

ISASI FORUM

“Air Safety Through Investigation”

JANUARY–MARCH 2013

THE FINAL WORD:

AIR FRANCE FLIGHT 447

Special section begins on page 5



**History of the Air France Flight 447
Accident Investigation, page 6**

**Air France Flight 447 Human
Factors Issues, page 9**

**Air France Flight 447 Flight
Recorders Issues, page 11**

**Air France Flight 447 Victims'
Families, News Media Issues, and
Innovations, page 14**

Russia's Interstate Aviation Committee

Page 16

Unmanned Aircraft System Accidents: Learning to Predict the Unpredictable

Page 18

Being Predictive in a Reactive World

Page 23

CONTENTS

FEATURES

5 The Final Word: Air France Flight 447

6 History of the Air France Flight 447 Accident Investigation

By Jean-Paul Troadec, Director, BEA, France—*Adapted from remarks presented by Director Troadec in his keynote address to the delegates of the ISASI 2012 on Aug.30, 2012, in Baltimore, Maryland, USA.*

9 Air France Flight 447 Human Factors Issues

By Sébastien David, Senior Safety Investigator, BEA, France, Head of the Air France Flight 447 Human Factors Working Group—*The aim of the HF group was to determine the set of safety provisions that affected the expected behaviors and skills of the crews in this situation.*

11 Air France Flight 447 Flight Recorders Issues

By Léopold Sartorius, Senior Safety Investigator, BEA, France; Head of the Air France Flight 447 Avionics Systems Working Group—*The author reports on the flight recorders readout operations of the Air France Flight 447 investigation.*

14 Air France Flight 447 Victims' Families, News Media Issues, and Innovations

By Martine Del Bono, Head of Public Affairs, BEA, France—*The BEA made it a priority to provide information to the victims' families.*

16 Russia's Interstate Aviation Committee

By Sergey V. Zayko, Vice Chairman, Interstate Aviation Committee, Russia—*A description of the Russian Interstate Aviation Committee makeup and operation.*

18 Unmanned Aircraft System Accidents: Learning to Predict the Unpredictable

By Thomas A. Farrier (MO3763) Chair, ISASI Unmanned Aircraft Systems Working Group—*The author discusses how to make informed judgments regarding the most critical UAS-related hazards requiring both investigation and mitigation.*

23 Being Predictive in a Reactive World

By Jim Burin (MO4448), Director of Technical Programs, Flight Safety Foundation—*The author asks that "given our current 'predictive' capabilities and, even more, given the reactive world we work in—particularly the safety world—is being predictive a realistic goal?"*

DEPARTMENTS

- | | |
|--------------------|---------------------------------------|
| 2 Contents | 31 ISASI Information |
| 3 President's View | 32 Who's Who—A brief corporate member |
| 4 Guest Commentary | profile of United Airlines |
| 25 ISASI RoundUp | |

ABOUT THE COVER

Members of the Brazilian Navy recover an A330-203 "fin" of Air France Flight 447 that crashed into the Atlantic on June 1, 2009, during its flight from Rio de Janeiro to Paris in which 228 persons of 32 nationalities perished. The three-year investigation was marked by the high level of international casualties, missing evidence, and substantial news media coverage. The BEA released its final report on July 5, 2012. (Photo courtesy the BEA)



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Publisher Frank Del Gandio
Editorial Advisor Richard B. Stone
Editor Esperison Martinez
Design Editor William A. Ford
Associate Editor Susan Fager

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A Need to Prepare for Two Different Worlds and Challenges

By Frank Del Gandio, ISASI President

With the start of a new year, ISASI always reviews the record of the outgoing year. A review of 2012, and the two



preceding years, may tell us something that relates to next year's annual ISASI seminar in Vancouver, B.C., Canada—the theme of which is “Preparing the Next Generation of Investigators.” The central message might be that aviation accident investigators and other safety professionals must be prepared for two very different worlds.

First, prepare yourself for a tired old line: worldwide, last year was the safest year in aviation history. This may be a line you have heard before; but it was true in 2012, and it was true by a wide margin. In fact, this statement has almost always been true. If you are old enough to have heard the line in 1955, it was a true statement then. It was also a true statement in 1960, and it was true again in 1970, 1980, and so forth. The system gets safer and safer with each passing decade, but the record in 2012 may be hard to duplicate, at least for a year or two.

Even with a generous definition of what constitutes an “airline,” by my count we had just 17 hull losses worldwide in 2012, including nonfatal accidents and cargo as well as passenger accidents. If we eliminate smaller turboprops that operate scheduled passenger service with 15 to 19 seats, we had 13 hull losses, just three of which involved Western-built jets. These numbers are well below 2011, when we had a total of 28 hull losses. Yet 2011—you guessed it—was the safest year ever at the time.

The recent record is especially impressive in the largest aviation markets. The EU and European Free Trade Association, the U.S., China, and Canada are the four largest markets. Add Singapore and the Organization for Economic Cooperation and Development countries of the western Pacific (Japan, Korea, Australia, and New Zealand), and we account for 77 percent of all aircraft departures. In 2012, that group had a grand total of one airline fatality, which occurred on a 17-seat turboprop, and no fatalities in jets or large turboprops. In 2011, the same countries had a total of just 14 fatalities: two on a cargo flight and 12 on a passenger flight. In 2010, these countries had a total of three fatal accidents and 52 fatalities, 42 of which occurred in one RJ accident.

In short, over the past three years, most of the world's aviation system had a total of just eight hull losses, six of which were fatal, and 67 fatalities. Though a single major accident could exceed the three-year total of fatalities, the performance of most of the world over the past three years has been remarkable.

This is the record in one aviation world. What about the

other world of aviation, the one that accounts for just 23 percent of airline activity? The short answer is not so good. Counting the smaller turboprops in scheduled passenger service, the world had 17 hull losses in 2012 and another 63 in the preceding two years, for a three-year total of 80 hull losses, with eight fatal hull losses and 1,771 fatalities.

The “other” 23 percent of the world's system accounted for 72 of the 80 hull losses (90 percent), 74 of the fatal hull losses (92.5 percent), and 1,704 fatalities (96 percent). Do the math.

Over the past three years, most of the world's aviation system had a total of just eight hull losses, six of which were fatal, and 67 fatalities. Though a single major accident could exceed the three-year total of fatalities, the performance of most of the world over the past three years has been remarkable.

You will find that this latter group of countries has a hull loss rate that is 30 times higher than the 77 percent group, a fatal hull loss rate that is 41 times higher, and a fatality rate that is a stunning 85 times higher.

Several countries merit special mention, but few are more noteworthy than Russia. Over the past three years, Russia has accounted for 11 hull losses, singlehandedly and rather comfortably surpassing the entire 77 percent group. Four other countries also deserve special mention: the Congo with five hull losses, Nepal with four hull losses, Indonesia with four hull losses, and Pakistan with three hull losses and 300 fatalities. Combined, these five countries account for just more than five percent of the world's operation, but 34 percent of hull losses and 40 percent of all fatalities. Elsewhere, several countries with next to zero airline activity have even higher accident rates than the Congo, Nepal, Indonesia, and Pakistan, though absolute numbers are small.

All this suggests that we need to prepare the next generation of investigators, other safety professionals, and investigative and regulatory authorities for very different challenges. Most of the aviation world (the 77 percent world) will be focused on mountains of operational data in order to manage remaining risk and to squeeze still more safety from the system. However, the second world of aviation still must address some issues that are a bit less subtle. The next generation(s) of investigators may find each other's world to be rather foreign. ♦

The Basics of Safety

By Steve Hull, Aviation Director for RTI London

(Adapted with permission from corporate member RTI Group LLC's RTI ViewPoint, Winter 2012–2013 issue.—Editor)

During my 41-year aviation career spanning aircraft engineering, flying, safety, and accident investigation, it could be assumed that I would have seen many changes in aviation—but in actual fact there have been remarkably few. I joined, as it was then, British European Airways in September 1970, the same year that the Boeing 747 took to the sky. Affectionately known as the Jumbo Jet, it held the passenger capacity record for 37 years until it was surpassed by the Airbus A380 a few years ago. In 1969 Concorde had made its first test flight, and in 1973 supersonic passenger travel became a reality.



So what changes have there been? The Concorde is a distant memory, and supersonic passenger travel has become a dream that once again appears to be years away. The world has realized the effects of carbon emissions, and the push is to try to produce aircraft that fly “on thin air instead of in thin air.” Airline passenger travel is more available to the majority as opposed to the minority, and, most importantly, aviation safety is reported to be every airlines’ No. 1 priority.

To concentrate on today and, in particular, aviation safety—what progress has been made? The major focus of most airlines is on data collection and information exchange. Therefore, there are probably millions of pieces of data that describe past events. For some airlines, the data help to understand the state of the operation, but, as has been quoted before, “data [are] important and will help, but data-driven safety only helps to fix what already went wrong.” Data have never prevented an accident. The collection of data is reactive, and it is proactive safety management that is preferred.

As a safety professional being proactive in safety management, you attempt to identify and reduce the latent conditions—and then equally you will reduce the incidents, serious incidents, and ultimately the accidents. This is a great theory, but in practice there is reluctance for airlines and nonairline organizations to take steps to identify and then remove the latent conditions. Airlines’ response is usually based on the outcome of an incident, as there is no doubt that the smoking hole will be met with an immediate and impressive response, as history shows us. A near miss will never get the same company reaction as an accident, although the process leading to both events may have or will have been identical.

As safety professionals, it then becomes our duty to constantly press for the latent conditions firstly to be recognized and then acted upon. If latent conditions are not recognized, then incidents must be highlighted. The danger, of course,

occurs if it is only the serious incidents that are reacted to. It takes a very mature and enlightened company to put resources into searching out and remedying latent conditions, as this is the area in which the most value will be obtained. Airline safety is primarily identifying areas of concern and then mitigating them. It cannot be based solely on “gut feel.”

Airlines have short memories when it comes to accidents. This is mainly due to our own success story. Aircraft are safer, pilots and engineers are better trained, and ATC is more sophisticated. The fortunate result is that we do not have accidents often enough to become proficient in accident re-

Safety is the identification, analysis, management, and elimination and/or mitigation to an acceptable level of hazards that threaten the capabilities of an organization.

sponse, etc.—unlike in the not-too-distant history when it was expected that an airline would lose an aircraft or two, so extra were ordered.

So as a safety manager, how are you expected to act? Having had firsthand experience, it is not a natural flow or a simple slip into automatic mode, as an old colleague once described. It is more a case of intuition. Arriving at an accident site is surreal, particularly if the accident is “one of yours.” How are you trained to react, or more importantly how do you react? Certainly the old adage of sitting on your hands for 15 minutes is useful. Firstly though, it is important to establish links with the interested parties and manage the site from an airline perspective. One thing for sure is that it will be a long, drawn-out process that does not require quick fixes or knee-jerk reactions, but instead a well-constructed and thought-out process that will span several weeks or months but hopefully not years.

The basics of managing safety have not changed significantly from the first crash in 1908 to what we do today. Sure, we gloss it up and use impressive acronyms, but the basics are the same. Safety is the identification, analysis, management, and elimination and/or mitigation to an acceptable level of hazards that threaten the capabilities of an organization.

So how can we progress safety for the future? There are a *(continued on page 29)*



THE FINAL WORD: AIR FRANCE FLIGHT 447

The Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) safety investigation into the accident of the Airbus A330-203 Air France Flight 447 on June 1, 2009.

The crash of Air France Flight 447 on June 1, 2009, marked the beginning of an exhaustive three-year investigation conducted by the BEA. The peculiar circumstances surrounding the accident, namely a high level of international casualties, missing evidence, and substantial news media coverage, contributed to making this investigation exceptional. The analysis of data from the flight recorders, avionics systems, and human factors led the BEA to release its final report on July 5, 2012.

The following four articles are adapted from the technical papers delivered at ISASI 2012, the Society's 43rd annual international conference on air accident investigation held in Baltimore, Maryland, USA, in August by those in the BEA who were intimately involved in the investigation: Jean-Paul Troadec, director; Sébastien David, senior safety investigator; Léopold Sartorius, senior safety investigator; and Martine Del Bono, head of the Public Affairs Department.

History of the Air France Flight 447 Accident Investigation

By Jean-Paul Troadec, Director, BEA, France

(Adapted from remarks presented by Director Troadec in his keynote address to the delegates of the ISASI 2012 on Aug. 30, 2012, in Baltimore, Maryland, USA.—Editor)

Allow me, first of all, to thank the organizers of this conference for having given the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile [BEA] a complete half day to speak about the history of the Air France Flight 447 accident investigation, whose final report was published on July 5, 2012. We have chosen to present to you three main components of the investigation: readout of the flight recorders, analysis of human factors, and relations with the families and the news media. Presentations will be made by two BEA investigators, Sebastien David, head of the Human Factors Working Group, and Léopold Sartorius, head of the Systems Working Group. You will then hear from Martine Del Bono, responsible for communications, news media, and family relations at the BEA. The investigator-in-charge, Alain Bouillard, regrets that he is unable to attend the conference.

We have now finally reached the end of three years of an exceptional investigation. It was exceptional firstly because of the international dimension: the 228 victims came from 32 nationalities, which led to numerous issues in communication such as language barriers and cultural differences, without speaking of time differences.



Members of the French Navy recover parts of Air France Flight 447.



Alain Bouillard, right, and crew view the flight data recorder recovery.

Exceptional, too, due to the almost simultaneous accident involving a Yemenia aircraft off the coast of Moroni, the investigation of which also heavily involved the BEA. This meant that in July 2009, the BEA was leading two undersea search campaigns, one in the Indian Ocean and the other in the middle of the south Atlantic. At this time, the BEA was also investigating a third major accident that occurred six months before in the Mediterranean Sea involving an A320.

An exceptional mystery also surrounded the exact circumstances of the Air France 447 accident as the aircraft had disappeared without any message from the crew and beyond radar coverage. These circumstances were only clarified thanks to the readout of the flight recorders in May 2011,

Exceptional news media attention accompanied the various stages of this investigation, marked by several phases of undersea searches and the publication of three interim reports. It was the first major aircraft accident in a new era of accelerated news media coverage.

Sadly, it was also exceptional in the number of violations by third parties of the ethics of safety investigation, which requires respect for the confidentiality of working documents that are not published by the authority in charge of the investigation. I have requested two police investigations, unfortunately without conclusions.

Finally, there was an exceptional level of controversy and unjust accusations against the BEA investigators, whose professional integrity and impartiality were called into question.

At this juncture, I would like to remind you that we are talking about the safety investigation conducted by the BEA. This investigation does not seek to determine responsibilities—that is the role of the judicial investigation that takes place in parallel and independently of ours, as laid out in French law. Unfortunately, in the mind of the public, it is not always easy to understand the difference. Many people expected the BEA investigation



Pitot sensor.

to point out responsibilities and even culpabilities.

The BEA investigation started on the day of the accident, June 1, 2009, under the authority of Paul Louis Arslanian, then head of the BEA.

Right from the start, priority was given to recovering the flight recorders—without their readout, the investigation could not be conclusive, even if the examination of parts recovered at the surface of the sea and the data collected from the ACARS messages gave some indications about the accident.

On April 2, 2011, during the fourth phase of undersea searches, the wreckage was located. The recorders, quickly recovered, could be read out in their entirety, after spending two years at a depth of 3,900 meters underwater. This Franco-American adventure was the subject of a presentation during the ISASI 2011 conference last year [see “Air France 447 Underwater Search and Recovery Operations—A Shared Government-Industry Process,” *ISASI Forum* October–December 2011, page 18]. The exact circumstances of the accident were then related in a further interim report, which was published on July 29, 2011.

The circumstances of the accident as described in that report generated some strong reactions, in an emotive context that unfortunately demonstrated the commentators’ lack of perspective. We then needed to understand the reasons for the pilots’ actions and how the loss of airspeed indications alone could have led to such a disaster.

Further progress in the investigation allowed us to understand the causes of the accident and to publish the final report on July



BEA Director Jean-Paul Troadec briefs the news media. Alain Bouillard, left, the investigator-in-charge, looks on.

5, 2012. In contrast to the previous report, this publication did not generate negative reactions, even on the part of those who had previously been so critical of the BEA one year before. In fact, this report illustrates the complexity of the event.

Of course, this accident had its origins in the obstruction of the pitot probes by ice crystals and, as a consequence, the temporary loss of airspeed indications. Above all, however, it resulted from the airplane exiting its flight envelope due to the crew’s losing situational awareness.

This category of accident, classified as loss of control, has emerged over the last decade or so as the most deadly in public transport. It involves airplanes of both classic design as well as recent planes with a high level of automation. The BEA, which is

associated with a large number of investigations worldwide, has investigated several accidents in this category.

We have also investigated a similar category of accidents classified as CFIT where, while still within the airplane’s flight envelope, the loss of flight path control resulting from a loss of situational awareness by the crew has led to disaster. We are currently carrying out a study of this category of accident.

A lot of work and research is being undertaken within the international aviation community on subjects related to loss of situational awareness by the flight crew. The BEA’s conclusions and recommendations on pilot training are consistent with these themes.

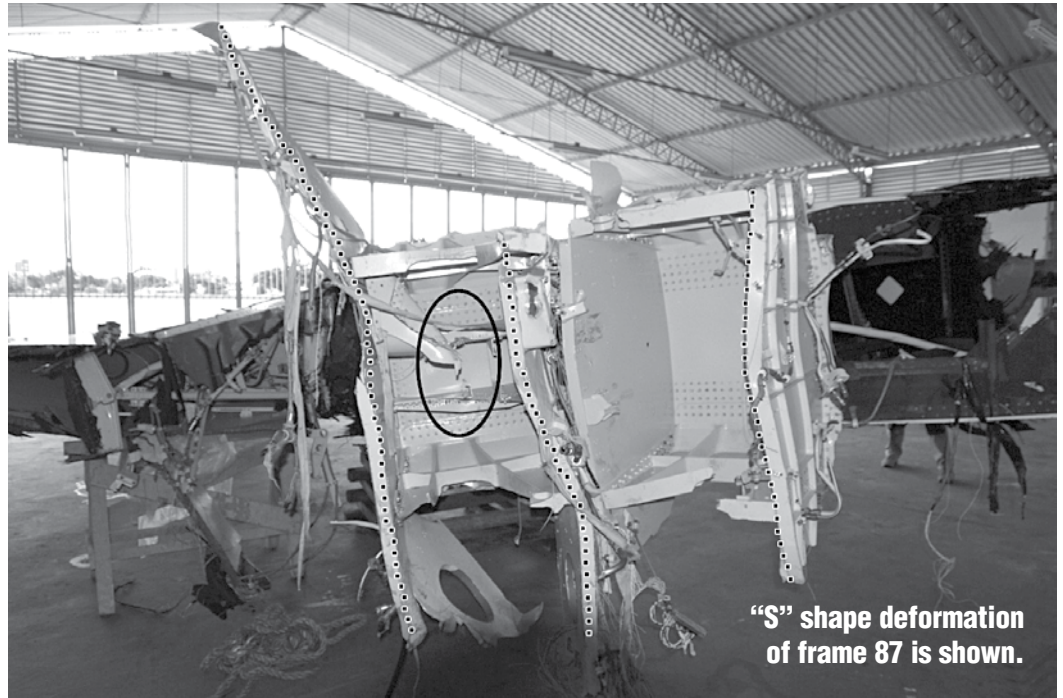


Air France Flight 447 engine recovery.

Automated systems are used on modern airliners during most of the flight, and they have considerably improved safety. The problem is that automated systems are not always used, either involuntarily when they disconnect or, in some situations, deliberately.

Then, whether it's a classic or a modern airplane type, flight path control requires that pilots have perfect situational awareness.

This comes from the quality of the information provided to pilots, the way in which it is presented, the consistency of the signals that they perceive via the various sensory channels, and their ability to make sense of these signals from



their training and experience.

Clearly, we can still increase the level of automated systems, improve their reliability, and strengthen protections.

But in the end, safety will still depend above all on getting the right adequacy between the cognitive capacities of pilots and the signals that are provided to them to understand and act on. This accident [Air France Flight 447] has also taught us that hypotheses used for safety analyses are not always relevant, that procedures are not always applied, and that warnings are not always perceived. Only an improvement in the quality of feedback will make it possible to detect any weaknesses in the safety model.

All these conclusions are the subject of BEA recommendations, in particular the 19 dedicated to training and ergonomics. These recommendations have been sent to their recipients who will answer by October [2012] if they accept them or not. We are confident that most of them will be accepted, as we have already had preliminary discussions with those recipients.

In accordance with Annex 13, our role as safety investigators could be limited to take note of these answers and, according to the European regulation, to react to these answers. But the acceptance of a recommendation is often just the beginning of a long process that could take years.

To assess the real impact of our investigations on safety, we should check the effective implementation of our investigations. This task, I will propose to our European counterparts to share with us, taking advantage of the newly created European safety recommendations database. ♦



Alain Bouillard presents the BEA's final Air France Flight 447 accident report to members of the news media.

Air France Flight 447 Human Factors Issues

The aim of the Human Factors Working Group was to determine the set of safety provisions that affected the expected behaviors and skills of the crews in this situation.

By Sébastien David, Senior Safety Investigator, BEA, France, Head of the Air France Flight 447 Human Factors Working Group

(Adapted with permission from the author's paper of the same title presented to the delegates of the ISASI 2012 on Aug.30, 2012, in Baltimore, Maryland, USA.—Editor)

Based on the work already performed by the other working groups, and particularly since the download of the flight recorders in May 2011, a Human Factors (HF) Working Group was launched three months later. The HF analysis was carried out by three Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) safety investigators and four HF experts, two of whom were pilots and provided the group with reasonable expectations that may be held regarding crew reactions and skills. The two other experts contributed their experience and their knowledge on the psychomotor, cognitive, social, emotional, and cooperative responses of human operators in general and of airline pilots in particular.

Coordination with other working groups was also essential to take into account the safety provisions that were supposed to guarantee the safety of the accident flight in the situation encountered. These provisions included, among others, explicit areas such as regulation, procedures to follow, and design features, which were designed to keep the flight safe. They also included implicit areas that are more or less clear: basic airmanship, best practices, and reasonable expectations regarding crew behavior.

The aim of the HF group was to determine the set of these safety provisions that affected the expected behaviors and skills of the crews in the situation of the accident. This involved identifying the failures that occurred during the flight, in relation to the explicit or implicit safety expectations. It also involved explaining these failures in the situation, by analyzing the interactions of the crew with the flight environment, the procedures available, and the information from the instruments and the airplane, as well as the interactions between crewmembers (the SHELL model).

Beyond the simple discovery of a psychologically probable, likely, or plausible explanation for the behavior recorded, the HF study also involved assessing the degree of specificity or generality of the behavioral responses recorded. Are they specific

to this particular crew, shared by all the airline's crews, or can they be generalized to all crews?

With regard to human factors, the behavior observed at the time of an event is often consistent with, or an extension of, a specific culture and work organization. To put it another way, it involves answering the question: "If another crew were substituted for this one, would the same responses be observed?"

The final aim is to contribute to identifying what should be modified in the whole of the safety provisions to significantly increase their effectiveness in a similar situation or in a generic situation including the same fundamental characteristics. For investigation authorities, the safety recommendations to be issued depend partly on the answer to the previous question.

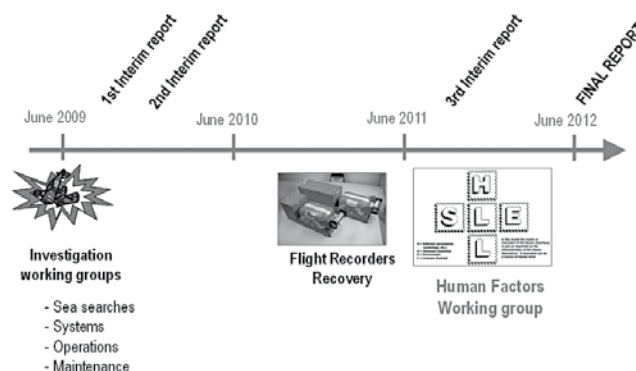
Analysis

Close coordination with the investigator-in-charge and other working group leaders enabled the HF Working Group to close in February 2012. HF work was mainly used for the analysis part of the final report and particularly for the accident scenario. It notably brought out the fact that when crew action is expected, it is always supposed that the crew will be capable of initial control of the flight path and of a rapid diagnosis that will allow crewmembers to identify the correct entry in the dictionary of procedures. A crew can be faced with an unexpected situation, leading to a momentary but profound loss of comprehension. If, in this case, the supposed capacity for initial mastery and then diagnosis is lost, the safety model is then in "common failure mode."

During this event, the loss of airspeed information due to

In the minute that followed the autopilot disconnection due to the obstruction of the pitot probes, the crew's failure to understand the situation and the destructuring of crew cooperation fed on each other until there was a total loss of cognitive control of the situation.

Air France 447 Human Factors Group—Overview



Air France 447 Human Factors Group—Overview

❖ Organization

Initiation of HF investigation:

- August 2011, after the release of the third interim report

Constitution:

- Four experts (HF, pilots...)
- Three BEA investigators

Meetings:

- Five meetings from September 2011 to January 2012

Coordination

- Close coordination with IIC and other working group leaders

❖ Group report

BEA internal document

- Used for the Final Report
- Same format as BEA reports
(based on the one recommended by ICAO Annex 13)



obstruction of the pitot probes by ice crystals during cruise completely surprised the pilots of Flight 447. After initial reactions that depend upon basic airmanship, it was expected that the problem would be rapidly diagnosed by the pilots and managed where necessary by precautionary measures regarding the pitch attitude and the thrust, as indicated in the associated procedure. But the apparent difficulties with airplane handling at high altitude in turbulence led to excessive handling inputs in roll and a sharp nose-up input by the pilot flying (PF). The destabilization that resulted from the climbing flight path and the change in the pitch attitude and vertical speed added to the erroneous airspeed indications and ECAM messages, which did not help the pilots diagnosis the situation. Thus, the crew's initial inability to master the flight path also made it impossible to understand the situation and to determine a solution. The crew, progressively becoming "destructured," likely never understood that it was "only" faced with a loss of three sources of airspeed information.

In the minute that followed the autopilot disconnection due to the obstruction of the pitot probes, the crew's failure to understand the situation and the destructuring of crew cooperation



Sébastien David is a senior safety investigator with the BEA, France, and head of the Air France Flight 447 Human Factors Working Group. Sébastien graduated in 1997 as an engineer from the French National Graduate School of Civil Aviation and joined the BEA Engineering Department in 1998 to work

initially on flight recorder readouts and performance studies. He then worked as a safety investigator for the BEA. During his career with the BEA, he has participated in many major investigations as an accredited representative and Recorders, Operations, and Human Factors Working Group leader and investigator-in-charge. He also holds a CPL, has been type rated on the Dassault Falcon 7X, and holds a master's degree in human factors.

fed on each other until there was a total loss of cognitive control of the situation. The airplane then went into a sustained stall, signaled by the stall warning and strong buffet. Despite these persistent symptoms, the crewmembers never understood that they were stalling and consequently never applied a recovery maneuver.

The combination of the ergonomics of the warning design, the conditions in which airline pilots are trained and exposed to stalls during their professional training, and the process of recurrent training did not generate the expected behavior. For example, recognizing the stall warning, even associated with buffet, supposes sufficient previous experience of stalls, a minimum of cognitive availability and understanding of the situation, and knowledge of the airplane (and its protection modes) and its

Air France 447 Human Factors Group—Conclusions

✓ Findings

- Training
- Basic Airmanship
- Human – Machine Interactions
- CRM
- Stress
- Procedures

✓ Inputs for Safety Recommendations

Air France 447 Human Factors Group—Analysis

1. From the cruise to the AP disconnection

- A. Cruise and crossing the ITCZ: perception and management of operational risk
- B. Relief of Captain

2. From the AP disconnection to triggering of stall warning

- A. Detection of problem
- B. Control of flight path
- C. Identification of the situation
- D. Attempt to control the flight path
- E. Return to handling the failure

3. After triggering of stall warning

- A. Piloting inputs
- B. Return of Captain
- C. End of HF analysis

flight physics. However, an examination of the current training for airline pilots does not, in general, provide convincing indications of the building and maintenance of the associated skills.

Thus, based on the double failure of the planned procedural responses (loss of indicated airspeed and stall), the HF analysis was able to show the limits of the current safety model. This led to safety recommendations in the final report to notably improve crew training and the ergonomics of information supplied to the crews. ♦



Air France Flight 447 Flight Recorders Issues

The crash of Air France Flight 447 on June 1, 2009, marked the beginning of an exhaustive three-year investigation conducted by the BEA. Here the author reports on the flight recorders readout operations. No one was sure what could be expected from flight recorders after almost two years of being immersed 4,000 meters under water.

By Léopold Sartorius, Senior Safety Investigator, BEA, France, Head of the Air France Flight 447 Avionics Systems Working Group

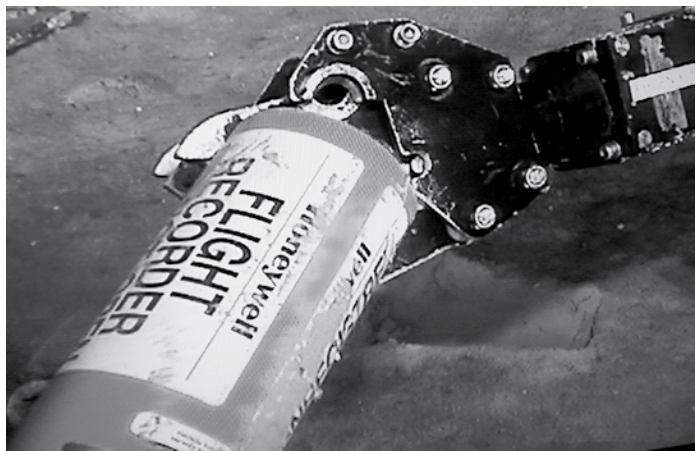
(Adapted with permission from the author's paper of the same title presented to the delegates of the ISASI 2012 on Aug.30, 2012, in Baltimore, Maryland, USA.—Editor)

Air France Flight 447's flight recorders were recovered on May 1 and 2, 2011. They were brought to the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) laboratory where the opening and readout operations started on May 12. Those operations had previously been discussed with and agreed to by all the participants involved, in particular the NTSB and Honeywell, manufacturer of the recorders. No one was sure what could be expected from the flight recorders after almost two years of being immersed 4,000 meters under water.

The worst-case scenario had been considered, given previous experience with this type of recorder. For example, recorders of this type were found within 40 days at a depth of about 1,000 meters after the A310 accident in Comoros that occurred only a few weeks after Air France Flight 447. When the A310 recorders were opened, parts of the memory boards and some of the chips showed major damage due to corrosion. Data could be almost

Recovery of avionics bay.





**Flight data
recorders
on the ocean
floor (above
and right).**



completely recovered only after exceptional efforts. However, the environmental conditions between the two cases differed significantly. In terms of temperature and salt concentration—two major factors for corrosion—the very deep cool and almost fresh waters of the Atlantic were a real advantage over the very saline and relatively warm Indian Ocean waters surrounding Comoros.

When the first crash-protected module from Air France Flight 447 was opened and the memory board removed, all the witnesses were amazed at the appearance of the board—almost pristine. There was therefore not much doubt left: if the data were still there, which was not an absolute, they would be recovered. And that is the way things went, after having dried the boards and replacing some damaged components on the CVR's boards.

One unresolved question was about the functioning of the underwater locator beacons (ULB) on each of the recorders, which were not heard during the first phase of the sea searches. Though both crash-protected modules were retrieved, only one was still attached to its casing. What is more, only this one had its ULB still in place, though damaged. The remaining ULB was tested at the BEA, resulting in no tangible evidence. The ULB was not transmitting as per design, but some physical damage may have been the result of a chemical rather than mechanical aggression. In any case, other tests had been going on with the French Navy to better understand the way the signal propagates with the ULB still attached to its crash-protected module. These demonstrated that the presence of that module, and the recorder casing, may affect the strength of the signal in some directions.

Operations to extract the data storage medium and prepare the readout were, as usual in France, videotaped and logged.



**Preserving
aircraft parts
after recovery.**



The presence of the judicial experts and other judicial representa-

tives was, however, easily accepted by the investigation authorities, mainly because they themselves were considered to be witnesses rather than actors. The BEA used, for the first time, four IP cameras to film, record, and broadcast images from various places in the laboratory: opening room, electronic room, X-Ray machine, plus a movable camera. Apart from getting a trace of what had been done throughout the process, this allowed other people (typically from the manufacturer or the airline) to follow the ongoing operations without disturbing the tranquility required to undertake this type of operation.

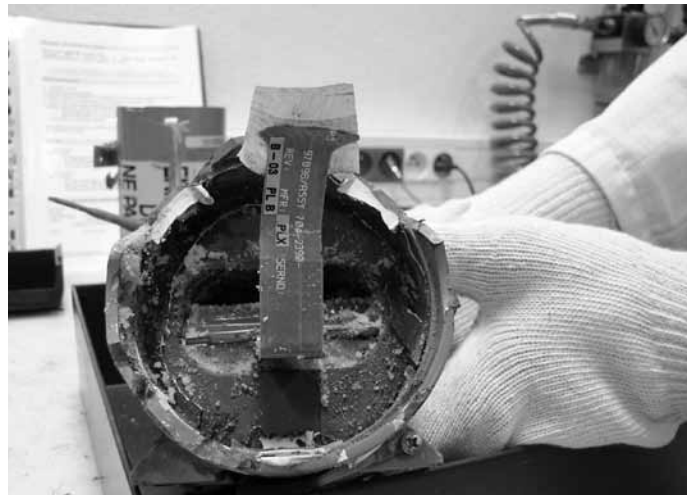
The data were then fully recovered, and the analysis could begin. Again, paradoxically, the investigation team was lucky



Léopold Sartorius is a senior safety investigator with the BEA, France, and head of the Air France Flight 447 Avionics Systems Working Group. Léo joined the BEA Engineering Department in 2002 immediately after graduating as an engineer from the French National Aeronautical Construction Graduate School. He was initially deeply involved in the development of the BEA's in-house flight data analysis software. And since 2003, he has participated in numerous international investigations as flight recorder, performance, or systems group leader and as an accredited representative. In 2011, Léo was named head of the Flight Recorders and Avionics Systems Division. He holds a PPL and has a master's degree in human factors.



FDR—recovered and ready for inspection.



FDR analysts begin their work.

to try to reconstruct the information displayed on the right side primary flight display (PFD)—the pilot flying.

Hence, every single recorded parameter was looked at to search for any link with the availability of air data sources, from the computer standpoint. This finally helped, and it was possible to compute or approximate the flight directors' guidance or determine, at least partially, the pitot probe No. 2 blockage history. This information was then made into a 2-D animation and provided to the Human Factors Working Group. Despite the limitations in terms of interpretation associated with this type of representation, by combining it with the CVR, it was possible to show how fast the events happened in the sequence. Without basing their analysis on the animation, the quantity of information available in a limited space made it possible for the Human Factors Working Group members to consider a wide range of aspects in a short time. ♦



Members of the Air France Flight 447 Avionics Systems Working Group who were involved in the readout phases.

enough to have ample time available to prepare the different tasks before the data were available. Whereas several hours or one day are generally given to preparing the lab, testing the tools and configuring the analysis software, 10 days could in this case be efficiently used to prepare the protocol and analysis (including plots and listings). In the end, it saved a lot of time. Where investigators often struggle to get the least piece of validated information from the flight recorders, they were in this case overwhelmed with the amount of data provided in a single day or two.

As usual in such cases, care had to be taken at the preliminary stage of the data analysis. Here, however, another facilitating factor was the knowledge that was gained from the ACARS messages, whose analysis had been going on for months. As a consequence, a lot of what was observed in the flight data was more or less expected, and none of the preliminary conclusions was called into question by the flight data.

However, as so often is the case, the devil is in the detail. And though the investigators had time, they did not have all the parameters they would have liked. Understanding what happened had taken a matter of hours, but it already appeared that it would require more time than usual to understand why. In the absence of image data from the flight deck, additional work had to be done

Victims' Families, News Media Issues, And Innovations

The BEA made it a priority to provide information to the victims' families. Thirty-two different nationalities were counted among the 228 victims, and 12 of these countries requested the status of observer state.

By Martine Del Bono, Head of Public Affairs,
BEA, France

(Adapted with permission from the author's paper of the same title presented to the delegates of the ISASI 2012 on Aug.30, 2012, in Baltimore, Maryland, USA.—Editor)

The Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) made it a priority to provide information to the victims' families. The bureau sometimes encountered challenges in establishing swift and direct communication due to a particular set of circumstances, reflecting the very nature of the accident.

Thirty-two different nationalities were counted among the 228 victims, and 12 of these countries requested the status of observer state. The four main countries affected by the tragedy—Brazil, France, Germany, and Italy—witnessed the creation of large associations of victims' families, thus requiring the implementation of broad communication procedures in foreign languages. France lost 73 nationals, Brazil 58, Germany 26, and Italy 9.

In accordance with the provisions of Annex 13 and European regulations, any information to be published (reports or findings) must first be released to the victims' families. Therefore, the time difference between Europe and South America required setting a specific time (approximately 1 p.m. GMT) to hold press briefings, after the

families were made aware of the latest findings.

The 23-month gap between the accident and locating the wreckage and the flight recorders, combined with leaks, online rumors, and news media speculations, led some family members to become disenfranchised with the BEA—and in some instances accused it of a lack of transparency. The BEA thus worked to restore confidence in the bureau. Another aspect of the communication strategy was to put an emphasis on the objective nature of the safety investigation to prevent any party from using findings or quotes in the legal framework.

Communication with the victims' families

The communication strategy developed by the BEA was straightforward. It was designed to ensure that the victims' families would be informed of any finding over the course of the undersea search operations and the publication of the three interim reports and the final report. This was performed both electronically, with more than 50 e-mails sent directly to the families prior to press releases, and physically with periodic meetings with representatives of the families. In addition, resources were dedicated to making validated documents available in French, English, German, and Portuguese. This was paramount to ensuring the families' understanding of the safety investigation at an extremely difficult time.

Leaks, misinformation, and the news media

The duration of the investigation, combined with partial leaks and resulting speculation, created a news media buzz that at times hindered the BEA's work with the victims' families. Three events should be highlighted that, far from having any scientific



Alain Bouillard, Air France Flight 447 investigator-in-charge, responds to news media questions.



Investigator-in-Charge Alain Bouillard conducts a news media press conference.

basis, simply contributed to perpetuating a sort of “blame game.”

1) On May 16, 2011, *Le Figaro* cleared the aircraft of any manufacturing defect. Later it pointed the finger at the pilots by including partly erroneous quotes from the crew.

2) On Aug. 2, 2011, a few days after the publication of the third interim report, the confidential draft of this document was leaked to the press, further fueling an already existing controversy over a

proposed safety recommendation that did not appear in the official version.

3) Lastly, Jean-Pierre Otelli released a book entitled *Erreurs de Pilotage (Piloting Errors)* on Oct. 14, 2011, in which he attempted to reenact the chain of events that took place based on a CVR transcript he had previously and unlawfully obtained.

Another factor, online rumors and speculation, proved counterproductive to carrying out an efficient communications strategy by dedicating resources to crisis communication. Social networks and forums contributed to rapidly spreading false information—thus reflecting Marshall McLuhan’s global village concept, and from which the international press based a great deal of its headlines to further the debate over who was to blame for the accident. This phenomenon seemed to arise from the dynamic of prioritizing the creation of information over its accuracy. This, in turn, left the victims’ families confused, in distress, and sometimes suspicious of the work of the BEA.

Information and innovations

To improve the release of information, the BEA implemented new online and multimedia capabilities. A technical team was assigned to record life aboard ships in the course of the five different undersea search operations, as well as to conduct multiple interviews with investigators to further public understanding of the nature of their work. Following the discovery of the wreckage



Martine Del Bono graduated from the CELSA (graduate school in the information and communication sciences, Sorbonne, Paris). She acquired substantial knowledge and experience in the fields of intercultural management and communication as head of International Communications at Sciences Po Paris. Del Bono joined the BEA in 2002. Her field of expertise encompasses all aspects of communication strategy. Her primary targets are access to information, crisis management, and aviation safety interests.



The BEA Public Affairs Department conducts one of its periodic briefings for family associations.



Recovered flight recorders are presented to the news media.

and later of the flight recorders, photos were sent electronically from the vessels and posted overnight on the BEA’s website.

Another initiative was to stream online both the presentation of the third interim report and that of the final report. Although this was initially intended to be accessible only to the families, the procedure was extended to include BEA’s international partners and counterparts, with the hiring of two English speaking interpreters.

Lastly, such an online presence required the BEA to increase its website capabilities. Each of the four reports was downloaded more than 100,000 times, with more than 75,000 downloads of the English version. Today the site contains four sections dedicated to covering three years of investigation: Chronology, Reports, Sea Search Operations, and Press Releases & Media Library.

The BEA investigated the first major aircraft accident within the new age of digital communication technologies. It had to work its overall communication strategy in a complex environment but remained dedicated to its mission and to the victims’ families with complete, accurate, and validated information. Crisis communication and communication strategies were both used extensively to contain and enable a safe, swift, and direct release of information, which proved to be crucial to the safety investigation and to preserving its integrity. ♦

Russia's Interstate Aviation Committee

By Sergey V. Zayko, Vice Chairman,
Interstate Aviation Committee



**Helicopter crash scene
somewhere near the tundra,
north of Russia.**

(The following description of the Interstate Aviation Committee makeup and operation was presented to the delegates of ISASI 2012, in Baltimore, Maryland, USA, during a panel discussion.—Editor)

The Interstate Aviation Committee (IAC/MAK), Russia, was established in December 1991 pursuant to the interstate Agreement on Civil Aviation and Airspace Use. The principal aim of the IAC is to ensure safe and orderly development of civil aviation of the member states of the agreement.

In July 1992, the agreement and status of the IAC, in line with the provisions of the Convention on the International Civil Aviation and with the procedures of the International Civil Aviation Organization (ICAO), were registered by ICAO, and the IAC was included into the list of intergovernmental organizations.

The IAC has entered into cooperative agreements with such international organizations as ICAO, EASA, IATA, IFALPA, IPA CIS, EurAsEc, and others, as well as agreements in the areas of

airworthiness, flight safety, and aircraft accident investigation with many countries.

The IAC operates on the basis of and in compliance with the international regulations and national legislations of the member states of the agreement who delegated to the IAC proper powers in the following spheres:

- Certifying aircraft, aircraft engines, and aircraft components, as per IAC's certification base rules, which are in harmony with the appropriate rules of the United States and Europe. All work is done in close cooperation with the design bureaus and certification centers, which were established on the basis of the studies from leading aviation industry research institutes. Aircraft and aircraft equipment of third countries are certified in accordance with the manufacturer request supported by the civil aviation administration of the state of design. The IAC activities related to the certification of aircraft and aircraft manufacturers conform to the standards and recommended practices of Annex 8 to the Convention on International Civil Aviation.
- Certifying international and categorized aerodromes, aero-



The annual IAC high-level council meeting in progress.

drome equipment, and equipment manufacture on the basis of the system of aviation rules, developed by the IAC, which has been approved and accepted by the member states of the agreement. The IAC activities related to the certification of international and categorized aerodromes, aerodrome equipment, and equipment manufacture conform to the standards and recommended practices of Annex 14 to the Convention on International Civil Aviation.

- Coordinating issues in the area of civil aviation development for the purposes of forming and implementing concerted policy of the member states of the agreement on civil aviation. This includes meeting member states' national interests; organizing and coordinating issues of cooperation in the sphere of safety management system; facilitating border and customs procedures; interacting in emergency situations; ensuring aviation security and taking counteraction measures to aviation terrorism; and ensuring aviation specialists training, air medicine, etc.
- Coordination of harmonizing the national development programs of the air traffic management (ATM) system to comply with the provisions of the national air traffic management systems' concept as accepted by the member states of the agreement for the purpose of integrating the systems of member states into the European and world air navigation systems, using international standards.
- Realizing ICAO/IAC projects aimed at improving flight safety and continuing airworthiness in the member states of the agreement, on the basis of harmonizing national legislations, standards, and rules with international regulations and standards, and

training aeronautical specialists of the member states of the agreement in accordance with the ICAO programs.

- Independently investigating all aircraft accidents that involve the aircraft of the member states of the agreement, both in their territories and elsewhere, as well as accidents involving foreign aircraft in the territories of the member states of the agreement and other aircraft accidents covered by the appropriate international agreements. The IAC activities related to aircraft

accident investigation conform to standards and recommended practices of Annex 13 to the Chicago Convention of ICAO.

The work related to aircraft accident investigation is being overseen by the Aircraft Accident Investigation Commission (AAIC) and the Aircraft Accident Investigation Scientific and Technical Support Commission (AAI STSC). Investigators have at their disposal a modern laboratory, which provides capabilities for flight recorders data recovery, readout and analysis, flight dynamics analysis, aircraft and systems fracture analysis, acoustic/

Interstate Aviation Committee investigators interact closely with specialists from other leading investigation bodies and international organizations, participating in corresponding seminars, working groups, meetings, and conferences.

phonoscopic analysis, and research in the field of human factors.

IAC specialists render all-round support in investigations conducted abroad of accidents involving aircraft developed and manufactured in the member states of the agreement. For 20 years, representatives from 56 states of the world have been working in the IAC laboratory within the framework of such international investigations. IAC investigators interact closely with specialists from other leading investigation bodies and international organizations, participating in corresponding seminars, working groups, meetings, and conferences.

IAC is a member of the International Transportation Safety Association (ITSA) and the International Society of Air Safety Investigators (ISASI).

IAC headquarters are located in Moscow. IAC activity is conducted in accordance with the aviation code of the Russian Federation and law by which the Federal Assembly of the Russian Federation ratified the agreement between the government of the Russian Federation and the Interstate Aviation Committee on the condition that IAC stays in the territory of the Russian Federation. ♦



Sergey Zayko (second from right) participates in an ISASI 2012 panel discussion.

UNMANNED AIRCRAFT SYSTEM ACCIDENTS: Learning to Predict

The author discusses how to make informed judgments regarding the most critical UAS-related hazards requiring both investigation and mitigation, as opposed to those that simply are the most commonly encountered.

By Thomas A. Farrier (MO3763),
Principal Safety Analyst,
ClancyJG International, Inc., and
Chair, ISASI Unmanned Aircraft
Systems Working Group

(Adapted with permission from the author's paper of the same title presented to the delegates of the ISASI 2012 on Aug. 30, 2012, in Baltimore, Maryland, USA.—Editor)

In some respects, the emerging unmanned aircraft system (UAS) sector has followed the evolutionary path blazed by prior technological innovations in aviation, such as the introduction of commercial jet airliners in the 1950s. But it has done so with unprecedented speed, and with the huge advantage of a century's experience with the basic challenges of aviation to inform their developmental efforts. The number of unmanned aircraft likely to be conducting civil operations in just a few years is completely out of proportion with the body of experience-based knowledge that has been assembled to date about the hazards associated with them.

Previous aviation safety lessons were hard won and incrementally learned; today, the UAS generation of safety challenges has arrived at the aviation community's doorstep as a potentially unruly teenager instead of a newborn infant. At the same time, UAS advocates mindful of the inherent limitations of unmanned aircraft are lobbying hard to carve out

various regulatory exemptions for their operations. Such demands represent a desire for permanent *accommodation* of UAS rather than true integration, since they would result in a system to which different users are held to different standards and, in effect, different levels of safety.

With respect to unmanned aircraft systems as a whole, the air safety investigator community has three challenges: how to investigate UAS accidents and incidents, how to apply the fruits of those investigations to reduce the likelihood of similar events in the future, and how to make informed judgments regarding the most critical UAS-related hazards requiring both investigation and mitigation, as opposed to those that simply are the most commonly encountered. In this adapted article, I focus on the last of these issues.

Historical perspectives on aircraft accident investigation

From the start of heavier-than-air flight more than a century ago, the aviation community has had to address a vast array of safety challenges, all of which necessitated the development of investigative processes and procedures suitable to identifying and remedying them. There is a stark logic associated with how these activities progressed over time.

Figure 1 shows how one fundamental technological problem after another had to be addressed as aviation's horizons expanded. Unmanned aviation is not charting the same path and cannot be expected to proceed with the same degree of caution as early aviation pioneers exercised. The unmanned is a more calculated approach to the costs and benefits of aviation, made with due consideration for potential liability, but also made with the great advantage

Figure 1. Chronology of air safety advancements and their catalysts

	Safety focus areas	Landmark accidents	Major U.S. prevention efforts
1910	Engine reliability Airframe strength		
1920	Night/all-weather operations Basic flying regulations		
1930	Passenger safety Air traffic safety	T&WA (Kansas) T&WA (Missouri)	Insurance industry (Jerry Lederer)
1940	Aerospace physiology Aviation weather		Creation of CAA/CAB
1950	Crashworthiness Route structure	NA 101 (EWR) TW 2/UA 718 (Grand Canyon)	Flight Safety Foundation
1960	Jet airliner safety Radar surveillance	UA 736/USAF F-100F (LAS) TW 266/UA 826 (NYC)	Creation of FAA/NTSB
1970	Design/maintenance practices	TK 981 (France) KL 4805/PA 1736 (Tenerife)	NTSB midair collision studies
	Crew resource management	UA 173 (PDX)	
1980	Airspace management Hazardous weather	PS 182 (SAN), AM 198 (Cerritos) DL 191 (DFW)	
1990	Runway incursions Controlled flight into terrain	NW 1482/299 (DTW) AA 965 (Cali)	Commerical Aviation Safety Team
2000	Approach/landing Loss of control	AA 1420 (UT)	
2010		AF 447 (South Atlantic)	

the Unpredictable

of involving aircraft orders of magnitude less expensive than manned aircraft.

In addition, Figure 1 shows it wasn't until relatively recently that broad safety concerns affecting the bulk of the operating community and the flying public started being replaced by more focused issues associated with the completion of individual flights. To date, UAS manufacturers generally do not appear to be working together to address broad-based reliability issues that should be of mutual concern, especially those associated with making UAS integration into the national airspace system (NAS) safe, rather than simply minimally permissible. Manufacturers' energies are being expended on making their own systems more efficient (endurance being one of the most desirable properties of unmanned aircraft), and they have displayed little interest in imposing any increased payload or onboard power requirements on themselves.

This apparent blind spot is in part due to the reluctance of some aviation stakeholders to require unmanned aircraft and their pilots to meet the same standards as those expected of manned aircraft and their pi-

lots, which in turn is based on the different priorities stakeholders have with respect to aircraft capabilities, mission accomplishment, and risk tolerance. However, it also is traceable to a lack of manned aviation experience on the part of many UAS manufacturers, as well as a lack of hard data regarding broad UAS-specific safety issues. All of these challenges must be confronted if unmanned aircraft systems are to be successfully brought into wider use for commercial and public safety purposes.

Determining UAS investigative and record-keeping requirements

Investigators unfamiliar with how unmanned aircraft systems work might

More than five years ago, RTCA Special Committee (SC) 203 developed a UAS conceptual diagram that identified three basic components ("segments") of unmanned aircraft systems: the "aircraft segment" that flies, the "control segment" from which the pilot-in-command (PIC) flies the aircraft, and the "airspace system" segment within which the aircraft flies and the pilot interacts with air traffic control (ATC) as necessary. In addition, each of the three principal segments in the SC-203 model is connected to the others through so-called "communications segments," which deliberately were kept generic because of the vast differences in how they operate from one system to the next.

To date, UAS manufacturers generally do not appear to be working together to address broad-based reliability issues that should be of mutual concern, especially those associated with making UAS integration into the national airspace system (NAS) safe, rather than simply minimally permissible.

ask, "Why do some UAS occurrences deserve focused investigative attention while others warrant formal tracking for statistical and reliability purposes and a few can safely be disregarded?" The short answer is that some kinds of events are the result of systemic issues associated with the design or operation of unmanned aircraft while others involve operational or equipage issues where the manned and unmanned aviation sectors intersect. These are the events worth capturing and in some cases delving into in detail.

Unmanned aircraft that malfunction with no resulting effect on manned aircraft around them and that do not offer lessons learned beyond the immediate UAS involved should, for now, be accorded the lowest investigative and record-keeping priority possible to avoid a completely unmanageable influx of new and difficult-to-exploit data. The following brief discussion should help readers understand the distinction between critical and noncritical UAS occurrences from a systems perspective.

This model has withstood the test of time to the extent that any UAS in existence may be overlaid upon it, and each segment described by SC-203 will have a recognizable analogue. However, it does not completely describe the full environment within which the system operates in terms of interrelationships between all of the segments and other aircraft, which is necessary to understand the nature of UAS-related hazards and possible accidents.

The modified model (see Figure 2, next page)—referred to as the "UAS Kite"—allows the introduction and impact of hazards to be more easily visualized.

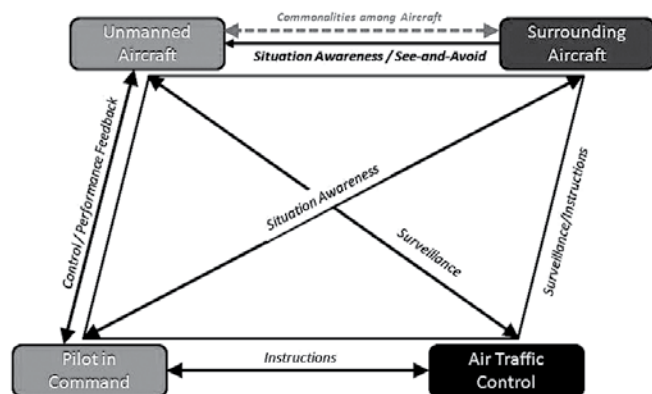
From a top-level perspective, a UAS-related hazard occurs in controlled airspace when anything affects the normal operation of any of the four vertices of the unmanned aircraft/PIC/ATC/other aircraft parallelogram so as to create the potential for an undesired outcome. In addition, anything that disrupts any of the communications segments similarly may result in increased risk. The criticality of



Tom Farrier has been an ISASI member since 1995. He began his aviation safety career in the U.S. Air Force, serving as an on-scene investigator as well as performing prevention and programmatic duties at wing, major command, and headquarters Air Force levels. After his military retirement, he was national safety coordinator for the National Air Traffic Controllers Association, later becoming director of safety for the Air Transport Association. Since 2005, he has been a government contractor addressing aerospace safety matters ranging from heliport design to space tourist safety to his current work in the emerging field of unmanned aircraft systems



Figure 2. The “UAS Kite” model for hazard and risk assessment



the communications segment between an unmanned aircraft and those surrounding it is evident because it is the only potentially one-way segment; other aircraft may see and react to the unmanned aircraft (assuming it is large enough to be readily observed), but most UAs cannot do likewise. The UAS Kite also can be applied to illustrate the different safety issues associated with UAS operations in uncontrolled airspace. By removing the ATC vertex (as opposed to simply disabling it as in the event of an “ATC-zero” scenario), the entire model becomes unbalanced. The UAS PIC has few means available to become aware of surrounding aircraft, and there is no ATC segment to monitor the flight path of the unmanned aircraft and provide advisories to other aircraft.

Finally, the UAS-Kite provides clues regarding the *criticality* of hazards with respect to how they may affect its vertices. If the operation of any segment is degraded (including where manned aircraft pilots operate in the vicinity of unmanned aircraft in shared airspace without awareness of the latter), risk increases. This includes the added line at the top of the kite, identifying “commonalities among aircraft” as an additional “segment” for the purpose of hazard identification and assessment.

From a regulator’s and investigator’s

through assessment of the basic nature of the segments’ in-service interactions and interrelationships in a given state. However, this starting point must be further refined to maximize the effectiveness of the scarce air safety investigator resource.

Setting UAS investigative priorities for air safety investigators

The vast differences in performance and onboard capabilities among different types of UAS have introduced significant complications into the regulatory equation. However, it is possible to prioritize among individual UAS-related occurrences on a case-by-case basis by addressing three aspects of unmanned aircraft and their operations:

- The commonalities among UAS that lead to similar types of accidents, incidents, and unusual occurrences.
- Commonalities between manned and unmanned components.
- Expected interactions between manned and unmanned aircraft operations.

Through advance consideration of these factors, their incorporation into appropriate regulations, and future interpretation of them in the context of specific accident and incident scenarios, investigators should be able to prioritize scarce resources toward those inquiries most likely to generate information usable to improve

perspective, the UAS-Kite offers a starting point for setting priorities for rulemaking and information gathering. These activities may be based on the unmanned aircraft systems and operating environments for which safety officials are responsible, and may be tailored

the safety of UAS operations across their size, performance, and capability spectra.

Commonalities among unmanned aircraft system attributes

Rethinking unmanned aircraft system safety in the context of investigative priorities first requires concentrating on three key UAS attributes:

- Lack of onboard see-and-avoid capability.
- Vulnerability to pilot loss of control due to electronic link failures.
- Vulnerability to local or systemwide failure of the global position satellite (GPS) system.

The basic difference between manned and unmanned aircraft is, of course, the remote location of the unmanned aircraft’s pilot. This difference is why these three serious and recurring hazards associated with unmanned aircraft operations must not only be acknowledged but also directly confronted. The inability of a UAS PIC to conform to right-of-way rules has long been recognized as a significant threat in any aviation system where VFR and IFR aircraft share airspace. But technologies specifically intended to routinely mitigate this threat are literally years away, and are unlikely to be capable of being installed in any but a handful of the largest and most sophisticated unmanned aircraft.

By the same token, control link failures—perhaps even a greater hazard than the lack of see and avoid or a viable alternate means of compliance for it—are known to occur with varying degrees of frequency from system to system. But conversations about them are routinely avoided despite the potential unpredictability they bring to unmanned aircraft operations, especially in controlled airspace.

Finally, virtually all unmanned aircraft systems that exceed modelers’ radio-controlled aircraft in basic capabilities incorporate some application of GPS technology to report the unmanned aircraft’s position, to enable some kind of

An unmanned aircraft of any type that is out of its PIC's direct line of sight and then loses GPS functionality has the potential to become both autonomous *and* directionless—a very bad combination.

preprogrammed response to a loss of their control link, or both. The failure of part or all of the GPS constellation can constitute a significant and perhaps intolerable single-point failure mode. An unmanned aircraft of any type that is out of its PIC's direct line of sight and then loses GPS functionality has the potential to become both autonomous *and* directionless—a very bad combination.

The system states under which different unmanned aircraft systems encounter see-and-avoid-, lost-link-, or GPS-related problems have a significant bearing on the severity of possible outcomes when they occur. This is partly because of how UAS pilots-in-command interact with their and other aircraft in different modes of operation, and partly because of the options—or lack of options—available to the PIC when problems are encountered.

There are three system states relevant to this proposition: “line of sight,” “beyond visual range,” and “beyond line of sight.” Line-of-sight operations are those conducted with the unmanned aircraft in view of its PIC at all time. Beyond-visual-range operations are those in which the aircraft remains within electronic line of sight of its ground control station but is too far away to be seen by the PIC, who must rely on information passed back from the aircraft via data downlink (e.g., GPS location, camera view) to maneuver and navigate the aircraft. Beyond-line-of-sight operations are those in which the unmanned aircraft is beyond the electronic horizon—far enough away that the curve of the earth prevents straight-line electronic communications with it—and command, control, and communications links with its ground control station must be relayed through a satellite, repeater, or similar intermediate retransmission system. Any accident or serious incident involving a given unmanned aircraft system must be documented and compared with similar systems operating in the same system state. While the hazard encountered may

drive a uniform risk shared by all, it also could be that a lesser-severity outcome is an indicator that something much worse might have occurred if a less-capable UAS had been involved.

The bottom line of this discussion is that regardless of the physical or technical differences among individual unmanned aircraft or unmanned aircraft systems, the hazards associated with them are essentially identical in comparable system states. The existing mitigations for these hazards vary widely from one UAS to the next, but that diversity of solutions actually can form the basis for identifying best practices and best equipage concepts for preventing them.

The only way to know why some systems are more (or less) susceptible to certain types or severities of occurrences is to individually investigate them as they happen. To avoid being completely overwhelmed by events, investigators should concentrate on those involving see-and-avoid breakdowns, control (uplink) and data (downlink) failures, and GPS-related malfunctions, along with the failure of any system intended to provide an alternate means of compliance with existing see-and-avoid rules.

Commonalities between manned and unmanned aircraft equipment


The second investigative priority for UAS-involved accidents and incidents is where a powerplant or avionics common to both manned and unmanned aircraft malfunctions. (This would be identified as a degradation of the “commonalities among aircraft” segment on the UAS-Kite.) While a full-up investigation of each occurrence most likely would not be necessary in most cases, the consequences of such malfunctions in *unmanned* aircraft might be less severe than could be the case in *manned* applications. A certain amount of advance and ongoing self-education will be necessary to recognize which systems might incorporate such shared equipment and

to ensure that the unmanned/manned connection is clearly identified for each UAS overseen by the investigative authority.

UAS certification in the U.S. will for the most part be based upon conformity with consensus standards rather than adherence to technical standard orders (TSO). By the same token, certain key UAS components, such as radios and transponders, must be expected to function within the same tolerances and with the same degree of reliability required of those meeting TSO requirements. As such, it is likely that at least some unmanned aircraft systems will incorporate off-the-shelf, i.e., certified, avionics for these purposes. Therefore, failures of all such components must be scrutinized carefully, regardless of the aircraft or system within which they are installed, and reporting and investigation requirements identical to those required for comparable failures in manned aircraft should be established for them accordingly.

Another peculiarity of unmanned aircraft is that some are designed around existing powerplants, including some currently used in manned aviation as well as nonaviation variants of the aviation-approved models. Whenever UAS engine failures are reported, the responsible air safety investigators will need to dig into the specifics of the *exact* type of engine in use. In some cases, it is relatively easy to determine if a specific engine model, such as one built by an established company like Rotax or Wankel, has been certified for manned aircraft, and word needs to be circulated through manned channels if a failure involving a certified engine takes place in an unmanned aircraft.

In many cases, however, the challenge may be to determine if an observed failure in a nonaviation-certified powerplant with parts commonality with an aviation model could reasonably affect manned aircraft. This is not currently a priority for most investigation authorities, but it actually represents an opportunity to improve manned



A generally unspoken but fairly obvious expectation regarding manned and unmanned operations in shared airspace is that there are going to be a *lot* of unwanted encounters between the two, and many have the potential to occur in airspace that has been extremely safe for decades.

aircraft safety based on unmanned aircraft experience. As such, it should be explored whenever practical as unmanned aircraft become more numerous and the use of off-the-shelf components to build and equip them continues to expand.

Interactions between manned and unmanned aircraft operations

The final priority for investigators should be to ensure that all possible avenues are open to them to become aware of every instance in which manned and unmanned aircraft come into conflict with each other. This means ensuring a close ongoing relationship with air navigation service providers and airport operators, as well as establishing a trusted anonymous reporting system for both manned and unmanned pilots if one does not already exist.

While statistical tracking of both midair (MAC) and near midair collisions (NMAC) involving UAS will be essential, it will be equally important to dig deeper into both—especially the latter—wherever practical to validate or cast doubt on many assumptions being made in conjunction with granting unmanned aircraft greater freedom to operate.

There is natural concern about the possibility of controlled flight into terrain and loss of control accidents involving unmanned aircraft, but most observers tend to concentrate on the MAC threat as being the most pressing. Part of the challenge of bringing focused attention to the MAC threat in the context of unmanned aircraft operations is the same as has been experienced with manned aviation: relating NMAC circumstances to those that actually result in collisions. MAC and NMAC events often are reported and investigated through two entirely different processes, with the former investigated as accidents and the latter as air traffic events.

NMAC reporting and investigating tends to be somewhat skewed because it often is done in response to suspected or objectively measured violations of sepa-

ration minima rather than actual or perceived close calls. As such, NMAC reports are good at measuring the effectiveness with which controlled airspace is managed and operated within required tolerances, but rarely do they delve into the kinds of issues often seen in actual midair collisions—distraction, sun angles, undetected convergence, etc.

The toll of the midairs that do occur (in the U.S., seven out of 10 were fatal in 2009, while only about one out of every six other types of accidents was fatal) makes it imperative to understand the circumstances under which both MACs and NMACs are likely to occur in detail, and to gauge the risk of unmanned aircraft being involved in both accordingly. In particular, it means documenting the aviation environments within which they take place—in terms of both location and system state—to ensure that existing safety margins are not inadvertently compromised, and to be positioned to exhaustively examine every MAC involving a manned and an unmanned aircraft regardless of the cost or extent of damage suffered by either.

A generally unspoken but fairly obvious expectation regarding manned and unmanned operations in shared airspace is that there are going to be a *lot* of unwanted encounters between the two, and many have the potential to occur in airspace that has been extremely safe for decades. According to the FAA, “Recent studies of midair collisions involving aircraft by the National Transportation Safety Board (NTSB) determined that...[the] vast majority of accidents occurred at or near uncontrolled airports and at altitudes below 1,000 feet.” This can be attributed at least in part to the strict limitations imposed on pilots flying in denser aviation environments, especially Class B and C airspace.

Those very locations are likely to become some of the most desirable for unmanned aircraft operations in the near future, in part for electronic news gathering and commercial purposes but far more frequently

to support public safety missions. Such increased activity certainly is justifiable, and much if not most of it could be argued as being in the public’s interest. But when matched against the growing calls for relief from the regulatory requirements mandating transponders and two-way radio communications with ATC—the same rules that have made midairs almost nonexistent anywhere except in uncontrolled airspace—the wisdom of having separate sets of safety rules for manned and unmanned aircraft becomes suspect.

Given the fact that the smallest unmanned aircraft are both the least likely to be equipped for radar detection by ATC and the most likely to escape visual detection by manned aircraft pilots, the entire aviation community needs better information regarding the likelihood of MACs with unmanned aircraft, as well as the outcomes of all such occurrences.

The feasibility of preventing future occurrences

Having determined the three sets of circumstances under which given UAS-related events should be formally investigated, analyzed, and statistically tracked or simply recorded—commonalities among UAS, commonalities between manned and unmanned aircraft components, and hazardous interactions between manned and unmanned aircraft operations—one final consideration rarely of concern to investigators inquiring into manned aircraft occurrences must be taken into account: the likelihood that effective recommendations for future prevention actually can be made or, if made, will be implemented.

Investigations can be expensive affairs, and unmanned aircraft accident and incident investigations often have the potential to be significantly more complex than their typical manned aircraft counterparts. In-depth inquiries into events in which similar unmanned aircraft systems, or manned aircraft with common pow-
(continued on page 30)

(Adapted with permission from the author's paper of the same title presented to the delegates of the ISASI 2012 on Aug. 28, 2012, in Baltimore, Maryland, USA.—Editor)

The big push today is for safety to be more predictive instead of reactive, the theme of ISASI 2012 being one example. This is a noble and worthwhile effort. However, regulators and safety investigation organizations are reactive by nature, so it is not an easy task. ISASI members are the ones who generate this reaction, since investigations are reactions to events. This will not and should not change. However, given our current “predictive” capabilities and, even more, given the reactive world we work in—particularly the safety world—is being predictive a realistic goal? This really raises two primary questions: 1) Can we be predictive? and 2) Would prediction be successful in reducing risk? We will attempt to answer these questions later. As some background to answering them, let's step back to the very basics of safety and safety 101.

Safety is risk management. You can talk about SMS, ATOS, GASP, TEM, IOSA, CAST, etc., but safety comes down to this one



Jim Burin has 44 years of aviation experience and 36 years of experience in the aviation safety field. He is a retired Navy captain, having commanded an attack squadron and a carrier air wing during his 30-year career. Prior to joining the Flight Safety Foundation, he was the director of the School of Aviation

Safety in Monterey, Calif. He is the chairman of the foundation's international ALAR effort and led the foundation's international efforts in smoke-fire-fumes, functional check flights, and runway safety.

In addition, we not only want to just reduce risk, but we would also like to reduce risk in the highest-risk areas. It would be good to prevent one accident every 10 years but even better to prevent 10 accidents every year. We have data that show us what the high-risk areas are. Figure 1 is the annual Boeing accident summary for 2002–2011. You don't need to be a trained analyst to look at this chart and determine what the high-risk areas are. So safety is essentially one thing—managing risk, and the key to managing risk is utilizing data to identify the hazards.

All safety professionals know that risk equals probability times severity. We also know that everything in life has risk. Managing that risk is called safety. So how do we manage risk? Well, you modify the probability or you modify the severity of a hazard. For example, for runway excursion risk, you can modify the severity by installing an EMAS bed at the end of a runway. This does not affect the probability of a runway excursion, but it does reduce the severity, and thus the overall risk of a runway excursion. Likewise, you can establish stabilized approach criteria and have a no-fault go-around policy. These will reduce the probability of a runway excursion and again the risk. However, these will not affect the severity if an excursion occurs.

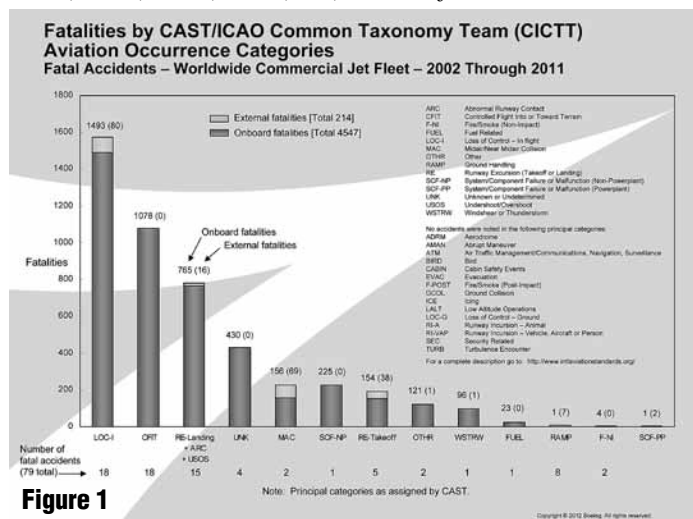


Figure 1

very basic concept—you need to eliminate, reduce, or acknowledge the risks you face. The first (and most difficult) step in any listing of risk management procedures is identifying hazards. If you don't know them, it is difficult to address them and thus to reduce risk. To identify hazards, you need data—accident data, incident data, and other data.

High-risk organizations

Now some organizations operate in higher risk environments than others, i.e., they are high-risk organizations. In other words, in their risk calculations, severity is a large number. Due to the type of operations, and particularly the consequences of risk management failures, some organizations operate in high-risk environments, and risk management is not just important—it is critical.

Examples of this type of organization are the nuclear industry, the oil and gas industry, the chemical industry, medical, and,

Being Predictive in a Reactive World

By Jim Burin (MO4448), Director of Technical Programs, Flight Safety Foundation

of course, aviation. It turns out that these organizations have some common elements they use to successfully manage risk. These elements include good procedures that are written, well developed, and kept current; investigating risk-management failures with the goal of preventing them from happening again; sharing information on risk-management successes and failures; being proactive when addressing risk; and utilizing data in their risk-management efforts.

The following are definitions for some of the terms that have been used that will be helpful as we continue:

Reactive—Wait until an accident happens then address the risks.

Proactive—Do something before an accident happens by utilizing history, data, etc. Safety has a well-earned reputation for being a leader in risk management because of its proven ability to be proactive.

Predictive—Do something based on potential risk to avert an accident that has not happened (yet).

Figure 2 depicts a scale of how these definitions might be viewed with reactive at one end of the spectrum and predictive at the other. Prediction is really not difficult when talking about the major risk areas identified earlier. For instance, we can all predict 90 percent of next year's major accidents. Fifty percent will be approach and landing accidents, and half of those will be runway excursion accidents. There will be at least two turbojet and four turboprop controlled CFIT accidents, and there will be



one or two upset aircraft accidents. A small percentage of the accidents each year are what is now called “black swan” events. These are events that, by definition, cannot be predicted. These include accidents like TWA 800, QF 32, and BA 038. We may never be able to predict events like these, but perhaps we can predict other critical areas to reduce risk.

Risk management and data

This brings us back to the two questions posed earlier: 1) Can we be predictive? and 2) Will it reduce risk? The answer to both of these questions is based on one thing—data. All our risk-management efforts today are based on data. If you don’t have data, it is unlikely you can get support for any risk-reduction effort. That is why the Flight Safety Foundation’s ALAR and CFIT efforts were successful in the 1990s—they replaced a lot of qualitative ideas with quantitative facts, all based on data. Now the data we use can be from an accident investigation (i.e., reactive) or from a data study of previous accidents or incidents (i.e., proactive), or from potential events that haven’t even happened (i.e., predictive). One word of caution about data, particularly in today’s digital world, it is possible to have too much data. There are organizations that get so much data that just managing it on a day-to-day basis takes all their time, energy, and expertise, and the real value of the data is never fully exploited.

So back to the question of can we be predictive. The answer

depends on what you want to predict. At this time, it is unlikely that being predictive will discover some new, unknown high-risk area and prevent a black swan event. It is doubtful we will identify some new high-risk area like CFIT or LOC by prediction. We have already identified the high-risk areas. However, by using today’s data collection and analysis capabilities, prediction may enable us to look deeper into the already identified high-risk areas to gain more insight into how effective our risk-reduction efforts are and perhaps identify risk-reduction gaps that we have missed. So can we be predictive? Yes.

Now to answer the question “Will being predictive reduce risk?” I think the answer to this is again yes. Our wealth of data today enables us to not only look at past accidents and incidents, but to also see what is happening in normal day-to-day operations and to identify what the trends are. This is where the real benefit of prediction will be found—using data to look at trends that point to things that have not yet happened. Data enable us to look at the known high-risk areas and “predict” where we might look to reduce the risk even more—and without having an accident. Some examples are shown in the work ASIAS has done in identifying areas of multiple TAWS alerts, TCAS hot spots, and highlighting runway excursion risks before an excursion accident happens.

Decision-maker decisions

All this leads us to our reactive world and what support predictive efforts will get, i.e., what decision-makers will do. This is probably our biggest challenge when it comes to making prediction successful. Just because we can predict does not mean prediction will be successful in reducing risk. Decision-makers, particularly bureaucratic decision-makers, are reactive by nature. The only way we can hope to influence them is by going back to the basics of risk management. We need to be able to show the risk, and show the ability to reduce the risk by addressing the probability or the severity. The only way we will be able to do this is with data.

However, we must realize that even with data it may be difficult to get decision-maker support due to the reactive nature of the system. Sometimes support is hard to get even when being reactive. For example, let’s say we could have predicted TWA 800. What would have been the result? Remember, it has taken 15 years to start seeing the risk-reduction actions identified in that accident, and this was not a predicted risk. This event happened! We knew that CFIT was the leading killer in the 1990s, yet it took the Cali accident to make TAWS mandatory—and then seven years after the accident happened! The fact is that even being reactive has sometimes been difficult or at best very slow.

There are two keys to being predictive in a reactive world: 1) Have the data to verify the risk and show it is worth addressing and 2) Have the support of the decision-makers. The key to both of these is data. Data will enable us to use our predictive capabilities to further reduce risk. Decision-makers, this includes individuals and the safety and regulatory systems themselves, are reactive by nature. However, with today’s data capabilities we can hopefully use prediction to generate a risk-reduction action before an accident. Data will also allow us to address the age-old safety dilemma: How do you prove that you prevented an accident from happening if it doesn’t happen? By utilizing incident and normal operational data in our prediction process, we will be able to show that we reduced the risk of an accident and hopefully avoid having to react to one. ♦

ISASI 2013 Planners Prepare Program

ISASI'S 44TH ANNUAL international conference on air accident investigation to be held in Vancouver, B.C., Canada, Aug. 19–23, 2013, is deep into its registration and program planning stages. Planners expect to have the seminar website, which will be accessible via a link on ISASI's website, www.isasi.org, up for use very soon. The theme of the conference is "Preparing the Next Generation of Investigators."

The Call for Papers has been issued, noting that papers should address the theme of the seminar or timely matters of air safety. The time table for submissions shows that the expression of interest date is Feb. 4, 2013. Deadline for submission of abstracts (300 words) of the paper is March 4. Authors of papers selected for presentation will be notified by April 4. Deadline for submission of the final paper is July 19. All contact with the Technical Committee regarding technical papers may be made through e-mail address isasi2013@msn.com.

Richard Stone, Technical Committee chairman, notes that the technical program will include a panel of aeronautical educators presenting comments on "Preparing the Next Generation of Investigators" and a panel of original equipment manufacturers from GE, Rolls-Royce, and others also addressing the theme of the seminar. The tutorial program will involve a session on "Composite Material and Investigations," with presenters from Boeing, Airbus, TSB Canada, and AAIB Australia.

Barbara Dunn, seminar chairperson, said the annual event will be held at the Westin Bayshore Hotel, which is on the shores of Coal Harbour overlooking the stunning North Shore Mountains. The hotel is located only a short walk to the downtown business district, shopping, and entertainment. The 1,000-acre Stanley Park is mere steps away via the famous Seawall. Amenities include an exercise room, indoor and outdoor

pools, treatments in the Vida Spa, and unique dining experiences in three hotel restaurants.

Vancouver geography

Vancouver is located on the southwest corner of the mainland of British Columbia and is bounded on three sides by water. To the city's north, Burrard Inlet separates Vancouver from north Vancouver and west Vancouver. On its western boundary is the Pacific Ocean's Strait of Georgia. And to the south, the Fraser River separates Vancouver from its smaller satellite communities. The Coast Mountains, which rise more than 5,000 feet (1,500 meters), gloriously preside over the city. Vancouver's population is approximately 628,621 in a region of more than 2.3 million. A major port, Vancouver is the province's largest city as well as Canada's third largest. Summer in Vancouver is pleasantly warm. July and August temperatures typically reach 71.6 ° F (22° C) but can easily climb to near 86 ° F (30° C). Thanks to ocean breezes, it is usually a few degrees cooler by the water. These are ideal weather conditions for pursuing outdoor adventures such as hiking, mountain biking, golfing, and walking.

Getting there

Vancouver is British Columbia's main transportation hub. Air travelers have two international airports to choose from, one of which is the second largest passenger gateway on the West Coast of North America. Vancouver International Airport (YVR) is B.C.'s primary air transportation hub and is located in Richmond, approximately 30 minutes from downtown Vancouver via car or the Canada Line (rapid transit), and is the gateway to flights from around the world. The Abbotsford International Airport, approximately an hour east of Vancouver, is a convenient hub for the region's air service from across Canada.

The Canada Line (part of the SkyTrain rapid transit system) provides a direct link between YVR and downtown Vancouver. Traveling on the Canada Line is fast, easy, and affordable—passengers arriving at YVR can board the Canada Line and arrive in downtown Vancouver in approximately 30 minutes. ♦

Kapustin Scholarship Deadline Is April 15

The ISASI Rudolf Kapustin Memorial Scholarship Fund administrators, Richard Stone and Ron Schleede, urge all members to quicken their search for students to apply for the memorial scholarship offered by ISASI. The deadline for applications is April 15, 2013. Full application details and forms are available on the ISASI website, www.isasi.org. Fund administrators stress the need for applicants to adhere to the deadline date and not to exceed the word limit of the required 1,000-word essay.

Instituted in 2002 to memorialize all deceased ISASI members, the fund has provided scholarship help to 24 worthy students. What began as a two scholarship award has in 2012 grown to four. The requirements are that applicants must be enrolled as full-time students in an ISASI-recognized education program, which includes courses in aircraft engineering and/or operations, aviation psychology, aviation safety, and/or aircraft occurrence investigation, etc., with major or minor subjects that focus on aviation safety/investigation.

An award of US\$2,000 is made to each student who wins the competitive writing requirement, meets the application requirements, and registers to attend the ISASI annual seminar. The award will be used to cover costs for the seminar registration fees, travel, and lodging/meals expenses. Any expenses above and beyond the amount of the award will be borne by the recipient. ISASI corpo-

ISASI ROUNDUP

Continued . . .

rate members are encouraged to donate "in kind" services for travel or lodging expenses to assist student scholarship recipients.

Students granted a scholarship also receive

- a one-year membership to ISASI.
- tuition-free attendance from the Southern California Safety Institute (SCSI) to any regularly scheduled SCSI course. This includes the 2-week Aircraft Accident Investigator Course or any other investigation courses. Travel to/from the course and accommodations are not included. For more information, go to www.scsi-inc.com/.
- a tuition-free course from the Transportation Safety Institute. Travel to/from the course and accommodations are not included. More information is available at www.tsi.dot.gov/.
- tuition-free attendance from the Cranfield University Safety and Accident Investigation Center for its five-day Accident Investigation Course, which runs as part of its master's degree program at the Cranfield campus, 50 miles north of London, UK. Travel to/from the course and accommodation are not included. Further information is available at www.csaic.net/.

All ISASI members are encouraged to promote the scholarship program and urge eligible students to submit applications, which are available on ISASI's website. ♦

Lederer Award Nominations Sought

The ISASI Awards Committee is seeking nominations for the 2013 Jerome F. Lederer Award. For consideration this year, nominations must be received by the end of May.

In announcing the opening of nominations, Gale Braden, committee chairman, said, "No new nominations for the award were received this past year. Usually we

Past Jerome F. Lederer Award Winners

1977—Samuel M. Phillips
1978—Allen R. McMahan
1979—Gerard M. Bruggink
1980—John Gilbert Boulding
1981—Dr. S. Harry Robertson
1982—C.H. Prater Houge
1983—C.O. Miller
1984—George B. Parker
1985—Dr. John Kenyon Mason
1986—Geoffrey C. Wilkinson
1987—Dr. Carol A. Roberts
1988—H. Vincent LaChapelle
1989—Aage A. Roed
1990—Olof Fritsch
1991—Eddie J. Trimble
1992—Paul R. Powers
1993—Capt. Victor Hewes
1994—U.K. Aircraft Accidents Investigation Branch
1995—Dr. John K. Lauber
1996—Burt Chesterfield
1997—Gus Economy
1998—A. Frank Taylor
1999—Capt. James McIntyre
2000—Nora Marshall
2001—John Purvis and The Transportation Safety Board of Canada
2002—Ronald L. Schleede
2003—Caj Frostell
2004—Ron Chippindale
2005—John Rawson
2006—Richard H. Wood
2007—Thomas McCarthy
2008—C. Donald Bateman
2009—Capt. Richard B. Stone
2009—Australia Transport Safety Bureau
2010—Mike Poole
2011—Paul-Louis Arslanian
2012—Curt L. Lewis

get one to three nominations per year. Surely there are some deserving investigators among us. Therefore, I urge you to nominate a person (or persons) whom you believe deserves consideration for this award."

The purpose of the Jerome F. Lederer Award is to recognize outstanding contributions to technical excellence in accident investigation. The award is presented each year during the annual ISASI seminar to a recipient who is recognized for positive advancements in the art and science of air safety investigation.

The nomination process permits any member of ISASI to submit a nomination. The nominee may be an individual, a group of individuals, or an organization. The nominee is not required to be an ISASI member. The nomination may be for a single event, a series of events, or a lifetime of achievement. The ISASI Awards Committee considers such traits as duration and persistence, standing among peers, manner and techniques of operating, and of course achievements.

Once nominated, a nominee is considered for the next three years and then

dropped. After an intervening year, the candidate may be nominated for another three-year period. The nomination letter for the Lederer Award should be limited to a single page.

Chairman Braden says, "This award is one of the most significant honors an accident investigator can receive; therefore, considerable care is given in determining the recipient. Each ISASI member should thoughtfully review his or her association with professional investigators, and submit a nomination when they identify someone who has been outstanding in increasing the technical quality of accident investigation."

Nominations should be mailed or e-mailed to the ISASI office or directly to the Awards Committee chairman, Gale Braden, 13805 Edmond Gardens Drive, Edmond, OK 73013 USA; e-mail address, galebraden@cox.net. ♦

AAIB Singapore to Host Accident Investigation Forum

The Air Accident Investigation Bureau of Singapore (AAIB) will host its Second International Accident Investigation (IAI) Forum on April 23–25, 2013, at the Singapore Aviation Academy.

The IAI forum's aim is to bring together the world's top government investigation officials and experts to discuss issues relating to the organization, infrastructure, and management of accident investigation. The forum is open to investigation officials responsible for discharging their country's obligation under Annex 13 to the Convention on International Civil Aviation, regulatory officials, and aviation safety professionals from the private sector.

Owing to the success of its inaugural forum in 2010, the AAIB has decided to make the IAI forum a triennial event. Nancy Graham, director of the Inter-

national Civil Aviation Organization (ICAO), Air Navigation Bureau, will deliver a keynote address. Topics to be presented, among others, are

- development of a new ICAO Annex 19 on safety management.
- the outcome of the ICAO Safety Information Protection Task Force.
- the conclusions of the AIG roundtable held in Singapore on Oct 16–17, 2012, and chaired by Marcus Costa, chief of the ICAO Accident Investigation Section.

AAIB's inaugural forum was strongly supported by ICAO, the European Civil Aviation Conference (ECAC), the International Society of Air Safety Investigators (ISASI), the Flight Safety Foundation (FSF), and the U.S. National Transportation Safety Board (NTSB). Twenty-nine countries were represented by the 149 government investigation officials and aviation safety professionals who attended. The IAI forum served as a platform for ICAO to inform, explain to, and discuss with the safety investigation community the developments and issues being pursued by ICAO.

For more information on the second IAI forum, fax Steven Teo at (65) 6542-2394 or e-mail steven_teo@mot.gov.sg. ♦

ANZSASI Announces Call for Papers

As announced in the October–December 2012 *Forum*, the New Zealand and Australian Societies will be holding their annual Trans-Tasman seminar in Christchurch, New Zealand, on June 8–9, 2013. Registration details will be released shortly; but in the meantime, the hosting Societies are issuing their Call for Papers.

A representative for the event noted, “We would like offers of papers addressing contemporary air safety investigation and air safety issues. Submit an abstract and short bio by March 1, 2013, to Alister Buckingham at alister.buckingham@caa.govt.nz and send a copy to flister@xtra.co.nz.”

The seminar venue, Chateau on the Park, is adjacent to the Christchurch central business district, and is a 15-minute taxi or shuttle ride from Christchurch International Airport. The seminar will follow the usual format, with a welcome reception on Friday evening, two full days of presentations on Saturday and Sunday, and the seminar dinner on Saturday night.

Seminar and hotel registration details are now available on the ISASI and ASASI websites (www.isasi.org and www.asasi.org). ♦

ISASI Archives Rest With Embry-Riddle Aeronautical University

In September 2005, ISASI donated its entire accident/incident library to Embry-Riddle Aeronautical University. The ISASI collection contains back issues of *ISASI Forum*, ISASI seminar *Proceedings*, accident/incident reports, and air safety publications.

Following the lengthy scanning process by the university, the library was put online. Made available in 2007, the collection is open to ISASI members as well as to members of the Embry-Riddle community, safety scientists and investigators, aviation safety personnel, academic researchers, and others interested in accident investigation and aviation safety.

ISASI President Frank Del Gandio says, “I suspect there are many of you who have accumulated information, reports, articles, etc., that could be added to the library and be beneficial to others. The archives at Embry-Riddle also collect research files, correspondence, accident case files, etc. If you have any information of this nature and are interested in sharing it with

others, please forward the material to the attention of Melissa Gottwald at Embry-Riddle Aeronautical University (Melissa.gottwald@erau.edu). Materials forwarded to Embry-Riddle will not be returned and will become the property of Embry-Riddle.”

The digitized library may be accessed at <http://archives.pr.erau.edu/coll/ms009.html>. Access may also be gained via a link on the home page of ISASI's website: www.isasi.org. You may browse the ISASI collection online or search or browse the entire digital library. The mailing address is Aviation Safety and Security Archives, Embry-Riddle Aeronautical University, 3700 Willow Creek Road, Prescott, AZ 86301. The physical location of the archives is Robertson Aviation Safety Center II (Building 22) on the Prescott Campus. ♦

AsiaSASI Concludes First Asia-Wide Safety Workshop



Lo, chief inspector of accidents of Hong Kong, delivers the workshop's opening speech.

The Inaugural Asian Society of Air Safety Investigators (AsiaSASI) workshop was successfully held on Oct. 18–19, 2012, at the Singapore Aviation Academy. The two-day workshop featured 14 speakers from safety investigation agencies and the aviation industry (including insurers). The use of unmanned vehicles for

debris mapping, safety protection for investigators at the crash site, understanding aviation insurance, and training investigators were among the many topics presented. The workshop provided the participants with very useful information, and the topics generated

ISASI ROUNDUP

Continued . . .

many questions and much discussion.

Norman Lo, chief inspector of accidents of Hong Kong and director general of the Hong Kong Civil Aviation Department (HK CAD), opened the workshop on behalf of HK CAD, which serves as the president of the AsiaSASI.

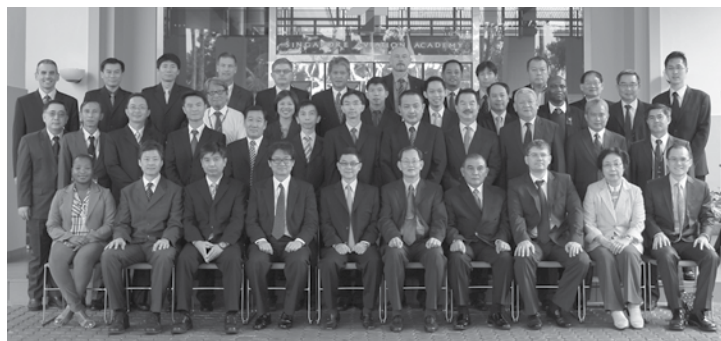
In his opening speech, Lo stressed that “safety is No. 1 in priority in the air transport industry. The entire aviation community includes airlines, emergency service, airport operators, F&B service providers, and regulators. They all have to work together every second to make the sky safe to fly.”

Formed in 2009, AsiaSASI has been promoting collaboration and experience sharing among air accident investigation authorities in the Asia region. “This workshop has indeed proven to be a good platform for AsiaSASI members to network, share ideas, and forge cooperation in accident and incident investigation. Through participation, AsiaSASI members benefited from stronger bonds with air safety investigators around the world,” said an AsiaSASI spokesperson.

As an effort to promote ISASI, invitations to take part in this inaugural AsiaSASI workshop were also extended to non-ISASI members, and the response was encouraging. The workshop was attended by 40 participants from 20 international investigation agencies and airline and airport operators from neighboring regions like Indonesia, the Philippines, Singapore, Taiwan, and Kazakhstan. ♦

Pakistan SASI Hosts Reachout Workshop

The Pakistani Society of Air Safety Investigators (PSASI) hosted an ISASI Reachout workshop titled “A Practical Approach to Safety—Human Factors and Accident Investigation” in Karachi from Sept. 24–Oct. 5, 2012. The program also covered material failures, inflight



Participants in the AsiaSASI inaugural workshop.



Above: Participants gather for the opening of the PSASI workshop. Left: In the back row, from the left: Caj Frostell, Rashid Bhatti, Mike Doiron, and Naseem Syed Ahmed. In the front row, from the left: Syed Adnan Haris, Air Marshal Azim Daudpota, and Engineer Hafeez Ud Deen.

fire analysis, electrical fire analysis, metallization evidence analysis, analysis of operational evidence, the role of the judiciary, and crisis management.

The Pakistan Society became a member of the international organization in August 2012 upon ISASI's International Council approval of an affiliation agreement that established the name of the society and parameters of affiliation. PSASI President Retired Wing Commander Naseem Syed Ahmed said, “[The society] is an initiative by aviation safety professionals in Pakistan to improve the safety culture and aircraft accident investigation processes through education, training, and motivation. Their efforts are aimed at improving the safety risk-management capabilities of organizations and individual safety professionals alike. PSASI members are highly educated, well trained, and experienced aviation personnel with long ca-

reers in military and civil aviation, who have specialized in accident investigation and safety management systems.” PSASI is composed of corporate members Pakistan International Airlines (PIA) and Pakistan Airlines Pilot Association (PALPA) and 13 individual members.

The Reachout course was held at the PIA training center in the vicinity of Karachi (Jinnah) International Airport. On behalf of the ISASI President Frank Del Gandio, Caj

Frostell, ISASI's international councilor, thanked PSASI, PIA, and PALPA for hosting the course and for providing air travel and other services. ISASI instructors were Mike Doiron for the human factors subjects and Caj Frostell for the accident investigation subjects. PSASI instructors were Retired Air Commodore Rashid A. Bhatti and Naseem Syed Ahmed.

At the closing ceremony, ISASI certificates were presented to 31 participating safety professionals.

Concurrent with the workshop, PSASI held a members meeting at which Caj Frostell gave a briefing on ISASI's by-laws and Code of Ethics and Conduct. The PSASI president reported on previous activities and outlined the activity plans for 2013. ♦

New Members

Corporate Members

Aero Republica, Bogotá, Colombia
 Jorge Robles
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Guest Commentary: The Basics of Safety

(continued from page 4)

number of initiatives in the workplace, e.g., IS-BAO, IOSA, SMS, ISAGO, LOSA, safety plans, etc.—all of which have good intentions. But how effective are they? That is the question that needs to be asked. Whatever happened to the safety basics? Complicated processes can be confusing and can be less than helpful or even considered to be an excuse not to carry out those safety basics.

Safety can be taken for granted, and this is certainly true in some airlines. But if safety is genuinely the No.1 priority, then safety departments must be staffed by the best qualified and most motivated people who receive suitable remuneration for their expertise. It should never be an area that is classified as “the rocking chair of the airline,” where good servants are hired for a couple of years past retirement age to top up their pensions.

It can be argued that to become an effective safety manager one needs an all-round knowledge of aircraft and the

airline operation. I agree, but safety must be an area in which energetic thinkers and analysts are encouraged to join for a career, not as a stopgap for better things or a retirement home for aging employees.

For me, safety is a daily challenge and is not about fighting fires but more about stopping the fires from starting. Since retirement, I now find myself in a position where I am able to help airlines, insurers, and the legal side of aviation to better understand the benefits of a sound and reliable safety system.

Safety should never be taken for granted or accepted as a given, and, as the aviation director for RTI London, I work toward the goal of ensuring that all in aviation are aware of that.

RTI is an established international consultancy with a wide range of high-value capabilities for independent investigation of large and small aircraft accidents and incidents, safety analysis, and tailored safety management system development. The RTI aviation team of experts, who possess a broad range of experience and capabilities, is available to apply and, indeed, instruct the basics of safety. ♦

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Unmanned Aircraft System Accidents: Learning to Predict the Unpredictable

(continued from page 22)

erplants, could encounter significantly worse outcomes under similar conditions might be the best predictive tools possible. But unless blood is shed, they simply may not be considered worth the cost.

Proponents of system-safety-based approaches to controlling risk typically identify five opportunities in the lifecycle of a given system to address identified hazards (also known as “design order precedence”):

- as the system is being designed,
- through modifications to established designs,
- through incorporation of “engineered features” to actively interrupt accident sequences and reduce risk,
- through incorporation of subsystems designed to warn of an imminent hazard, if modification is not practical, and
- through development of procedures and training intended to

Beyond safer UAS operations in the future, one other reward is likely to accrue from these efforts: a risk-driven approach to data accumulation will also naturally lead to safer *manned* operations wherever safety efforts for manned and unmanned aircraft can be applied to positively influence one another.

avoid encountering a hazard or to manage its effects.

In a perfect world, these principles would be universally applicable at the earliest possible point in time. For most unmanned aircraft systems, that should mean there is ample opportunity to ensure that known hazards are designed out, and the currently small numbers of most unmanned aircraft fleets should simplify the modification of those currently in service.

Unfortunately, the greatest hazards associated with unmanned aircraft systems relate to their intrinsic limitations in seeing and avoiding other aircraft and their reliance on continuous electronic connectivity between the PIC and his or her unmanned aircraft. Secondly, the autonomous response to the loss of a control link relied upon by the vast majority of unmanned aircraft is utterly dependent on the reliability of the GPS constellation and its local reception. These must be understood to be fundamental attributes of the concept of unmanned aircraft themselves. At best they can be mitigated, but they never can be eliminated.

The question of whether unmanned aircraft should be allowed into the sky already has been decided. So the challenge in many, if not most, future UAS investigations is likely to be finding feasible and defensible strategies for protecting other aircraft and the public from the consequences of inadequate or absent alternatives to onboard see-and-avoid disruptions in pilot/aircraft connectivity and GPS-related failures. Removing the threats themselves is unlikely to be an acceptable option.

The stark choice many investigators will have to face for the foreseeable future is to determine if the consequences or provable threat associated with a given UAS-related event will justify confronting likely resistance to most or all of the possible

recommendations that could best prevent its recurrence. While this often is part of the challenge at the conclusion of a major investigation, for unmanned aircraft systems it must, for now, be a consideration as to whether to initiate an inquiry in the first place. If the payoff won't warrant the overall costs, be they financial or political, it may not be worth doing any more than simply documenting the occurrence for future information and then moving on.

Summary

The purpose of any safety investigation is to identify ways to prevent the occurrence of a similar accident in the future. From that perspective, it is always desirable to investigate any out-of-the-ordinary event involving an aircraft in operation, regardless of the severity of the outcome. However, it is impractical to expend significant time and resources on low-consequence events unless those events

- involve an actual failure of procedures or design features intended to prevent undesirable interactions between manned and unmanned aircraft,
- could reasonably be assumed to result in a far worse outcome under similar circumstances based on the absence of relevant mitigations or the ineffectiveness of those already in place, or
- might have different outcomes if different aircraft or participants were involved, or if they occurred in different system states.

In keeping with the above, it is clear that *any* undesired interaction between a manned and an unmanned aircraft warrants an investigative response. However, as discussed throughout this article, there are a variety of factors investigators must weigh before committing scarce resources to investigations where the return on investment would be questionable. The midair collision threat is the greatest, in terms of both potential consequences and the public's likely concern following any such occurrence. Therefore, any collision or significant disruption of normal operations in controlled airspace involving an unmanned aircraft will warrant a visible, aggressive investigative response.

It is likely that the air safety investigator community will learn to anticipate the vulnerabilities and hazards associated with unmanned aircraft systems and their operation at the same accelerated rate that the sector itself is advancing. In the meantime, it is essential that air safety investigators help regulators gather as much relevant data as possible regarding UAS hazards and risks as quickly as possible. Investigators need a basis upon which to be able to make useful UAS-related recommendations (and to be prepared to investigate potentially new types of accidents), and regulators need hard information upon which to develop meaningful boundaries for UAS operations in airspace shared with manned aircraft.

Beyond safer UAS operations in the future, one other reward is likely to accrue from these efforts: a risk-driven approach to data accumulation will also naturally lead to safer *manned* operations wherever safety efforts for manned and unmanned aircraft can be applied to positively influence one another. ♦

(The views expressed in this paper are the author's and do not necessarily reflect official positions of the Federal Aviation Administration, ClancyJG International, or its clients.)

ISASI Information

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(farrierT@earthlink.net) ♦

Speakers and Technical Papers Presented at ISASI 2012—Baltimore, Maryland, USA

Tuesday, August 28

Seminar Opening—*Frank Del Gandio*,
President of ISASI and Seminar Chair
Keynote Address—*Honorable Deborah A.P.*
Hersman, Chair; U.S. NTSB
Making Safety Predictive in a Reactive
World—*Jim Burin, Flight Safety*
Foundation
The Role of Voluntary Safety Programs in
SMS—*Tim Logan, Southwest Airlines*
Facing the Change: From Organizational
Responsibility to Personal Accountability—
Carmen Hanford, Royal Australian Navy
Safety Boards and the Evolution of
Predictive Safety Management—Mike
Cunningham, TSB Canada
The A320 Overrun in Sao Paulo, in July,
2007—*Fernando Camargo, CENIPA, Brazil*
Ultra Low Cost FDR for GA and Legacy
Aircraft—*Major Adam Cybanksi, Royal*
Canadian Air Force

Wednesday, August 29

Keynote Address—*Honorable Wendy*
Tadros, Chair; TSB Canada
Monitoring Emerging Risks through the
Analysis of Data: Techniques Used by
Australian Investigators—*Stuart Godley,*
ATSB, Australia
Maintenance Safety Survey: Transferring
Predictive Safety Tools from Flight Ops to
Maintenance—*Marie Langer, Cranfield*
University, UK
Managing a Major Accident Investigation in a
Small Country; Ethiopian #409, off the Coast of
Beirut—*Capt. Mohammed Aziz, MEA/Air Liban*
The Benefits of a Safety Studies Program to
Proactively Promote Aviation Safety—*Joseph*
Kolly and Loren Groff, U.S. NTSB
Design of an Innovative Stall Recovery
Device—*Kindumos Gorinchem and John Stoop,*
Delft University of Technology, the Netherlands
From Daedalus to Smartphones and NextGen:
The Evolution of Accident Investigation Tools
and Techniques—*Jay Graser, Gemitek*
Revisiting Trajectory Analysis: Evolving the
Cranfield Model—*Matthew Greaves, Cranfield*
University, UK

The Use of Odd's Ratios to Quantify the
Relationship between Causal Factors and
Errors—*Michael Sawyer and Katie Berry,*
Fort Hill Group

Thursday, August 30

Reactive & Proactive Flight Data Usage—
AIB Nigeria and Mike Poole, Flightscape
Issues in the Investigation of UAS
Accidents—*Tom Farrier, Former USAF,*
ISASI UAS Working Group
A Holistic Approach to Aircraft Accident
Incident Investigation—*Phillip Sleight,*
AAIB, United Kingdom
Learning from Experience—*Capt. Harry*
Nelson, Airbus
Keynote Address—*Jean-Paul Troadec,*
Director, BEA
Flight Recorders: AF447—*Léopold*
Sartorius, BEA
Human Factor Issues: AF447—*Sébastien*
David, BEA
Media and Victims' Families Issues: AF447—
Martine Del Bono, BEA ♦



WHO'S WHO

United Airlines Owns a Long-Standing Commitment to Safety

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

United Airlines and its Express partners operate an average of 5,557 flights a day to 378 airports on six continents. In 2011, United carried more traffic than any other airline in the world: 142 million passengers on 2 million flights. Safety is integral and is the essential element of every process and activity and of every department, division, manager, employee, and shareholder.

The Aviation Safety Department (ASD), under the Corporate Safety Division, at United is responsible for the analysis of operational data, the investigation of incidents and accidents, and the review of safety information sources used to define flight operational risk and facilitate risk mitigation. ASD's mission statement reflects this fundamental role: Find Truth—Facilitate Change.

In collaboration with all operating divisions, ASD has put in place a safety management system (SMS) to provide for the systematic management of risk across the operation. The SMS is built upon four components: safety policy, safety risk management, safety assur-

ance, and safety promotion. One of the critical data inputs of this evolutionary and comprehensive safety system for managing risk is to begin with the proactive identification of safety threats. In an SMS, each employee is responsible for timely reporting any observed safety threat to trigger the safety risk

UNITED



management process. The integration of system safety and quality management produces an environment in which safety outcomes are predictable and risk can be managed to a level that is as low as reasonably practicable.

United Airlines is the first and only major airline that has Aviation Safety Action Programs (ASAPs) to cover all operational areas of the airline. Currently United has 10 ASAPs, many of which run parallel with each other until the programs originating at legacy airline Continental and legacy airline United are merged. These programs cover pilots, flight attendants, dispatchers, maintenance workers, customer service, ramp, storekeepers, and some instructors.

The Flight Operations Quality Assurance (FOQA) program provides a tool

to enable the ASD to analyze data and identify operational risks and trends otherwise not detectable. The FOQA program obtains and analyzes data recorded in flight from a fleet of 706 aircraft to improve crew performance, training programs, air carrier operating procedures, air traffic control proce-

dures, airport maintenance and design, and aircraft operations and design.

The Flight Safety Investigations Team conducts comprehensive, independent flight safety investigations of any incident that occurs under the command of the pilot that shows potential for personnel injury or damage to property. The sole objective is to prevent accidents and incidents. The processes are nonpunitive and not designed to apportion blame or liability and work in concert with the ASAP, FOQA, and SMS programs for overall enterprise risk mitigation.

To be effective, the investigation process is dependent on proactive involvement of subject-matter experts (SME) from various divisions and areas of expertise to actively participate in the investigation on party working groups. SME support is critical to ensuring a factual, independent, collaborative investigation. ♦