain the chain of custody of examination parts involved with government investigations, Boeing air safety investigation and EQA organizations maintain a partnership with the Western Pacific Regional Office of the U.S. National Transportation Safety Board.
Figure 1 EQA customer distribution. NTSB. We maintain robust processes for component shipment; and when needed, onsite secure storage is available and only accessible by NTSB personnel.

Pattern recognition

Boeing EQA performs examination and analysis of components through all phases of the component’s life from development, test, and production to in-service and accident investigations. Analytical services can include test methodology and planning as well as failure mode and probable cause identification. This accumulated wealth of information from the examinations of many components is conducive to the recognition of patterns but does not preclude the discovery of new phenomenon.

The primary role of EQA is to support the development of new aircraft and continuing airworthiness of in-service aircraft. The majority of EQA workload is outside of air safety investigation, as shown in Figure 1. The investigation work conducted throughout the year for the development, production, and in-service areas helps our experts expand their knowledge base. In turn, this greatly enhances EQA’s pattern recognition capabilities and also helps to build relationships with airlines, suppliers, and government agencies that we might work with during incident or accident investigation support.

Rules of etiquette

Over many years of conducting these examinations, the Boeing EQA team has created a set of rules that are presented at the start of each examination. These rules of etiquette (see Figure 2) help to establish the ground rules and structure of the examination. More importantly, they also help set the tone, or atmosphere, in which the work is conducted. We have found that these rules help maintain focus while establishing that every participant’s input is valued and respected.

In the examples that follow, the processes, technical capability, and experience of Boeing EQA helped to enable collaboration among examination participants. In this atmosphere, important discoveries were made that provided key information to the investigations that the examinations supported.

Case Study 1—COPA Flight 201

The first case study deals with the COPA Flight 201 accident that occurred in Panama in 1992. This accident involved a COPA Airlines B-737-200 enroute from Panama to Colombia that broke up in flight and crashed into dense jungle in Panama after deviating around a storm. Unfortunately, all 40 passengers and seven crew members were lost, making this the worst aviation accident in Panama.

An investigation ensued in which Boeing provided technical advisers to the U.S. NTSB.

The digital flight data recorder (DFDR) was recovered during the investigation, and flight data were successfully recovered. Roll attitude and heading information from the DFDR confirmed inter-

Figure 2 Boeing EQA rules of etiquette.

Figure 3 Attitude direction indicator.
a number of attitude reference system components, including the panel containing the vertical gyro transfer switch, the roll synchronization portion of VG1, and the standby artificial horizon indicator. These examinations were conducted with participants from the NTSB, Panamanian DAC, COPA, and the component manufacturers.

The attitude reference system on the 737-200 provides the captain and first officer with the airplane's attitude in both pitch and roll axes during flight. Two systems are installed: system No. 1 feeds information to the captain's ADI, while system No. 2 feeds information to the first officer's ADI. In addition to the ADIs, the system consists of amplifiers, vertical gyros, and a vertical gyro transfer switch (see Figure 5). The vertical gyros (VG1 and VG2) operate when the airplane is displaced in the roll or pitch plane by transmitting electrical signals from roll/pitch synchros within the gyro, which are amplified to drive the horizon tape on the ADIs. The vertical gyro transfer switch shown in Figure 4 has three positions (BOTH ON VG1, NORMAL, and BOTH ON VG2). In the NORMAL setting, VG1 provides indication to the captain’s ADI, while VG2 provides independent data to the first officer's ADI. When the flight crew determines one of the vertical gyro is unreliable, the switch is moved from the NORMAL position to energize either VG1 or VG2 to supply information to both attitude reference systems. The airplane also contains a standby artificial horizon indicator (see Figure 6) that serves as a completely independent backup system for the attitude reference system. It provides its own visual indication of airplane attitude in pitch and roll using its own gyro, which is independent of VG1 and VG2. In this accident, the vertical gyro transfer switch was found in the BOTH ON VG1 position. With the switch in this position, both the captain's and first officer's ADIs were displaying information from VG1.

During the examination of the transfer switch at the Boeing EQA lab, a broken wire in the COMPASS portion of the panel was found. The fracture was determined to have resulted from mechanical overload and was unrelated to the VG1 circuit.

When the VG1 roll synchro rotor was initially examined, an open circuit was observed between the yellow and green coil lead wires of the rotor (Figure 7). During the examination of the cause for an open circuit, EQA personnel found a location (Figure 8) where a winding was compromised and suggested to the team that a short to the iron core ground may exist in this area. As the location in question was found covered by the original conformal coating, this anomaly had apparently been present since the part was originally manufactured. As the examination progressed, the open circuit in the coil was determined to be the result of impact damage and was not associated with the winding anomaly. The focus then shifted to examining the winding anomaly more closely.

Figure 8 shows the location of the anomaly after the conformal coating was removed. One of the wires from the coil was found pinched between a nylon plug and an armature pole labeled as “5” at the area highlighted by the arrow. The adjacent armature pole surface was examined by a scanning electron microscope (SEM) and found to have an impression consistent with the dimensions of the coil wire. This was determined to be the location of an intermittent short in the roll synchronization coil. The examination team determined that resulting voltage loss on this coil can cause the attitude direction indicator to freeze or jam intermittently in position.

In this examination, the collaborative investigative process narrowed down the list of relevant components to be considered for examination. There was willingness on the part of participants to take new suggestions into account, such as looking for short circuits to ground on VG1 by shifting focus beyond just the open circuit between lead wires found during initial continuity checks. The experience of participants was utilized to recognize patterns during physical examination to determine that the anomaly was likely present since the original manufacture and had not been caused by impact.

Case Study 2—Oxygen Mask Examination
This example is from investigation activities concerning a B-737 flight deck fire. This event occurred shortly after pushback and caused extensive fire damage in the flight deck area. All passengers and crew were able to safely evacuate. Boeing was asked to participate in the investigation as a technical advisor to the NTSB. Boeing’s EQA performed an examination on the remnants of a flight crew oxygen mask (see Figure 9) to determine the position of the regulator input knob to assist in determining possible oxygen leakage scenarios.

The 737 flight crew oxygen system
supplies the flight crew with low-pressure gaseous oxygen that is stored in a cylinder. Flight crew oxygen masks supply the oxygen to the crew and are stored in panel-mounted stowage boxes on the flight deck. The masks have diluter-demand regulators and controls that are independently adjustable by each crewmember. Each crew oxygen mask has one regulator input selector knob with three positions: NORM, 100%, and EMERGENCY. As the mask is pulled from the stowage box, a shutoff valve opens and allows oxygen to be supplied at the setting selected on the regulator input knob.

In the NORM position, a mix of air and oxygen proportional to the cabin pressure altitude is supplied on demand only when the crewmember inhales. In the 100% position, pure oxygen is supplied on demand only when the crewmember inhales. In the EMERGENCY position, pure oxygen is supplied in a continuous flow.

The examination followed the chain of custody protocol with the NTSB and documented each step in the unpacking process in order to document the as-received condition of the heavily damaged mask. The mask manufacturer helped to identify several key features listed below that could be used to determine regulator input knob positions by reviewing component drawings with participants before the examination.

- Horizontal spring at the top of the input knob.
- Internal lever called the dilution lever that sits on an internal orifice.
- Input knob molding ribs, four per side.
- Input knob molding detents, triple position set 180 degrees apart.
- Harness inflation lever pivot.

An exemplar crew oxygen mask was supplied by the manufacturer and was examined and documented by DR/CT in each input knob position. The plan view DR images in Figure 10 show the exemplar unit on the left in the EMERGENCY position beside the as-received regulator on the right. The input molding ribs and harness inflation pivot were two key features observed by participants to be in the same positions on both masks. Side view DR/CT images of the two masks were also reviewed and indicated that the dilution lever appeared to be in a similar position on the event mask. However, due to the extensive heat damage that existed in this area, the results of examining this feature were determined by participants to be inconclusive.

Initially, the investigation did not hold out much hope that anything about the state of the regulator could be determined due to the extensive fire damage shown in Figure 9. However, the examination process brought together oversight from the government investigative agency, expert knowledge from the mask manufacturer, as well as the on-site facilities and expertise available at Boeing’s EQA to successfully determine the position of the input knob. All participants agreed that the evidence showed the regulator input knob was in the EMERGENCY position.

Boeing documented the EQA activities and findings in a complete report provided to the investigator-in-change.

Case Study 3—Contact Dendrite Growth

In this example, an examination was performed on a basic switch used on one of our airplane models. Chronic failures of this component were being observed in Boeing’s production system, and parts were being returned to the supplier. As part of Boeing’s quality management system corrective action process, an investigation at the supplier commenced. Initial findings from external electrical connector pin examinations showed that the same internal circuit was shorted together, although this circuit was designed to be normally open in an unpowered state. To determine the root cause of this condition, Boeing and the supplier agreed that further examinations would be performed at Boeing’s EQA where both nondestructive and destructive examinations could be performed.

Figure 7 Roll synchro rotor remnant.

Figure 9 Remnants of a flight crew oxygen mask.

The circuit of interest is energized and de-energized by the position of contacts internal to the switch. A potential cause of a short circuit condition is welding between the metallic contacts, which can occur due to high in-rush currents. DR was the initial nondestructive method selected to determine if this condition existed between the contacts in a failed unit without disturbing their position. A DR image of the switch and the internal contacts in question is shown in the image on the left in Figure 11. The DR examination found that contact welding did not exist, but...
and it was determined by participants that destructive disassembly of the switch would be necessary.

Destructive disassembly revealed an unexpected finding. A crystalline substance was found on and bridging the normally open contacts (middle photo in Figure 11). This completed the electrical circuit, thus causing the faults and failures experienced. The investigation then focused on characterization of the crystalline substance.

Chemical analysis of the substance was performed, and the material was determined to be composed primarily of silver. The contacts of the switch are made from silver that is gold plated. This lead the investigation to further examine the condition of the contact surfaces using microscopy. SEM images of the mating contact surfaces show the presence of cracks in the gold plating, which exposed the silver substrate (upper right photo in Figure 11). Fern-like structures consistent with dendrite characteristics were observed originating from cracks in the gold plating (bottom photo in Figure 11). These discoveries lead to the addition of a less-reactive nickel strike over the silver material in the mating area of the contact surfaces prior to gold plating, which resolved the issues with the switch.

Well-established quality processes, professionalism, and trust between Boeing and the supplier initiated internal discussion and examination activities to resolve this issue. Highly skilled resources and analytical capabilities were shared and leveraged to perform detailed analysis to fully characterize the unusual contaminant. Results were shared between all parties to enhance product quality and reliability. The knowledge gained from the collaborative efforts benefited all parties about the understanding of new phenomenon.

Conclusions
As investigation participants, we are used to examining the culture of organizations and the effects of that culture. A group of participants assembled to perform an examination is itself an organization that rapidly develops its own culture as the examination proceeds. In the examples presented in this paper, the unspoken influences of participants were at work setting the organizational culture. Everyone brings knowledge and experience to an examination. How and when they share can depend on the surrounding environment and atmosphere. In our experience, the culture of each examination can be broadly categorized as competitive or collaborative. More precisely, each examination tends to fall somewhere on a broad spectrum with competitive and collaborative describing the two end points.

The processes and practices followed by participants in the examples discussed and the atmosphere developed among them created the collaborative culture that Boeing’s EQA strives to achieve. While Annex 13 and investigative authority policies such as the NTSB party system encourage this, following individual practices during examinations such as the EQA rules of etiquette can help ensure an atmosphere of openness, collaboration, and mutual respect. This contributed greatly to the discoveries made during the examinations and their respective investigations.

The proper hope in an examination is that we are all after the truth and a better understanding while avoiding this speculation: “As for probabilities, we must not give way into the fascination temptation of trying to make things fit into a certain theory, like the pieces in a jigsaw puzzle.” We have to continue to turn the spade to ascertain the underlying truth.

During the COPA Flight 201 investigation, many components were examined, and multiple findings were made from these activities. A key discovery was made concerning a badly damaged component during an oxygen mask examination. A relatively new phenomenon of dendrite growth was found in the case of the switch contact. All of these findings led to the underlying truth within these investigations, which ultimately enhances aviation safety.
Four Students Selected for Kapustin Scholarships

By J. Gary DiNunno, Editor, ISASI Forum

SASI Secretary Chad Balentine, who serves as chairman of the Society’s Randolph Kapustin Memorial Scholarship Committee, reports that committee members Balentine, Alicia Story, and Erin Gormley reviewed applications and essays and awarded the 2017 scholarships to four students. ISA-
SI created the scholarship program in 2002 as a way to memorialize all deceased Society members and named the scholarship after Kapustin who served as the ISASI Mid-Atlantic Regional Chapter president for many years and was a strong air safety advocate throughout his career. There have been 43 recipients of the scholarship since its inception, including the 2017 selected students.

The 2017 scholarship winners are
• Maria Gregson, University of Nottingham, UK, author of What Makes a Good Safety Recommendation in the Aviation Industry?
• Dylan Grymonpré, Carleton University, Ont., Canada, author of Investigations—Do They Really Make a Difference?
• Mahmoud Masood, University of Central Missouri, U.S.A, author of Enough Said About Air/Ground Crew Errors: Let’s Investigate Investigation Errors
• Ross Rozanski, University of Southern California, U.S.A., author of Accident Reports and Aeronautical Decision Making: Implementing Case-based Reasoning to Improve General Aviation Safety

Scholarship guidelines, history, and application forms are available at www.isasi.org under the Awards tab. Application submissions with the required essay are due on April 15 of each year. The scholarship recipients present their essays during the annual seminar, and an edited version appears in ISASI Forum. The essay printed in this issue is the first of the four that the Scholarship Committee picked for the 2017 award.

Maria Katherine Gregson has studied for her MEng (mechanical engineering) at the University of Nottingham from 2013 to the present. Her interests are in aerospace, stress analysis, and project management. She has taken or is taking modules in Introduction to Aerospace Technology, Aerospace Industry Organization, Aircraft Propulsion Systems, Mechanics of Solids, Computer Modeling Techniques, Stress Analysis Techniques, Finite Element Analysis, and Management Studies. Maria’s final year project is in the air accident investigation field—examining safety recommendations. For several years, she served as an intern at Rolls-Royce during summers and is participating in the Rolls-Royce Graduate Scheme (civil aerospace) that began in September 2017. Maria is a passionate rower and a Formula 1 racing fan. She participated in a four-week internship in 2013 with the Mercedes AMG Petronas Formula 1 Team.

What Makes a Good Air Safety Recommendation?

By Maria Gregson, Faculty of Engineering, University of Nottingham, UK

Incidents and accidents within the aviation industry require investigations by the national safety agency (NSA) to find the root cause and, when necessary, issue safety recommendations as stated in International Civil Aviation Organisation (ICAO) Annex 13 [1]. There are accidents that make headline news such as the Concorde crash in 2000 [2] or the uncontained engine failure on the Qantas A380 in 2010 [3] and others that the public does not hear about. An investigation must take place if an accident or incident results in death, serious injury, or indicates a defect in the aircraft.

Existing work suggests that, compared to the efforts concentrated on root cause investigation, there is less emphasis on the creation and implementation of safety recommendations [4]. Research has found that recommendations may be at risk of causing unintended consequences [5] and are deemed to be only 70% effective by investigators themselves [6]. It is by issuing and accepting safety recommendation that the origins of incidents are addressed with the aim of preventing recurrence and developing the safety of the aviation industry. So how do investigators improve the likelihood of getting these recommendations accepted?

Currently there is some guidance on what a safety recommendation should contain by ICAO in Annex 13 Chapter 6 [7] along with its Manual of Aircraft Accident and Incident Investigation [6, 8]. For member states of the European Aviation Safety Agency (EASA), 996/2010 Article 17 [9] also provides some guidance. The NSAs, including the UK Air Accident Investigation Branch (AAIB), have their own manuals; however, these are not available to the public.

Using public domain information, the current status of safety recommendations from the AAIB is readily available. In this work, a sample of 25 incidents investigated by the AAIB that occurred on fixed-wing commercial aircraft between 2005 and 2015 were pooled, producing a total of 136 safety recommendations. The AAIB’s annual safety reports were used to identify the recommendations accepted.

To assess if the content influenced whether the safety recommendation would be accepted, they were split into three categories
• Regulation and legislation—covering the legal aspect.
which often increases the length of the process. There is also the factor that regulatory bodies are the largest party of recipients of safety recommendations and therefore must prioritize responses. In summary, this analysis shows that the content covered can affect the likelihood of acceptance.

This analysis looked only at AAIB-issued safety recommendations, but how can the global standard be analyzed? To address this, it is useful to look at an agency that is the recipient of safety recommendations from numerous NSAs. In this case, EASA was used. Its annual safety recommendation review shows the safety recommendations the agency has responded to for that particular year. Reviewing the 2014 and 2015 version of this document, it was clear to see there was a varied standard in safety recommendations. Initially a SMART analysis was attempted to evaluate the standard; however, this proved too ambiguous. A better way was looking for certain criteria that created a good safety recommendation. These included containing a specific addressee; clear objective; succinct, supporting evidence; and finally stating the issue, not the solution. Interviews with industry experts validated this approach and added to the list of criteria detailed in Table 1.

The sample of 10 interviewees covered the perspectives of NSAs, regulators, and manufacturers as well as academia, as shown in Figure 3. The interviews allowed additional information to be gathered and validation of the AAIB and EASA document analysis. They also acted as a means of overcoming barriers, such as not having access to AAIB’s investigator manual or the SRIS tool.

The general consensus was that communication has the greatest effect on whether the safety recommendation is accepted. It is important that this is in the drafting stage as it means the addressee and investigator can agree on content and wording of the safety recommendation, ensuring a clear understanding. Some agencies already do this; however, by implementing this process globally the variation in the standard of safety recommendations could be reduced.

Another useful observation from the interviews was the effect of fatalities. There were mixed views on whether fatalities affect the likelihood of accepting safety recommendations. There was agreement that in ideal practice it shouldn’t, but due partly to news media influence, it may well. This could be due to an increased focus, commitment of greater resources, or to lawsuits for compensation. Common reasons given by the experts for not accepting a safety recommendation included

- badly formulated and poorly supported safety recommendations,
- different views between investigators and addressees, and
- results of a cost-benefit analysis.

When an incident results in fatalities, it is the latter of these that is affected most, unless the likelihood of the incident recurring is seen to be minimal. There was, however, agreement by all participants that NSAs should not have legal power to enforce safety recommendations.

Noting that the majority of the interviewees stated that investigators were not the best placed to assess unintended risk is important. This should fall to the addressees who are the subject-matter experts. This finding agrees with Lefevre’s study in which investigators realized they had a part to play in evaluating potential new risks but stated the main responsibility lies with the addressee [11].

The global standard could be improved and variation reduced by incorporating the factors mentioned in Table 1 into guide-
lines for writing a safety recommendation. EASA is working on harmonization within Europe through ENCASIA Working Group 6. The work includes developing the SRIS tracking system and recently elaborating a Safety Recommendations of Union Wide Relevance (SRUR) approach.

In summary, the results of analyzing the acceptance of AAIB safety recommendations and identifying key factors that contribute to a good safety recommendation could be used by NSAs to improve guidelines and process for investigators. The main conclusions were that safety recommendations covering regulation and legislation are harder to implement, the current global standard is very varied, and communication is key in getting them accepted. It is a challenge for investigators to write good-quality safety recommendation, and NSAs need to provide guidance as best they can. ICAO and agencies such as EASA and the Federal Aviation Administration need to work together to assist NSAs with this challenge and increase global harmonization. This is crucial to ensuring that the outcome of investigations are effective in improving the safety and reliability of the aviation sector.

Table 1: What Makes a Good Safety Recommendation?

<table>
<thead>
<tr>
<th>Requirement of a Safety Recommendation</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific addressee</td>
<td>Shouldn’t state too many addressees and should have a lead clearly identified.</td>
</tr>
<tr>
<td>Succinct</td>
<td>Preamble to safety recommendation should be separate.</td>
</tr>
<tr>
<td>Clear objective</td>
<td>Clearly state what outcome is desired and for what, e.g., if for a specific engine/aircraft.</td>
</tr>
<tr>
<td>Supporting evidence in main report</td>
<td>Should be obvious why it is required and well justified to strengthen why safety recommendation is needed.</td>
</tr>
<tr>
<td>State issue but NOT solution</td>
<td>Not stating the solutions helps reduce unintended risk.</td>
</tr>
<tr>
<td>Standalone</td>
<td>Should be able to read it and know exactly what it means without reading the report.</td>
</tr>
<tr>
<td>Communication</td>
<td>Between investigators and addressee(s) DURING the drafting process, not waiting until publication.</td>
</tr>
<tr>
<td>Wording and language</td>
<td>Use standard aviation language and avoid using words that can easily result in no change such as “review” or “re-examine.” Ensure standard of language by working with NSAs fluent in the language in which the safety recommendation is written.</td>
</tr>
<tr>
<td>Should be required</td>
<td>Single accident does not make for a good safety recommendation.</td>
</tr>
<tr>
<td>Placement in report</td>
<td>Should feature in main report with justification not just in a list in section four.</td>
</tr>
<tr>
<td>Well researched</td>
<td>Research other occurrences and action addressees are already taking.</td>
</tr>
<tr>
<td>Practical</td>
<td>Not too onerous.</td>
</tr>
</tbody>
</table>

*International Federation of Airworthiness (IFA) is not a regulatory body, but the participant’s experience was in that area.

Figure 3: Participants in the interviews.
LINKAGES BETWEEN OCCURRENCES AND SAFETY SYSTEM PERFORMANCE

By Heather Fitzpatrick, Senior Transport Safety Investigator, Australian Transport Safety Bureau (ATSB)

(Adapted with permission from the author’s technical paper entitled Investigating Linkages Between an Occurrence and an Organization’s Safety System Performance presented during ISASI 2016 in Reykjavik, Iceland. The full presentation with references can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)

Aviation organizations with a well-designed safety management system (SMS) can reduce safety-related risk in their operations if the system is performing well (ATSB, 2012). Analyzing the effectiveness of system performance as part of a safety investigation is now more prevalent, including how that performance may be linked to a specific occurrence.

The ATSB investigation analysis methodology categorizes issues as individual factors, local conditions, risk controls, and organizational influences (ATSB, 2008). In matters of system-related organizational influences, how can investigators clearly establish a linkage to the occurrence event?

One example of how this linkage can plausibly be established is in the application of the ATSB’s “fatigue and fatigue risk management system (FRMS) investigation framework.” Based on the work of Dawson and McCulloch (2005), as well as other research and methodologies employed by international investigation agencies, the framework consists of five areas of fatigue risk. Evidence is required to support an assessment of that fatigue risk, for example

- fatigue-related errors,
- ability to maintain adequate alertness while on duty,
- sleep obtained,
- provision of adequate sleep opportunity, and
- organizational support for managing risks of fatigue impairment.

The last of these evidence sources may inform one or more organizational influences in an investigation. The ATSB investigation framework also provides guidance as to how this evidence will be used in fatigue analysis to satisfy firstly the test for existence and secondly the test for influence for the particular occurrence under investigation.

This paper details the utility of the ATSB’s fatigue and FRMS framework in establishing a tangible link between the performance of an organization’s systems and an occurrence event. The applicability of a similar framework to the examination of an organization’s SMS more broadly is also discussed. This has been done within the context of two complex investigations.

The introduction of SMSs to industry

The trend for aviation organizations to implement formal SMSs has increased since around the 1990s, buoyed by the development of the International Civil Aviation Organization’s (ICAO) Global Aviation Safety Plan in 1997 and culminating in the release of Annex 19 and what is now the third edition of ICAO’s Safety Management Manual in 2013. Additionally, the requirement that each ICAO signatory state develop a state safety program has furthered the incorporation of SMS requirements into national legislation, including in Australia.

In this context, Australia’s state aviation safety program (2012) defined an SMS as follows: a systematic approach to managing safety risks, an SMS encompasses organizational structures, policies, and procedures. It is based on the idea that safety is best achieved through strong interwoven systems, rather than through individual processes or practices. It is also underpinned by a philosophy of mutual responsibility and accountability, rather than relying solely on regulatory compliance.

The concept of achieving safety through “strong interwoven systems” is an important influence on the consideration of how to review the effectiveness of an organization’s SMS. A key component of this concept is that the performance of an organization’s SMS relies on coordination between its policies, processes, and practices.

Reviewing the effectiveness of SMSs

In 2011, in response to the move by Australia’s transport industries toward incorporating SMS into their operations, the ATSB commissioned a study titled A Systematic Review of the Effectiveness of Safety Management Systems. The study examined the published research literature on the efficacy of SMSs, safety programs, and related management processes and identified the characteristics of these systems most related to the quality of an organization’s safety management. Noting that organizations that provide an appropriate investment and commitment to an SMS should receive a positive return on safety, the study also stated that “the effectiveness of Safety Management Systems may well not lie in specific

Heather Fitzpatrick

background is predominantly in aviation safety and risk management design and implementation and human factors. This has included undertaking safety specialist roles for three different airlines in Australia, Hong Kong, and Singapore, and as an aviation safety advisor to different sectors of the industry including defense, regulators, aeromedical operations, and agricultural and sport aviation. She is currently working as a senior transport safety investigator with the ATSB, based in Canberra, Australian Capital Territory. She specializes in aviation human factors and is a private pilot.
components of the system, but rather in the level of sophistication and effort applied across the system as a whole.”

This statement seemingly complicates the review of a safety system’s effectiveness as, for example, it is not simply a case of comparing discreet activities against the related prescriptive regulation. However, in the context of an investigation, it is possible to focus on an organization’s practices in achieving specific outcomes. This can include how the organization

• identifies operational risks,
• provides appropriate guidance through safe practices, and
• monitors its key areas of business.

Any examination of an organization’s SMS needs to be done in the context of a comprehensive analysis methodology. The following discussion describes such an investigation in the context of the ATSB’s analysis methodology.

Investigating organizational influences in the context of ATSB’s analysis methodology

It has been widely accepted by investigators that most accidents are due to a combination of factors originating at all levels of the organization. The quality of a safety investigation’s analysis activities is critical in determining the contributing and other safety factors and issues in the development of an occurrence and, by implication, the potential for safety enhancement as a result of the investigation. However, safety investigations require analysis of complex sets of data and situations in which the available data can be vague, incomplete, and misleading. To address this situation, in 2008 the ATSB introduced a comprehensive investigation analysis framework.

ATSB’s investigation analysis model

The ATSB investigation analysis model is based on the widely used Reason model of organizational accidents. It consists of five levels of safety factors, including the occurrence events, individual actions, local conditions, risk controls, and organizational influences. Annex A is a diagrammatical representation of the model.

Organizational influences are those conditions that establish, maintain, or otherwise influence the effectiveness of an organization’s risk controls. This includes an organization’s SMS, including the framework developed and the safety philosophies, policies, processes, and practices.

Before any findings are made, they need to be tested or verified. In the ATSB analysis framework, this involves using a structured process to examine the available evidence and conduct tests for existence, influence, and, if required, importance.

The testing process determines whether a potential safety factor is a “contributing safety factor” (it passes the tests of existence and influence), an “other factor that increased risk” (passing the tests of existence and importance but failing the test of influence), or “not a safety factor” (of no consequence to the investigation). The ATSB guidelines for testing existence, influence, and importance have three main components:

• background information on critical reasoning,
• a process for developing and evaluating arguments, and
• criteria for evaluating each test.

When testing an aspect of an organization’s SMS, the most challenging step seems to be that of influence—does it have any linkage to an occurrence event? The answer may be, “well, it depends on the nature of the finding.”

Types of findings relating to organizational influences

Organizational influences will be reflected in one of two types of findings.

• A contributing safety factor indicates that the condition not existed at the relevant time, then either the occurrence would probably not have occurred, the consequences would not have been as grave, or another contributing safety factor would probably not have occurred or existed (ATSB, 2008). With respect to an organization’s SMS, investigators need to explore the extent to which any underperforming/absent elements contributed to the occurrence. This can be a significant challenge.

• Other factors that increased risk that are considered not to have contributed to the occurrence, but often indicate the presence of safety issues in a system.

A “safety issue,” which can include either contributing or other safety factors that increased risk, is a finding with the potential to adversely affect the safety of future operations and is a characteristic of an organization or a system, rather than a characteristic of a specific individual.

The identification of a safety issue suggests that it is reasonable or practicable for the relevant organization(s) to address the issue. It is important for safety-enhancement purposes to further analyze those issues and the reasons why they occurred. When analyzing aspects of an organization’s SMS, findings will more naturally lend themselves to being classified as another factor that increased risk, rather than being contributory.

One tangible means of demonstrating how organizational influences may link to an occurrence event is to con-
sider fatigue and fatigue management.

**ATSB’s fatigue and FRMS investigation framework**

Due to the fatigue risk associated with transport operations, investigators should consider the possibility of fatigue as a safety factor for virtually all investigations in which human performance issues are apparent. This could be expected to include an examination of the involved organization’s management of its fatigue risk.

Based on the work of Dawson and McCulloch (2005) as well as other research, and methodologies employed by a number of international investigation agencies, the ATSB has determined a framework to assist its investigators with the collection of fatigue-related evidence. The framework supports a rigorous assessment of fatigue risk and its involvement in the development of an incident or accident.

**Components of ATSB’s fatigue and fatigue risk management investigation framework**

The framework consists of five areas of fatigue risk with corresponding fatigue risk controls/indicators. Evidence standards are defined in support of the assessment of that fatigue risk that broadly categorize the risk as organizational- or individual/group-focussed. Guidance is provided as to how the evidence will be used to test for existence, influence, and importance for the particular occurrence under investigation. The five areas include:

- fatigue-related errors,
- ability to maintain adequate alertness while on duty,
- sleep obtained (quality and quantity),
- provision of adequate sleep opportunity, and
- organizational support for managing risks of fatigue impairment.

The last of these is the most relevant in the context of this paper. An organization’s FRMS policy, procedures, and practices are reviewed, as are the rostering practices, the provision of training in fatigue and its management, reporting trends, and the systems for analyzing workforce occurrences and risks.

Annex B contains a detailed diagram of the framework, which is designed to be read from the bottom up, consistent with the chronological order in which an investigation progresses.

**A recent example of the application of ATSB’s framework**

On the evening of Dec. 4, 2014, a Saab 340B was on scheduled passenger service from Sydney to Narrandera, New South Wales. After takeoff from Runway 34L, the crew inadvertently did not retract the landing gear. The crew later identified this and instinctively retracted the gear while the aircraft was above the maximum landing gear retraction speed. A review of the application of the ATSB’s fatigue investigation framework to this investigation follows.

**Evidence collection**

Figure 1 is an example of the fatigue investigation framework “in action.” It outlines the evidence collected during investigation AO-2014-189 in support of each of the five areas in the fatigue investigation framework.

**Analysis**

It is difficult to definitively state that a crewmember was experiencing the effects of fatigue such that his or her performance was negatively impacted and that this contributed to the occurrence. However, in this case, the evidence indicated a high likelihood that the first officer was experiencing acute fatigue. This was reported in the final investigation report as follows: The first officer reported obtaining a total of between four and six hours of sleep in the 48 hours prior to the occurrence. Accordingly, it is reasonable to conclude that the first officer was experiencing a level of acute fatigue known to have at least a moderate effect on performance.

While it is difficult to conclude that fatigue alone led to the first officer’s errors on this occasion, it was considered contributory to the occurrence. The ATSB found that at the time of the occurrence the first officer was experiencing a level of fatigue that affected performance. However, the first officer’s ability to self-assess the level of fatigue was impeded by a lack of training and objective tools to determine suitability to operate.

Organizational fatigue management policies, processes, and practices were also analyzed, with the following reported in the final investigation report: At the time of the occurrence the content of the operator’s fatigue training was limited to a general overview of fatigue, sleep, and fatigue countermeasures that may not provide the crewmembers with an adequate opportunity to develop the skills or utilize tools that could best help them identify signs of fatigue in themselves or others.

The operator managed its flight crews’ flight and duty times to comply with Australian Civil Aviation Order 48 at the time of the occurrence. Although compliant with those requirements, the operator’s rostering processes did not wholly account for the potential for the conduct of the flight check to have impacted the first officer’s sleep preceding the check, or unforeseen extension of the first officer’s previous duty period and the associated time between sign-off and being able to leave the airport.

The investigation also examined the operator’s fatigue management processes and practices to determine if they were reasonable. This included consideration of, and reference to, the regulatory requirements at the time of the occurrence.

**Developing the report**

Recognizing the operator’s compliance with relevant fatigue management regulations at the time, while emphasizing the benefits of further improvements to address key issues identified as part of the investigation, presented a challenge when developing the investigation report.

The second point is important in developing the investigation report, as it represents the safety educational message that would ideally be adopted by other operators not directly involved in the occurrence, thereby reducing their safety risk. In this respect, the investigation report addressed the two points as follows:

Operator compliance with the existing regulations: To reinforce the operator’s compliance with the existing regulations and show their efforts to progress to the new set of fatigue management rules, the report noted:

In March 2013, the Australian Civil Aviation Safety Authority released new
<table>
<thead>
<tr>
<th>Framework components</th>
<th>Sources of evidence in support of an investigation</th>
<th>Examples of evidence from AO 2014 189</th>
</tr>
</thead>
</table>
| Fatigue-related errors | • Account of events via interview.  
• Performance—actions, communications, decisions—leading up to and during the occurrence. | • The first officer recalled that they were tired before the flight.  
• Crew errors were consistent with the effects of fatigue on performance (attention, decision-making, and reaction time). |
| Ability to maintain adequate alertness while on duty | • Self/other reported observations of alertness.  
• Fatigue proofing strategies.  
• Subjective alertness scale responses.  
• Workload dimensions (physical, cognitive, pace of work). | • The first officer recalled feeling “drowsy” earlier in the day and “pretty tired” prior to sign-on.  
• Elevated workload of the departure due to the first officer’s reduced familiarity and adverse weather in the region. |
| Sleep obtained | • Sleep quantity and quality over the last 72 hours.  
• Estimation of individual need for sleep.  
• Description of the sleeping environment.  
• Other factors—that is sleep disorders, alcohol or drug use, use of stimulants and so on.  
• Recorded data—that is, actigraphy. | • The first officer obtained about four hours of sleep in the preceding 48 hours.  
• First officer’s usual sleep was eight hours each night.  
• First officer’s sleeping environment was affected by storms in the region the night before the occurrence.  
• Stress associated with a check flight the day before significantly affected the first officer’s sleep two nights before the occurrence. |
| Provision of adequate sleep opportunity | • Planned and actual duty rosters.  
• Fatigue risk assessment of rosters.  
• Suitability of sleeping environment.  
• Commute method and duration | • Duty rosters recorded a time away from duty for the first officer of between about 2200 the evening before and 0800 on the day, providing a minimal sleep opportunity.  
• At the time of the occurrence, the operator was not required to undertake biomathematical modelling on roster patterns.  
• The first officer’s commute was 1 hour each way from the airport, reducing the available sleep opportunity. |
| Organizational support for managing risks of fatigue impairment | • Documented FRMS or fatigue management policies and procedures.  
• Use of fatigue-modelling tools.  
• Fatigue reporting and action management.  
• Fatigue awareness training content, attendance.  
• Individual knowledge/attitudes about fatigue management. | • Individual fatigue assessment tools to assist in determining fitness for duty not in use at the time.  
• Fatigue training limited to an overview of fatigue, sleep, and fatigue countermeasures.  
• The first officer did not perceive the risk of fatigue from limited sleep. |

**Figure 1: Fatigue-related evidence collected as part of AO-2014-189.**

rules on fatigue management for flight crews. At the time of the occurrence, air operators that already held or had applied for an air operator’s certificate after April 2013 had until April 2016 to transition to the new fatigue management rules. Consistent with this timeline, the operator was planning for its transition to meet those requirements at the time of the occurrence.

Emphasizing the opportunity for operators to adopt fatigue management improvements: In an effort to increase the likelihood that operators would be receptive to the safety educational message, the report reiterated that the operator was not required to have implemented an FRMS at the time. For example, when discussing the operator’s fatigue training in the context of the new rule set, the investigation report stated:

Noting that the operator was not required to comply with the new fatigue rules on training at the time of the occurrence, it could be expected that, as they work towards implementing those requirements by May 2017, the training content will be revised.

The ensuing safety education message included that...while this occurrence highlights the difficulties associated with assessing fatigue, operators...can reduce fatigue risk by providing the crew with adequate rest opportunity, comprehensive training in fatigue management, and tools designed to support objective self-assessment of their alertness.

**Investigating an organization’s SMS performance**

The ATSB intends to develop a specific framework for the investigation of SMSs. A number of recent ATSB investigations have demonstrated the value of approaching this task in a similar manner to that of the investigation of fatigue by:

- reviewing the errors in individual actions,
- ascertaining possible local conditions and risk controls relating to the safety processes and practices of the organization, and
- considering how one or more components of the SMS may not be performing as it could reasonably be expected to.

In addition, the Transportation Safety Board of Canada’s (TSB) Guide to Investigating for Organizational and Management Factors, 2nd Edition (2014) is an important reference for investigators who need to address
organizational influences. In particular, incorporating the Degani and Weiner (1994) hierarchy of influences (philosophies, policies, processes, and practices) into this approach facilitates the identification of "mismatches between procedures and actual practices," something that is invaluable when applied to the investigation of an organization's SMS.

Key challenges so far
The TSB (2014) outlined a series of challenges that continue to arise when investigating organizational and management issues, including the investigation of an SMS. These challenges included:
- the identification of investigation scope,
- weak and missing links in evidence and analysis,
- the potential for hindsight bias, and
- investigators’ experience with investigating management issues.

Recent ATSB investigations have similarly encountered a number of challenges in these areas, as well as some additional challenges that may be valuable for investigators to consider.

Accurately articulating the linkage between an organization’s SMS and the occurrence
If a contributing safety factor involving the performance of an organization's SMS has been identified, demonstrating that linkage often requires a significant amount of contextual and analytical explanation (particularly due to the "strong interwoven" nature of an SMS). This can, in turn, inadvertently lead to a perception by the reader that the volume automatically indicates that the SMS-related finding is the most important part of the investigation. The challenge can be addressed by ensuring that any SMS processes or practices that aren’t essential to explaining the finding are removed and the content streamlined as much as possible.

The inclusion of third-party organizations within the scope of the investigation
An ongoing and high-profile ATSB investigation includes the review of four different organizations’ SMSs and their relationship to each other. The resulting challenge is to pinpoint the precise points of linkage between these organizations. However, one approach that the TSB (2014) has documented is to overtly focus on the hierarchy of influences in any safety system (that is, what is documented/spoused versus what actually happens). This has been of great assistance to the ATSB in reviewing these organizational and SMS linkages.

Acceptance of safety messaging within the organization and wider industry
The requirement to implement safety and FRMSs remains relatively new and unfamiliar for many sectors of the aviation industry. Comprehension of the various requirements and their implementation can prove difficult. As a consequence, some operators have been highly sensitive to an investigation focusing on something that, it is often perceived, they "didn't even have to do." This is understandable and is an important consideration for any investigator as a safety message can be lost if perceived as unjust. The ATSB has recently addressed this risk by balancing acknowledgements against regulatory compliance with descriptions of additional improvements in the organization’s safety systems.

A recent investigation highlighting an operator’s SMS performance
At 1748 Australian eastern daylight saving time on Dec. 29, 2014, a Cessna 172S departed Cambridge Airport, Tasmania, to photograph yachts participating in the 2014 Sydney Hobart race. On board the aircraft were the pilot and a photographer. After completing a run on one yacht at a height of about 50 feet, the aircraft entered a steep climbing turn. The aircraft had almost completed a 180-degree turn when the upper (right) wing dropped sharply while the aircraft’s nose pitched down to almost vertical. The aircraft impacted the water’s surface in an almost vertical, nose-down attitude with wings about level. Both aircraft occupants were fatally injured, and the aircraft was seriously damaged.

Analysis
In this case, the most relevant aspect on which to focus was the operator’s capability to identify operational safety risks. Without adequate identification methods, the prioritization and treatment of risks is also affected. In investigation report AO-2014-192, the operator’s ability to identify operational risks was reported as follows:

The main source of safety risk information was the safety reports submitted by the crew, in an environment where the reporting culture had only recently improved among the small flight crew workforce.

The risk management process was only utilized for managing operational or organizational changes, which precluded the proactive identification of risks in existing operational activities such as low-level flying.

The ability for managers to be aware of existing operational risks was reduced
<table>
<thead>
<tr>
<th>Influence (text extracted from the TSB, 2014)</th>
<th>Sources of evidence in support of an investigation</th>
<th>Examples of evidence from AO 2014 189</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Philosophy</strong></td>
<td>• Interviews with the chief executive officer and safety manager.</td>
<td>• Planning for future implementation/improvements, including plans for a full-time safety manager.</td>
</tr>
<tr>
<td>&quot;An organization’s philosophy provides a broad specification for how it wants to operate and communicates values throughout the organization.&quot;</td>
<td>• SMS manual.</td>
<td>• Safety commitment statement versus senior level perceptions on a formal approach to safety, particularly with respect to SMS implementation outside of compliance requirements.</td>
</tr>
<tr>
<td><strong>Policy</strong></td>
<td>• SMS manual.</td>
<td>• Past and future resourcing (that is, safety-specific staffing and investments).</td>
</tr>
<tr>
<td>&quot;An organization’s policies represent broad specifications of the manner in which management expects tasks to be carried out.&quot;</td>
<td>• Operations manual.</td>
<td>• Perceptions on key safety risks</td>
</tr>
<tr>
<td><strong>Processes</strong></td>
<td>• Risk and hazard registers.</td>
<td>• Documented methods of safety information communication and decision-making among managers.</td>
</tr>
<tr>
<td>&quot;An organization’s procedures dictate the specific steps an individual should take to accomplish a task. They operationalize the philosophy and policies by indicating how work will be carried out.&quot;</td>
<td>• Risk assessments of specific operational activities.</td>
<td>• Safety reporting processes for the pilots.</td>
</tr>
<tr>
<td></td>
<td>• Interviews with the chief pilot, safety manager, chief flying instructor.</td>
<td>• Methods and triggers for developing risk assessments (designed as change- and task-based).</td>
</tr>
<tr>
<td></td>
<td>• Interviews with the regulator (operational and safety system oversight).</td>
<td></td>
</tr>
<tr>
<td><strong>Practices</strong></td>
<td>• Planned and actual duty rosters.</td>
<td>• Duty rosters recorded a time away from duty for the first officer of between about 2200 the evening before and 0800 on the day, providing a minimal sleep opportunity.</td>
</tr>
<tr>
<td>&quot;An organization’s practices represent what actually happens in day-to-day operations... [because] in reality, practices may differ from procedures for any one of a number of reasons.&quot;</td>
<td>• Fatigue risk assessment of rosters.</td>
<td>• At the time of the occurrence, the operator was not required to undertake biomathematical modelling on roster patterns.</td>
</tr>
<tr>
<td></td>
<td>• Suitability of sleeping environment.</td>
<td>• The first officer’s commute was 1 hour each way from the airport, reducing the available sleep opportunity.</td>
</tr>
<tr>
<td></td>
<td>• Commute method and duration</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2**

due to the narrow application of documented risk management processes and tools (including the risk register).

The resources to facilitate the implementation and improvement of the SMS were limited to the time that the chief flying instructor could spend in the role of safety manager. This reduced the opportunity to implement the operator’s risk management processes and tools more extensively.

There was some discussion as to appropriate references against which to compare the operator’s SMS, as a prescriptive approach was too punitive. In the end, the International Standards Organization ISO31000 2009 risk management standard was used to demonstrate the overall intention of risk management practices.

### Considerations in drafting the report

As discussed earlier in the paper, in order to increase the likelihood of a receptive response from the affected organization and wider industry, striking a balance between a thorough account and being perceived as too focused on weaknesses needs to be achieved. In this endeavor, the ATSB settled on the following text in the investigation report:

- At the time of the occurrence, the evidence gathered as part of the investigation indicated that the operator’s SMS complied with the applicable regulatory requirements, and
- While it was not established that the safety risk management processes and practices directly contributed to the occurrence, there were aspects that the operator could consider working toward to more effectively identify all key operational risks.

Overall, the SMS content in the final investigation report was relatively detailed. The intent was to provide sufficient explanation for the SMS-related finding in the context of a topic that has not commonly appeared in investigation reports until recently.

### Conclusion

As safety can best be achieved through “strong interwoven systems,” the responsibility of the investigator is to explore these systems when considering organizational influences. The ability to demonstrate either a tangible linkage between the performance of an organization’s systems to an occurrence event or its importance in future operations is likely better facilitated through a framework that takes into account the hierarchy of influences and a range of evidence sources.
Safety Recommendations: Strengthening EASA’s Safety Risk Management Process

By Mario Colavita, Safety Investigation Officer, EASA

(Adapted with permission from the author’s technical paper entitled Safety Recommendations: A Foundational Building-block to EASA’s Safety Risk Management Process presented during ISASI 2016 in Reykjavik, Iceland. The full presentation with references can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)

The European Aviation Safety Agency (EASA) plays a key role for European aviation safety, in particular both as certification authority and regulator. For this reason, EASA is also one of the main addressees of the safety recommendations issued by the safety investigation authorities of the EU member states (MS).

In addition to what is established by ICAO Annex 13, Regulation (EU) 996/2010 identifies specific obligations for both the originator and the addressee of a safety recommendation in order to ensure an effective follow-up (Article 18, Follow-up to safety recommendations and safety recommendations database).

In particular, Article 18 (5) of the above-mentioned regulation, jointly with the Commission Regulation (EC) No. 1321/2007 of Nov. 12, 2007, which sets implementing rules for the integration into a central repository of safety-related information on civil aviation occurrences, established the Safety Recommendations Information System database, which has been in place since January 2012. According to Article 18 (5) of the regulation, the safety investigation authority of each MS shall record in this EU database all safety recommendations it issued and the responses it received.

To address this topic, the European Network of Civil Aviation Safety Investigation Authorities (ENCASIA) established a dedicated working group (WG 6) to harmonize the use of the Safety Recommendations Information System database among the MS and analyze its contents to identify important safety recommendations of EU relevance.

Furthermore, on Dec. 5, 2012, the EU Commission issued a decision on access rights to the European central repository of safety recommendations and their responses. According to Article 2 of this decision, all safety recommendations are considered public.

EASA management of safety recommendations

EASA is processing safety recommendations received with a high level of priority, and a customized version of the Safety Recommendations Information System database has been used since the beginning to record and monitor not only those addressed to it, but also any others related to areas under its scope and remits.

The Safety Intelligence and Performance Department is in charge of, through the Safety Investigation and
defined since 2014 is that a safety recommendation will be considered "open" until the expected action has been completed. In addition, EASA’s assessments of the safety recommendations received (see Figure 2) will be provided on occasion of the closing replies.

**Processing SIA assessment of EASA responses to safety recommendations**

Recently, EASA has introduced an internal policy to process the safety investigation authority (SIA) assessment of responses, in a way that goes beyond regulatory requirements.

Any time that a "not adequate" assessment is received, whether in the presence of an intermediate or a final reply, the safety recommendation will be reevaluated by the ISIRC. In support of this reevaluation, the SIA will be contacted to provide the justification of the assessment received, if not already contained in the response assessment. A similar approach will be followed in the case of a "partially adequate" assessment, but only when this is referred to a closing reply and in the presence of new elements clarifying the rationale of the assessment.

When these additional steps have been completed and a disagreement still remains between EASA and the originator, the final position of the agency on the safety recommendation will then be consolidated at the level of the EASA Safety Committee.

**Use of safety recommendations in EASA’s safety risk management process**

The latest introduction in EASA of a safety risk management process is based on the introduction of safety risk portfolios that provide for 10 different operational domains the data-driven input to the decision making process that supports the European Plan for Aviation Safety.

The safety risk portfolios collect a list of systemic safety issues—the areas of safety concern that may cover one or more identified safety deficiencies that may lead to an accident—specifically identified per each aviation domain.

The objectives of safety risk management are to enable

- prioritization of safety actions that are most efficient in reducing risk levels and
- adequate internal and external coordination on the identification and assessment of safety issues, as well as the programming of the safety actions.

The safety issues have been identified by using the following three pillars:

- the analysis of historical occurrence data,

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a careful review of relevant safety recommendations, and
joint expert judgment of the agency, the MSs, and industry through the network of analysts (NOA) and the collaborative analysis groups, respectively.

In particular, the safety recommendations represent a primary and strategic asset to be used among the different data streams that may lead to the identification of the set of safety issues that can affect European aviation products, services, or European passengers.

Within each safety risk portfolio, the safety issues are grouped into operational, technical, human, and organizational areas.

Use of safety recommendations to identify systemic safety issues
The first safety risk portfolio has been established for the aviation domain commercial aviation transport—fixed wing. In that occasion, the review was carried out considering all safety recommendations addressed to EASA, with no restriction applied in terms of time of receipt, and only filtering those that had the status, at the starting date of the review (March 2015), of
• “open” and
• “closed,” but only with the final assessment being “agreement” or “partial agreement.”

The rationale for this original approach stands on the assumption that in case of “disagreement,” the safety recommendation is acknowledged as not relevant in terms of safety or out of EASA’s remits. However, in later reviews carried out for other domains, this approach has been changed with the intent of making use of the safety elements also contained in the safety recommendations assessed with disagreement.

The additional filtering applied to the initial data set was that the safety recommendations had to be considered of global concern. Since the formal introduction of the concept of safety recommendation of union relevance endorsed by ENCASIA in fall 2015, any of the two definitions is considered enough to pass in the screening.

The initial screening conducted under the above-mentioned conditions reduced to 316 the number of safety recommendations selected for the following review. During the review, each safety recommendation was associated with at least one “main topic” and up to a maximum of two “subtopics.” This led to the identification of 91 main topics and 134 subtopics.

This information was then condensed and identified an initial set of 20 safety issues by building a cross-referenced matrix made of 1,820 elements. Consolidation of the result was achieved by cross-checking with the outcome of the parallel activity carried out by a dedicated working group through the systematic review of the accidents and incidents reports ascribed to the ADREP category of “Loss of Control In-flight” (LoC-I) found in the EASA database and that occurred in the timeframe between 2009

Table 1. List of safety issues identified for commercial air transport fixed-wing aircraft.

<table>
<thead>
<tr>
<th>Category</th>
<th>Safety Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>• Detection, recognition, and recovery of deviation from normal operations</td>
</tr>
<tr>
<td></td>
<td>• in adverse weather conditions.</td>
</tr>
<tr>
<td></td>
<td>• Ground handling operations.</td>
</tr>
<tr>
<td></td>
<td>• Maintaining adequate separation between aircraft on the ground and in the air.</td>
</tr>
<tr>
<td></td>
<td>• airairair</td>
</tr>
<tr>
<td></td>
<td>• Preflight preparation/planning and inflight replanning.</td>
</tr>
<tr>
<td></td>
<td>• Aircraft maintenance.</td>
</tr>
<tr>
<td></td>
<td>• Fuel management.</td>
</tr>
<tr>
<td></td>
<td>• Bird strikes.</td>
</tr>
<tr>
<td></td>
<td>• Calculation and entry of takeoff and landing parameters into aircraft system</td>
</tr>
<tr>
<td></td>
<td>• handling and execution of go-arounds.</td>
</tr>
<tr>
<td></td>
<td>• Prevention and resolution of conflict with aircraft not fitted with transponders.</td>
</tr>
<tr>
<td></td>
<td>• Dangerous goods handling.</td>
</tr>
<tr>
<td>Technical</td>
<td>• Handling and operation of the aircraft following a technical failure.</td>
</tr>
<tr>
<td></td>
<td>• False or disrupted ILS signal capture.</td>
</tr>
<tr>
<td></td>
<td>• Contamination of controls or critical surfaces.</td>
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<tr>
<td></td>
<td>• Damage tolerance to RPAS collisions.</td>
</tr>
<tr>
<td>Consequences</td>
<td>• Suitability of recording devices.</td>
</tr>
<tr>
<td></td>
<td>• Survivability and evacuation.</td>
</tr>
<tr>
<td>Human</td>
<td>• Personal readiness and crew impairment.</td>
</tr>
<tr>
<td></td>
<td>• Flight crew perception and awareness/decision-making and planning.</td>
</tr>
<tr>
<td></td>
<td>• CRM and communication.</td>
</tr>
<tr>
<td></td>
<td>• Monitoring of flight parameters and automation modes.</td>
</tr>
<tr>
<td></td>
<td>• Knowledge of aircraft systems and use of associated procedures.</td>
</tr>
<tr>
<td>Organizational</td>
<td>• Implementation of reporting systems and safety management.</td>
</tr>
<tr>
<td></td>
<td>• Oversight of organizations</td>
</tr>
</tbody>
</table>

![Figure 3 - Distribution of safety recommendations on “CRM and Communication” per Addressee](image-url)
and 2014 in commercial air transport fixed-wing operations (65 occurrences).

As previously mentioned, final contribution from expert judgment of the agency, the MSs, and industry through the NoA and the collaborative analysis groups was used to review and refine the portfolio to reach the format eventually published in EASA’s annual safety review 2016 (see Table 1).

Use of safety recommendations to assess a safety issue

Once the safety risk portfolio has been set, priority is given to those safety issues identified as the most critical based on their direct contribution to a fatal outcome as determined by the historical data of accidents.

As part of the safety risk management process of the agency, each single scenario in which the safety issue has been subdivided is then subsequently assessed to determine its associated risk, to understand existing weaknesses in the system that permit the safety issue to develop toward a fatal outcome, and to draft possible safety actions to mitigate the identified risk.

The ultimate objective of the assessment of the safety issue is to identify the main areas in which improvements could be sought. Although there is no prescribed approach to the analysis of the safety issue or its scenarios, the modelling more often used is in accordance with a bowtie modelling, applied by a group of multidisciplinary profiles (assessment team). Bowtie modelling has shown to be a practical tool to identify and evaluate the effectiveness of each single barrier and mitigations already in place.

In the frame of the analysis of the safety issue, the safety recommendation data set is used once again to identify the most recurrent weaknesses as well as to weigh the request of the civil aviation community to further improve on the topic, appraise the effort already put in place by EASA, and evaluate the most recurrent topics in the context of the safety issue.

The analysis of the safety recommendations is made in parallel on both the EASA and EU Safety Recommendation Information System databases. For the first time, this review was carried out during the assessment of the safety issue on crew resource management and communication.

The outcome of the review in terms of addressee distribution is shown in Figure 3.

This information reveals that from the EU aviation community perspective, operators and national aviation authorities (NAAs) are seen as the players more often required to act on the topic. This led to the consideration that one of the actions to be strengthened from the agency’s and NAA’s perspective is a focus oversight on the subject, to better identify the correct implementation of crew resource management concepts.

When extended to the responses, the EASA databases showed that 22 more safety recommendations have been dealt with by the agency through actions in the area of crew resource management and communications—most of them containing information about regulation provisions related to the matter given by the agency experts or were being taken into consideration within the framework of different rulemaking tasks.

The analysis of the most recurrent topics found in the total set of safety recommendations provided the results shown in Figure 4.

The results of this analysis were found in good agreement with the outcome of a similar analysis carried out on the events sequence describing European Coordination Center for Accident and Incident Reporting Systems LoC-I events in which crew resource management and communication were considered a relevant contributory factor. The convergence of these two elements will stimulate further consideration given to the most recurrent topics to identify possible improvements.

Figure 4: Recurrent topics in safety recommendations about CRM.
ISASI Students Work with Naval Museum to Investigate WW II Aircraft Accident

Kimberly Fuentes, an Embry-Riddle Aeronautical University alumna, reports that since 2016, the DeLand Naval Air Station Museum, located in Florida, has been working diligently to recover a Douglas SBD-5 Dauntless aircraft.

During World War II, the aircraft was used as a naval scout plane and an antisubmarine bomber. From 1942 to 1946, the DeLand Municipal Airport was a naval air station, where hundreds of pilots trained for the war. On Nov. 27, 1944, a pilot and passenger were training in antisubmarine bombing over a water target. As the pilot began to pull out of the dive, the nose of the aircraft struck the water, which led to the aircraft crashing into the water.

Seventy-three years later, a resident informed the museum of the aircraft’s location. Since then, the museum has partnered with many organizations, from the Naval History and Heritage Command to Spruce Creek Scuba (a local diving club), to locate the aircraft’s engine.

The museum’s goal is to recover the engine and any personal items of the deceased and return them to their families. Through the help of these organizations, the DeLand Naval Air Museum has been able to locate parts of the aircraft but not the engine. The museum has also been interested in determining the accident sequence but wasn’t sure how to proceed. One of its volunteers offered to ask Embry-Riddle Aeronautical University’s (ERAU) ISASI Student Chapter.

The ERAU Daytona Beach, Florida, ISASI Student Chapter partnered with the naval air museum and created a subgroup for the investigation. The students worked tirelessly to assist the museum. Their discussions and research helped to determine the type of maneuver the pilot could have used, locate the relatives of the deceased, and possibly determine the location of the engine. After a few months, the ISASI team joined the naval air museum at the crash site to find the engine. Thanks to the perseverance of the team, a blip on a radar indicated where the engine was located. However, in order for the museum to be able to retrieve the engine, an onsite Florida-certified archeologist was needed. After sending hundreds of letters, Stan Storz, the head of the DeLand Naval Air Museum, was able to garner the attention of the governor of Florida and Dr. Price, an underwater archeologist from Tallahassee. Currently, the museum and its partners are waiting for Dr. Price’s decision to retrieve the aircraft engine. Until then, the museum will continue its work restoring aircraft, and the ISASI team is planning to publish a report about the investigation.

For more information on the museum, go to www.delandnavalairmuseum.org/index.html. ♦

Sharing Experiences on FDR Readouts with the Nigeria AIB

At the request of the International Civil Aviation Organization’s Western and Central African Office, the Transport Safety Investigation Bureau (TSIB) of Singapore visited the Accident Investigation Bureau (AIB) of Nigeria on July 10–14, 2017, to assist in the evaluation and readiness of Nigeria’s AIB flight recorder readout facility. The evaluation was performed by Michael Toft, the deputy director of the TSIB Singapore, and Caj Frostell, the Banjul Accord Group Accident Investigation Agency (BAGAIA) commissioner. Nigeria is one of seven BAGAIA countries. Frostell is also the ISASI international councillor, and the TSIB Singapore is the secretary of AsiaSASI.

Toft thoroughly inspected and tested the equipment. He assessed that Nigeria’s AIB facility had the capability, equipment, and preparedness to download and read out data from most of the common recorder types. The Nigeria AIB facility serves the needs of Nigeria, the other six BAGAIA countries, and neighboring countries in West, Central, and South Africa. The flight recorder readout assistance to other BAGAIA countries, other countries of the Economic Community of West African States (ECOWAS), and Central and South Africa is one of the major projects of the enthusiastic head of the Nigeria AIB, Commissioner Akin Olateru.

The Nigeria AIB assigned six investigators to helm the readout facility in Abuja. Toft conducted a three-day training for these investigators, sharing his experience and tips on readout operations and data analysis. He also encouraged the Nigeria AIB to seek on-the-job training opportunities at flight recorder readout facilities abroad to increase Nigeria’s readout expertise. ♦

From left, Akin Olateru, commissioner of the Nigeria Accident Investigation Bureau; Caj Frostell, the Banjul Accord Group Accident Investigation Agency commissioner; His Excellency Senator Hadi Sirika, minister of state–aviation; and Michael Toft, deputy director of the Transport Safety Investigation Bureau of Singapore.
Anthony Brickhouse, an ISASI student coordinator, reports that 23 members of the Embry–Riddle Aeronautical University (Daytona Beach, Florida, campus) Student Chapter of ISASI visited Delta Air Lines headquarters in Atlanta, Georgia, on February 18. Delta’s flight safety team, which includes several ISASI members, hosted the student group. The day began with a quick overview of the agenda, and then the students formed smaller groups to tour various aspects of the operation.

During the tour, the students experienced a B-777-200LR full-motion simulator. They also saw the various tools used to train Delta flight crews. Another part of the tour took students to the facilities for training Delta inflight service crewmembers, including cabin trainers and the water evacuation pool. While touring the Flight Operations Customer Center, students received a real-time briefing from a dispatcher working a developing situation. Another exciting and educational part of the morning featured an exercise that allowed students to don personal protective equipment, get covered in simulated bloodborne pathogens, and then safely duff the gear. The students quickly learned how important it is to always follow accepted industry practices.

Members of the Delta flight safety team briefed the students during lunch, and then the students spent the afternoon touring the Delta Flight Museum and Delta Tech Ops, the largest airline maintenance, repair, and overhaul facility in North America and the third largest worldwide. The day ended with a group dinner at a midtown Atlanta restaurant. On Sunday, students visited the Georgia Aquarium before heading back to Daytona Beach. Special thanks goes out to Capt. Bill Klein, Shannon Masters, Joshua Alber, David Hahahan, Taylor Smith, Greg Masters, and Maryam Gracias.
EXTENDING THE NETWORK AND USING AVAILABLE RESOURCES

Continued from page 9

advisors (ATR and Pratt & Whitney Canada) to examine the main wreckage, two engines, and two AFUs.

Sixty-six items of wreckage, including avionic devices and wire harnesses, were collected for further examination. Twenty-five devices were shipped to the BEA for NVM readout, including AFU cables from both engines and MPC and PCBs from MFC 1/MFC 2. Twenty-two devices were shipped to the TSB for readout and further examination, including AFUs, DCUs, FEUs, TQ sensors, NL sensors, NH sensors, NP sensors, and EECs and PECs from both engines. There are five DUs and PCBs from CAC 1/CAC 2 stored at the ASC for examination, if necessary.

**Finding:** The available evidence indicated that the intermittent discontinuity between the torque sensor and the AFU number 2 was probably caused by the compromised soldering joints inside the AFU number 2.

Safety recommendation to ATR, Pratt & Whitney Canada, and UTC Aerospace Systems: Work with the manufacturers of engines and aircraft to assess the current operating parameters and aircraft risks associated with the PW127 series engine AFU to minimize or prevent occurrences that could result in uncommanded autothrottle.

**Conclusion**

Investigators always will need to work with manufacturers, airlines, and experts from various fields. However, the only way for investigative agencies to be able to perform truly independent investigations is to maintain a good level of expertise and modern technical capabilities and to link collected information and the related agencies so that they can work together.

We believe that international collaboration is the key to success—use all available resources and share and learn from other parties. The ASC was once a young investigative body that could benefit from the help of more experienced agencies such as the ATSB, the BEA, the NTSB, and the TSB. Today, the ASC is providing help to the safety community and giving technical assistance in several fields such as flight recorder readout. Bilateral and regional cooperation among safety agencies is necessary to bring emerging technologies into accident investigations—even if this requires effort to adapt to each other's culture and overcoming language barriers.

The major lessons learned from the two ATR 72 accident investigations include facilitating and maintaining procedures to handle damaged flight recorders and NVMs, contacting accredited representatives to receive a list of available NVMs at an early stage, an FDR database and qualified investigators are keys to fulfilling early readout demand, and an FDA is one of the systematic tools for SMS investigation.

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October-December 2017 ISASI Forum • 31
ISASI's International Council met on Aug. 20, 2017, in San Diego, California. ISASI President Frank Del Gandio opened the meeting with a general discussion of current events. Treasurer Bob MacIntosh provided an overview of the Society's financial state, which is positive. He presented a proposed 2018 budget to the council members, who, upon review and discussion, approved the budget for the upcoming year.

Vice President Ron Schleede provided an update on ISASI membership from a written report that Membership Committee Chair Tom McCarthy submitted. Taking into consideration the members who haven’t renewed their membership, Schleede noted that the number of new members has kept overall membership about the same as last year. As of July 19, 2017, ISASI had 138 corporate members and 1,231 individual members.

Seminar Committee Chair Barbara Dunn told meeting participants that 361 delegates and 37 companions had registered for the ISASI 2017 seminar, and 116 participants registered for one of the two tutorial sessions offered prior to the seminar. MENASASI Vice President Tom Curran discussed the 2018 seminar to be held in Dubai, United Arab Emirates, on Oct. 30–Nov. 1, 2018. The Hague, Netherlands, is the seminar site for the 2019 ISASI meeting, and the 2020 seminar will take place in Montreal, Canada.

ISASI’s Executive Advisor Dick Stone raised several issues relating to helicopter safety investigation, including having more helicopter accident investigators become Society members and having flight recorders in more helicopters for investigation purposes. He suggested that ISASI could establish a Helicopter Working Group with the goal of improving helicopter safety.

ISASI Secretary Chad Balentine, chair of the Kapustin Scholarship Award Committee, mentioned that the selection team had a large number of applications and essays to consider for four available scholarships in 2017. He said that the team will scan future essays with plagiarism-checking software to ensure the work is original and referenced material is properly attributed.

Tom Farrier, chair of ISASI’s UAS Working Group, reported that his team is working on revisions to ISASI’s UAS Accident Investigation Guidelines and a database on global safety issues. He observed that the ISASI Russian Regional Society translated the entire UAS handbook into Russian and provided copies to interested parties.

ESASI President Olivier Ferrante said that the European Society held its regional seminar in Ljubljana, Slovenia, on April 19–20, 2017. There were 109 participants mostly from Europe and some from AsiaSASI and MENASASI. He noted that there were more than 20 presentations on a wide variety of air safety topics.

Pang Min Li of AsiaSASI mentioned that AsiaSASI’s Executive Committee held its annual meeting in Taipei, Taiwan, on June 20, 2017, and intends to hold an AsiaSASI seminar in 2018. In conjunction with the Executive Council meeting, the Aviation Safety Council hosted an Investigative Practice Technical Workshop that 35 participants attended. Pang said that the term for the current AsiaSASI Executive Council expired on Sept. 4, 2017. Elections for a fifth Executive Council took place in July with the following results: President—Japan Transport Safety Board; Vice President—Hong Kong Civil Aviation Department; and Secretary—Transport Safety Investigation Bureau, Singapore.

The council reviewed and approved a new ISASI membership form that will replace various ones currently on the Society’s website. The council revisited the topic of creating a digital version of ISASI Forum and viewed a beta demonstration of what it might include. The council asked that members be polled on an informal basis regarding their interest in a digital-only subscription. ISASI members received an e-mail question to which they could respond through the end of October.