ISASI FORUM

"Air Safety Through Investigation"

OCTOBER–DECEMBER 2013

Contents

Features

Departments

About the Cover

ISASI Fellow Myron (Pappy) Papadakis and ISASI President Frank Del Gandio display the coveted ISASI Jerome F. Lederer Award presented to them at ISASI 2013, the society's annual seminar on air accident investigation held in Vancouver B.C., Canada. Photo: E. Martinez

ISASI FORUM "Air Safety Through Investigation"

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AIR SAFETY INVESTIGATORS
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Bringing Change to Our Industry Means Safer Flight

By Frank Del Gandio, ISASI President

(Excerpted from opening remarks presented to the delegates of the ISASI 44th annual international conference on air safety accident investigation in Vancouver, B.C., Canada,on Aug. 20, 2013.—Editor)

Good morning. Welcome to ISASI 2013 and to Vancouver. Again, we have the good fortune to meet with representatives from 34 countries in a wonderfully interesting city. Vancouver is Canada's largest metropolitan area west of Toronto. With nearly 2.4 million people, diversity is a key, and more than half of its people speak a native language other than English. Close to our hotel, you can enjoy a great harbor, an interesting city, and Stanley Park. We are 15 minutes from downtown, and in just a short trip you can be in terrain that goes from sea level to more than 3,500 feet, and it just gets higher from there. Some of us, on the optional tour day, will visit the home of the 2010 Winter Olympics at Whistler.

Our theme is "Preparing the Next Generation of Investigators." As implied, aviation is changing rapidly. Technology changes rapidly and constantly, as it has done for more than a century. Aviation markets also are changing, with sustained, rapid growth in much of Asia, the Gulf, and much of South America. We also are witnessing the entry of new countries into the international aircraft market.

E. MARTINEZ

President Del Gandio opens ISASI 2013.

Perhaps the most visible change is the sharp decrease in the number of major accidents. Every year airline officials declare that airline travel is safer than ever before. The catch is that the statement is true almost every year. The statement was true in the 1930s, then in the 1940s, then the 1950s, and so on. It remains true today.

In 2012, worldwide we had 17 hull losses during airline revenue operations, and that assumes a rather generous definition of "airline." As of now, 2013 is setting a similar pace in hull losses. But measured by fatalities, 2013 should be the safest year ever, and by a wide margin. Though this happy story could

change abruptly with a single major accident, the system has performed remarkably well in most of the world in recent years.

The Asiana accident in San Francisco provides testimony to how safe airline travel has become—though we all agree that three fatalities are three too many. Just 15 years ago this would have been a headline story for no more than a couple of days. Today, with so few major accidents, it continues to receive public attention almost two months after the event. Just 15 years ago, a comparable story would have been overtaken within a week or two by a much bigger accident. That is no longer the case in much of the world.

The bad news is that the remaining accidents in the world continue to be dominated by the usual suspects. Where accident rates remain high, the airline community probably cannot hope to bring about a sudden revolution in safety. We will need the help of other communities, but we can make a contribution. We can hope to identify best practices for those national systems, and we can help to prepare their investigators and regulators.

This is the world for which we must prepare tomorrow's investigators. They will be working in an ever increasingly high-tech world, and that will include general aviation. They also will be working in a world where a couple of dozen countries will continue to need significant assistance if they are to improve airline safety as well. Yet they also will be working in a world with fewer and fewer major accidents, and perhaps with a more varied world fleet than we have known in the past decade or two.

This performance has only increased public expectations. In a very real way, we have worked under a de facto standard of zero accidents for a decade or so. The public might concede that an accident can happen any time, but in fact the public now demands zero accidents in most of the world.

All this has implications for the types of skills investigators and regulators will need, and for the type of world view they will need to be successful. It also continues to affect how we understand and measure whether safety margins are improving, where they are improving, and where they are not.

Before I close, let me thank Barbara Dunn for chairing the Seminar Committee; Dick Stone, a former ISASI president, for organizing the Technical Committee; and to all the others who contributed to what I know will be a very successful seminar.

Also, I express my hope that everyone in the room will participate fully in the seminar. Talk to people and ask questions because someone in this room can provide a definitive answer to nearly any aviation question any of us might have. ◆

What Will Be in the Rearview Mirror of Next-Generation Investigators?

By Wendy Tadros, Chair, Transportation Safety Board of Canada

(Excerpted from remarks presented by Chair Tadros in her keynote address to the delegates of the ISASI 44th annual international conference on air safety accident investigation on Aug. 20, 2013, in Vancouver, B.C., Canada.—Editor)

To those of you joining us from all over the world, I'd like to extend a hearty welcome to Canada and Vancouver. An exciting week has been planned, and I look forward to hearing how you are going to prepare the next generation of investigators. This theme couldn't have come at a more important time for us at the TSB [Transportation Safety Board of Canada] and for the air safety community as a whole.

Today, I want to challenge you to peer into your future. But first I want to start by looking in the rearview mirror. In my time at the board, the business (or nuts and bolts) of investigations has changed. Now, more than ever, we are leveraging technology, going beyond determining just what happened to really trying to understand why. We are highlighting trends and communicating what we have found so things will be made safer.

I want to talk about the evolution of the investigator—from old-school to newer-school. And about where you might go next. Along the way, I want to touch on some advances in technology, the importance of human factors, improvements in liaising with families, and communications—and how these innovations have been driven by investigators like you.

At the forefront of changes in the last two decades is the introduction of leading-edge technology. You now have infrared spectrometers to identify nonmetallic trace materials—like oil on a windshield or hydraulic fluid on a runway. You use ultrasound to detect flaws in welds or castings. Then there are the X-ray CT scanners—modified versions of what hospitals use to detect brain tumors or heart abnormalities. Only now they are industrial versions, designed to look through thicker materials so you no longer have to destroy any evidence to see inside.

And if we don't have it at the TSB, we borrow it from partners like the NTSB—as we did this summer with its laser scanners that can generate 3-D models of anything from an aircraft cockpit to a ruptured railway tank car.

There have been advances in flight recorder technology, too, to the extent that the TSB has recommended that smaller aircraft be fitted with lightweight flight recorders. In parallel, there have been advances in retrieval of nonvolatile memory—a part of so many of today's devices, which often survive impact and contain downloadable data.

To all of this, we can add photogrammetry. We can create contour maps, 3-D models, or figure out which of two helicopters involved in a mid-air collision was at the wrong altitude. With enough photographs to work with—or, as in one case, actual video filmed by a passenger—we can even determine approximate flight paths.

These new tools add a level of sophistication, a level of detail that simply wasn't available to us before.

And this has meant that we need experts who understand the technology and its capabilities and who will use it to maximum effect to get to the bottom of what happened in accidents. All so we can more definitively pinpoint what went wrong—and what needs to be fixed. But while technology is the most tangible change we have seen in the last two decades, it is not the only change.

There are now many intangible factors investigators look at.

We have moved from just carefully examining the machine and how it failed. Today we often spend just as much time looking at the organizations and the people who run those machines. That takes a different skill set.

As I said earlier, the role of the investigator is evolving—from old-school to newer-school. We are learning more about why people make the decisions they do, especially when they're under pressure: time pressure, economic pressure, or just the basic pressure to get the job done.

In this broader view, investigators now consider accidents in the context of an organization's overall policies and priorities—because we know that accidents are never the result of just a single individual or factor. We know they are almost always organizational. And that is a big evolution.

As part of this newer world view, we

E. MARTINEZ

Chair Tadros challenges accident investigators to "peer into your future," but first takes them on a visit to the past.

don't talk about pilot error any more. People make mistakes. However, what we've learned about human factors is that sometimes, to the people flying through the middle of the storm, those decisions seem perfectly reasonable—or at least perfectly understandable, at the time anyway.

And more and more, today's investigators are delving into the whys behind that decision-making. You are looking in depth at issues such as fatigue and more and more at cockpit resource management.

As it becomes clearer how fatigue affects people's decisions, we are focusing on fatigue in more of our investigations. To do this, we've had to increase our own understanding of the science of fatigue. We've had to hire experts and better train our investigators in the field.

Our understanding of cockpit resource management, or CRM, has also developed in recent decades. Today's investigators need to know how people interact with one another in the cockpit and how crews make their decisions. They need to figure out if these interactions played a role in the accident.

To do this, our investigators have had to rethink some of the old approaches.

In Canada this really came to the forefront with the 2009 Sikorsky S-92 crash off the coast of Newfoundland. And it is something we are intensively looking at in our ongoing investigation of the B-737 crash near Resolute Bay in Canada's Arctic.

We are far from alone in this. CRM is something that is being examined in many international investigations, most notably by the BEA [Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile] in the investigation into Air France 447.

Another key area that has evolved is the way in which investigators and our organizations liaise with those whose lives have been affected by transportation accidents.

I'm talking about the families, the loved ones, and the survivors. In 1996, when TWA Flight 800 exploded off the East Coast of the United States, it forced Americans to design new ways of delivering family assistance. In Canada, it's a lesson we're still learning. It started with the 1998 crash of Swissair Flight 111. Before that, we hadn't devoted a lot of time to the people who were grieving. With Swissair, that changed.

Investigators began giving briefings and showing families the wreckage so they could see we were working as hard as we could—working to get answers for them. This emphasis was new for our investigators—and it, too, required a whole new skill set.

Speaking of new skill sets, the final change I want to talk about is how we communicate. Most things are electronic now, and we get it out there on our website, through webcasts, and Twitter and Flickr. And we blog about the lessons learned.

At the TSB, we use these new social media tools to reach a broader audience, really for two reasons. First, we think it is better if more Canadians support the work we do. But before they can support it, they have to understand it, and these new tools help us explain what we do. The second reason is that we hope the right people will take note and take the right action to reduce the safety risks we have worked so hard to uncover.

And once the accident report is out, we no longer automatically move on to the next one. We talk to industry, regulators, and the public, and we come back to the safety themes if we see them again, and we talk about them all over again.

Again, it's old school versus new school.

In my time at the TSB, I've seen phenomenal change. But here's the thing about change: back in the early days, none of those things I just talked about were standard elements of any investigation. And when each one came along, it wasn't as if there was instant, universal acclaim for its adoption. Every single one of these new ideas started off as an experiment.

Investigators had to be willing to go against the current and say, "Look, we

(continued on page 30)

In my time at the TSB, I've seen phenomenal change. But here's the thing about change: back in the early days, none of those things I just talked about were standard elements of any investigation. And when each one came along, it wasn't as if there was instant, universal acclaim for its adoption. Every single one of these new ideas started off as an experiment.

The Principle Of National Sovereignty In Air Safety Investigation

By Jean-Paul Troadec, Director, Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA), France

(Adapted from remarks presented by Director Troadec in his keynote address to the delegates of the ISASI 44th annual international conference on air safety accident investigation in Vancouver, B.C., Canada, on Aug. 22, 2013.—Editor)

The organization of aviation safety investigations is regulated by a basic text, Annex 13 to the Chicago Convention. This text is an essential reference for the conduct of international investigations. In general, it has made it possible for investigations to be undertaken systematically after accidents and the most serious incidents and for the safety lessons from them to be shared with the international aviation community.

It is based in particular on an intangible principle of international law—the sovereignty of the state of occurrence, which is responsible for the investigation and solely authorized to communicate on its progress.

Is this principle of international law still effective regarding the objective of safety investigations?

For this, an investigation would have to be conducted systematically by a relevant and motivated authority whenever the importance of the event justified it and that the international aviation community be duly informed of the safety lessons resulting from it.

This is generally the case, but there are exceptions.

Of course, all major accidents, or nearly all, are the subject of a safety investigation, but it is not always conducted effectively and diligently, despite the implication and support of the safety investigation authorities that are associated with it—the main ones being the state of manufacture of the aircraft and that of the state of operation or registry.

The reasons for this are various. The investigation authority's lack of experience or lack of resources, the fear of raising questions awkward for national interests, lack of motivation, various types of pressure…. At the BEA, we occasionally see specific investigations stall despite all our efforts to have them move forward. Of course, most investigations end up being completed, but sometimes so late that it is almost useless. It took the BEA five years of continuous effort with the investigation authority to finally obtain the report on the accident of the MD-80 that occurred in 2005, and four years for the report on the Yemenia accident that occurred in 2009 to be published.

What can we do when the investigation authority keeps quiet whereas, being associated with the investigation, we believe it necessary for air safety to take urgent safety measures and to inform the parties concerned?

For incidents in particular, there is the problem of assessing the merits of an investigation in relation to the safety lessons that could be drawn from it. Yet the state of occurrence is not necessarily the best place to judge, especially if its experience is limited. The other question bears on the investigation authorities' limited resources, which may not encourage the authorities to use all the resources to conduct investigations into events that only concern them indirectly, compared with other priorities. This situation may occur when the incident threatens the operator of a third country, without implicating the air traffic control or airport services of the country of occurrence.

There are, therefore, serious incidents

E. MARTINEZ

Director Troadec in his keynote address speaks about safety investigation that may not be conducted effectively and diligently and offers a framework of new practices to compensate for the lack of resources, skills, or motivation of some authorities.

that are not the subject of investigations because the state of occurrence decided so, either from incorrect assessment of its potential consequences or due to lack of resources.

This was the case recently when an A330 suffered icing of all three of its angle of attack sensors, causing the airplane to pitch down, a situation from which the crew recovered as a result of an improvised input.

Yet in an era where, fortunately, the number of major accidents has fallen steeply, investigations into serious incidents are one of the tools enabling us to detect new risks because operators, acting in the framework of their SMS, do not necessarily have access to all the information enabling them to carry out an in-depth safety analysis.

How then can we ensure that all investigations into major accidents are conducted in a diligent way and that information that is useful for aviation safety is communicated as soon as possible to the aviation community? How can we ensure that the potential seriousness of incidents is correctly assessed and that an investigation is conducted whenever safety lessons can be learned?

An attempt to find a solution is given in Appendix 13 itself, which provides for an investigation to be delegated by the state of occurrence to another state without, however, any existing texts to regulate this practice.

A total delegation of investigation into a major accident bearing on all the aspects dealt with in Appendix 13 is difficult to imagine, as the accident calls into question considerations that go beyond the safety investigation and that directly concern the political and administrative authorities of the state of occurrence, such as managing the site of the accident, managing the bodies and autopsies, relations with the victims and their families, coordination with legal authorities, airport or ATC problems, and so on. Yet if the investigation is not delegated, the current regulations do not authorize the authorities taking part in the investigation, whatever their level of involvement, which may be quite high, to communicate on the progress of the investigation.

Nothing, however, prevents sharing the functions attributable to the investigation authorities under Appendix 13 between the state of occurrence authority and another authority with the skills and resources required to conduct the technical and safety dimension of the investigation, including communication on the safety lessons learned.

The BEA's role in the investigation into the Afriqyah A330 accident anticipated this type of relations, which of course presupposes mutual trust.

Such a sharing of roles should be recognized and formalized in the framework of a protocol between the authorities concerned, and we think it would be useful for International Civil Aviation Organization (ICAO) to publish recommendations on this subject.

In contrast, full delegation of investigation into a minor accident or a serious incident is easier to implement and is more frequently undertaken when the state of occurrence is not directly involved in the event. Such a decision should be taken immediately after the incident after consultation with the authorities of the state of manufacture, registry, or operation in order to assess, in the event of doubt, the seriousness of the incident and to establish the authority that is best placed to conduct the investigation. This may be the case of the state of manufacture or the state whose safety authorities issued the airworthiness or operating certification.

What, however, can we do when no investigation is conducted or delegated, or when it is, it is done negligently whereas aviation safety appears to be compromised by the inertia of the authorities in charge of the investigation?

Legally, the participants in the investigation have no right to intervene. But from a moral point of view, can they do nothing if they deem that the investigation, whatever its stage of progress, brings to light a serious danger for air operations?

It seems unrealistic to imagine a procedure allowing the shortcomings of this authority to be declared and to replace it with another, as there is no supra-national authority able to do this. Nevertheless, it is our duty, as a participant in an investigation, to push any authority at fault to complete an investigation and, if this authority fails to fulfill its duties, to inform the aviation community of the safety lessons that should be drawn from it.

Faced with this type of situation, the

It is...unacceptable that some events that are serious enough for safety lessons to be learned are not the subject of investigations.

BEA has always respected the privilege of public communication given to the authority in charge of the investigation, but has also ensured that the main bodies involved were notified of urgent safety measures that needed to be taken, if any. Again, we also believe that this practice should be structured so that it is not interpreted as interference with the sovereignty of the state of occurrence.

In conclusion, I would like to stress that most investigations into accidents and serious incidents are conducted in a satisfactory manner, sometimes even by authorities with limited resources when they know they can rely on other authorities with the necessary capabilities.

It is, however, unacceptable that some events that are serious enough for safety lessons to be learned are not the subject of investigations.

While remaining within the scope of Appendix 13, which must remain the international benchmark survey of aviation safety, I propose a framework of new practices to compensate for the lack of resources, skills, or motivation of some authorities: Partial delegation of the investigation into major accidents, limited to the technical and safety dimension of the investigation and total delegation of the investigation on serious incidents when the event does not directly concern the state of occurrence.

And finally, as a last resort when the state of occurrence does not conduct an investigation diligently and when urgent safety measures are required, the right for the authorities participating in the investigation, in the context of the provisions of Appendix 13, to communicate to aviation stakeholders on the safety measures required. ◆

ISASI 2013

'Preparing the Next Generation of Investigators'

...was all about the evolution of the "tin kicker" from a mindset of seeking the "how" to a mindset that adds the "why."

By Esperison Martinez, Editor

From the theme of ISASI's annual international accident investigation and prevention training seminar a person could easily surmise that its content was directed to newbies entering the aviation accident investigation profession. But in reality, the 2013 seminar content was directed equally to seasoned accident investigators. Speaker after speaker detailed the technological, social, and cultural changes taking place in the realm of aviation accident investigation and prevention—changes that require shifts in the preparation, thinking, and performance of all accident investigators, today's and tomorrow's.

ISASI's 44th annual conference, held August 19–23 at the Westin Bayshore Hotel in Vancouver, B.C., Canada, drew 288 delegates and 30 companions. Exhibit areas and the seminar auditorium were spacious. Acoustics were excellent, enabling the delegates to clearly hear the 19 technical paper presentations and numerous other addresses that were presented.

Outside the Westin, the weather remained dry and a comfortable mid-70 degrees F, so attendees were able to take advantage of and enjoy the walking lane along the shore of Coal Harbour and its boat-packed marinas.

The general seminar program included a tutorial workshop day and three days of technical presentations. Networking time involved coffee breaks, two evening social events, and an awards banquet. Meetings of individual ISASI working groups and national societies took place. And the annual ISASI business meeting was conducted. The additional-cost optional day trip was to famed Whistler Mountain, site of the 2010 Winter Olympics and Paralympics Games.

ISASI's annual program was hosted by Canadian SASI, whose president, Barbara Dunn, served as the Seminar Committee chair. Other committee members included Richard Stone and Nick Stoss, Technical Program; Ron Schleede, Sponsors; Erin Carroll, Exhibitors; Barbara Dunn and Louanne Clitsome, Companion Program; and Barbara Dunn and Ann Schull, Registration.

Commenting on the overall conduct of the seminar, Chair Dunn said, "This is the third annual seminar the Canadian Society has sponsored in the past 12 years. Each created its own character and nature of enlightenment for attendees. This year's program focused on the next generation of investigators. From the comments passed on to me, the seminar was very successful in illuminating the challenges we all face."

Tutorial program

As always, two tutorial workshops preceded the main seminar technical program. Tutorial attendance required a separate registration. The workshops—"Investigating Occurrences Involving Composite Materials" and "Military Aviation Safety"—were held simultaneously, in separate but adjacent locations, to ease networking during break periods.

The Investigating Occurrences Involving Composite Materials workshop was attended by more than 70 persons and featured eight subject-matter experts who provided information pertinent to the investigation of composite failures and lessons learned.

Dr. Joseph Rakow, principal engineer, Exponent Failure Analysis Associates, addressed failure analysis of composite structures, which centered on the growing need for composites expertise. Andre Turenne, senior technical investigator, the Transportation Safety Board of Canada, presented the case study "Air Transat Inflight Composite Rudder Failure." Andrew Johnston, senior research officer, National Research Council Aerospace Portfolio, Structures, Materials and Manufacturing Lab, Ottawa, presented "Certification and Performance of Composites."

Andy McMinn of the U.S. DOT's Transportation Safety Institute spoke about site safety considerations that an accident investigator must be aware of when dealing with composite materials. He noted that during an aircraft accident, composite materials are easily fractured and can become a penetration hazard. McMinn added that composite materials exposed to an inflight or post-impact fire are especially hazardous as the gases and vapors emitted during burning are toxic. The fibers that are emitted are an acute eye, nose, mouth, and throat irritant.

Dr. Albert Moussa, founder and technical director, BlazeTech Corp, spoke about the flammability behavior of

Coffee break time proves ideal for interacting, which is considered an important aspect of the seminar.

PHOTOS: E. MARTINEZ

Educators panel (left to right): T. Anthony, moderator; A. Brickhouse; G. Braithwaite; J. Stoop; K. McGuire; B. Welch; L. Streeter; G. Masters; S. Lopes; and S. Masters.

composite structures. In particular, he addressed the flammability of fibers and resins. Leigh Dunn, a full-time research and teaching fellow at Cranfield University, spoke about understanding visual and macroscopic failure characteristics of polymer composite materials. Simon Lie, an associate technical fellow for Boeing Commercial Airplanes, addressed composite essentials for the investigator. Roland Thevenin, a senior composite expert at Airbus, presented "A Long Story of Innovations and Experiences," detailing Airbus's use of composite materials.

In the Military Aviation Safety Workshop, representatives of military forces and associated contractors presented 10 topics to more than 45 attendees.

Agne Widholm and Jens Olsson of the Swedish Accident Investigation Authority addressed "When the Exercise Became Reality" in association with the last flight of HAZE01. Michael Buran of Lockheed Martin presented "The Human Factor in Flight Test Program." Lt. Col. Robert Persson of the Swedish Armed Forces addressed "The Organizing of a Common Helicopter Command" from a flight safety perspective. WGCDR Alf Jonas of the Royal Australian Air Force talked about military air safety investigation Down Under. Closing out the morning session, Col. Mike Smith of the Military Air Accident Investigation Branch, UK, presented a case study of the aerial vehicle Hermes 450 Zk515 accident at Camp Bastion, Afghanistan.

Rombout Wever, NLR Netherlands, opened the afternoon session, speaking about implementing flight data monitoring for flight safety in the Dutch Air Force. Dr. Mark Friend of Embry-Riddle Aeronautical University spoke about leading indicators and risk analysis. Pat Daily from Convergent Performances spoke about preventing mishaps through personal intervention.

The afternoon session began with LCDR Natalee Johnston of the Royal Australian Navy answering the question "Immediate Risk Management—Is It Worth the Time?" Closing the presentations, Hans Sjoblom, SAAB Aeronautics, Sweden, spoke about the Swedish view on military accident/incident investigations and how a blame-free culture benefits accident investigation results and a low-accident rate.

Technical program

During the first day of the technical program, the buzz of expectation from 288 attendees filled the air. They arrived on time; sought out seats with the best listening and viewing post, and passed the last few moments becoming acquainted with their seat mates.

Seminar Chair Dunn didn't disappoint. Precisely at 8:30 she opened the program with a brief "welcome back to Canada in a much better atmosphere than our Sept. 11, 2001, seminar" and introduced President Frank Del Gandio. Alluding to the seminar theme "Preparing the Next Generation of Investigators," he titled his presentation "Bringing Change to Our Industry Means Safer Flight."

"Welcome to ISASI 2013 and to Vancouver," he said. "Again, we have the good fortune to meet with representatives of 34 countries in a wonderfully interesting city…. Our theme implies aviation is changing rapidly. Technology changes rapidly and constantly…. Aviation markets also are changing, with sustained, rapid growth in much of Asia, the Gulf, and much of South America. We also are witnessing the entry of new countries into the international aircraft market.

"This is the world for which we must prepare tomorrow's investigators. They will be working in an ever increasingly high-tech world that will include general aviation. They also will be working in a world…where a couple of dozen countries will continue to need significant assistance if they are to improve airline safety as well." (See "President's View," page 3, for his full remarks).

Daniel Scalese speaks about recruiting the next generation of investigators through using university partnerships to advance air safety.

Keynote speaker of the day Wendy Tadros, chair, Transportation Safety Board of Canada, addressed the question "What Will Be in the Rearview Mirror of Next-Generation Investigators?" She challenged the delegates to peer into their future, but to start by "looking in the rearview mirror," because the "nuts and bolts of investigations have changed." She noted that today technology is being leveraged to go "beyond determining just what happened to really trying to understand why."

She said: "I want to talk about the evolution of the investigator—from old-school to newer-school. And about where you might go next. Along the way, I want to touch on some advances in technology, the importance of human factors, improvements in liaising with families, and communications—and how these innovations have been driven by investigators like you." (See "What Will Be in the Rearview Mirror of Next-Generation Investigators?" page 4, for her full remarks.)

Ron Schleede, ISASI vice president, followed at the lectern. In keeping with the tradition of revealing the names of the Jerome F. Lederer Award recipients so all would have time to offer congratulations, he named ISASI President Del Gandio and ISASI Fellow and safety advocate Myron "Pappy" Papadakis (see "Two Receive ISASI 2013 Lederer Award," page 14). In addition, he introduced the four students selected to receive ISASI Rudolph Kapustin Memorial Scholarship awards: Mackenzie Dickson, Embry-Riddle Aeronautical University, U.S.A.; Lauren Sperlak, Purdue University, U.S.A.; Jason Goodman, Embry-Riddle Aeronautical University, U.S.A.; and Camille Burban, Cranfield University, UK. The four awardees presented their essay submissions that won them the scholarship. (See "ISASI's Kapustin Scholarships Awarded," July–September *Forum*, page 19).

Photos of ISASI 2013 seminar activities can be viewed online at www.isasi.org.

In keeping with the seminar theme, Anthony Brickhouse, Embry-Riddle Aeronautical University professor and ISASI chairman of the newly instituted student Mentoring Program, recapped its progress since President Del Gandio announced its creation in January 2012. Anthony reported that the program has moved forward, with 27 ISASI member volunteers serving as mentors and 23 students participating in the program. He expects the program to grow as universities and colleges begin their fall semesters. He anticipates that the number of students seeking mentors will soon exceed the number of mentors available. Good relationships are being created, but "we need more mentors. The program is able to make matchup by geographical areas, even on a global basis," he noted. Persons interested in becoming mentors were asked to contact Brickhouse at isasistudentmentoring@gmail.com.

PHOTOS: E. MARTINEZ

Some of the 288 delegates who filled the plenary conference room during the three-day technical program.

The remainder of the first day was similarly filled with "next generation" topics, such as papers titled "Preparing the Next Generation of Investigators from a New Investigator's Prospective" (see page 20), "Teaching New Investigators to Think: From Ayn Rand's Objectivism to Sherlock Holmes Deductive Reasoning," and "Recruiting the Next Generation of Investigators Using University Partnerships to Advance Air Safety."

In addition, one of the three panels the Technical Committee developed included eight educators, end users, and manufacturers. The panel discussed preparing the next generation of investigators. Among the points made were

- characteristics that can't be trained—logic, personal relationships (a jerk is a jerk). Characteristics need to be evaluated at the interview. It's important who we select as much as what we select for.
- objectivity outweighs all during an investigation. What was the accident person perceiving at the time of the accident? Realize that the subject believes the action taken was the right one.
- educators' responsibility is to create experiences that motivate the student. Give real-world, hand-on experience by crash site training grounds.
- the investigator profession involves technical knowledge, integrity, truthfulness, credibility, and curiosity.
- forensics is a needed skill to deal with situations.
- safety investigators as data analysts of smaller incidents prevent larger accidents.

The second day's session concentrated on the more traditional topics of accident investigations and investigation techniques. Some of the day's titles included "Improving Our Capability to Investigate for Organizational and Management Factors," Airbus A320 Wing-Strike at Hamburg Airport Within Hours Via YouTube," and "The Investigation of a Lithium-Ion Battery Fire Onboard a Boeing 787" (see page 24).

The final day's presentation brought a mix of topics that included both the next

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generation and investigation techniques. (See sidebar of all authors and paper titles.)

Throughout the eight-hour, three-day technical program, the presentations kept the attendees involved. After each set of morning and afternoon sessions, a speakers' panel responded to floor questions. Generally, the Q&A followed the break for coffee networking time.

Business meeting

ISASI's annual business meeting was held midday on Thursday. President Del Gandio reported that the society was financially sound and that its membership rolls reflected 1,359 individual and 127 corporate members. He spoke about the society's newly gained ICAO observer status, which permits ISASI to partake in deliberations of the ICAO Air Navigation Commission, particularly those involving matters related to Annex 13—Aircraft Accident and Incident Investigation to the Chicago Convention.

He discussed the upgrade of the society's member communication efforts by creating electronic news sources. He said, "We are moving into the century of electronic communications." His other topics included the lack of applications for "Fellow" status. In urging participation, he noted that Ludi Benner, program chairman, was relinquishing the position. He thanked him for his exceptional service and said that Curt Lewis would assume the chairmanship. He also announced that the Korean SASI and both Middle East and North Africa SASI had become affiliated with ISASI. Lastly, he announced that the European Society had won the bid for the 2015 annual seminar. The event will be held in Augsburg, Bavaria, in southern Germany. And he reminded everyone that the ISASI 2014 seminar is being hosted by the Australian Society in Adelaide, Australia, on Oct. 13–17, 2014.

Ron Schleede spoke briefly about the progress of the ISASI scholarship program and the need to gain contributions to continue maintaining its successes. He began an impromptu donation challenge that garnered $2,650.

Treasurer Bob MacIntosh said the society's financial status was positive and that the International Council had

Above: Earnest conversation during break times leads to earnest questions to members of speaker panels, as shown on the right.

approved the 2014 budget of $215,000. ISASI's Virginia state tax relief, personal and property taxes, continues at the $4,000 level. He also urged everyone to continue recruitment and renewal of membership efforts.

Program social events

Three special social events for all attendees and companions were programmed into the weeklong event. The first, a welcoming reception, was held in the hotel's main floor restaurant—where travel weariness was lessened, old acquaintances were rekindled, and new ones begun.

After two days of sitting, listening, and taking notes, attendees were much appreciative of the second-day offsite dinner event. Where they were going, they didn't know. The destination was the Altitude Bistro restaurant at the top of Grouse Mountain. The ride up the mountainside to the peak of Vancouver in the Red Sky 100-passenger aerial tram was an event in itself. As the sky car moved high above towering douglas

If any self tensions existed on the 100-person aerial tram ride up to the peak of Vancouver, they eased upon exiting the Red Sky tram.

firs, the view below was just a tease of what awaited the eyes from the Bistro's panoramic windows: breathtaking views of the city of Vancouver, sparkling Pacific Ocean, and the Gulf Islands.

The third event was the awards banquet. Because of its peer-to-peer recognition aspects, it's the most awaited and most formal of all the social events (see "Awards banquet" page 12).

Special events

The overall seminar program included two special events: the companion program and the extra-cost, post-seminar one-day excursion.

Thirty companions enjoyed the two companion tour days. The first tour went from 9 a.m. to 4 p.m. It included bus tours through Gastown and Chinatown, with stops at Queen Elizabeth Park and the VanDusen Botanical Garden.

Gastown was designated a national historic site of Canada in 2009. Established in1867, its history is steeped in seaport, rough and rowdy resorts, and commerce center lore.

Chinatown is one of the largest historic Chinatowns in North America. Queen Elizabeth Park started its life in Vancouver as a basalt quarry. An entirely different atmosphere came with the walking visit to VanDusen Botanical Garden, with its huge collection of individual plants that represent ecosystems from across the world.

The second tour day was short. It involved walking about the 1,000-acre Stanley Park with its giant trees, dis-

PHOTOS: E. MARTINEZ

Members of the "Protection of Sensitive Information" panel prepare to speak: (left to right) D. King, moderator; F. Hilldrop; M. Costa; O. Ferrante; Y. Malinge; and T. Logan.

plays of totem poles, and spectacular bird's-eye view of Vancouver. The final stop, Granville Island, offered outstanding food markets, restaurants, and unique shopping attractions.

The post-seminar one-day tour visited Whistler Mountain, British Columbia's mountain playground. The scenery along the Sea to Sky Highway was spectacular. Whistler Village, with its cobblestone streets and a unique blend of West Coast and continental architecture, has a European feel. Village shops and sidewalk cafes allowed for shopping and relaxing in the sun.

Awards banquet

The awards banquet is an anticipated event by the attendees. It closes the three plenary days of technical talk and is the peer-to-peer night for recognition of deeds done and appreciated.

After a refreshment hour and a sumptuous dinner, President Frank Del Gandio took the stage and welcomed everyone to the closing event of the society's 44th annual seminar, its recognition night. Delivering appreciation for the seminar's day-to-day excellence and its successful outcome, he introduced the many who were responsible: organizers, event planners, fund-raisers, transportation providers, behind-the-scene workers, hotel management, the co-host sponsors, and booth sponsors, among others.

Next, he recognized new corporate members who have joined during the year. They included Becker Helicopter Pty. Ltd.; DRS C3 & Aviation Company; Pakistan Air Force–Institute of Air Safety; Saudi Arabian Airlines–Safety; Sky Trac System Ltd; Lion Mentari Airlines, PT; ASSET–Aviation International Pty, Ltd.; and Pakistan Airline Pilots Association.

Peer recognition began when President Del Gandio called on Timothy Logan and Dennis Post to join him on stage. They approached with quizzical looks, discovering that their technical paper, "Learning from and Preparing for Traditional Airline Accident Investigations While Transitioning to SMS Risk-Based Investigation Processes," was voted the Best of Seminar Award of Excellence (see page 16). The Excellence selection carries a US$500 prize, which the authors contributed to the ISASI Rudolph Kapustin Memorial Scholarship Fund.

But Logan's time on stage wasn't over. Recalled to the stage, Frank announced his selection and elevation to ISASI Fellow membership status. He became the 31st person so honored since the class was established in 1993.

The four college students selected to receive 2013 ISASI Rudolph Kapustin Memorial Scholarships—Mackenzie Dickson, Lauren Sperlak, Jason Goodman, and Camille Burban—were then presented their scholarship certificates, accompanied by loud applause from the audience.

Presentation of the Jerome F. Lederer Award capped the evening, as it always does. This year, however, the scrip was a bit different because one of the recipients was the president of the society. The other was Myron "Pappy"

Tim Logan accepts his Fellow membership certificate from President Del Gandio.

Vice President R. Schleede presents Frank Del Gandio his Jerome F. Lederer Award plaque.

President Del Gandio congratulates M. Papadakis and presents one of the two ISASI 2013 Lederer Award plaques awarded.

Speakers and Technical Papers Presented at ISASI 2013—Vancouver, B.C., Canada

Tuesday, August 20

Keynote Address: What Will Be in the Rearview Mirror of Next-Generation Investigators?—Wendy Tadros, Chair, Transportation Safety Board of Canada

Investigating accidents—But How to prevent the next?—Thomas Fakoussa

Preparing the Next Generation of Investigators—from a New Investigator's Perspective—Brian C. Kuo

Teaching New Investigators to Think: From Ayn Rand's Objectivism to Sherlock Holmes Deductive Reasoning—William D. Waldock and L. Pete Kelley

Recruiting the Next Generation of Investigators: Using University Partnerships to Advance Air Safety—Daniel Scalese

Wednesday, August 21

Keynote Address: Dr. Cho Taehwan, Chairman, Korea Aviation and Railway Accident Investigation Board (KARAIB)

Improving our Capability to Investigate for Organizational and Management Factors—Joel Morley and Jon Stuart

Learning From and Preparing for Traditional Airline Accident Investigations While Transitioning to SMS Risk-Based Investigation Processes—Timothy J. Logan and Dennis G. Post

The Investigation of a Lithium-Ion Battery Fire Onboard a Boeing 787 by the U.S. NTSB—Joseph M. Kolly, Joseph Panagiotou, and Barbara A. Czech

Airbus A320 Wingstrike at Hamburg Airport Going Around the World Within Hours Via YouTube—Johann Reuss

Investigating Runway Overruns—A Manufacturer's Perspective—Frederico Moreira Machado and Carlos Eduardo Bordignon Martinez

A New Capability for Crash Site Documentation—Major Adam Cybanski

Thursday, August 22

Keynote Address: The Principle of National Sovereignty in Air Safety Investigation—Jean-Paul Troadec, Chairman, BEA, France

Flight Data: Then, Now, and Coming Soon—Michael Poole

Delegating Full Investigative Authority to a Foreign Agency—Jon Lee

Building and Maintaining Relationships: Lessons You Should Have Learned in Kindergarten—John Purvis

Preparing the Next Generation of Investigative and Regulatory Authorities—Robert Matthews

The Agony and the Ecstasy of Utilizing Safety Data for Modern Accident Prevention and Investigation—Jeff Guzzetti

Aeroplane State Awareness during Go-around (ASAGA)—Johan Condette

Technical papers submitted and accepted but not presented

Benchmarking Aviation Safety Professionals Through Certification—Roger L. Brauer and Curt Lewis

Instant Flight Data Analysis—Paulo Manoel Razaboni

Preparing the next Generation of Investigators—Yang Lin

Papadakis (see page14).

Ron Schleede, ISASI vice president, made the presentation to President Del Gandio. In introducing Frank, Schleede recounted some of Del Gandio's accomplishments during the past 45 years, most of which were served with the Federal Aviation Administration.

At the lectern, and after ringing applause, Frank said, "I am truly honored. Thank you all. But it is a little embarrassing to be your president and to receive this award, too. Generally, winners get very little notice of their selection, but I had six weeks to think about this night. I decided that instead of speaking about myself, I would talk about Jerry Lederer, the namesake of our award."

He carried the audience through Jerry's early years and on through many of the air safety accomplishments that earned Jerry the title "Father of Aviation," conferred to him by the U.S. Congress in 1997. Frank concluded his talk saying, "I am truly honored to receive this most prestige air safety award, and I am also truly honored to be your president. Thank you from the bottom of my heart."

"Pappy" Papadakis joined Frank on stage and listened to his introduction: Frank said: "It is not that Pappy excelled at any one thing. It is because he was willing to fly Delta Air Lines aircraft every weekend and every holiday for 31 years so that he would have the work week to do things." Those "things" included 20-plus years of volunteer air safety work with the Air Line Pilots Association and a 35-year ISASI membership. Along the way, he investigated his first aircraft accident in 1967 while with the U.S. Navy. Since 1972 he has worked on 450 aviation accidents, sometimes investigating and sometimes evaluating, and he earned a law degree."

B. Dunn, right, and L. Naylor share in the exchange of the "seminar bell," which signals the beginning preparation for ISASI 2014, to be held in Adelaide, Australia, in October 2014.

Upon concluding the recitation of Pappy's accomplishments, Del Gandio turned, award in hand, and said, "Pappy by any measure you are most worthy of receiving our society's highest recognition. Congratulations." The audience responded loudly and then quieted as Pappy moved to the lectern.

Speaking in a quiet voice, he said, "I am really honored and still a little shocked by this honor. If General Smokey Caldera were alive, he would be looking at this installation with surprise and perhaps disbelief. General Caldera was a disciple of Shakespeare when it came to what to do with lawyers.

Pappy talked only in the briefest terms about his career, lauding those with whom he worked. He concluded saying, "I am honored to be a member of ISASI and proud to know people who do what you do. As I accept this honor, I will continue to work to justify this committee's choice."

Closing the evening was the traditional "passing of the bell," the chime used to summon seminar attendees back into session after breaks. 2013 Chair Barbara Dunn handed off the bell to Lindsay Naylor and urged all to attend ISASI 2014 in Adelaide, Australia, on Oct. 13–17, 2014. ◆

Two Receive ISASI 2013 Lederer Award

For only the third time in 36 years have two parties earned sufficient peer recognition to simultaneously receive the only recurring award given by the society.

By Esperison Martinez, Editor

For only the third time in 36 years have two parties earned sufficient peer recognition to simultaneously receive the only recurring award given by the society—the coveted ISASI Jerome F. Lederer Award. The dual-award presentation was made to ISASI President Frank Del Gandio and ISASI Fellow and safety advocate Myron Papadakis at the ISASI 2013 seminar award night dinner held in Vancouver, B.C., Canada, on August 22.

The award's namesake "flew west" at age 101 on Feb. 6, 2004. Jerry Lederer's aviation lore stretches back to the time of wooden wings and iron men when he joined the U.S. Air Mail Service in 1926 as an aeronautical engineer. His aviation safety prowess steadily grew and in 1997 the U.S. Congress recognized him as the "Father of Aviation Safety." Along his route to becoming a legend, Lederer, in 1965, became a member of the Society of Air Safety Investigators, the forerunner of ISASI. In 1969 he became the second president of the organization. In time, and in his honor, the society established the Jerome F. Lederer Award. ISASI presents the award in recognition of a single event, a series of events, or lifetime contributions to technical excellence in furthering aviation accident investigation and achieving ISASI objectives. Those objectives include enhancing aviation safety through the continuing development and improvement of investigation techniques.

The selection of the award recipient(s) is made by ISASI's Awards Committee, composed of 12 members from international and domestic units and chaired by Gale Braden. Four individuals were nominated to the committee. Using established balloting procedures, each committee member receives identical nominating data and makes a selection of first, second, or third choice for each nominee. The chairman than assigns a set number of points to each individual for each position vote received from the committee judges. The rigorous vetting and voting process produced a tie vote for the two candidates. Consequently, both were selected as awardees.

Introducing the award winner "Pappy" to the banquet guests, President Del Gandio said, "It is not that Pappy excelled at any one thing. It is because he was willing to fly Delta Air Lines aircraft every weekend and every holiday for 31 years so that he would have the work week to do things." Those "things" included 20-plus years of volunteer air safety work with the Air Line Pilots Association and a 35-year ISASI membership. Along the way, he investigated his first aircraft accident in 1967 while with the U.S.Navy. Since 1972 he has worked on 450 aviation accidents, sometimes investigating and sometimes evaluating. He earned his law degree in 1974, authoring an 800-page reference book *Aircraft Accident Reconstruction and Litigation*, which is recognized as the definitive text on the subject. About the book, Jerry Lederer wrote in the book's foreword page, "Engineers and probably lawyers will appreciate this book's refreshing review of aerodynamic, structural design, powerplants, and aircraft control techniques as well as applicable nuances of the law."

Upon concluding the recitation of Pappy's accomplishments, Del Gandio turned, award in hand, and said, "Pappy by any measure you are most worthy of receiving our society's highest recognition. Congratulations." The audience responded loudly and then quieted as Pappy moved to the lectern.

Speaking in a quiet voice, he said, "I am really honored and still a little shocked by this honor. If General Smokey Caldera were alive, he would be looking at this installation with surprise and perhaps disbelief. General Caldera was a disciple of Shakespeare when it came to what to do with lawyers. It is true most aircraft investigators are skeptical concerning trial advocates.

"There are reasons why most governments correctly ban attorneys from being parties to an investigation. Some say lawyers chase money and not safety…. That statement is only a little unfair because I submit that pinpointing fault, however that occurs, does enhance safety...just as does the finding of probable cause. Aviation manufacturers hate having a lack of safety impinge on profits. When an engineering mistake becomes an expensive mistake, a company is fast to learn the lesson and change dangerous conditions.

"Lawyers investigating an accident have the best of several worlds since we begin when the government investigation is complete. The government's work is done, and the law has an advantage of beginning where the field investigation ended. We are also equipped with legal discovery tools that allow us broad access to information.

"For the most part, legal investigations point out the 'lessons not learned.' Let it be said that perfect aviation safety is an unachievable goal. Searching for perfection is a worthy undertaking in the aviation arena. In the past 50 years in the aviation endeavor, I have met surviving family members who see acceptable risk in accidents in a very personal way.

"When we adjourn and return to our workplaces, about 90 percent of us will fly home. In front, the captain will feel the awe of a 600-mile-per-hour office and the responsibility for 300 lives. We hope our children and grandchildren will ply these same skies safely. In that aspect, we all wish that endeavor to be a safe one.

"Probably the world's best accident investigator USAF's Sam Taylor said it all. 'Pappy, learn to read the bent metal.

The story is written out here in the field where hurt happens.'

"I am honored to be a member of ISASI and proud to know people who do what you do. As I accept this honor, I will continue to work to justify this committee's choice. I shall try to act like the ancient Greek Diogenes in continuing to search for truth. It is proven that once armed with truth, good and safe decisions are made possible. That is what air safety investigators do for a living.

"Also I accept this great honor,...but I realize that this award will not get me into heaven…. However, I am sure I will achieve that goal because…heaven's gatekeeper will say, 'Come on in Capt. Papadakis. We know you are a religious person because in your 30 years of airline flying, every time you took off you had 300 passengers praying.'

"Seriously, in Texas vernacular—On Monday, God willing and the creek don't rise, I will be back in Texas acting like a tortoise in the marathon of life, just…keeping on keeping on."

Vice President Ron Schleede then came to the lectern and announced, "We have had a tie in the voting that results in two recipients for the Lederer Award. Frank, whom I have known for a long time, is one of the recipients. I also knew Jerry Lederer, and I know he would have been very pleased with Frank's selection.

Summarizing Frank's career, Schleede said, "Frank began his aviation career in 1968 with Pan American World Airways' Business Jet Division. In 1974, he became a Federal Aviation Administration [FAA] aviation safety inspector, and in 1980, he joined the air safety investigator ranks. Ultimately, he investigated more than 45 major accidents and performed 25 field investigations as the FAA investigator-in-charge (IIC).

"In 1987, he became the FAA's division manager of its newly formed Office of Accident Investigation's Recommendation and Safety Analysis Division. He brought to the job a vision of using seminars and training programs to energize and unlock inspectors' potential. Hence, he became instrumental in starting safety investigation classes in cabin safety, jet engine investigation, human factors, and helicopter accident investigation training programs, resulting in the overhaul of the FAA's Aircraft Accident School to become one of the industry's finest.

"During his 13 years as ISASI president, he has initiated numerous programs that have helped shape the investigator's profession and role for both the present and future years. These include the ISASI Rudolph Kapustin Memorial Scholarship; the ISASI Outreach Program, which helps train developing nations' aircraft accident investigators; and most recently, the ISASI Mentoring Program, among others.

"Frank's aviation career of more than 44 years has been a lifetime of passionately increasing the level of aviation safety through mentoring entry-level and journeyman aviation safety personnel, improving aircraft accident investigation techniques, and promoting quality aviation safety recommendations on a national and international basis," Schleede concluded as he turned and presented the award plaque to President Del Gandio.

At the lectern, and after a ringing applause, Frank said, "I am truly honored. Thank you all. But it is a little embarrassing to be your president and to receive this award, too. Generally, winners get very little notice of their selection, but I had six weeks to think about this night. I decided that instead of speaking about myself, I would talk about Jerry Lederer, the namesake of our award."

He then asked for a show of hands of those in the hall who had never met Jerry. More than half the audience of 240 raised a hand. That certainly was signal that his subject would be enlightening.

Frank spoke of his first exposure to Jerry's fame. "In 1985 as ISASI secretary, I heard a great deal of talk about Lederer and all the aviation wisdom he possessed. A year later at the ISASI seminar in Munich, Germany, I finally did shake his hand and got to spend a good deal of time with him. I quickly learned that he indeed was as aviation wise as his reputation alluded. From that day on, he became my mentor. We became close and exchanged many phone conversations in which he almost always made suggestions about how we should proceed in an investigation."

In all, Frank briefly covered Jerry's chronological history from his college years through his initial years of aviation safety work with the Air Mail Service to the time he was honored with the title of "Father of Aviation" by the U.S. Congress in 1997 and beyond. Indeed Jerry never wavered in his dedication to aviation safety, and year after year he chalked up accomplishments that included organizing the Office of Manned Space Flight Safety for NASA. There he became close to Neil Armstrong, the first man to step onto the moon. Frank closed his Lederer talk saying: "Jerry's mind never diminished; however, his body showed the years. He fell on a flight of stairs and 'flew west' just shy of 102 years old."

Frank concluded his talk saying, "I am truly honored to receive this most prestige air safety award, and I am also truly honored to be your president. Thank you from the bottom of my heart." ◆

"I am honored to be a member of ISASI and proud to know people who do what you do. As I accept this honor, I will continue to work to justify this committee's choice. I shall try to act like the ancient Greek Diogenes in continuing to search for truth. It is proven that once armed with truth, good and safe decisions are made possible." — Myron "Pappy" Papadakis

E. MARTINEZ

Myron "Pappy" Papadakis, left, ISASI Fellow and safety advocate, and Frank Del Gandio, ISASI president, with the Lederer Award.

Award of Excellence: Learning From and P Investigations While Transitioning to SMS

By Timothy Logan, Senior Director, Safety Risk Management, Southwest Airlines, and Dennis Post, Senior Safety Inv

(This paper received the Best of Seminar Award of Excellence for technical papers presented at ISASI 2013 in Vancouver, B.C., Canada, on Aug. 19–23, 2013. The seminar theme was "Preparing the Next Generation of Investigators." *In presenting this winning paper,* Forum *is departing from its usual editorial format and is publishing it in its technical paper format, as accepted by the ISASI 2013 seminar Technical Committee.—Editor)*

Abstract

United-States–based commercial airlines continue to experience the safest period of operations in aviation history, with the last United States commercial air carrier fatal accident, Colgan Air Flight 3407, occurring on Feb. 12, 2009. The continuing adoption of Safety Management Systems (SMS) across the global aviation industry calls for the next generation of investigators to become proficient in tactical, risk-based investigation practices, while also staying skilled at participating in major typically government-led investigations and able to respond to the catastrophic hull loss and multiple fatality events from which previous generations of investigators have learned.

Members of the next generation of investigators are entering an industry in which operational safety risks are more often identified through safety data and voluntary reporting programs (ASAP, FOQA, LOSA, VDRP) than accidents. Never before has the full might of the industry been able to shift toward predictive investigations rather than reactive.

The authors propose to describe how the next generation of investigators will need to transition from often years-long accident investigations to quicker, tactical, risk-based investigations without sacrificing depth or quality. At the same time, this new generation of investigators must continue to be prepared to participate in major typically government-led investigations on behalf of their organizations, and maintain preparedness for the major accident that they are also seeking to prevent. The authors will explore the complexities of this position through their respective positions: a leader of an airline safety department with 30 years of accident investigation experience and a five-year investigator functioning in this dual-process world.

Introduction

The "new" airline safety investigator is entering an industry where the work of the "old" safety investigator has nearly been made self-extinct. These new investigators are tasked with upholding and continuously improving the safety record of commercial aviation and must evolve their skills and techniques to the tasks that their organizations require of them. At the same time, these investigators and safety managers must also ensure that they and their teams are prepared for the major accident that they are seeking to prevent by learning from those that have come before them. This dual role, coupled with the ever-growing supply of safety data and the demand for answers to events, presents unique opportunities and challenges for today's airline safety investigator.

Airline accident investigations in the past

Airline safety organizations over the last 30 years have evolved as more information has become available on daily operations. As the safety information sources and related technology improved, so did the ability of airline safety organizations to move from a reactive to a proactive methodology. This led to new roles for traditional airline safety personnel and the requirement to adapt to the new technology.

Previously, in-house airline safety organizations operated as internal National Transportation Safety Board (NTSB) organizations whose function was to react to known incidents and accidents and work to identify fixes to improve safety. Most of the safety personnel were pilots, who may have had some military safety training, but for the most part relied on their piloting knowledge to help determine the direction of their organizations.

Accident investigator training primarily came from the military or from the few schools that grew out of the military accident investigation schools. Aviation safety degrees were virtually nonexistent.

The safety tools these organizations had were limited. Most did not have sophisticated employee reporting programs. Aviation Safety Action Partnerships (ASAP), Internal Evaluation (IEP), and Flight Operational Quality Assurance (FOQA) programs had not been developed yet. Flight data recorders (FDRs) had limited information on them but could be used to assist in an investigation. Most FDRs only contained between 6–17 parameters, and the boxes only held data for 24 hours. For the FDRs to be useful, the incident would have to be reported within a day or two so that the recorder could be removed before the data from an event were lost. Recorder readout capabilities were limited, and as a result the analysis could take more than a week before meaningful data were available.

As a result of these limitations, incidents had to occur and be prominent enough to be known by the airline for an investigation to be initiated. The investigation of a significant event usually was a slow methodical process. The safety programs functioned as purely reactive organizations reacting to known events through a methodical NTSB-like investigation process. For the most part, these organizations were imbedded in the flight operations departments of airlines with limited ability to

reparing for Traditional Airline Accident Risk-Based Investigation Processes

estigator, Southwest Airlines

effect change in organizations such as ground operations and maintenance.

Usually, these airline safety organizations worked very well with the NTSB. There was a close relationship, and a large portion of the on-the-job training received by airline safety personnel was gained during their participation in NTSB investigations. Accidents were not uncommon, so the majority of the time airline safety departments moved from accident to accident with little time to focus in a proactive mode.

The evolution from reactive to predictive

In the 1990s this all started to change. The dramatic improvements in the capability of the computer chip led to rapid developments in personal computer power, and the proliferation of the Internet revolutionized airline safety programs. The voluntary safety programs—ASAP, FOQA, IEP, and Voluntary Self Disclosure Program (VDRP)—led to a whole new source of information that fed into airline safety organizations. This was joined with a new realization that it was important to incentivize employees to report incidents. This provided specific information on line operations that before was just hearsay or "hangar talk." This enabled airline safety personnel to start moving away from reactive activities and begin to initiate proactive processes that didn't have to wait for an event to occur before corrective action could take place.

The result was a reduction in the accident rate that led to further emphasis on the proactive, with voluntary safety programs being a primary source of information used by airline safety organizations. As the volume and quality of voluntary safety data increased, so did the realization that there must be a systematic methodology to deal with these new sources of information. SMS was developed, combining traditional safety programs approaches with a quality-assurance aspect to form a continuous improvement process for the aviation safety organization.

This approach introduced data-driven, risk-based decision-making with a robust quality-assurance function to drive safety improvements. The engine that drives this process is the safety information that now flows freely in most airline safety programs. In addition, it has driven airline safety programs away from being flight-operations–oriented toward a systems-based process that looks at organizational interfaces, organizational decision-making, and organizational culture as an integral part of the proactive philosophy of SMS.

The availability of safety information and the incorporation of SMS principles have resulted in the ability of airline safety personnel to move away from simply reacting to known events and to concentrating on proactive processes to reduce operational risk. The focus is not on accident investigation but on preventing accidents and incidents using methodical processes to eliminate the hazards in the operation. With this fundamental shift, the personnel making up airline safety organizations must evolve to be able to effectively manage the volume of safety information, implement corrective actions, and continuously monitor the operation to measure the effectiveness of controls in place and identify new hazards.

The new airline safety employee

As previously stated, past airline safety personnel were usually pilots who may or may not have had accident investigation experience. This fit the reactive model of these programs.

Today, airline safety personnel come with varied experience and educational levels, which better aligns the risk-based, safety information age of the proactive programs. College degrees in aviation safety are prevalent across the world. Engineering degrees, information technology degrees, risk analysis, and human factors experience are all necessary within safety organizations to be able to extract and make sense of the voluminous amount of information now generated by voluntary safety information.

A good example is found in today's FOQA programs. An effective FOQA program requires expertise in analysis of flight

Timothy Logan is the senior director of safety risk management for Southwest Airlines and holds the FAA Part 119 position of director of safety. He has prior safety roles at Northwest Airlines and the Air Line Pilots Association. He served as a Boeing flight test analysis engineer participating in the initial certification of the B-757 and B-767. He holds a B.S. in aeronautical and astronautical engineering from Ohio State University and an MBA from George Washington University, with an emphasis in the management of science, technology, and innovation. He also holds a private pilot's license. He is the former chairman of the A4A Safety Council and Flight Safety Committee and was involved with the development of the Aviation Safety Information and Analysis System (ASIAS) program, which is sharing and analyzing voluntary safety information at the industry level. He is an ISASI member, serving as the president of the Dallas-Fort Worth Chapter.

Dennis Post, a senior safety investigator, has been with Southwest Airlines since 2008, where he began as a safety department intern. In his present role, he serves as the party coordinator to NTSB-conducted accident and incident investigations. He also conducts internal safety investigations and institutes corrective actions. He is an ISASI member with the Dallas-Fort Worth Chapter. He holds a B.S. in professional aeronautics from Embry-Riddle Aeronautical University in Daytona Beach, Fla., with minors in aviation safety, human factors psychology, and flight. He also holds a private pilot single-engine land certificate.

data, the ability to write analysis algorithms, and an ability to work with avionics engineers to ensure efficient acquisition of the data off the aircraft to the analysis software infrastructure. These skills are more slated for an engineer than a pilot. The pilot role is still important, but that expertise is needed at the end of the process where meaningful information is developed after the flight data are analyzed.

Airline investigators of current and future generations may be very much like airline investigators from years ago. They, like their predecessors, may come from the ranks of commercial pilots, aircraft engineers, and mechanics or from agencies like the FAA or the NTSB. However, a growing number of investigators are entering the airline safety industry directly from academia.

The number of universities offering degree programs in aviation safety continues to grow, and, coupled with internship opportunities within the airline industry, the pool of future investigators has greatly expanded. But unlike the investigators who preceded them, many of the new generation of investigators are entering the industry without the experience of being on scene for major accident investigations.

As United States commercial airlines maintain and improve the country's low accident rate, the opportunities for the traditional "tin-kicking" accidents have naturally dropped. Investigators now learn their techniques through a series of formal training programs and on-the-job training. Professional organizations such as ISASI are a vitally important piece of an investigator's training as well. The opportunity for a new investigator to learn from those who investigated the major airline accidents of previous decades is essential to the investigator's ability to continue the successes of accident investigation and aviation safety into the future.

Today's airline investigator will hand you a business card that is more likely to state "safety investigator" than "accident investigator." The investigator's responsibilities within his or her organization are expanded to include prevention and not just waiting for the proverbial bell to ring signaling the next accident. The model of an airline safety investigation has also changed, and investigators must be prepared to tailor their investigations to meet this change.

The new investigation model

Airline safety investigators used to spend most of their time on major accidents and incidents—the typically government-led, potentially years-long efforts for which our industry is known. In today's airline industry, an entirely new form of investigation has evolved, as the industry operates under the principles of SMS. The vast amount of safety data available to investigators both allows and requires them to conduct investigations of events before the events rise to the level of an accident.

These new investigations must be risk-based, tactical fact-findings of an event. As risk management teams are developed within the safety organization, they are able to identify the types of events that pose the greatest threat and to direct investigators accordingly. These new investigations often do not have a scene to which the investigator travels; rather the scene is a computer in an office or cubicle, a collection of images, statements, and aircraft performance data accessible within moments. Modern technology is the investigator's greatest tool, allowing quick determination of what events have occurred and of what level of investigation will be conducted.

Just as technology and rapidly accessible data are a tool for today's investigator, these can also be the greatest pitfalls. Investigators must be certain that they maintain the same unbiased focus in their search for causal factors that has defined their role within their organization. The investigator will need to balance a flurry of electronic conjecture, inquiries, and requests for updates from management, and perhaps even their own beliefs and opinions based on the information that they are seeing.

Another significant change and challenge presented by this new model of investigation is time. Once an event is identified as having risk and an investigation is opened, the investiga-

Award of Excellence

Tim Logan and Dennis Post earned the ISASI Award of Excellence for their paper *Learning From and Preparing for Traditional Airline Accident Investigations While Transitioning to SMS Risk-Based Investigation Processes*, which was judged Best Seminar Paper of those papers presented at the ISASI 2013 seminar on aviation accident investigation held in Vancouver, B.C., Canada, on Aug. 19–23, 2013.

The award was established through an anonymous donation by an ISASI member who wished to acknowledge a paper at the annual seminar that made an outstanding contribution to the advancement of technical methodologies in aircraft accident investigation. The Excellence selection carries a US$500 prize. The authors announced that they are contributing the $500 to the ISASI Rudolph Kapustin Memorial Scholarship Fund. ◆

E. MARTINEZ

Dennis Post, left, accepts President Del Gandio's presentation and congratulations as Tim Logan looks on.

tor is faced with the same questions that every investigator has always faced—"What caused this to happen (or nearly happen), and how can we prevent it?" But more than ever, the organization, the industry, and the traveling public expect that the answers to these questions will be provided just as quickly as the event itself was identified.

To combat the ever-ticking clock, the investigators must quickly identify their scope, their resources, and their method of reporting. While one investigation may result in a lengthy report rich with technical analysis, another may be a condensed brief report summarizing the important facts gathered from available information. These condensed investigations and reports are often the most challenging as the investigators must determine not only what is important to include in their report but also what may be excluded. The goal is to be effective in instituting change, and a traditional "blue cover" style accident report may not always be the most impactful way to do so in today's airline safety organizations.

The airline safety investigator is also usually tasked with upholding the carrier's regulatory reporting requirements for incident and accidents to various agencies such as the NTSB, the Occupational Health and Safety Administration (OSHA), the FAA, and the Department of Defense (DOD). In these cases, the investigator must be responsible for not only identifying those events that require notification, but for also slowing the rapid pace of the airline operation to secure and preserve data for a potential investigation. This can often place the investigator in a challenging position within his or her organization, as others not versed in the regulations struggle to understand why an event requires notification.

Airline safety investigators are likely not working on one investigation at a time, nor are they working on merely one type of investigation at a time. A single investigator may be simultaneously conducting investigations of ramp collisions, inflight turbulence injuries, maintenance errors, runway incursions, near mid-air collisions, and a multitude of other event categories. He or she may be conducting the investigation with a team of subject-matter experts or perhaps as the sole member of the team. Among all these changes and challenges, the theme of the new investigation model is the same—flexibility. The investigators must adjust their techniques and tactics to each event to achieve the ultimate goal of prevention of reoccurrence.

A watchful eye

As much as the daily role of airline safety investigators has changed to fit the new model of investigations, investigators maintain one crucial role true to their roots—major accident investigator. So how does an investigator who has never responded to a major aircraft accident prepare for the very event he or she is seeking to prevent from occurring?

As our industry well knows, being well prepared for an accident will make the response and investigation much smoother. In addition to the training and the mentoring received, the investigator who has not responded to a major accident can ensure that he or she and the organization are prepared by being an effective emergency response manager. Just as new investigators at airlines may not have major accident investigation experience, they will likely find others in their organization who have not, but will be called upon as technical group members should an accident occur. Investigators must work with their organization to ensure that their emergency response plan is well-written, supported by all levels of management, and that trained and qualified individuals are ready and willing to assist should a major accident occur.

While the investigator may or may not be in charge of the emergency response plan, he or she should be its greatest champion. Participation in drills and procedural reviews and meeting with the team members on a regular basis are crucial to a successful response and investigation.

Conclusion

Airline operations are in the safest period in the history of commercial aviation. Airline safety programs have evolved from reactive processes to being driven by proactive, data-driven, risk-based approaches that lead to continuous reduction in overall operational risk.

The airline safety investigator has also had to evolve to match the dramatic changes in these safety programs. New skills and education are required, and new approaches must be developed to match the speed and flexibility of modern airline operations. No longer do airline leaders have patience to wait on safety improvements. Safety metrics are measured in the same context as the airline balance sheet and with the same vigor. Airline leaders are much more engaged in their safety programs and, thus, hold safety programs accountable for expected improvement. No longer is safety information hangar talk. It is the engine that drives SMS and the day-to-day work scope of the airline safety workforce.

Accident investigation is a skill that is still needed, but it is not the primary skill for today's safety investigator or manager. There must be a realization that this skill must be prepared for, trained, and practiced because when it happens, it is a shock to the airline system and will impact every aspect of a continuously running SMS. To ignore it is to place in peril the success of the airline's SMS. Blending old skills with new is an important aspect of an airline safety investigator's toolbox. Qualified safety personnel must be trained and developed for a program to be successful. Let's hope that the "new" safety investigator never has to practice the "old" skills. ◆

A New Investigator's Insight into Gaining a Profession

As a junior investigator, the author provides his perspectives regarding the development process for next-generation investigators from several aspects: recruiting, investigator's attributes, and on-the-job training to maintain competence. His aim is to illustrate the challenges from evolving trends of future investigations and how young investigators should position themselves to become qualified investigators for future occurrences.

By Brian C. Kuo, Ph.D., Aviation Safety Council, New Taipei City, Taiwan (Chinese Taipei)

(Adapted with permission from the author's paper entitled Preparing the Next Generation of Investigators—From a New Investigator's Perspective *presented at the ISASI 2013 seminar held in Vancouver, B.C., Canada, on Aug. 19–22, 2013, which carried the theme "Preparing the Next Generation of Investigators." The full presentation, including cited references to support the points made, can be found on the ISASI website at www.isasi.org under the tag "ISASI 2013 Technical Papers."—Editor)*

With advances in innovative technologies, travelers today are able to fly in more efficient, more reliable, and, most importantly, safer airplanes. Such success is accomplished by the progression in aircraft technologies themselves, and by improvement in air traffic management and airport infrastructure. As demand in commercial air transportation continues to grow, the aviation system makes global aviation safety more reliable, maintaining improvements recorded over the last decade.

However, aircraft incidents, and even accidents, still occur occasionally. To reveal the probable causes of an aircraft accident, it is the air safety investigators' responsibility to carefully examine all collectable evidence related to the occurrence before coming to a conclusion and citing safety recommendations. In a major accident investigation, which always draws attention from the public and news media, the image of investigators is viewed as highly professional, and their announcements are treated with respect. Such responsibilities make air safety investigators very influential; thus, the significance of training investigators to be qualified for unanticipated investigative tasks stands out.

The continuously lowering fatal accident rate in civil aviation in the modern world over past decades has to be partially credited to air safety investigators. Although they might work strenuously at a hazardous crash site over an intensive time frame, much of the success in aviation safety has been due to the knowledge or lessons learned from prior aircraft accident investigation conducted with the aim of ensuring that accidents in similar circumstances will never recur.

However, the improving record of global aviation safety implies that air safety investigators would receive less opportunity to make use of their specializations in a real investigative atmosphere. This is particularly true for young/junior investigators as they make their entry into this industry during the unprecedented era of low aviation occurrences in civil aviation. Consequently, on-the-job training and exercises to maintain their proficiencies become an important agenda for the new generation of investigators.

Junior investigators, furthermore, may realize that in the aviation industry the traditional or reactive investigative practice may have approached its limits. Proactive practices to identify safety hazards, assess risks, and put controls in place to prevent accidents from occurring have gradually evolved. While it seems more difficult to invest in preventing something that may never happen than to spend money after an accident to prevent it from happening again, it is necessary to remind next-generation investigators to adopt new techniques for future investigations—and to position themselves and their agencies sufficiently well so that the investigative skills and agency operational processes follow the global trends.

This article will present a brief introduction of investigator recruitment, followed by a description of the current guidelines for the international standard for air safety investigator training. Then the author will compare that standard to the training he received upon joining the Aviation Safety Council (ASC) three years ago. As a fairly junior investigator, the author will provide his perspectives regarding the development process for next-generation investigators on several aspects, from recruiting sources, investigator's attributes, and on-the-job training to maintain his competence. The aim is to illustrate the challenges posed by the evolving trends of future investigations and the significance of how young investigators should position themselves to become qualified investigators for future occurrences.

Investigator recruitment

While considerable practical experience in aviation is usually a prerequisite for prospective accident investigators to build upon their investigation skills, it is still possible for new graduates to be hired by an investigation agency as long as they possess the required background that fits into the specialized area to which the agency assigns the new investigator. In this case, graduate candidates with aerospace/aeronautical engineering or mechanical engineering majors could benefit, as they have a better understanding of aviation fundamentals; hence, they are able to quickly get on track to investigative duties if proper training in specialized areas is given.

Because being an aircraft accident investigator usually requires a long-term commitment, a new-hire graduate is more apt to devote him or herself to an investigator career over a long term if continuous on-the-job training is offered. Such a new investigator would become a valuable asset for the agency as he or she matures with investigation experience gradually obtained over time.

It has to be understood that even within the aviation industry, few people can find their niche as an air safety investigator directly. Therefore, an investigation agency, no matter if it is an independent authority or an accident investigation unit within a regulatory authority, recruits its new investigators with experience acquired from civil or military aviation as a pilot, aircraft maintenance specialist, or air traffic controller. Recruitment of these types of personnel will provide an immediate supply of investigative manpower after receiving agency orientation and basic training in aircraft accident investigation techniques. However, it has to be noted that for such new investigators there is a trade-off between the amount of previous aviation experience and the length of time he or she could serve as an investigator.

A good understanding of English, usually an intermediate level or even a negotiable level for more senior positions, is absolutely essential for an aircraft accident investigator who is not a native English speaker. As most aircraft manuals are written in English, it is necessary for investigators to be able to finish reading a manual within a reasonable time frame, and with good understanding of the content. Oral communication in English is sometimes necessary during an investigative meeting, while report writing in English will be required during an international investigation.

Training guidelines

In response to several state members' request for common standards for the training of investigators, ICAO developed training guidelines for aircraft accident investigators during its AIG meeting in 1999. The publication of Circular 298, "Training Guidelines for Aircraft Accident Investigators," outlines the experience and employment background required for training as an aircraft accident investigator, as well as appropriate training schedules in order to qualify a prospect investigator for various investigative roles. Circular 298 sets several training stages:

- **Phase 1:** Initial training
- **Phase 2:** On-the-job training
- **Phase 3:** Basic accident investigation courses
- **Phase 4:** Advanced accident investigation course and additional training

Phase 1 familiarizes a new investigator with the investigation legislation in his or her country, and with the standard operating procedures of the agency. Besides the legislation and rules, the initial training will cover a range of topics from international standards (i.e., ICAO Annex 13 and Document 9756), equipment, initial response, on-call procedures, the organization of an investigative team, and introducing investigators to their duties. Once the initialization training is completed, an investigation agency will provide on-the-job training to a new investigator according to the duties that match his or her qualifications.

This is when a new investigator becomes further familiarized with the investigative tasks, including collecting factual information, analyzing the factual information, determining the conclusion, and issuing safety recommendations (depending on the SOP of the individual agency). The new investigator also will gain experience in on-site investigation techniques. It is also believed that at least one senior investigator will be involve with the on-the-job training of a new investigator to expedite learning effectiveness.

Attending a basic aircraft accident investigation course within a new investigator's first year of service is recommended by ICAO in Circular 298. Such a course could be found at an investigation agency affiliated training center and at universities and industry partners (e.g., flight recorder manufacturers and aviation organizations). The curriculum will cover a wide range of investigative topics so that the new investigator can have a comprehensive understanding of each of the investigation aspects, which is especially important for one conducting a general aviation investigation as he or she might be the sole person dispatched to the scene. A more advanced investigation-related course can be taken as the investigator gains more experience.

At Phase 4, the investigator can select the topic of the course that best fits the person's interest and that would help him or her conduct investigative duties at the agency.

Author's training

A similar roadmap as the one described in Circular 298 for new investigators can be found at the Aviation Safety Council. As an example, the author, an aerospace engineering major, was recruited two-and-half-years ago by the ASC. Before

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being hired by the ASC, the author had accumulated about one year of work experience as a post-doctoral researcher on aviation emissions following his doctoral research. The initial training took about one month to complete. It covered a wide range of topics, including organization SOPs, domestic legislation, international standards, and the introduction of technical groups in an investigation —Flight Operations, Salvage, Flight Recorders, Human Factor, ATS, Airport Infrastructures, Aircraft Structures, etc. Since the author is a member of the investigation lab at ASC, specialization sessions on site survey with GPS tools (see Figure 1) and flight recorder readout and analysis were planned.

With the completion of the initialization training, the author was able to join the investigation teams for three aviation occurrences as one of the members of the Flight Recorder Group before attending the NTSB's training center basic aircraft accident investigation training. The completion of Phase 3 marked the ninth month of service since the author joined the ASC. Phase 4 took place in the second year as the author felt the need to learn all the features of the flight data analysis software that the ASC has used for years. Therefore, the company that developed the software arranged the training. In the near future, flight recorder manufacturer training on recorder operations and data analysis is under consideration.

The ASC also uses an assessment system for new investigators. A freshman begins his or her career at the ASC with an OJT status until he or she completes on-the-job training (Phase 2) for one investigation assignment in a technical group, and the basic aircraft investigation courses (phase 3), and is ready to be promoted to an investigator. After completing the assignment in three investigations, he or she becomes eligible to apply for group chairman qualification. The author recently received a promotion to recorder group chairman qualification and is in charge of the recorder group activity of one serious incident.

Attributes and capabilities

Neither a well-organized training program nor abundant industrial experience will guarantee qualified investigators. To become a competent aircraft accident investigator, certain personal attributes and capabilities are necessary in addition to good basic training and practical experience. Therefore, in developing a new air safety investigator, an investigation agency will never forget to look into the following:

- **Personal attributes—**Air safety accident investigators require impartiality and integrity in collecting factual information. With an unbiased mind, an investigator is able to earn the trust of all parties within the investigation team. On the other hand, any presumption or a default position can cause an investigator to lose the respect of his or her team and the public. It could be understood from the public's point of view that aircraft accident investigation is so extremely technically complicated that the public regards safety investigators as highly professional. This attitude enables an investigation agency to gradually build its reputation, as it relies on past investigation reports to educate the public about what has been done to prevent an accident of similar circumstances from recurring and which, as a result, has contributed to the lowering of the global accident rate in the past decade.

  Investigators also need to possess the ability to analyze collected factual information in a logical manner, and, with perseverance, to pursue the reason behind irregularities. As the investigation process of an aircraft accident can be tedious and intensive in time, investigators must not be afraid of making errors, as long as a clear investigative roadmap is drawn and he or she remains focused with resilience.
- **Technical writing and logical thinking—**The aviation occurrence report is the final product that summarizes the work done by investigators and is a tool of communication with the public that explains what happened in an aircraft accident and how the aviation industry will prevent it from happening again. For most of the investigation agencies around the world, investigators are not assisted by technical writers to polish their investigation reports. Thus it is significant that investigators not only conduct their investigation in a logical way, but also compose their reports in an organized and reasonable manner.

  At the ASC, the targeted readers of its aviation occurrence reports are the general public who are no younger than undergraduate freshmen; however, outstanding high school students should be able to understand the majority of a report's content. That being said, it is the investigators' responsibility to write reports with sufficient information, a fluent history of the flight, use of good logic, and a detailed but not an overwhelming analysis of the factual information.

  The investigation process, including report writing, can be viewed as being similar to conducing academic research. This approach believes that to accomplish the objectives of an investigation, which can be viewed as a research project, strategies to attack the problem and to help answer the questions that arose from the accident need to be well-planned. And the research efforts need to be periodically presented in writing as interim reports with final results presented as a full-length research paper, which corresponds to the aviation occurrence report. Like any good research paper, an accident investigation cannot be regarded as successful without a final report with noteworthy findings.

  There also exists a belief that while a person with considerable aviation experience might be a good candidate to become an air safety investigator, he or she might not have received enough academic training on technical writing on presenting a report. On the other hand, a new investigator recruited directly from academia with a suitable background can have good technical writing skills, but a lack of industrial experience

Figures 1: On-the-job training includes occurrence site survey using GPS tools.

Figures 2 and 3, above: ASC investigator recurrent training on underwater recorder search. Figures 4 and 5, below: ASC investigator annual high mountain training.

Investigators cannot rely simply on past techniques to perform investigations on modern and future occurrences. To conquer future challenges, a continuous learning attitude along with the support from the agency would definitely be the best way to further refine themselves to be qualified and competitive air safety investigators.

would be critical, thus limiting future development. To resolve the former problem, short courses or training in technical writing could be useful; and for the latter, continuous on-the-job training and learning, which is described below, is the absolute solution to maintaining the competence of new investigators.

- **Continuous learning**—People nowadays are living in a world filled with a wealth of information, a benefit from advances in technologies. Safety investigators, too, have greatly benefited in their professional field. For example, take flight recorders. When looking back 30 years, no one could have ever imagined that investigators in the 21st century would able to take advantage of flight data recorders that can record more than 3,000 parameters (and this will keep growing!). Modern aircraft accident investigators, therefore, must cope with such a wealth of data to maintain their competence; they can no longer rely on 20th century techniques to investigate 21st century accidents. All available tools need to be used. This is particularly true for the next generation of investigators; otherwise the drastic augmentation of data available would make them knowledge poor.

This highlights the significance of continuous learning for air safety investigators. This goal can be achieved by each individual and through the support of the safety agency. New investigators should regularly look into exploring new technologies—for instance GIS platforms and use of UAV in site surveying—as tools that assist their investigation work. It is also helpful if they periodically conduct literature surveys, such as accident investigation reports from other AIBs. Wide literature survey not limited to aviation could stimulate some ideas that may fit well into aviation safety. For example, in civil aviation the trend "from reactive to proactive" and the adoption of Safety Management Systems to the ICAO annex were partially inspired by the successful execution in the maritime mode.

From an agency's side, systematic offers of on-the-job training for investigators would be appreciated if the investigators have their own clear roadmap to develop in accordance with their professional interests and assignments by the agency (see Figures 2, 3, 4, and 5). In addition, an agency can encourage their investigators to conduct safety studies/research on topics of the agency's concerns. A safety study, dissimilar to an investigation analysis, contains broader coverage of information and data and could produce systematic findings and trends.

At the ASC, improving runway safety has been on its priority list for many years. Accordingly, a runway excursion workgroup was established and run until recently. Through continuous literature survey and use of data from actual aviation occurrences in Taiwan, the ASC investigators enriched their knowledge in factors that contributed to runway excursion events, and results were generously shared with domestic carriers during the annual safety symposiums.

The core values, in the author's opinion, that an accident investigation bureau should put at the top of its priority list when recruiting air safety investigators are personal attributes, the ability to write technical reports and think logically, and last but not least the willingness to continuously learn.

Appropriate personal attributes and the ability of presenting (i.e., writing) investigation reports in a logical manner are definitely the basics for air safety investigators when performing their duties. In addition, a continuous learning attitude from the next generation of investigators enables them to exploit available tools to deal with the growing information and booming amount of data that comes with advancing technologies and to expand the knowledge database beyond what they already possess.

Again, investigators cannot rely simply on past techniques to perform investigations on modern and future occurrences. To conquer future challenges, a continuous learning attitude along with the support from the agency would definitely be the best way to further refine themselves to be qualified and competitive air safety investigators. ◆

Investigating A Lithium-Ion Battery Fire

In January 2013, the U.S. NTSB undertook an incident investigation of a fire in an auxiliary power unit lithium-ion battery. The authors offer insight into that investigation and discuss details of the materials laboratory examinations, including the methods and equipment used. Also discussed are the specific challenges of investigating "new and novel" technology, such as the formation of multidisciplinary and internationally diverse teams of experts and facilities and the use of unconventional testing techniques.

By Joseph M. Kolly, Director, Office of Research and Engineering; Joseph Panagiotou, Fire and Explosion Investigator in the Materials Laboratory Division; and Barbara A. Czech, Associate Director, Program Management (All are with the U.S. National Transportation Safety Board.)

(Adapted with permission from the authors' paper entitled The Investigation of a Lithium-Ion Battery Fire Onboard a Boeing 787 by the U.S. National Transportation Safety Board *presented at the ISASI 2013 seminar held in Vancouver, B.C., Canada, on Aug. 19–22, 2013. The theme of the seminar was "Preparing the Next Generation of Investigators." The full presentation, including cited references to support the points made, can be found on the ISASI website at www.isasi.org under the tag "ISASI 2013 Technical Papers."—Editor)*

Lithium-ion (Li-ion) battery technology is rapidly becoming a preferred choice for battery power across all segments of society. This relatively new technology offers significant improvements in energy and power density over conventional battery technologies, such as lead acid, nickel cadmium (NiCd), and nickel metal hydride (NiMH). In transportation vehicle applications, Li-ion batteries deliver more energy and power with less weight and maintenance than conventional batteries, making them a desirable choice of manufacturers.

The Boeing 787 Dreamliner uses several types of Li-ion batteries to power different systems on board the aircraft. The largest type of these batteries is used in two systems on board the aircraft. One provides power to start the Dreamliner's auxiliary power unit (APU) and another (the main battery) provides power to selected electrical/electronic equipment during ground and flight operations. To date, the Dreamliner has experienced two failures of this type of battery in two separate incidents.

Here we describe the NTSB's laboratory examination procedures used to analyze the fire-damaged Li-ion battery from the Logan International Airport incident. The objectives of the examinations were to (1) Document the condition of, and damage to, the battery; (2) Determine the origin of the failure; and (3) Determine the cause of the failure.

Incident summary

On Jan. 7, 2013, about 10:21 Eastern Standard Time, cleaning personnel discovered smoke in the aft cabin of a Japan Airlines (JAL) Boeing 787-8, JA829J airplane, which was parked at a gate at Logan International Airport. About the same time, a maintenance manager in the cockpit observed that the APU—the sole source of airplane power at the time—had automatically shut down. Shortly afterward, a mechanic opened the aft electronic equipment (E/E) bay and found heavy smoke and fire coming from the front of the APU battery case. No passengers or crewmembers were aboard the airplane at the time, and none of the maintenance or cleaning personnel aboard were injured.

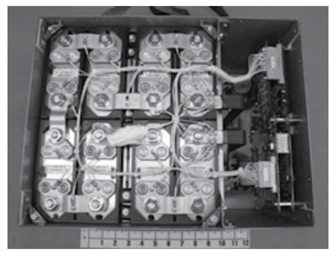

Figure 1: Exemplar for the 787 main and APU batteries.

Aircraft rescue and firefighting personnel responded, and one firefighter received minor injuries. The airplane had arrived from Narita International Airport, Narita, Japan, as a regularly scheduled passenger flight operated as JAL Flight 008 and conducted under the provisions of 14 Code of Federal Regulations Part 129.

Nine days later, on Jan. 16, 2013, a "serious incident" involving the main battery occurred aboard a B-787 operated by All Nippon Airways during a flight from Yamaguchi to Tokyo, Japan. The airplane made an emergency landing in Takamatsu, Japan, shortly after takeoff. The Japanese Transportation Safety Board (JTSB) is investigating this incident with support from the NTSB. The main

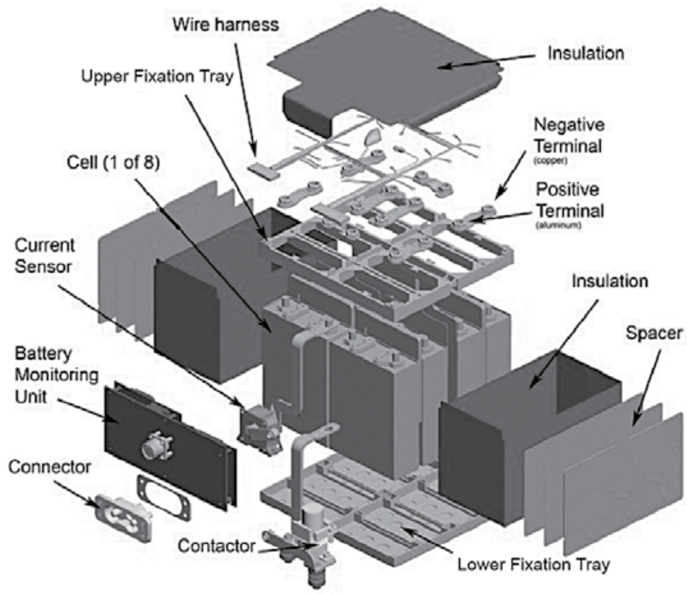

Figure 2: Components of the main or APU battery.

Table 1: Battery and Cell Specifications

Specification	Battery	Cell
Nominal capacity (ampere-hour)	75	75
Nominal voltage (volts)	29.6	3.7
Operational voltage range (volts)	20 to 32.2	2.5 to 4.025
Weight (pounds)	61.8	6
Dimensions (inches)		
Width	10.9	5.2
Depth	14.2	2.0
Height	8.5	7.7

Note: Battery specification information was based on information from a Thales Avionics Electrical Systems document. Cell specification information was provided by GS Yuasa.

battery and APU battery on the Boeing 787 are of the same make and model. Therefore, both the NTSB and JTSB investigations have continuously shared investigative information and techniques.

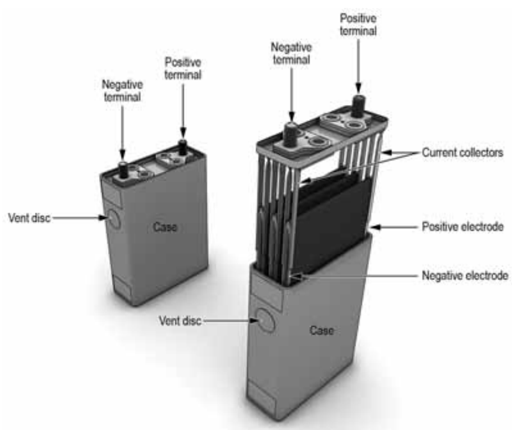

Figure 3: Cell design with three internal electrode winding assemblies.

Battery design

Both the main and APU batteries consist of eight Li-ion cells that are connected in series and assembled in two rows of four cells (see Figure 1). Table 1 shows the specifications for the APU battery and cells. The insulation sheets provide electrical insulation and physical separation between each cell and between the cells and the aluminum battery case, which is electrically grounded. Upper and lower fixation trays secure the position and orientation of the cells in the battery case.

In addition to the eight individual battery cells, the battery case contains two circuit boards that comprise the battery monitoring unit (BMU); a Hall effect current sensor for current monitoring; a contactor; bus bars for the main current pathways between the cells and to the J3 connector, which leads outside the battery case; and sense wires leading to the BMU. By and large, these components are noncombustible, with the exceptions of the polymeric insulation and spacer materials. Figure 2 shows the battery components.

Battery cell design

Each cell has three internal electrode winding assemblies, as shown in Figure 3. Each winding assembly is about 33 feet long and is configured as a multilayer continuous sheet of an electrode, followed by a separator, followed by another electrode, and then another separator. These windings are welded to current collectors, which then are affixed to the cell's electric terminals.

The electrochemistry is similar to that of other cobalt oxide Li-ion batteries. One electrode (the anode) is a copper foil coated in carbon; the other electrode (the cathode) is an aluminum foil coated in a lithium cobalt compound. The electrolyte is composed of lithium salt in an organic solvent. This cell has primarily nonflammable components, but the electrolyte is flammable.

Examination methods and procedures

The fire-damaged APU battery was removed from the aircraft by firefighters on scene. It was subsequently shipped to the NTSB materials laboratory in Washington, D.C., for examination. An investigative group was formed consisting of NTSB materials laboratory staff, supported by technical expertise from the parties to the investigation. In this instance, additional expertise was sought to augment the examination and analysis procedures. Technical consultants from other federal agencies and private laboratories with specific experience in Li-ion technology research and failure analysis were added to the investigative group.

Many of destructive and nondestructive examination methods were employed at the NTSB's laboratories and other laboratory and testing facilities. These examinations included optical and scanning electron microscope (SEM) analysis with energy dispersive spectroscopy (EDS), radiographic analysis (digital radiographs and computed tomography [CT] scans), and microhardess testing.

Initial examination of battery assembly

Initial visual examination indicated thermal and mechanical damage, including localized hot spots, on the external surface of the battery case. SEM/EDS analysis was conducted on these hot spots and determined they originated in the inside of the battery case, therefore ruling out external sources such as electrical short circuiting and mechanical damage as an initiating event. The aluminum top (lid) of the case was bulged upward, exposing the internal components. The top was removed to reveal

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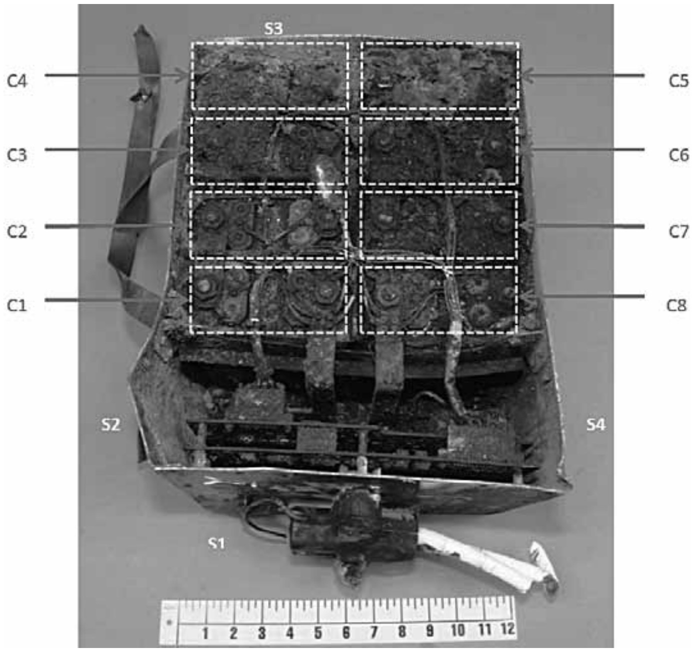


Figure 4: Opened battery case showing approximate cell locations.

the upper surface of the battery assembly, which exhibited severe thermal damage to the entirety of its internal components. Voltage measurements taken of each cell indicated the battery was completely discharged, and electrical continuity measurements indicated that all cells except for cell 8 had shorted "closed."

The thermal damage to the battery components, such as charring of materials and distortions of the cells, indicated areas of higher interest and probability of identifying an origin of the thermal event. However, the level of damage obscured clear distinction of the components and prevented immediate disassembly of the battery. A more deliberate disassembly process was necessary to avoid destroying any potential evidence that might indicate the root cause of the failure. Figure 4 shows the condition of the battery as received in the laboratory (with the top of the case removed).

Disassembly of the damaged battery was guided by the use of radiographic imaging of the intact assembly. This imaging method rendered a nondestructive view of the entire volume of the battery assembly. Once analyzed, the fire-damaged battery components could be carefully extracted from the case, with the prior knowledge of the internal structure that helped to identify and avoid destruction of any possible mechanical deformation or foreign debris that might be present.

Radiographic imaging of the damaged APU battery (and for comparison purposes of the undamaged main battery) was conducted at Chesapeake Testing in Belcamp, Maryland, under NTSB supervision. The batteries were documented using X-ray, CT scans, and digital radiography.

Because of the physical size of the battery, the imaging equipment must have sufficient energy to penetrate the battery, and sufficient volumetric and weight capacity to support and rotate the battery for imaging. In this instance, a Nikon Metrology 450 kV Microfocus scanner was used. The X-ray source in this equipment has an X-ray focal spot size of 80 μm.

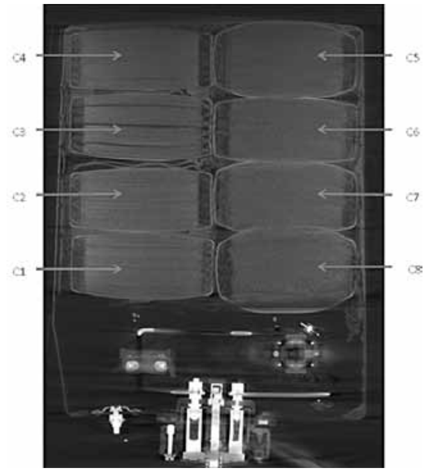


Figure 5: Radiographic image of JAL APU battery indicating cell locations.

To produce digital radiograph images, the battery was subjected to a process similar to a conventional X-ray. As such, the images contain elements throughout their volume superimposed on each other. The whole battery was imaged at least twice, and the separate images were obtained at positions rotated by up to 90 degrees.

For the CT scans, the battery was loaded into the imaging unit and placed on a turntable. The battery was then rotated in front of the X-ray source, and the X-rays were captured by a detector after they went through the battery. The X-ray source produced a cone of X-rays, and the portion of the battery imaged was adjusted slightly after each scan volume was completed until the entire assembly (or region of interest of the assembly) was scanned.

The scan volume created in the scanning process was approximately 1,600 pixels by 1,700 pixels by 2,000 pixels in volume for a whole battery scan and had resulting file sizes ranging between 5.8 gigabytes and 24 gigabytes.

Each CT volume was evaluated using the VGStudio Max software package. Post-processing using this software permits viewing individual two-dimensional planes or "slices" cut across the image in detail or can be used to create a three-dimensional reconstructed image of the component. During the CT scan evaluation, some sections of the components were digitally removed to allow closer observation of interior parts. This procedure was beneficial when searching the images for signs of foreign materials within the battery case, external to the cells.

The results of the radiographic imaging work indicated that although several of the battery cells had permanently deformed (bulged), they remained mostly intact. In the radiographic image (see Figure 5), one can clearly see the bulging of the cells and the electrode windings that remained within each cell. Also evident was both cell-to-cell and cell-to-battery-case contact. The imaging revealed an absence of foreign materials within the battery and external to the cells.

Following a complete review of the radiographic images, the battery was prepared for disassembly at the NTSB materials laboratory. The radiographic images provided critical benefits to this procedure. Investigators could view the internal vol-

Figure 6: View of battery with battery case panel pulled back to reveal cells 5 through 8.

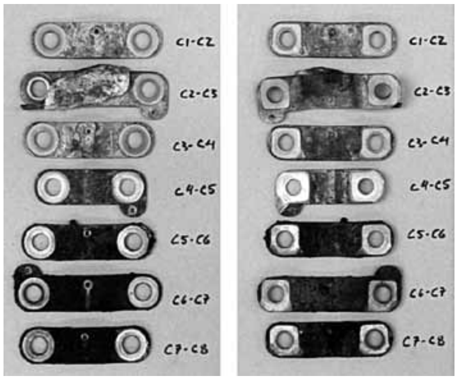


Figure 7: Views of bus bar contact surfaces. The photo on the left shows the contact surfaces facing the washer and the nut. The photo on the right shows the contact surfaces facing the battery terminal.

ume of the battery to aid in disassembly and reduce damage during disassembly. They could also document the precise orientation of components that would be lost upon disassembly.

From this image (see Figure 5), it is apparent that the cells on the right side of the figure (cells 5–8) experienced greater mechanical damage, in the form of bulging, than those on the left side. This pattern also corresponded to more severe thermal damage to the polymeric materials on the right side of the battery.

Disassembly began by removing the rivets along the seams of the aluminum battery case and folding down the sides (see Figure 6.) Figure 6 shows the side of the battery that experienced the greatest thermal and mechanical damage. When the sides of the cells were exposed, it was apparent that cells 5–8 had relieved pressure through their vent discs. Cells 1–3 also vented but with less deformation of their vent discs.

Bus bar examinations

Next, the bus bars and wiring harness were removed, and then each of the eight cells was removed. Each bus bar was removed from each cell and examined. Photographs of both sides of the bus bars connecting the batteries are shown in Figure 7.

For each bolted connection, the condition of the faying contact surfaces was visually evaluated using a 5X to 50X zoom stereo microscope. No dark oxides or interference colors associated with high-temperature resistive heating were observed on the surfaces of the bus bars.

Metallurgical cross-sections of some of the bus bars were prepared to facilitate microhardness testing and microstructural evaluation. Figure 8 shows the section of the bus bar connecting cells 4 and 5.

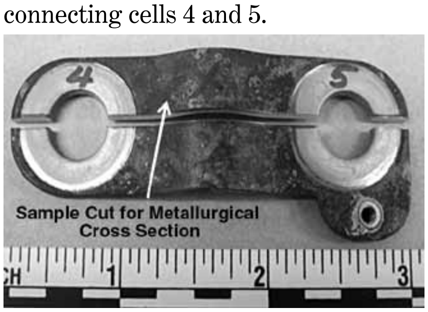
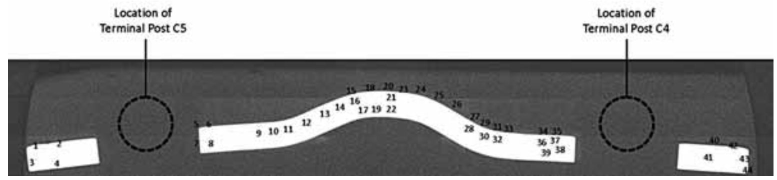


Figure 8: Section cut through the bus bar connecting cells 4 and 5.

The cross-sections were mounted and polished, and their microhardness was tested in accordance with ASTM E384-11e1. The locations of the microhardness indentations are displayed in Figure 9. The mounted samples were then microetched in accordance with ASTM E407-07e1. No microstructural changes, such as grain growth or hardness changes associated with localized heating, were observed.



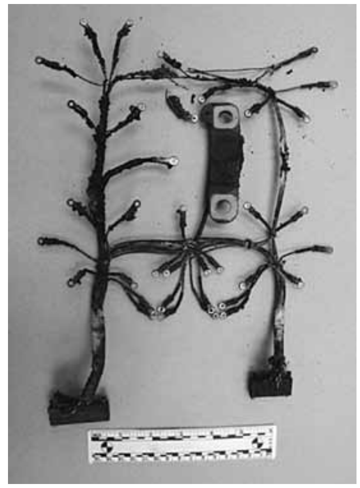


Figure 9 (above): Microhardness indentation locations of C4–C5 bus bar. Figure 10 (left): Wiring harness, as removed. (View is from the bottom.)

Wiring harness examinations

When enough of the charred debris had been removed from the top portion of the battery to permit evaluation, the physical condition of the BMU's cell voltage-sensing wiring harness was evaluated (see Figure 10.)

The overall appearance of the wiring harness was consistent with exposure to a high-temperature environment with areas of varying severity. The insulation on the wires was mostly intact, but it exhibited varying degrees of thermal discoloration and staining from the expelled battery cell contents (carbonaceous, electrolyte, and cathode material). Evaluation of the thermal damage to the wiring harness suggested an area of higher temperatures or an area of longer exposure to elevated temperatures during the event. This also corresponded to areas of higher thermal damage to items such as the upper and lower fixation trays. The concentrated thermal damage suggested an area of higher interest for establishing an origin. The harness was also X-rayed, and the radiographic images revealed no indications of discontinuity in the copper conductor wire.

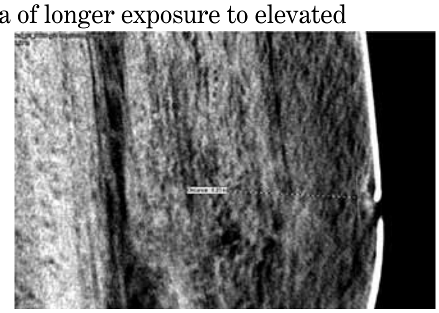


Figure 11: CT scan of cell 5 showing breach in case.

Detailed cell level examinations

Following the disassembly of the battery, each cell was subjected to additional radiographic imaging. The resulting CT scans had a scan volume of approximately 1,300 pixels by 650 pixels by 1,850 pixels for each battery cell. As an example of the detail that can be obtained, the CT scan shown in Figure 11 clearly shows a breach in the case of cell 5 less than 0.10 inch long.

Prior to the extraction of the electrode windings from the cells, these scans were examined for any signs of damage, contamination, or other anomalies. Once these scans were reviewed, they were used to guide the disassembly process of the electrode windings from the cell case.

The disassembly procedure used a Dremel® abrasive disc

Figure 12: Cell 6 electrode unwound on table.

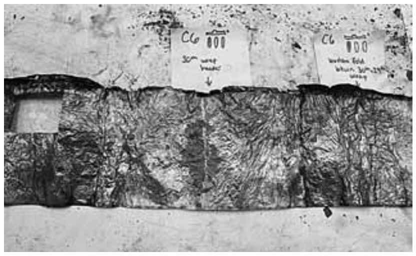


Figure 13: Cell 6 electrode with anomalous areas of interest.

cutoff tool to circumnavigate the top of each cell case, at the location of its weld seam. Cuts were also made down the longitudinal sides of one of the cell's faces to excise a panel of the cell case. This then allowed the header and windings to be removed from the remainder of the cell case. The current collectors attaching the windings to the cell header and terminals were then cut to liberate the individual electrode windings. Each of the three electrode windings was then carefully unwound on an examination table. Figure 12 shows one 33-foot-long length of the thermally damaged electrode from cell 6, unrolled on an examination table for visual inspection.

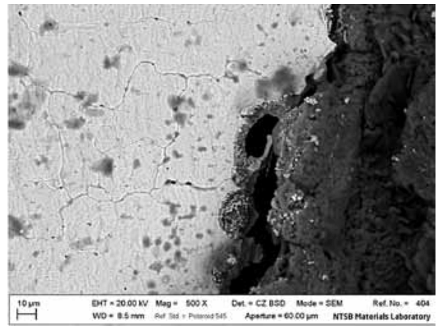
The entire surface of both sides of each electrode was then examined by the unaided eye and digitally photographed. Any anomalous areas of interest were carefully sectioned and examined further with digital microscope and SEM. Areas of special interest included those showing unique thermal damage, such as burn-through spots and regions of discoloration. Figure 13 shows such anomalous areas on the electrode from cell 6. They are characterized by localized hot spots identified by purple hues in the copper foil. Additionally, these hot spots exhibit radiating patterns and repeat in the same relative position along the wraps of the winding. Small holes along the top edge of the copper foil indicate short circuiting between the electrodes of the winding.

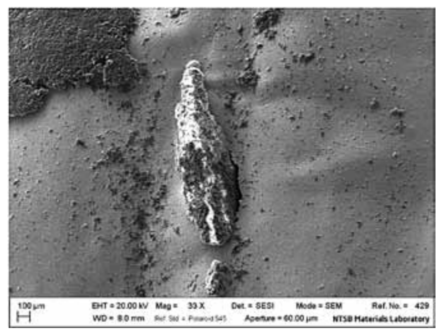
In these areas, SEM imaging was performed at magnifications of 100–1,000X, and EDS was employed on anomalous features to examine their elemental constituents. The SEM/EDS examinations were conducted to identify any evidence of dendritic growth of lithium, copper plating, or foreign materials. These features are known to cause field failures of Li-ion batteries and therefore are of high interest to the investigation. Examples of SEM images in the areas contained in the previous photograph are shown in Figures 14–16. SEM/EDS proved very capable of characterizing these anomalies but can be extremely time consuming. This is largely due to the limited field of view afforded by the SEM. This resulted in several hours of SEM analysis per anomalous region of interest.

Initial findings

The results of the examinations at the NTSB materials laboratory, with the results from radiographic examinations, enabled the NTSB to make public release of an initial set of findings earlier this year. The examinations revealed multiple cell failures within the battery, as evidenced, in part, by mechanical deformation and bursting of the vent discs. This condition led the experts to conclude that the battery experienced a thermal runaway in which the failure of one battery cell cascaded to other neighboring cells within the battery assembly. The initial failure was determined to be an internal short circuit in cell 6. This finding was supported, in part, by observations that cell 6 was located in the area of greatest thermal and mechanical damage. Additionally, clear evidence of internal short circuits was found within the electrode windings of cell 6.

Work continues to determine the cause of the internal short circuit. As of this writing, mechanical damage and external electrical short circuits of the battery have been ruled out as factors in the battery failure. The NTSB is still considering manufacturing and design issues, as well as issues associated with the battery charging system.





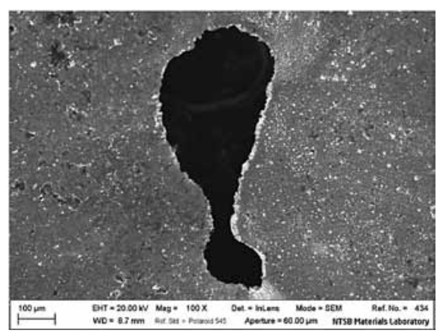


Figure 14 (top): Grain boundary decohesion near a foil hole, cell 6. Figure 15 (middle): Aluminum lump projecting through the bottom of a copper foil wrap, cell 6. Figure 16 (bottom): Hole in the bottom of the copper foil adjacent to the aluminum protrusion in Figure 15, cell 6.

Conclusions

The in-service failure of the Li-ion APU battery on board the Boeing B-787 Dreamliner required a unique mix of technical expertise and analytic techniques to document the damage and condition of the battery, and determine the cause and origin of the failure. Investigators from the NTSB materials laboratory were supported by experts from the parties to the investigation, and by additional expertise from other federal agencies and private consultants.

A combination of destructive and nondestructive analytic techniques was used to disassemble the battery into its components and examine each individually. Radiographic imaging successfully guided the disassembly and eliminated unnecessary destruction of evidence. Visual and microscopic examinations aided the radiographic imaging by identifying overall damage patterns and localized damage, which supported, in part, the finding of a thermal runaway condition that began with an internal short circuit in cell 6. Other methods (including microhardness testing and EDS) helped to rule out external short circuits and mechanical damage as factors in cause of the battery failure. ◆

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What Will Be in the Rearview Mirror of Next-Generation Investigators?

(continued from page 5)

need to do this because it matters, because it will make a difference. We need to have our own lab with the best tools. We need to look in-depth at human and organizational factors. And we need to keep the families and the public apprised of our investigations."

Investigators faced resistance. But it's investigators like you who held their ground—who helped to make the case for change. Because of the work you have done, we know accident rates are coming down.

But to make sure we continue to see progress in key areas, more change is needed in all of our countries. And the way I see it, you investigators need to be the catalyst for that change.

I like to say the reason we hired you is because you are people who question. And hopefully you don't use the status quo as a crutch.

Because a few decades from now, somebody else will be standing at a podium just like this reporting on the developments in their time frame—in *their* rearview mirror. And you will want to be in it.

What part are you going to play over the next 20 years? What do you see when you peer into the future? What are you going to help change in the span of your career? What innovations of yours will they be talking about tomorrow?

Will you be going beyond the standard 72-hour sleep/rest check to look at quality of sleep, time of day, and whether circadian rhythms were involved? Will you be pushing to find out about acute fatigue and chronic sleep debt? Will you make it the "new normal" to understand how the organizations we investigate are managing fatigue?

Investigators play a big role in how we communicate because you are often the trusted public face of an organization. You are on the ground at the accident site and there along the way as the public is updated. And when it comes time to make the findings public, you are there, too, telling the story and calling for change.

How will this role evolve? Will you help get those safety messages out on the street just a little quicker so they can prevent the next accident?

Or will you find new ways to communicate to make the safety message that much stronger? Will you push the means of sharpening your own skills and encourage your organization to expand its expertise by hiring the brightest of the brightest?

Maybe—just maybe—you will find new ways to move beyond one investigation at a time or even beyond the work of one accident investigation board to global trends driven by global data. Who knows?

Or in the vein of "think big or go home," will you take an idea and turn it around 180 degrees for a whole new perspective on how we investigate?

Whether incremental or game-changing, I don't know what these changes will be. That is for you to say. That is your history to write. ◆

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Who's Who

Dassault Aviation: A Key Player in the Aerospace Industry

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

Dassault Aviation is a key player in the aerospace industry, both in Europe and internationally. It is the last aviation group still owned by its founding family; and it is the only company in the world to design, manufacture, and support both combat (Rafale, nEUROn, Mirage) and business jet aircraft (Falcon).

A designer of complex airborne systems, Dassault Aviation can draw from almost a century of experience and ambitious lines of development. As an industrial driving force and a catalyst for the keenest of strategic technologies, the Dassault group led the industrial and technical revolution of the digital enterprise.

As a pivotal component of a high value-added industry, Dassault Aviation contributes to the development of a wide range of companies, laboratories, and educational establishments. Thanks to its skilled and experienced teams, Dassault is able to develop a degree of know-how and craftsmanship that is unique in Europe. This expertise is shared with many French and international partners.

Flight safety within Dassault Aviation

In 1987 Serge Dassault created the Flight Safety Division of Dassault Aviation. However, safety has been the group's motto long before this date.

Our team recognizes the need to constantly improve the safety of our aircraft (Falcon and military) from the conception and production phases to the operation of the aircraft itself. This leads to constant and very productive discussions among all key players of the group. From the test pilot and skilled workers to the design office, customer service, and other departments, all are involved in increasing safety. Our concerns for safety translate strongly into the way we help pilots operate our aircraft.

For instance, starting in 2003, we introduced the Enhanced Avionics System (EASy Flight Deck) on Falcon aircraft. This innovative avionics suite permits tasks to be performed "heads up" seamlessly. Icons and menus can be selected, or made to appear, as needed and controlled with the ease of a point and click trackball. This layout dramatically improves crew coordination and situational awareness and aims to complete a Falcon "family" cockpit. The Falcon 7X also benefitted from the military side of research with the introduction of the digital flight control system.

Additionally, Dassault Aviation is involved in several flight safety organizations, such as the Flight Safety Foundation (a member since 1993) and the International Society of Air Safety Investigators (as a corporate member). ◆